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Practice Guideline

European Resuscitation Council Guidelines 2025 Executive Summary

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Abstract

The 2025 European Resuscitation Council (ERC) Guidelines present the most up-to-date evidence-based guidelines for the practice of resuscitation across Europe. The ERC Guidelines 2025 are based on evidence produced by the International Liaison Committee on Resuscitation (ILCOR) in the form of systematic reviews, scoping reviews, and evidence updates, published as the ILCOR Consensus on Science with Treatment Recommendations. The certainty of evidence of these ILCOR treatment recommendations was used to issue the ERC Guidelines 2025 Recommendations. In some cases, the ERC made good practice statements when evidence was absent for certain topics. If no ILCOR review was available, the ERC writing groups conducted their own reviews to provide recommendations. The ERC Guidelines 2025 cover the epidemiology of cardiac arrest, the role that systems play in saving lives, adult basic life support, adult advanced life support, resuscitation in special circumstances, post resuscitation care, newborn resuscitation and support of transition of infants at birth, paediatric basic and advanced life support, resuscitation ethics, education for resuscitation, and first aid. These guidelines are a framework of recommendations for the approach to out-of-hospital and in-hospital resuscitation; the implementation is achieved locally taking local legislation and health care regulations into consideration.

Introduction

The history

The European Resuscitation Council (ERC) aims to preserve human life by making high-quality resuscitation available to all.[2] To achieve this, up-to-date evidence-based European resuscitation guidelines for the prevention and treatment of cardiac arrest and life-threatening emergencies have been published since 1992. The 1992 guidelines covered basic[3] and advanced life support (ALS).[4] Two years later in 1994, a guideline for paediatric life support (PLS)[5] and a guideline for the management of *peri*-arrest arrhythmias[6] followed. Guidelines for basic and advanced management of the airway and ventilation during resuscitation[7] were published in

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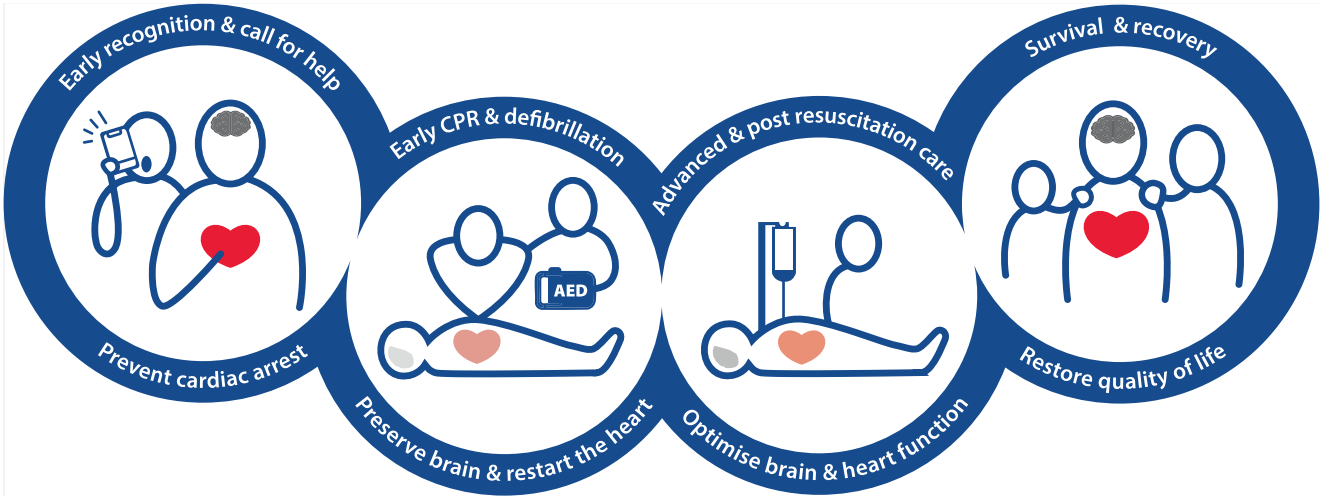


Fig. 1 – Chain of survival.

1996 and updated ERC guidelines on basic life support (BLS) and ALS in 1998.[8,9] In 2000, international guidelines were produced in collaboration with the International Liaison Committee on Resuscitation (ILCOR).[10] Subsequently, the ERC produced its guidelines every 5 years: 2005[11], 2010[12] 2015[13], and 2021[14] (with a one-year delay because of COVID-19). In addition, the ERC published guideline updates in 2017 and 2018[15,16] based on the ILCOR Consensus on CPR Science and Treatment Recommendation (CoSTR) publications.[17,18] An ERC update was published in 2020 and concerned resuscitation in the context of COVID-19.[19] The ERC Guidelines 2025 are based on an extensive update on resuscitation science from ILCOR's CoSTR 2025[27] and provide the most up-to-date evidence-based guidelines for laypersons, healthcare professionals and all stakeholders responsible for health policy across Europe.

The chain of survival

The four-ring ERC Chain of Survival was first presented 20 years ago[1,11] as a concept to highlight time-sensitive interventions that aim to improve survival of cardiac arrest victims. It included early recognition and activation of the emergency medical services in the first ring, early CPR and defibrillation in the second and third ring, and post-resuscitation care in the fourth ring.

The chain of survival has been revised for the ERC Guidelines 2025 so that it reflects recent developments in resuscitation science in prevention of cardiac arrest, survivorship, and long-term recovery following cardiac arrest. Following discussions about the numbers of rings and additional text, the ERC has retained the four-ring chain of survival and retained the simplicity of the original drawing.

Prevention of cardiac arrest was already part of the first ring, but to emphasise its growing importance it was moved to the header of this ring. The content of that ring was kept as before: early recognition of a deteriorating patient or cardiac arrest (in- or out-of-hospital) and early call for help. The second ring condensed the former two central rings and integrated early cardiopulmonary resuscitation and defibrillation as an integrated approach to restart the heart and preserve brain and heart function. The new drawing visualises a person providing an AED while CPR is ongoing. The third ring is now advanced- and post-resuscitation care, aiming to optimise heart and brain function. The newly designed final ring emphasises the importance of recovery to restore the quality of life for the cardiac arrest survivor and their community. Restoration of heart and brain function is depicted by a return to the same colours used for these organs in the first ring (Fig. 1).

International Liaison Committee on Resuscitation[21]

The International Liaison Committee on Resuscitation (ILCOR, https://www.ilcor.org) includes representatives from the American Heart Association (AHA), the ERC, the Heart and Stroke Foundation of Canada (HSFC), the Australian and New Zealand Committee on Resuscitation (ANZCOR), the Resuscitation Council of Southern Africa (RCSA), the Inter-American Heart Foundation (IAHF), the Resuscitation Council of Asia (RCA), and the Indian Resuscitation Council Federation (IRCF), and as a collaborating organization International Federation of Red Cross and Red Crescent (IFRC).

The vision of ILCOR is to save more lives globally through resuscitation,[22,23] through promoting, disseminating and advocating international implementation of evidence-informed resuscitation and first aid, using transparent evaluation and a consensus summary of scientific data.[24] As one of the founding members, the ERC works closely with ILCOR to achieve those goals. The core activity of the ILCOR task forces is the systematic assessment of evidence to produce the international CoSTR.

From 2000 to 2015, researchers from the ILCOR member councils evaluated resuscitation science in 5-yearly cycles. After the publication of the 2015 international CoSTR,[25] ILCOR committed to a continuous evidence-evaluation process, and publication of annual CoSTR updates.

The 2025 CoSTR summary and the 96 systematic reviews, the 43 scoping reviews, and the 112 evidence updates of resuscitation science were published in *Resuscitation* and *Circulation* as the 2025 CoSTR,[27–34] which are the basis for the evidence informing the ERC Guidelines 2025 (Table 1).

Table 1 – Summary outline of the process steps for the 2025 CoSTR (reproduced from CoSTR 2025[28]).

Processes for Systematic review (SR)
Develop PICOST (including inclusion and exclusion criteria)
Confirm content expert team
Level of importance allocated to individual outcomes
Develop and fine-tune database specific search strategies
Registers systematic reviews (SR) with PROSPERO
Revised search strategies used to search databases
Articles identified by the search are screened according to inclusion and exclusion criteria
Compile final list of studies to include
Assessment of bias for individual studies
Data extracted for creation of tables
GRADE Evidence Profile table created
Evidence to Decision framework completed
Draft Consensus on Science (CoS) statements and Treatment Recommendations (TRs)
Revised draft of CoS and TR
Summary statement created (including recommendation about future reviews)
Public invited to comment on draft CoS and TRs
Detailed iterative review of CoS and TRs to create final version for posting and publication

The ERC Guidelines 2025 development process

High-quality, evidence-informed guidelines are used increasingly to organise healthcare systems, and to guide healthcare professionals in their daily clinical practice.[35]

The Institute of Medicine established quality standards for clinical practice guidelines in 2011,[36] followed by the Guidelines International Network in 2012.[37–39] The ERC follows these principles for guideline development. This includes full transparency of the guidance on panel composition, decision-making processes, conflicts of interest management, guideline objective, development methods, evidence review and creation of recommendations, ratings of evidence, guideline review, and funding. A written protocol describing the guideline development process was developed and approved by the ERC Board before the start of the guideline development process and made available to the public on the ERC website.[40]

Composition of Guidelines Writing Groups

The ERC Articles of Association and Bylaws guided the formal process of the ERC guidelines development.[2] The ERC Director of Guidelines and ILCOR is elected by the General Assembly of the ERC and mandated to co-ordinate the Guidelines development process. The ERC Guidelines Steering Committee was created to support the Director of Guidelines and ILCOR. Key for the formation of the Guidelines Steering Committee was diversity (e.g. gender distribution, early and mid-career and senior resuscitation professionals), which resulted in the following member composition: ERC Director Guidelines and ILCOR (Chair), ERC Director of Science, ERC Director of External Affairs, ERC Chair and Chair-elect, Editor-in-Chief of Resuscitation, representatives from each writing group, Chair of the ERC Diversity, Equity, and Inclusion Committee, and an ERC project manager. All writing groups were represented in the Guidelines Steering Committee, and each Guidelines Steering Committee member was part of no more than two writing groups.

An open call for writing group members was made in February 2024. Following a review of conflicts of interest (described below), writing group chairs and members were appointed by the Board. Members were appointed based on their expertise and credibility as leading (or emerging) resuscitation scientists/clinicians/methodologists, a balance of professions (medicine, physician, non-physician, nursing, paramedicine), diversity (gender, ethnicity, seniority (senior and mid-career level), and geography across Europe.

The ERC also invited content experts for specific ERC Guidelines 2025 from the European associations that have a seat in the ERC General Assembly: members of the European Society for Emergency Medicine (EuSEM) participated in the ERC Guidelines 2025 adult

Basic Life Support (BLS), adult Advanced Life Support (ALS), Paediatric Life support (PLS), Special Circumstances, Systems Saving Lives, Ethics and First Aid; the International Federation of Red Cross and Red Crescent (IFRC) in First Aid and Education, the European Society for Intensive Care Medicine (ESICM) in Post Resuscitation Care and adult ALS; the European Society of Anaesthesiology and Intensive Care (ESAIC) in Special Circumstances, Systems Saving Lives, BLS, ALS; and the European Society of Cardiology (ESC) in ALS and Post Resuscitation Care. Following the recommendations on guideline development, we included a community advisor (volunteer lay persons, survivors, co-survivors, family members of a survivor or non-survivor, etc.) in nearly all writing groups to include also the view of the communities and the public in the ERC guidelines 2025.[41,42]

The appointed writing groups ranged in size from 13 to 22 members, and most were physicians ($n = 86$, 63 %). Thirty-eight percent of writing group members were female, and 28 (20 %) were early or mid-career researchers. The writing group members came from 29 countries including Australia, Austria, Belgium, Brazil, Canada, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Malta, Netherlands, Norway, Poland, Romania, Serbia, Slovenia, Spain, Sri Lanka, Sweden, Switzerland, Tunisia, United Kingdom, and United States.

The competences and role description for writing group members included:

- Provide measurable clinical and scientific expertise in resuscitation (e.g. PubMed citations,[43] h-factor retrieved from Google Scholar,[44] i-Cite RCR).[45]
- Actively participate in the majority of Guidelines writing group virtual meetings.
- Systematically review the published literature on specific topics at the request of the Guidelines writing groups.
- Present review findings and lead discussions within the group on specific topics.
- Develop and refine clinical practice algorithms and the Guidelines.
- Fulfil the International Committee of Medical Journal Editors (ICMJE) requirements for authorship.
- Be prepared to be publicly accountable for the contents of the Guidelines and promote their adoption.
- Being an ERC member (except invited persons from European associations, and community advisors).
- Comply with the ERC non-disclosure agreement and the conflict-of-interest policy.[46] (Fig. 2)



Fig. 2 – Stepwise process for the development of the ERC Guidelines 2025.

Conflict of interest management

Conflict of interest (COI) was managed according to international recommendations[47] and followed the ERC policy for COI (Supplement B).[46] Guidelines Steering Committee and writing group members completed an annual COI declaration. The COI declarations were reviewed by the ERC Governance Committee which prepared and submitted a report to the Guidelines Steering Committee. The ERC guideline development process allowed public access to individual writing group members' COIs through a request form via the ERC webpage.

The members of the Guidelines Steering Committee, the writing group chairs, and at least 50 % of the writing group were required to be free of commercial conflicts of interest. At the chair's discretion, writing group members with a COI were still able to participate in discussions that related to the topic, but were not involved in voting, decisions, drafting or approving recommendations.

The ERC has financial relationships with business partners who support the overall work of the ERC.[48] The development of the ERC guidelines occurred entirely independently from the influence of business partners. None of the Guidelines Steering Committee members or the writing group members were paid by the ERC or any other entity to write these guidelines.

Diversity equality, equity and inclusion[49–52]

The ERC is committed to integrate diversity, equality, equity and inclusion (DEI) as core principles in the development of the ERC guidelines 2025.[50] A representative of the ERC DEI committee joined the Guidelines Steering Committee to guide this integration. The DEI considerations in the guideline process include recommendations for resuscitation in low-resource settings, graphic tables suitable for those with colour vision impairment and subti-

tled linked videos to facilitate understanding for those with hearing difficulties.

Each writing group included at least one early-mid career researcher (20 % of authors in these guidelines), and where possible a lay person was also involved as a community advisor.[53]

Diversity was considered when forming the writing groups and the Guidelines Steering Committee in terms of gender (38 % female, compared with 27 % in 2021), age (51.3 ± 10.9 years, compared with 56.8 ± 10.8 years in 2021), and geographic location (28 countries, 23 European and 5 non-European, compared with 24 countries, 22 European and 2 non-European in 2021).

The ERC guidelines are based on ILCOR treatment recommendations that integrate equity as part of the Evidence to Decision framework.[54,55] Where possible, we checked the equity in the guideline recommendations using (A) the World Health Organization (WHO) INTEGRATE tool for equity to formulate concise guidelines for clinical practice[56], (B) the residence, race, ethnicity, culture, language, occupation, gender/sex, religion, education, socioeconomic status, and social capital (PROGRESS) plus tool, [57,58] and (C) the INternational CLinical Epidemiology Network (INCLEN) tool for low-resource settings.[59] The ERC intends to extend the develop the DEI process in the future.[59–62].

Scope of the guidelines

The ERC Guidelines 2025 address resuscitation practice for the ERC network of 31 national resuscitation councils.[2] The intended audience are lay persons, first aiders, first responders, community healthcare staff, ambulance staff, hospital staff, instructors, teachers in schools, educators, those responsible for healthcare policy and practice, and everybody in the community who is interested in improving survival after cardiac arrest. The ERC Guidelines 2025 are relevant to both the community (out-of-hospital) and hospital settings. The scope of the individual guidelines was developed by the writing groups in the beginning of 2024. The different guideline scopes were posted for public consultation for 2 weeks in May 2024 before being finalised and approved by the ERC General Assembly in June 2024.

The 2025 Guidelines cover the following topics

- Epidemiology in resuscitation[63]
- Systems saving lives[64]
- Adult basic life support[65]
- Adult advanced life support[66]
- Adult special circumstances in resuscitation[67]
- Adult post resuscitation care (in collaboration with the European Society of Intensive Care Medicine)[68]
- Newborn resuscitation and support of transition of infants at birth[69]
- Paediatric life support[70]
- Education of resuscitation[71]
- Ethics in resuscitation[72]
- First Aid[73]

Resuscitation in low-resource settings

Previous ERC guidelines were – and still are – developed predominantly by people from high-resource settings, and for patients and caregivers living in high-resource settings. These guidelines have always assumed an EMS and hospital system equipped with all up-to-date devices, trained personnel (or capacity to train all personnel), and at least 24/7 referral options to tertiary care. This may be true for many parts in Europe, however, not all European regions can be considered as high-resource as there are e.g., lower- or middle-income countries, remote areas, or offshore facilities, etc.[74,75] Within remote areas, the available infrastructure varies.[76] Also, natural disasters, pandemics, or armed conflicts may quickly turn high-resource settings into low-resource settings.

The ERC guidelines are also used in low-income countries and, in line with the ILCOR's focus on the truly global applicability of recommendations,[77] the ERC Guidelines 2025 include considerations on how to apply the recommendations in low-resource settings wherever possible. The guideline recommendations for low-resource settings have been developed together with experts from the respective resource settings whenever possible.

In the context of the ERC Guidelines 2025,'low-resource settings' refers to conditions where healthcare systems are significantly constrained to provide optimal care. Thus, it may not only refer to low-income settings but any area, setting, or situation with significant constraints to the healthcare system, even in in some high-resource countries that are facing increasing financial challenges. Low-resource settings often suffer from a less developed medical infrastructure: This means limited access to essential resources like funding, medications, equipment, transport, or trained staff. These limitations severely impact the ability to provide quality healthcare services to the population at an evidence-based level.

Methods

The step-by-step process for guideline development is summarised in Fig. 2. The ERC Guidelines Steering Committee defined the different ERC Guidelines 2025. An open call for writing group members was made in February 2024. Following a review of conflicts of interest (described below), writing group chairs and members were appointed by the Board. The writing groups developed the scope of their guidelines using a standardised template which contained the overall objective, intended audience, setting for their use, and the key topics that would be covered. These guideline scopes were presented for public comment and revised. The writing groups then identified, discussed, and synthesised the relevant evidence. Based on this, existing guidelines recommendations were updated, new evidence from ILCOR systematic or scoping reviews was integrated into existing recommendations. If topics were not covered by ILCOR, ERC writing groups also undertook their own reviews to assess the available evidence and to synthesise key information and themes.

Evidence reviews

The ERC Guidelines are informed by the continuous ILCOR Evidence Evaluation process which is described in detail elsewhere.[27,28] (Table 1) For the ILCOR CoSTR, three types of evidence evaluation were performed: systematic reviews, scoping reviews, and evidence updates.

ILCOR systematic reviews follow the methodological principles described by the Institute of Medicine, Cochrane Collaboration, and Grading of Recommendations Assessment, Development, and Evaluation (GRADE).[78,79] The reviews are presented according to the Preferred Reporting Items for a Systematic Review and Meta-Analysis (PRISMA).[80]

ILCOR systematic reviews generally have a focused and narrow structured question following the Population, Intervention, Comparison, Outcome, Study design, Timeframe framework. Each treatment recommendation indicated the strength of the recommendation and the certainty of the evidence according to GRADE methodology. The strength of recommendations reflects the extent to which the

ILCOR Task Force was confident that the desirable effects of an action or intervention outweighed the undesirable effects. Such deliberations were informed by the Evidence to Decision Framework developed by GRADE[81] which enables consideration of the desirable effects, undesirable effects, certainty of evidence, values, balance of effects, resources required, cost effectiveness, equity, acceptability and feasibility. A strong recommendation indicates that the desirable effects outweigh the undesirable effects, and typically uses terms such as 'we recommend'. Weak recommendations (low confidence that the desirable effects outweigh the undesirable effects) typically use the term 'we suggest'. Only systematic reviews could result in new or modified ILCOR treatment recommendations that were summarized in the ILCOR CoSTRs.[82]

ILCOR introduced adolopments of recently performed systematic reviews including an update of the literature search and assessment of the evidence according to GRADE methodology,[83] aiming to make a consensus on science statement and, if appropriate, a treatment recommendation.

ILCOR scoping reviews take a broader approach to a topic, and were reported in accordance with the PRISMA extension for scoping reviews utilising narrative summaries across a broader range of subjects that would not be possible through more narrowly focussed systematic reviews.[84,85] Scoping reviews, unlike systematic reviews, cannot formulate a treatment recommendation. Instead, they can trigger a future systematic review, or a good practice statement can be formulated to provide guidance in an area where no or only very weak evidence exists.[86,87] (Table 2)

ILCOR evidence updates[28] were designed to address topics that were previously reviewed to identify if any new evidence had emerged. Such evidence updates either provided assurance that previous treatment recommendations remained valid or highlighted the need to update a previous systematic review. Evidence updates do not enable changes to be made to treatment recommendations or good practice statements but may prompt new recommendations through updated systematic reviews.

Systematic reviews from other organisations available in public domains were eligible for inclusion if they were conducted and reported according to AMSTAR (Assessing the methodological quality of systematic reviews)[88] and PRISMA recommendations.[80]

Table 2 – Certainty of evidence for a specific outcome (or across outcomes).

Grade	Description certainty level
High	We are very confident that the true effect lies close to that of the estimate of the effect
Moderate	We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low	Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low	We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Decision-making processes

The ERC guidelines 2025 are based on the 2025 ILCOR CoSTRs.[27–34] Where treatment recommendations or good practice statements are provided by ILCOR, they have been followed by the ERC. For topics that had no ILCOR recommendation or good practice statement, the ERC writing groups performed their own reviews and discussed the available evidence within the writing groups until consensus was achieved. The writing group chairs ensured that each working group member had the opportunity to present and debate their views and ensured that discussions were open and constructive. All discussions took place during many videoconferences that were held between April 2024 and June 2025. Failure to reach consensus was made clear in the final wording of the recommendation. The quorum for conducting writing group business and for reaching consensus was at least 75 % of the writing group members. The ERC guideline recommendations were endorsed by all writing group members.

Stakeholder consultation and peer review

The scope document was posted on the ERC website for public comment between 16 May 2024 and 12 June 2024. The drafts of all ERC Guidelines 2025 were posted between 5 and 30 May 2025 for open peer review via the ERC guidelines web site. The opportunities to review and comment on these documents were advertised through e-mail, social media (Facebook, Instagram, LinkedIn, X/former Twitter) and the ERC network of 31 national resuscitation councils. Those providing feedback had to identify themselves and highlight any relevant conflict of interest. All national resuscitation councils of the ERC were asked to comment on the guidelines and agreed to the ERC Guidelines 2025.

The ERC Guidelines 2025 drafts received 820 written responses – 7 % of responders reported a conflict of interest of which 29 % were commercial conflicts and 71 % academic. Feedback comments were distributed to the writing groups. Where appropriate, writing groups adapted their draft guidelines accordingly. The final drafts of the guidelines were approved by the ERC Board and the members of the ERC General Assembly in June 2025.

Guideline updates

In 2016, ILCOR started a continuous evidence evaluation process and published each completed CoSTR on the ILCOR website along with annual ILCOR CoSTRs in Circulation and Resuscitation. The ERC recognises the substantial time, effort and resources required to implement new evidence in resuscitation science and to incorporate this into resuscitation guidelines. As the ERC is cognisant of the confusion that could be caused by frequent changes to guidelines, the ERC decided to maintain the 5-year cycles for routine updates to its guidelines and resuscitation course materials. Each new CoSTR published by ILCOR is reviewed by the ERC Science and Educational Committees, and the ERC Directors of Science and ILCOR, to assess its potential impact on the ERC guidelines and education programmes. If important practice changing ILCOR statements are made, which are in conflict with ERC guidelines, the ERC may provide guideline updates to those topics in between the 5-year cycles. This ensures timely judgement of the potential impact of implementing any new science (lives saved, improved neurological outcome, reduced costs) while considering the challenges of a change (cost, logistical consequences, dissemination and communication).

Availability

All ERC guidelines and updates will be freely available through the ERC website and as a freely-downloadable open-access publication in the ERC official journal, *Resuscitation*. National resuscitation councils can translate ERC guidelines for non-commercial use locally.

Financial support and sponsoring organisation
These guidelines are supported by the ERC, which is a non-profit organisation. A budget is set annually by the ERC Board to support the guideline development process.

Concise guidelines for clinical practice

Each ERC Guidelines 2025 has an extended table with changes or new recommendations compared with the ERC Guidelines 2021. Most of the ERC guidelines will be used in emergencies where efficient and timely action is critical. The concise guidelines for clinical practice sections are intended to provide clear, succinct recommendations with easily understood algorithms to provide the reader, mostly healthcare professionals but also trained or untrained lay persons, with unambiguous, step-by-step instructions. As such, these components of the ERC guidelines do not include information about the certainty of evidence or strength of recommendations which can be found in the evidence informing the guidelines sections or in the ILCOR CoSTR publications.[89]

Evidence informing the guidelines

The concise guidelines for clinical practice are followed by the evidence that informs these guidelines in each of the ERC Guidelines 2025. Most ERC recommendations are based on the ILCOR CoSTRs. The certainty of evidence is determined by the ILCOR task forces and ranges from very low to high (see Table 2).[90,91]

In many areas of resuscitation science, there is no evidence or insufficient evidence to formulate an evidence-informed recommendation.[92] However, treatment options are needed for clinical practice, and in such cases the expert opinion of the writing group produced a consensus on current approaches to treatment based on best clinical experience and practice. The guidelines clearly document which aspects are evidence informed versus expert consensus.

The recommendations of the ERC Guidelines on Resuscitation 2025 – Concise guidelines for clinical practice

Epidemiology in resuscitation
These ERC Guidelines 2025 cover the key information on the epidemiology and outcome of out of hospital cardiac arrest (OHCA) and in hospital cardiac arrest and (IHCA).[63] (Fig. 3).

Out-of-hospital cardiac arrest

- The annual incidence of emergency medical services (EMS) treated OHCA in Europe is 55 per 100,000 inhabitants.
- The mean age of patients is of 67 ± 17 years and 65 % are male.
- Seventy percent of OHCAs occur in private locations.
- A shockable rhythm is the initial presentation in 20 % of cardiac arrests; 91 % have a medical aetiology.

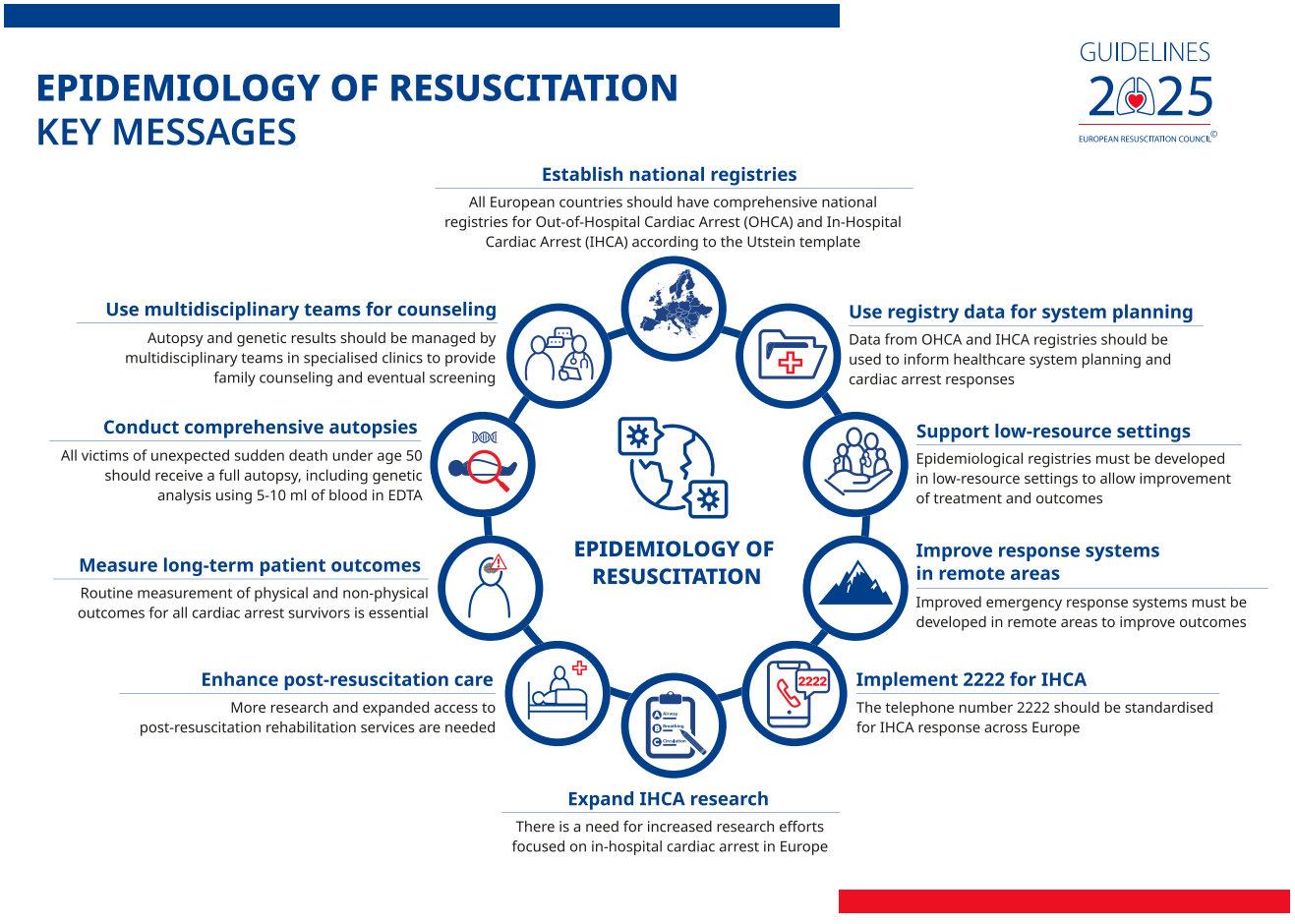


Fig. 3 – Key messages epidemiology in resuscitation.

- Nine European countries have an OHCA registry with full population coverage and 17 countries have a first responder system at least at a local level.
- The bystander CPR rate in Europe is 58 % with significant regional variations (from 13 % to 82 %).
- The use of an automated external defibrillator (AED) before the EMS arrive varies from 2.6 % to 59 % between European countries.
- Survival after OHCA in Europe is 7.5 % with a range in European countries from 3.1 % to 35 %.

In-hospital cardiac arrest

- The annual incidence of IHCA in Europe is 1.5–2.8 per 1000 hospital admissions.
- The proposed standard internal telephone number to alert the emergency team (2222) for IHCA in Europe is implemented in only 2 % of countries (Fig. 4).

Long term survival and return to societal participation

- In European countries where withdrawal of life sustaining treatment is practised, poor neurological outcomes occur in less than 10 % of cardiac arrest survivors, whilst in situations where withdrawal of life sustaining treatment is not practised survival with poor neurological outcome is more common.
- The majority of OHCA survivors indicate the need for post-discharge follow-up with access to a multi-disciplinary team.
- One out of three OHCA survivors receive cardiac rehabilitation and only one out of ten receive brain injury rehabilitation.

Genetic variants and autopsy in cardiac arrest patients

- A clinically actionable pathogenic or likely pathogenic variant in a gene potentially related to the cause of sudden cardiac arrest is identified in up to 25 % of OHCA cases younger than 50 years.
- Autopsy in young sudden cardiac arrest victims is currently not routinely performed in many European countries.

Low resource settings and remote areas

- The rate of bystander CPR and AED use is lower in low resource settings compared to high-resource settings.
- Lower resourced countries tend to lack OHCA registries according to the Utstein template and based on a reference territory.
- Early BLS and rapid response by an EMS are crucial and determines the prognosis of an OHCA patient also in remote areas.

Systems saving lives

The Systems Saving Lives Guidelines 2025 of the ERC address the impact, organisation, and implementation of topics that support and enable successful resuscitation beyond the individual rescuers competences.[64] (Fig. 5).

The chain of survival

- The chain of survival is a concept that summarises the complex systems saving lives approach. It is intended for everyone involved in resuscitation care, including laypersons, healthcare professionals, educators, and stakeholders. The concept can be used for a variety of purposes, ranging from raising awareness to inclusion in educational materials.
- For simplicity and consistency, the four-link format is used by the ERC.
- For specific situations or target audiences, a multifaceted chain system (i.e., the basic chain of survival plus additional elements) may be applied.

The formula of survival

- The formula of survival depicts the overarching system behind a successful chain of survival and its underlying factors. It can be used to highlight the complex interaction of science, education and implementation to achieve optimal outcomes.

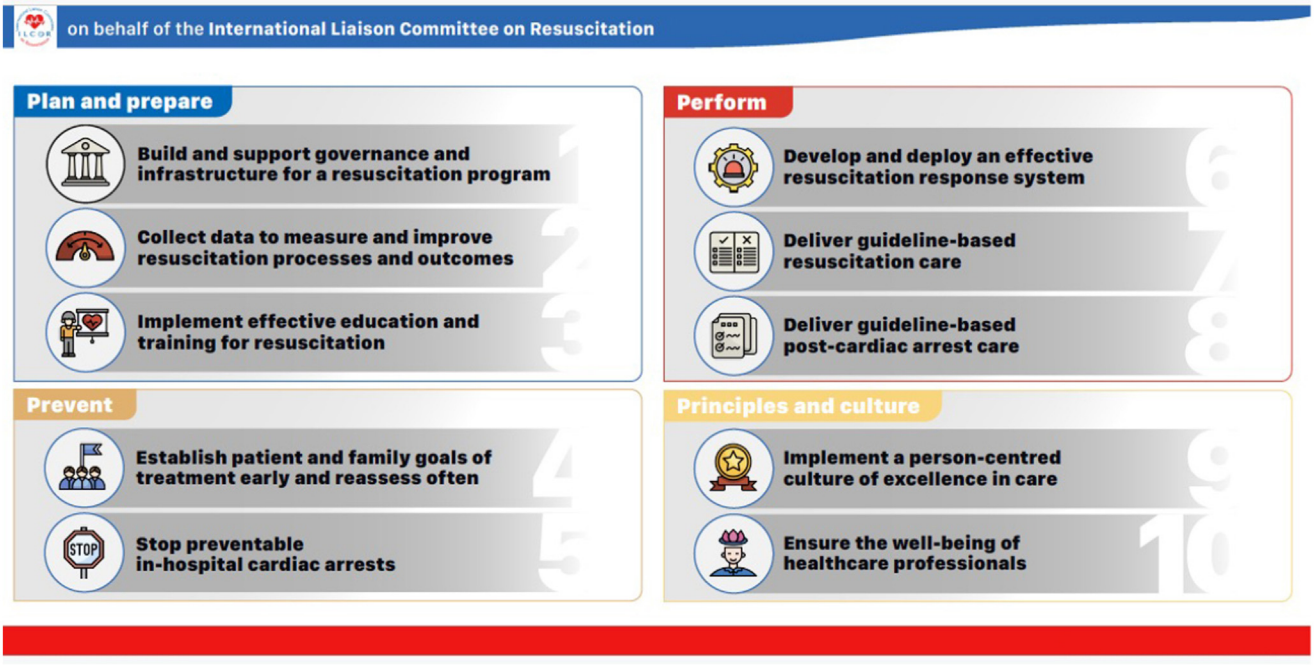


Fig. 4 – 10 Steps to improve in-hospital cardiac arrest quality of care and outcomes.

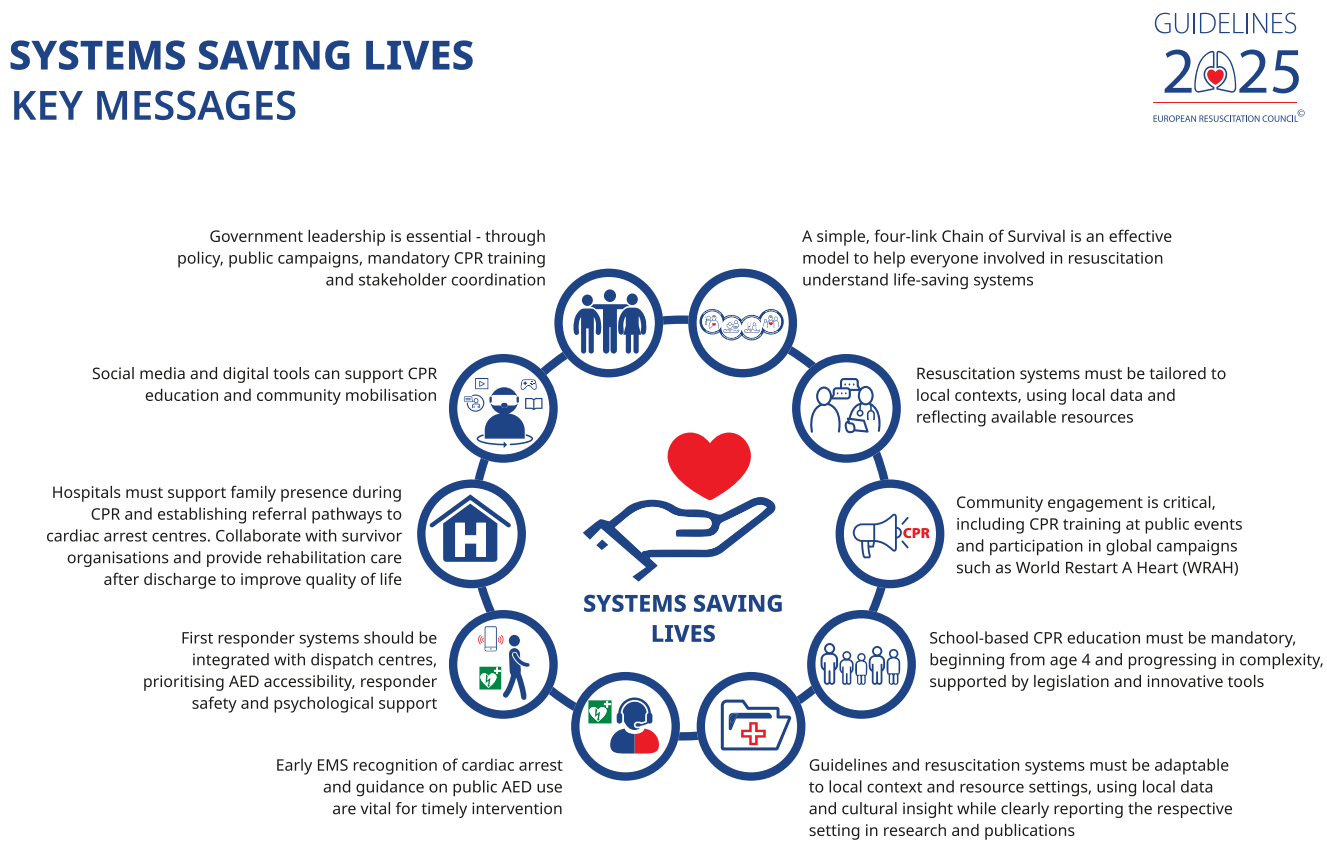


Fig. 5 – Key messages systems saving lives.

- The three interactive factors are: science (referring to the continuous evaluation of evidence by ILCOR and the development of evidence-informed guidelines by the ERC); education (referring to resuscitation training for those who may potentially, or actually take care of cardiac arrest patients—training that must be effective and up to date); and implementation (referring to a well-functioning chain of survival at both regional and local levels, potentially adapted to various resource settings).

Advocacy

- Multi-national collaborative bodies, national governments, local authorities, and national resuscitation councils (NRC) should advocate for policies that increase survival rates and improve the quality of life for cardiac arrest patients through the following actions:
  - o Promotion of comprehensive policies/legislation: advocate for policies that increase survival rates and enhance the quality of life for cardiac arrest patients.
  - o Public awareness campaigns: increase public awareness through initiatives such as World Restart a Heart and Get Trained, Save Lives.
  - o Mandatory CPR education: implement mandatory CPR education for children, students (e.g., Kids Save Lives), and drivers (e.g., Learn to Drive, Learn CPR).
  - o Enhanced workplace preparedness: strengthen policies for workplace preparedness (e.g., Alliance for Workplace Awareness and Response to Emergencies – AWARE).
  - o Stakeholder engagement: collaborate with stakeholders to support cardiovascular health and harmonise CPR policies (e.g., the European Alliance for Cardiovascular Health).
  - o CPR training at major sporting and large-scale events: offer free short CPR training sessions at major sporting events and other large-scale gatherings to raise awareness and increase knowledge among attendees.

Awareness campaigns and initiatives to promote CPR

- Community initiatives to promote the implementation of BLS should be endorsed and supported.
- Multi-national collaborative bodies, national governments, local authorities, and national resuscitation councils should actively participate in World Restart a Heart (WRAH) to raise awareness of bystander CPR and the use of AEDs, train as many citizens as possible, and develop new and innovative systems and policies.

Kids save lives (KSL)

- All schoolchildren should receive BLS training every year, with an emphasis on the Check–Call–Compress approach.
- BLS education should start at an early age (around four years of age), progressing to comprehensive training that includes chest compressions by ages 10–12, ventilation by age 14, and AED usage by ages 13–16.
- Children who have been trained should be encouraged to educate family members and friends, aiming to teach at least ten others within two weeks. Take-home CPR training kits should be distributed to maximise the multiplier effect.
- CPR education should also be extended to higher education, particularly for healthcare and teaching students.
- Technology-enhanced learning (e.g., extended reality, serious games, smartphone apps) should be incorporated to engage schoolchildren effectively and supplement traditional training methods.
- Ministries of education and policymakers should mandate BLS education in schools by law across Europe and beyond, supported by legislation, funding, and public awareness campaigns in every country.

Resuscitation in low-resource settings

- Experts from all resource settings are encouraged to investigate and report on populations, aetiologies, and outcomes of resuscitation, following established reporting standards such as the Utstein reporting template.
- Experts from all resource settings should be consulted regarding cultural differences and the regional and local acceptability, applicability, and implementation of guidelines and recommendations.
- All reports and research on resuscitation should include a brief section on the respective resource setting, for example the income classification of the country.
- In situations where standard guidelines are not applicable, specific recommendations may be developed for low-resource settings (such as areas with limited funding, ships, alpine regions, or remote areas) concerning essential equipment, education, and procedures for managing cardiac arrest both during and after the event.

Social media

- Social media (SoMe) platforms should be leveraged to support public awareness campaigns, disseminate knowledge on CPR for any age group, foster community participation, and further the mission of the ERC.
- SoMe platforms could be used as research tools for data collection, analysis, education, awareness campaigns, communication, and information sharing on cardiac arrest.
- SoMe platforms should be incorporated into CPR training programmes. Educational and healthcare institutions are encouraged to use concise, engaging videos and interactive materials to reinforce learning and retention.
- Real-time engagement should be encouraged. Live question-and-answer sessions, interactive posts, and gamified learning should be used to increase engagement and knowledge retention in CPR training.
- The validation of SoMe content by experts should be promoted. Institutions are encouraged to ensure that educational materials shared on social media align with international BLS guidelines to prevent the spread of misinformation.
- SoMe-driven initiatives should be monitored and evaluated. Further research is needed to determine their impact on CPR training efficacy, bystander CPR rates, and patient survival outcomes.

First responders

- Every healthcare system should implement a first responder programme.
- Registered first responders who are near a suspected OHCA should be notified by the EMS dispatch centre and dispatched to both public locations and private residences, in order to reduce the time to first chest compression and shock delivery, and to improve survival rates with favourable neurological outcome.
- Systems that dispatch first responders should be linked to AED registries and should prioritise both the physical safety and psychological support of first responders.
- Cardiac arrest events should be reported in a standardised manner to monitor system performance and support continuous quality improvement.

EMS organisation in response to cardiac arrest

- EMS should use standardised algorithms or criteria to identify cardiac arrest promptly.
- EMS should teach, monitor, and improve OHCA recognition in dispatch centres.
- EMS should implement and evaluate dispatcher-assisted public access AED systems, including linkage to AED registries.
- EMS dispatch centres should implement systems allowing call handlers to deliver CPR instructions for cardiac arrest patients.
- The use of locked or inaccessible AED cabinets is discouraged.
- All ambulances responding to OHCA should be equipped with a defibrillator.
- EMS should organise prehospital critical care teams for adult and paediatric OHCA.
- EMS should monitor and address low resuscitation exposure among personnel to ensure teams include members with recent experience and implement proper training to overcome low exposure.
- EMS systems treating OHCA should implement system improvement strategies to enhance patient outcomes.
- EMS systems may implement termination of resuscitation (TOR) rules to determine whether to stop resuscitation or continue during transport following local validation of the TOR criteria and considering specific local legal, organisational and cultural context (Fig. 6).

In-hospital cardiac arrest management

- Hospitals should consider introducing a rapid response system (RRS).
- Hospitals should use system improvement strategies to enhance patient outcomes.
- Hospitals should implement protocols for managing family presence during CPR and provide respective education for healthcare teams.
- Hospitals are encouraged to use the “Ten Steps Toward Improving In-Hospital Cardiac Arrest Quality of Care and Outcomes” framework to guide structured, system-wide improvements in resuscitation quality, outcome, and team well-being.



Fig. 6 – Optimising emergency dispatch for cardiac arrest response.

Cardiac arrest centres (CAC)

- Adult patients with non-traumatic OHCA should be cared for at a CAC whenever possible.
- Healthcare systems should establish local protocols to develop and maintain a cardiac arrest network.

System performance improvement

- Organisations or communities that treat cardiac arrest should implement system performance improvement strategies to enhance patient outcomes.

Survivorship and co-survivorship

- Healthcare systems should create and implement policies for the care of cardiac arrest survivors and their co-survivors (e.g. families, close friends, and partners also impacted by the event) from pre-discharge to long-term follow-up. These policies should adopt a multidisciplinary approach, responsive to the needs of both survivors and co-survivors. Healthcare professionals should receive adequate education to support both the identification of needs and the provision of appropriate care.
- National resuscitation councils (NRCs) should connect with and support cardiac arrest survivor organisations within their countries, strengthening ties with healthcare systems, survivors, and co-survivors.
- Engaging in partnerships among NRCs, and with organisations that have broader missions—such as cardiovascular healthcare organisations—can help address the diverse needs of survivors and co-survivors and optimise resource utilisation.
- Healthcare systems should actively engage cardiac arrest survivors, co-survivors, and the public as partners in policy development and research to enhance the quality, relevance, and integrity of outcomes.

New technologies and artificial intelligence

- Artificial intelligence (AI) and digital health technologies show potential to improve cardiac arrest outcomes but are not yet ready for routine clinical use, and their application should be limited to research or controlled settings.

Adult basic life support

The ERC Guidelines 2025 adult Basic Life Support cover cardiac arrest recognition, alerting emergency services, chest compressions, rescue breaths, automated external defibrillation and safety considerations.[65] Evidence pertaining to CPR quality measurement and new technologies are embedded within each of the relevant sections (Fig. 7).

If you encounter someone who appears to be unresponsive follow the **3 steps to save a life**:

- **Check**
  - o Is it safe to approach?
  - o Is the person conscious?
- **Call** EMS immediately if they are unresponsive.
  - o Assess breathing.
  - o If you are unsure the call-taker will assist you.

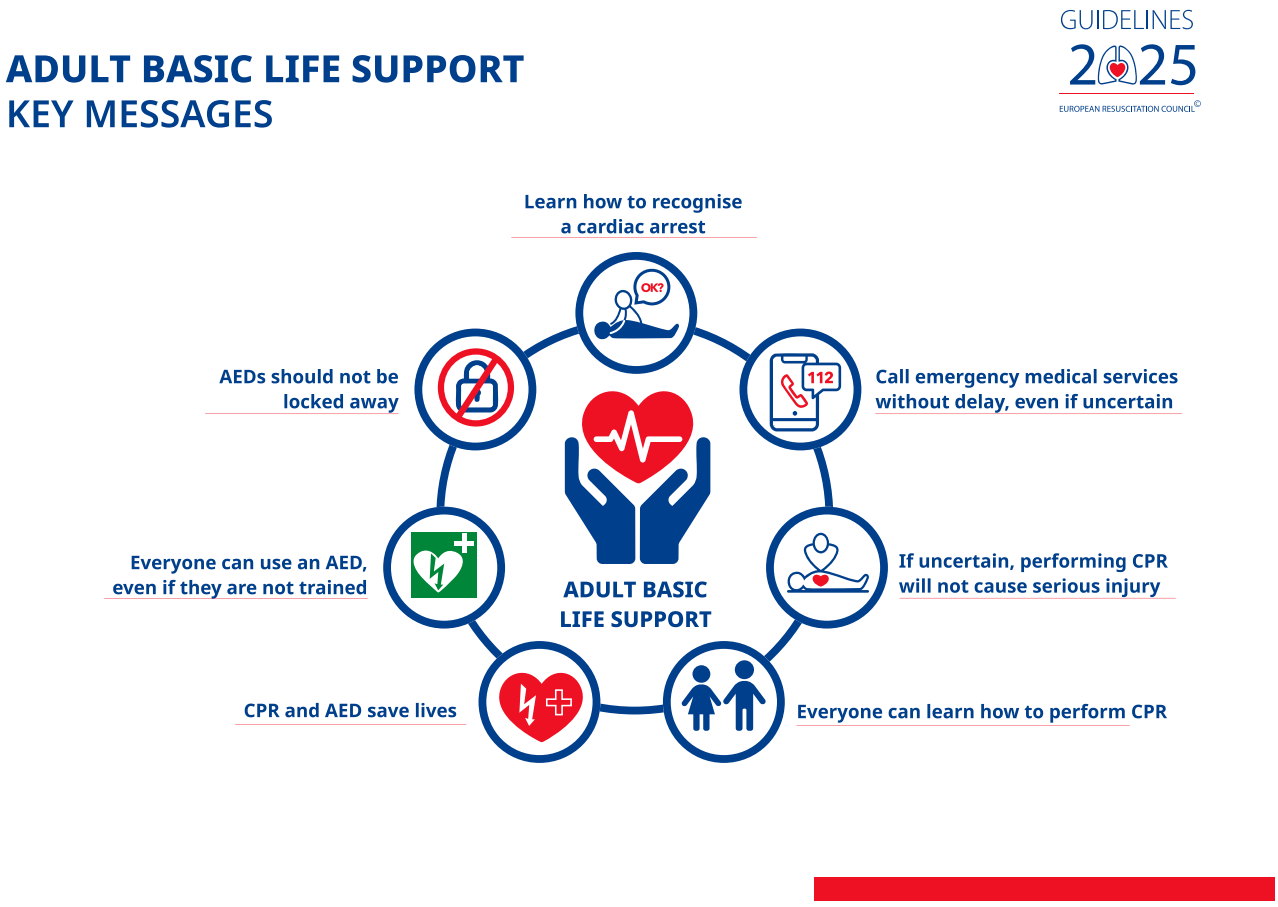


Fig. 7 – Key messages adult Basic Life Support.

- **CPR**: Start CPR immediately if they are **unresponsive with abnormal breathing**.
  - As soon as an AED is available, attach it and follow the AED instructions.
  - If you are unsure the call-taker will assist you (Fig. 8).

Recognising cardiac arrest

- Suspect cardiac arrest in any person who is unresponsive.
- Call your local emergency number without delay.
- Assess breathing while you wait for the call to be answered.
- Slow, laboured breathing, as well as other abnormal patterns such as agonal gasping or panting, must be recognised as signs of cardiac arrest; in such cases, or when in doubt, always start CPR.
- A short period of seizure-like activity may occur at the onset of cardiac arrest. Once the seizure stops, assess breathing.
- If any person is unresponsive with abnormal breathing, cardiac arrest should be assumed.
- If you are uncertain the call taker will be able to assist you.
- If there is any doubt, assume cardiac arrest and start CPR.

Alerting the emergency medical services

- If you have a mobile phone, activate speaker mode, call the local emergency number without delay.
- Assess breathing while you wait for the call to be answered.
- If you are alone and do not have a mobile phone, or there is no mobile phone network/satellite connection, you can shout for help and then continue to assess breathing.
- If you think no-one will come to help, then you will have to leave the person to alert the local emergency service. Do this as quickly as possible.
- If they remain unresponsive and are not breathing normally when you return from summoning help, immediately start CPR.

Role of the dispatcher

- Dispatchers should use standardised protocols to facilitate recognition of cardiac arrest.
- Once cardiac arrest is recognised, dispatchers should provide CPR instructions to all callers.

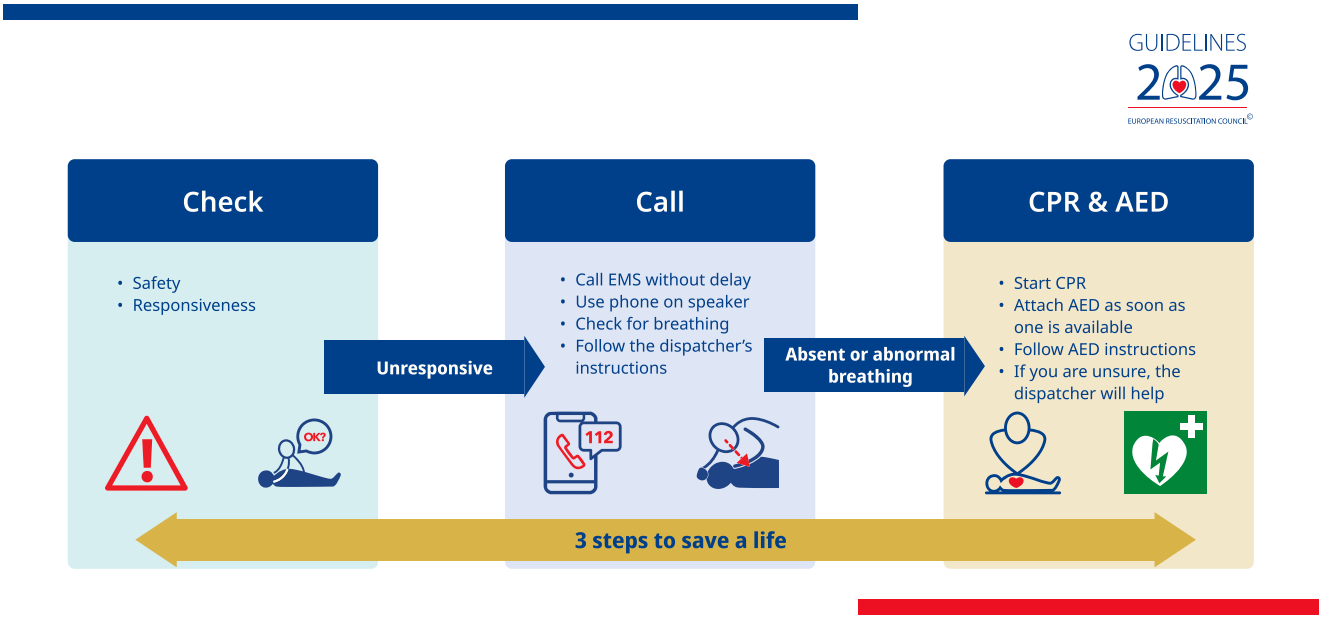


Fig. 8 – Three steps to save a life.

- Dispatchers should assume the caller does not know how to perform CPR, and provide chest-compression-only instructions. If the caller subsequently states they know how to perform rescue breaths, then dispatchers should facilitate 30:2 CPR.
- Once CPR is underway, dispatchers should ask if there is an 'AED' or 'defibrillator' at the scene.
- If no AED is available at the scene, and more than one bystander is present, dispatchers should guide bystanders to the nearest AED.
- As soon as an AED is available at the patient, dispatchers should instruct the bystander to activate the AED and to follow the AED instructions.
- Where first responder systems have been implemented, dispatchers should activate registered community volunteer responders to the incident and to retrieve a nearby AED.

High quality chest compressions

- Commence chest compressions as soon as possible.
- Place the heel of one hand on the lower half of the sternum ('in the centre of the chest').
- If you are unable to adequately visualise the sternum due to clothing, it is reasonable to displace or remove such garments to identify the correct anatomic landmark.
- Place the heel of your other hand on top of the first hand.
- Interlock your fingers of the hands to ensure that pressure is not applied over the ribs.
- Keep your arms straight.
- Position your shoulders vertically above the persons chest.
- Compress to a depth of at least 5 cm, but not more than 6 cm.
- Compress the chest at a rate of 100–120 min^{-1} with as few interruptions as possible.
- Allow the chest to recoil completely after each compression; avoid leaning on the chest.
- CPR is most effective when performed on a firm surface. However, rescuers should not move a person from a 'soft' surface e.g. bed to the floor. Start CPR on the bed and, if needed, compress the chest deeper to compensate for the soft mattress.

Rescue breaths

- If you have been trained to provide rescue breaths, alternate 30 chest compressions with 2 effective rescue breaths.
- When providing rescue breaths, deliver just enough air to make the chest start to rise; avoid excessive ventilation.
- If you are unable to ventilate the chest after 2 attempts, consider foreign body airway obstruction.[73]
- If you have not been trained to provide rescue breaths, perform continuous chest compressions without interruptions (Fig. 9).

Using an automated external defibrillator (AED)

- All laypersons and healthcare professionals should be encouraged to use automated external defibrillators (AED).

How to find an AED

- Ensure that AED locations are indicated by clear signage.
- Signage should state that AEDs can be used by anyone and that no training is needed.
- AED locations may also be identified using electronic mapping systems available on some mobile phone and computer applications.
- The local emergency service should be able to direct callers to the nearest available AED.

When and how to use an AED

- Use an AED as soon as it is available.
- Open the AED case (if present). Some AEDs automatically turn on when opened. If not, identify the power button and turn it on.

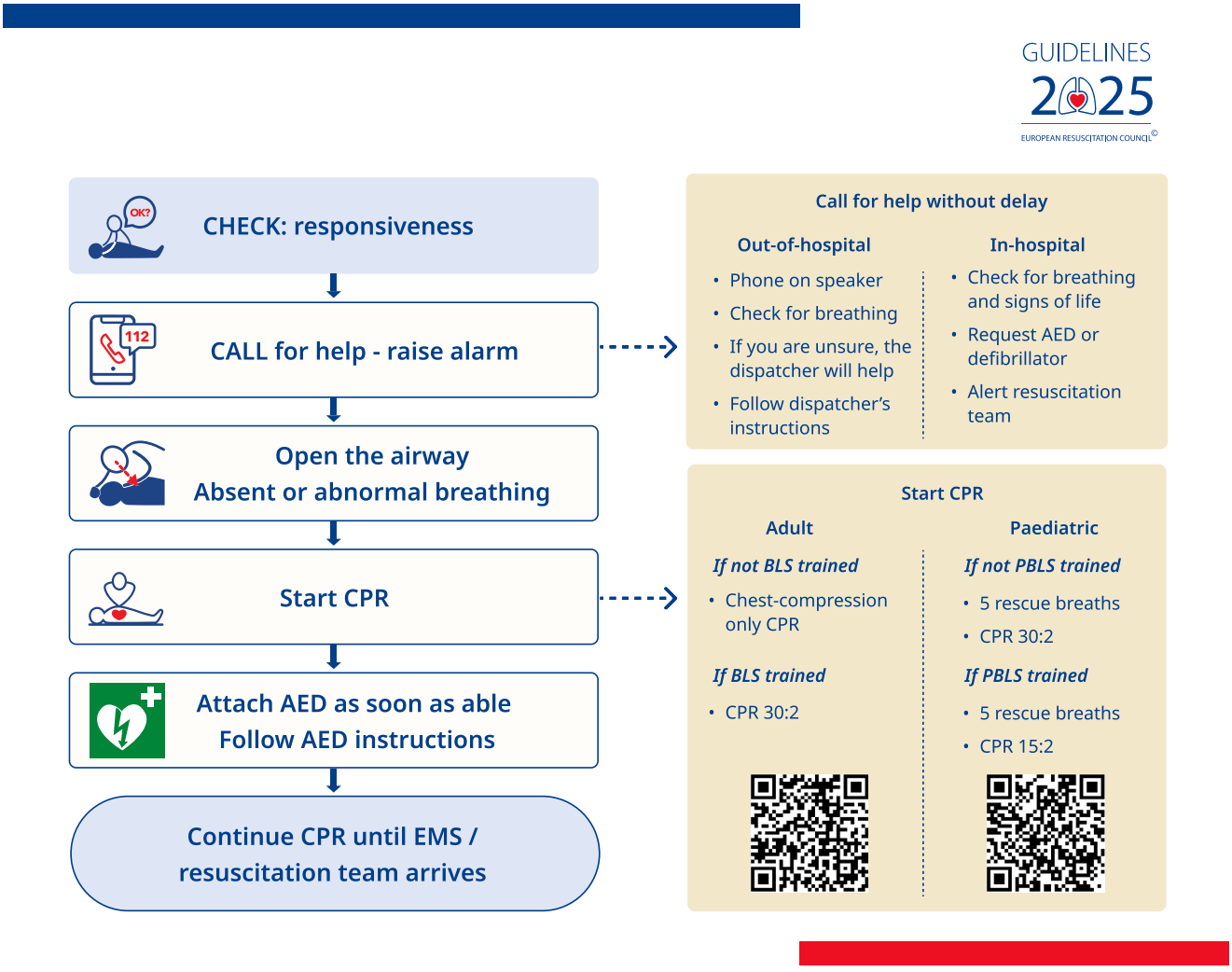


Fig. 9 – ERC Basic Life Support algorithm.

- Follow the audio/visual prompts from the AED.
- Attach the electrode pads to the person's bare chest according to the position shown on the AED.
- If more than one rescuer is present, continue CPR while the defibrillation pads are being attached.
- Ensure that nobody touches the person whilst the AED is analysing the heart rhythm.
- If a shock is indicated, ensure that nobody is touching the person.
- Some AEDs (fully automatic AEDs) will deliver a shock automatically, while others (semi-automatic AEDs) will require the rescuer to press the shock button to deliver the shock.
- After the shock has been delivered, immediately restart chest compressions.
- If no shock is indicated, immediately restart CPR chest compressions.
- Continue to follow the AED instructions.
- Usually, the AED will instruct the rescuer to perform CPR, then, after a set time interval the AED will instruct the rescuer to pause CPR to undertake rhythm analysis.

Where to place AEDs

- AEDs should be placed in clear sight.
- AED cabinets should be unlocked and readily available 24 h a day, 7 days a week, 365 days per year.
- Locations with a high population flow, such as airports, shopping centres and train stations should have on-site AEDs that are readily available for public use.
- Communities are encouraged to deploy AEDs in public spaces, particularly those with a higher incidence of cardiac arrest.
- AEDs should be registered with the local emergency service, especially if they are linked to AED registries and first responder programs.

Safety

- Ensure the safety of yourself, the person in cardiac arrest, and any bystanders.
- Lay people should start CPR for presumed cardiac arrest without concerns of harm to patients not in cardiac arrest.
- The risk of infection to rescuers performing CPR is low.

- The risk of harm to rescuers, from accidental shock during AED use, is low.
- The risk of physical injury to the rescuer, from performing CPR, is low.
- Consider the wellbeing of layperson and bystanders – offer them psychological support.

Adult advanced life support

The ERC adult Advanced Life Support (ALS) Guidelines 2025 provide insight on the prevention of cardiac arrest and advanced treatments for cardiac arrest out-of-hospital and in-hospital.[66] (Fig. 10).

Prevention of in-hospital cardiac arrest

The ERC recommends:

- Shared decision making and advanced care planning which integrates resuscitation decisions with emergency care treatment plans to increase clarity of treatment goals and also prevent inadvertent deprivation of other indicated treatments, besides CPR. These plans should be recorded in a consistent manner.
- Hospitals use a track and trigger early warning score system for the early identification of patients who are critically ill or at risk of clinical deterioration.
- Hospitals train staff in the recognition, monitoring and immediate care of the acutely ill patient.
- Hospitals empower all staff to call for help when they identify a patient at risk of physiological deterioration. This includes calls based on clinical concern, rather than solely on vital signs.
- Hospitals should have a clear policy for the clinical response to abnormal vital signs and critical illness. This may include a critical care outreach service and, or emergency team (e.g. medical emergency team, rapid response team).
- Hospital staff should use structured communication tools to ensure effective handover of information.
- Patients should receive care in a clinical area that has the appropriate staffing, skills, and facilities for their severity of illness.
- Hospitals should review cardiac arrest events to identify opportunities for system improvement and share key learning points with hospital staff.
- Hospitals should participate in national cardiac arrest audit as a benchmark for local performance.

Prevention of out-of-hospital cardiac arrest

- Coronary heart disease (CHD) is the leading cause of sudden cardiac arrest (SCA), responsible for 80 % of cases, particularly in older patients. Non-ischaemic cardiomyopathies contribute to 10–15 % of SCA cases. In younger individuals, the main causes of SCA include inherited heart diseases, congenital heart defects, myocarditis, and substance misuse. In these patient groups, risk stratification is possible, and preventive treatments may be effective.

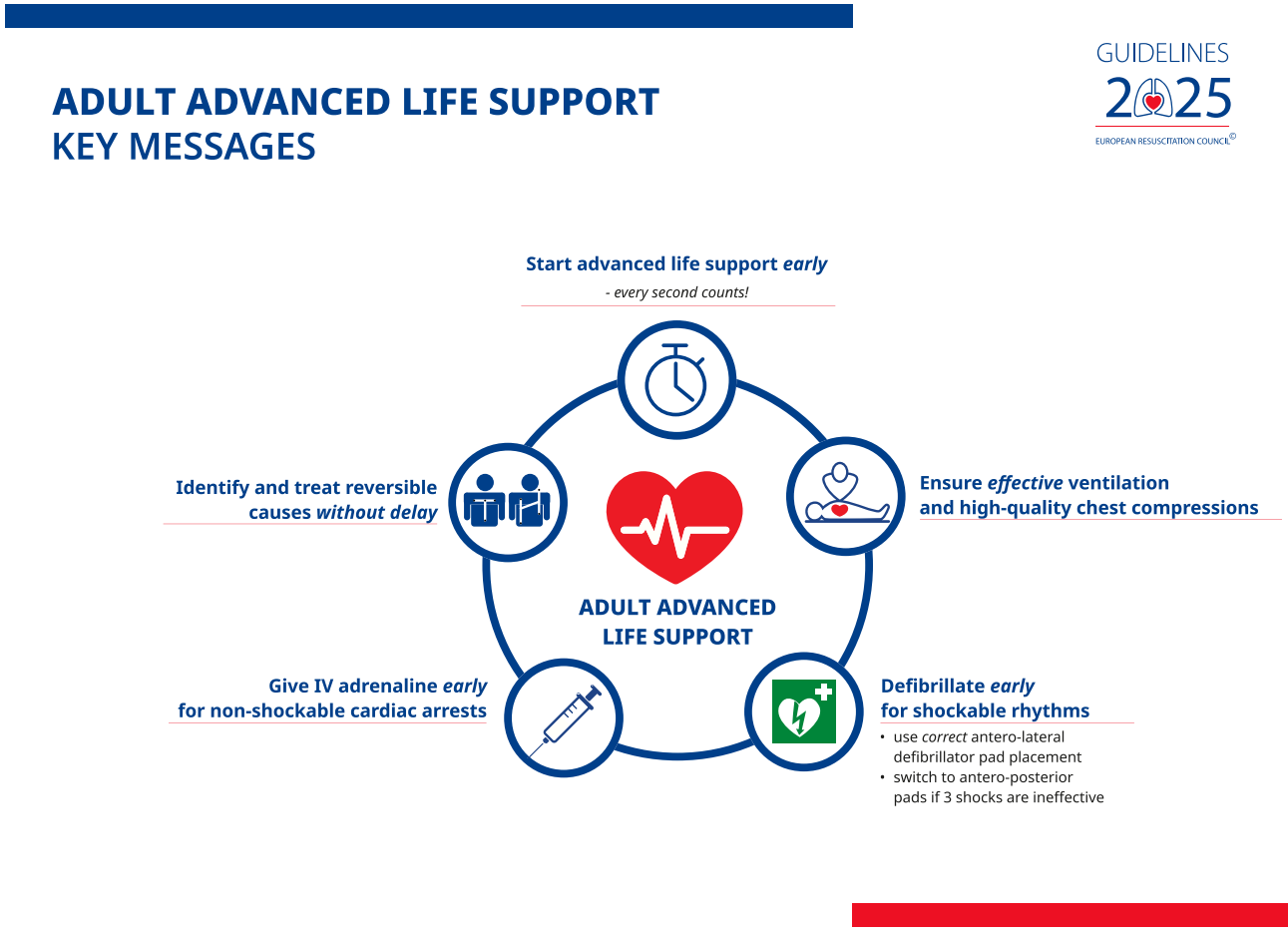


Fig. 10 – Key messages adult Advanced Life Support.

- Predicting SCA is challenging because most cases happen in individuals with undiagnosed heart disease. As a result, systems should emphasise detection of early warning signs, implementation of an efficient EMS system, and focus on the prevention of cardiovascular disease (CVD) risk factors. Symptoms such as chest pain, syncope (especially during exercise, while sitting or supine), palpitations, dizziness or sudden shortness of breath that are consistent with cardiac ischaemia or an arrhythmia should be investigated.
- Overtly healthy young adults who have SCA can also have preceding signs and symptoms (e.g. syncope/pre-syncope, chest pain and palpitations) that should alert healthcare professionals to seek expert help to prevent cardiac arrest.
- Young adults presenting with characteristic symptoms of arrhythmic syncope should have a specialist cardiology assessment, which should include an electrocardiogram (ECG) and in most cases echocardiography, 24-h ECG monitoring and an exercise test.
- Systematic evaluation in a clinic specialising in the care of those at risk for SCA is recommended in family members of young victims of SCA or those with a known cardiac disorder resulting in an increased risk of SCA.
- Identification of individuals with inherited conditions and screening of family members can help prevent deaths in young people with inherited heart disorders.
- Follow current European Society of Cardiology (ESC) guidelines for the diagnosis and management of syncope and arrhythmias.

Treatment of in-hospital cardiac arrest

- Start ALS as early as possible.
- Hospital systems should aim to recognise cardiac arrest, start CPR immediately, defibrillate rapidly (<3 min) for shockable rhythms, give adrenaline rapidly for non-shockable rhythms, and identify and treat reversible causes.
- All hospital staff should be able to recognise cardiac arrest rapidly, call for help, start CPR and defibrillate (attach an AED and follow the AED prompts, or use a manual defibrillator).
- Hospitals should adopt a standard 'Cardiac Arrest Call' telephone number (2222).
- Hospitals should have a resuscitation team that immediately responds to IHCAs.
- The hospital resuscitation team should include team members who have completed an accredited adult ALS course that incorporates teamwork and leadership training.
- Resuscitation team members should have the key skills and knowledge to manage a cardiac arrest including manual defibrillation, advanced airway management, intravenous access, intra-osseous access, and identification and treatment of reversible causes.
- The resuscitation team should meet at the beginning of each shift for introductions and allocation of team roles.
- Hospitals should standardise their resuscitation equipment.
- Termination of resuscitation rules (TOR) should not be used as a sole strategy for terminating an in-hospital resuscitation attempt.

Treatment of out-of-hospital cardiac arrest

- Start ALS as early as possible – EMS systems should be organised to provide a rapid ALS response with sufficient qualified personnel. This may include a prehospital critical care team and take into account which interventions can be provided on scene.
- Adults with non-traumatic OHCA should be considered for transport to a cardiac arrest centre according to local protocols.
- EMS may consider implementing criteria for the withholding and termination of resuscitation (TOR) following local validation of the TOR criteria, taking into consideration specific local legal, organisational and cultural context.
- Emergency medical systems should monitor staff exposure to resuscitation and low exposure should be addressed to increase EMS team's experience in resuscitation (Fig. 11).

Debriefing

Use data-driven, performance-focused debriefing of rescuers to improve future CPR quality and patient outcomes.

ALS in low-resource settings

- ALS guidelines may have to be adapted according to resources and in low-resource settings there may need to be a greater focus on prevention, early first aid, and basic life support measures.
- Rescuers should be aware that even in high-income settings, ALS may be constrained by limited resources.
- A two-tiered approach incorporating basic and advanced interventions may be the safest and most effective.

CPR-induced consciousness

- Cardiopulmonary resuscitation induced consciousness (without ROSC) is uncommon but increasingly reported. Rescuers may consider using sedative or analgesic drugs (or both) in small doses to prevent pain and distress to patients who are conscious during CPR.
- Neuromuscular blocking drugs alone should not be given to conscious patients.
- The optimal drug regimen for sedation and analgesia during CPR is uncertain. Regimens may be based on those used in critically ill patients and according to local protocols such as small doses of fentanyl, ketamine and/or midazolam.

Defibrillation

Automated external defibrillation (AED) versus manual defibrillation during ALS

- Manual defibrillators should only be used by rescuers who can quickly and accurately identify a cardiac arrest rhythm (within 5 s) and, if needed, deliver a safe shock with minimal interruption (less than 5 s) of chest compressions.
- Advanced life support providers must be proficient in using both an AED and a manual defibrillator.
- If an AED is already in use when ALS providers arrive, they should follow its shock prompts. When possible, they should transition to a manual defibrillator during a 2-min CPR cycle.

Defibrillation strategy

- Continue CPR while a defibrillator is retrieved and pads applied. High quality CPR improves the chances of successful defibrillation.
- Give a shock as early as possible when appropriate.
- Deliver shocks with minimal interruption to chest compressions and minimise the pre-shock and post-shock pause. This is achieved by continuing chest compressions during defibrillator charging, delivering defibrillation with an interruption in chest compressions of less than 5 s and then immediately resuming chest compressions.

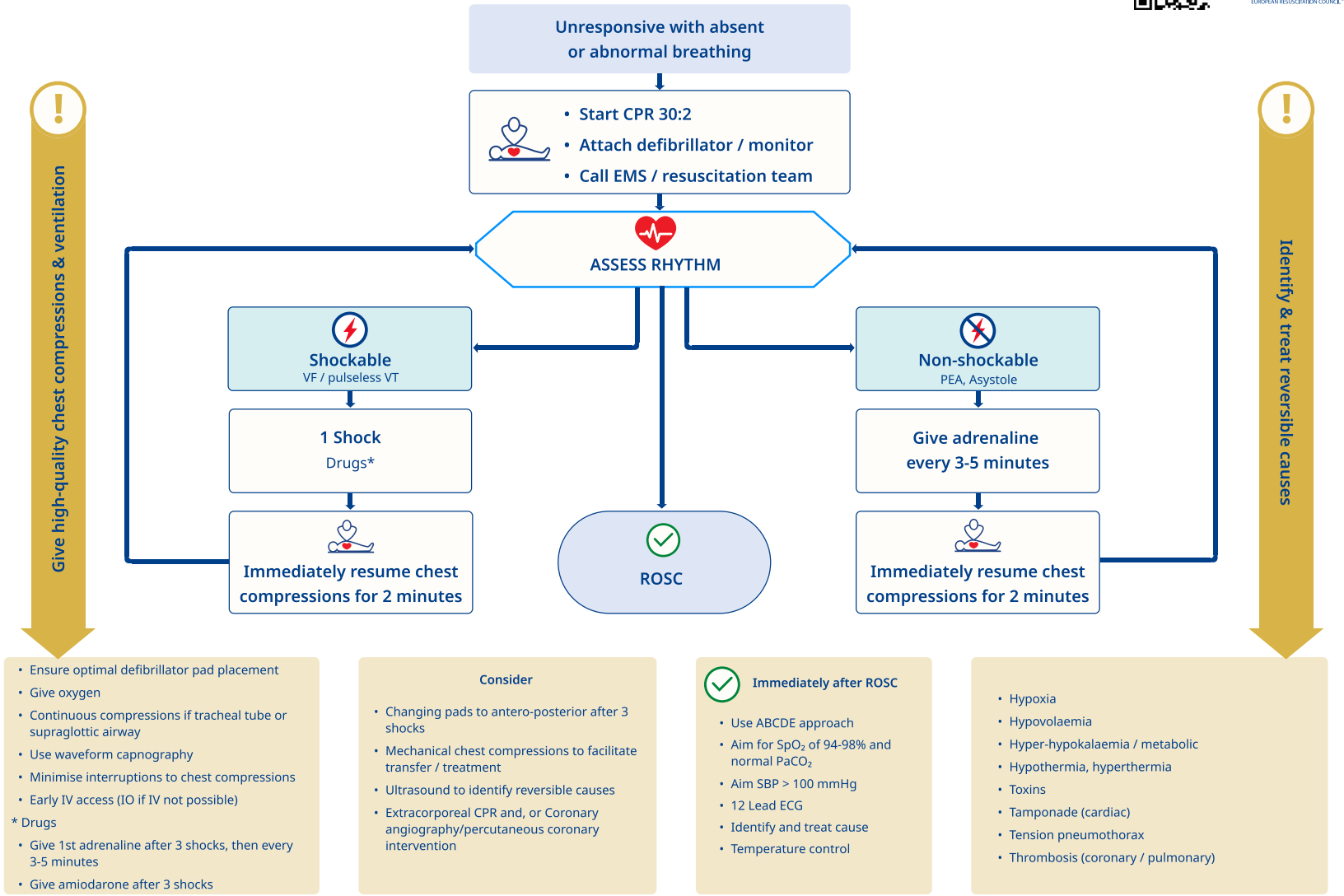


Fig. 11 – Adult Advanced Life Support algorithm.

- Immediate defibrillation of VF of any amplitude (even fine VF) should be attempted.
- Immediately resume chest compressions after shock delivery. If there is a combination of clinical and physiological signs of return of spontaneous circulation (ROSC) such as return of consciousness, purposeful movement, arterial waveform or a sharp rise in end-tidal carbon dioxide (ETCO2), consider stopping chest compressions for rhythm analysis, and if appropriate, a pulse check.
- When using a defibrillator that displays the ECG with the motion artefact caused by chest compressions removed, the underlying cardiac arrest rhythm may guide the decision to perform a rhythm and pulse check every two minutes. If asystole is displayed there would be no need to pause chest compressions for a rhythm check.

Safe and effective defibrillation

- Minimise the risk of fire by taking off any oxygen mask or nasal cannula or bag mask and by placing them at least 1 m away from the patient's chest. When using a mechanical ventilator, oxygen exhaust from ventilation circuits should be directed away from the chest. A self-inflating bag or the ventilator circuits should remain attached to a supraglottic airway or tracheal tube.
- Charging the defibrillator in anticipation of each rhythm check may minimise hands-off time prior to shock delivery and is an acceptable alternative strategy if delivered without prolonging peri-shock pauses.
- A shock with a manual defibrillator can be safely delivered without interrupting mechanical chest compression.
- Do not defibrillate during manual chest compressions (even when wearing clinical gloves), as that practice is not safe to the rescuer.

Defibrillation pads and paddles

- There is insufficient evidence to recommend a specific pad or paddle size for optimal external defibrillation in adults.
- When available, defibrillation pads are preferable to paddles as they offer practical benefits for routine monitoring and defibrillation. Pads enable the operator to stand clear during defibrillation and minimise pre- and post-shock pauses to chest compressions by enabling hands-free operation. Better contact with the chest wall may also reduce the risk of arcing and subsequent fires.
- When using defibrillation paddles, apply firm force to both defibrillation paddles to optimise skin contact, minimise transthoracic impedance and reduce the risk of electrical arcing.
- Antero-lateral pad position is the position of choice for initial pad/-paddle placement. In particular, ensure that the apical (lateral) pad is positioned correctly (i.e. below the armpit in the mid-axillary line).
- Consider an antero-posterior pad position for vector change defibrillation following three failed shocks in cases of refractory shockable rhythms. The anterior pad is placed to the left of the sternum, avoiding as much breast tissue as possible. The posterior pad is placed at the same height, centred just medial to the left scapula.
- In patients with an implantable pacemaker/defibrillator (ICD), place the pad more than 8 cm away from the device, or use an alternative pad position. Consider an alternative pad position when the patient is in the prone position (bi-axillary), or in a refractory shockable rhythm.

Energy levels and number of shocks

- Use single shocks followed by a 2-min cycle of chest compressions.
- The use of up to three stacked shocks may be considered only if initial ventricular fibrillation/pulseless ventricular tachycardia (VF/pVT) occurs during a witnessed, monitored cardiac arrest with a defibrillator immediately available, e.g. during cardiac catheterisation or in a high dependency area. (For the purposes of adrenaline and amiodarone administration after three failed shocks, the initial three stacked shocks should be counted as the initial shock).
- Energy levels:
  - For biphasic waveforms (rectilinear biphasic or truncated exponential biphasic, but not pulsed biphasic), defibrillation shock energy levels for the first shock is at least 150 J.
  - For pulsed biphasic waveforms, deliver the first shock at 130–150 J.
- If the first shock is not successful and the defibrillator is capable of delivering shocks of higher energy, it is reasonable to increase the energy for subsequent shocks.
- If the rescuer is unaware of the recommended energy settings of the defibrillator, for an adult use the highest energy setting for all shocks.
- Use standard energy levels in obese patients.

Refractory ventricular fibrillation

- Consider escalating the shock energy, after a failed shock.
- For refractory VF, defined as continuous VF after three consecutive shocks, and having ensured correct antero-lateral pad positioning, consider using a defibrillation vector change by using an alternative defibrillation pad position (e.g. antero-posterior). After a failed third shock, prepare to place a fresh set of pads, at the time of the following rhythm check. Optimise transthoracic impedance by shaving the anticipated areas of placement for the pads (if necessary).
- Dual (double) sequential defibrillation (DSD), involves using a combination of antero-lateral and antero-posterior pad positioning, discharged in close succession and has been advocated for use in refractory shockable rhythms. Given the practical challenges of using two defibrillators to deliver DSD and the limited evidence for its efficacy the ERC does not recommend its routine use.

Ventricular fibrillation waveform analysis for optimising shock success

- Rescuers should give defibrillation shocks according to AED prompts or use a manual defibrillator for ventricular fibrillation/pulseless ventricular tachycardia (VF/pVT) according to the ALS algorithm – there is currently no role for VF waveform analysis (e.g., based on amplitude) for identifying the optimal time for defibrillation.

Patients with actively discharging implantable cardioverter defibrillators (ICD)

- Rescuers may sense a significant shock across their arms if a shock is delivered by an ICD while they are performing external chest compressions, even when wearing clinical gloves.
- If an ICD fails to terminate a shockable rhythm, conventional external shocks should be delivered, placing any defibrillation

pad/paddle more than 8 cm from the defibrillator box (as above).
- If the ICD is incorrectly detecting arrhythmias and shocking inappropriately, a magnet placed over the ICD can temporarily stop shocks but will not disable pacing (if programmed).

Airway and ventilation
- During CPR, start with basic airway techniques and progress stepwise according to the skills of the rescuer until effective ventilation is achieved.
- Give the highest feasible inspired oxygen during CPR.
- Start effective ventilation breaths as soon as possible ensuring the rate and tidal volume are appropriate to prevent both inadequate ventilation (hypoventilation) and excessive ventilation (hyperventilation).
- Deliver effective bag-mask ventilation breaths by optimising mask seal and airway patency and if necessary and feasible, use a two-person technique for bag-mask ventilation.
- Give each inspiratory breath over 1 s to achieve a visible chest movement.
- When using a supraglottic airway (SGA), an i-gel is preferred to a laryngeal tube.
- Tracheal intubation should only be attempted by rescuers with a high success rate and with the use of continuous waveform capnography. The expert consensus is that a high tracheal intubation success rate is over 95 % within two attempts at intubation.
- Aim for less than a 5-s interruption in chest compression for tracheal intubation.
- Use direct or video laryngoscopy for tracheal intubation according to local protocols and rescuer experience. In settings where video laryngoscopy is immediately available, it is preferable to use video laryngoscopy instead of direct laryngoscopy.
- A sustained $ETCO_2$ trace on waveform capnography must be used to exclude oesophageal placement of the tracheal tube. It can also confirm proper ventilation with an SGA and a face mask.
- Once a tracheal tube or a SGA has been inserted, ventilate the lungs at a rate of 10 min^{-1} and continue chest compressions without pausing during ventilations. With a SGA, if gas leakage results in inadequate ventilation, pause compressions for ventilation using a compression-ventilation ratio of 30:2.
- If using mechanical ventilation, use a volume-controlled mode during chest compressions set the ventilator
  - to a tidal volume of 6–8 mL kg^{-1} (predicted body weight), or to achieve a visible chest movement, the maximum inspired oxygen,
  - a respiratory rate of 10 min^{-1},
  - an inspiratory time of 1–2 s,
  - a positive end expiratory pressure (PEEP) 0–5 cm H_2O,
  - the peak pressure alarm at 60–70 cm H_2O,
  - and the flow trigger off.

  Ensure mechanical ventilation is effective and if not, use manual ventilation.
- If standard airway management strategies (oropharyngeal airway and bag-mask/SGA/tracheal tube) fail during cardiac arrest, appropriately trained rescuers should attempt surgical cricothyroidotomy to enable oxygenation and ventilation.

Drugs and fluids

Vascular access
- Attempt intravenous (IV) rather than intraosseous (IO) access first, to enable drug delivery in adults in cardiac arrest.
- If IV access cannot be rapidly achieved within two attempts, it is reasonable to consider IO access as an alternative route for vascular access during adult cardiac arrest.

Vasopressor drugs
- Give adrenaline 1 mg as soon as possible for adult patients in cardiac arrest with a non-shockable rhythm.
- Give adrenaline 1 mg after the third shock for adult patients in cardiac arrest with a shockable rhythm.
- Repeat adrenaline 1 mg every 3–5 min whilst ALS continues.

Antiarrhythmic drugs
- Give amiodarone 300 mg IV for adult patients in cardiac arrest who are in VF/pVT after three shocks have been administered.
- Give a further dose of amiodarone 150 mg IV for adult patients in cardiac arrest who are in VF/pVT after five shocks have been administered.
- Give the first dose of amiodarone after three shocks, and the second dose after five shocks, irrespective of whether the shockable rhythms are sequential (refractory) or intermittent (recurrent).
- Lidocaine 100 mg IV may be used as an alternative if amiodarone is not available or a local decision has been made to use lidocaine instead of amiodarone. An additional bolus of lidocaine 50 mg can also be given after five defibrillation attempts.

Thrombolytic drugs
- Consider immediate thrombolytic drug therapy when pulmonary embolism is the suspected or confirmed cause of cardiac arrest.
- In select patients with suspected pulmonary embolism, consider CPR for 60–90 min after administration of thrombolytic drugs.

Fluids
- Give fluids during CPR only if cardiac arrest is caused by hypovolaemia.
- Use either isotonic saline or balanced crystalloids for fluid infusion during CPR.

Other drugs
- Do not routinely give calcium, sodium bicarbonate or corticosteroids during cardiac arrest.

ALS in highly-monitored cardiac arrest, and physiology-guided CPR
- A sudden decrease in $ETCO_2$ may indicate a cardiac arrest or very low cardiac output state.
- Consider starting chest compressions if the systolic blood pressure decreases and remains <50 mmHg despite interventions.
- In adults undergoing continuous intra-arterial blood pressure monitoring, we suggest that adrenaline is initially given in small increments (e.g., 50–100 μg IV) rather than a 1 mg bolus. If a total of 1 mg has been given with no response, ensure that there is no

extravasation and consider giving further IV adrenaline doses of 1 mg every 3–5 min.
- A pragmatic approach during physiology-guided CPR is to aim for a diastolic blood pressure of ≥30 mmHg (when using intra-arterial blood pressure monitoring) and an $ETCO_2 \geq 25$ mmHg (3.3 kPa).

Waveform capnography during advanced life support
- Use waveform capnography to confirm correct tracheal tube placement during CPR.
- Use waveform capnography to monitor the quality of CPR.
- An increase in $ETCO_2$ during CPR may indicate that ROSC has occurred. However, chest compression should not be interrupted based on this sign alone. Use a combination of clinical and physiological signs of ROSC (e.g., consciousness, purposeful movement, arterial waveform, rise in $ETCO_2$) before stopping chest compressions for rhythm analysis, and if appropriate, a pulse check.
- Do not use a low $ETCO_2$ value alone to decide that a resuscitation attempt should be stopped.

Use of ultrasound imaging during advanced life support
- Only skilled operators should use intra-arrest point-of-care ultrasound (POCUS).
- POCUS must not cause additional or prolonged interruptions in chest compressions.
- POCUS may help identify treatable causes of cardiac arrest such as cardiac tamponade and tension pneumothorax.
- Right ventricular dilation in isolation during cardiac arrest should not be used to diagnose pulmonary embolism.
- Do not use POCUS for assessing contractility of the myocardium as a sole indicator for terminating CPR.

Devices

Mechanical chest compression devices
- Consider mechanical chest compressions only if high-quality manual chest compression is not practical or compromises provider safety.
- When a mechanical chest compression device is used, minimise interruptions to chest compression during device application by using only trained teams familiar with the device.

Resuscitative endovascular balloon occlusion of the aorta (REBOA)
- The ERC does not recommend the routine use of REBOA for cardiac arrest unless being evaluated in a clinical trial.

Intra-arrest cooling
- We do not recommend intra-arrest cooling during advanced life support (unless there is severe hyperthermia).

Extracorporeal CPR
- Extracorporeal CPR (ECPR) may be considered as a rescue therapy for selected adults with IHCA and OHCA when conventional CPR is failing to restore spontaneous circulation, in settings in which this can be implemented.

Peri-arrest arrhythmias
- The 2025 ALS Guidelines and the algorithms focus on those arrhythmias that require immediate treatment before or after cardiac arrest.
- Rescuers should seek expert advice if the arrhythmia and/or life-threatening features persist.
- The assessment and treatment of all arrhythmias address the condition of the patient (stable versus unstable) and the nature of the arrhythmia. Persistent arrhythmias require careful evaluation, as they are often linked to underlying structural heart disease and may indicate unresolved issues such as myocardial ischaemia. In addition to an arrhythmia occurring immediately after ROSC, life-threatening features in an unstable patient include:
  - Shock – recognised by hypotension (e.g., systolic blood pressure <90 mmHg) along with signs of compensatory mechanisms, such as increased sympathetic activity, and evidence of inadequate organ perfusion.
  - Syncope – as a consequence of reduced cerebral blood flow.
  - Heart failure – manifested by pulmonary oedema (failure of the left ventricle) and/or raised jugular venous pressure (failure of the right ventricle).
  - Myocardial ischaemia – may present with chest pain (angina) or may occur without pain as an isolated finding on the 12-lead ECG (silent ischaemia).

Tachyarrhythmias
- Electrical cardioversion is the preferred treatment for tachyarrhythmia in the unstable patient displaying potentially life-threatening adverse signs or immediately after ROSC.
- Electrical cardioversion is recommended for stable patients with monomorphic VT who have structural heart disease or when it is unclear whether there is underlying heart muscle damage.
- Conscious patients require careful anaesthesia or sedation before attempting synchronised cardioversion – be aware of the risk of haemodynamic deterioration with anaesthesia/sedation.
- When cardioverting atrial or ventricular tachyarrhythmias, the shock must be synchronised to occur with the R wave of the ECG.
- For atrial fibrillation:
  - An initial synchronised shock at maximum defibrillator output, rather than an escalating approach, is a reasonable strategy based on current data.
- For atrial flutter and paroxysmal supraventricular tachycardia:
  - Give an initial shock of 70–120 J.
  - Give subsequent shocks using stepwise increases in energy.
- For ventricular tachycardia with a pulse:
  - Use energy levels of 120–150 J for the initial shock.
  - Consider stepwise increases in energy if the first shock fails to achieve sinus rhythm.
- If cardioversion fails to restore sinus rhythm and the patient remains unstable, give amiodarone 300 mg intravenously over 10–20 min (or procainamide 10–15 mg/kg over 20 min) and re-attempt electrical cardioversion. The loading dose of amiodarone can be followed by an infusion of 900 mg over 24 h.
- Pharmacological treatment may be considered in haemodynamically stable patients with monomorphic ventricular tachycardia if there is an increased risk with sedation or anaesthesia.
- Consider amiodarone for acute heart rate control in patients with AF and haemodynamic instability and severely reduced left ventricular ejection fraction (LVEF). For stable patients with LVEF < 40 % consider the smallest dose of beta-blocker to achieve a heart rate less than 110 min^{-1}. Add digoxin if necessary (Fig. 12).

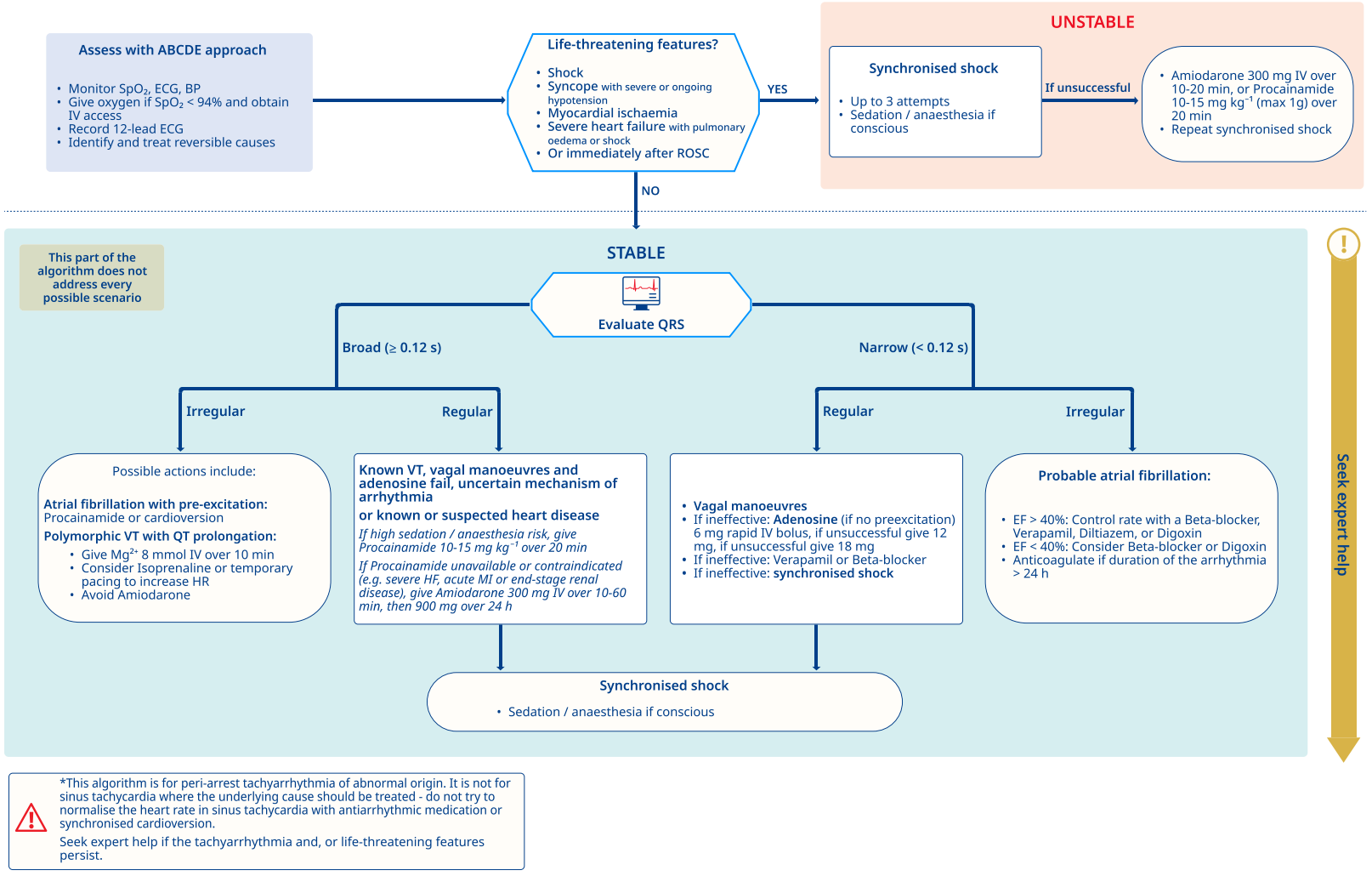


Fig. 12 – Peri-arrest Tachyarrhythmia algorithm.

Bradycardia

- If bradycardia is accompanied by adverse signs, give atropine 500 μg IV (IO) and, if necessary, repeat every 3–5 min to a total of 3 mg.
- If treatment with atropine is ineffective, consider second-line drugs. These include isoprenaline (5 μg min^{-1} starting dose), and adrenaline (2–10 μg min^{-1}).
- For bradycardia in patients with cardiac transplant or spinal cord injury, consider giving aminophylline (100–200 mg slow intravenous injection). Do not give atropine to patients with cardiac transplants – it can cause a high-degree atrioventricular block or even sinus arrest.
- Consider giving glucagon if beta-blockers or calcium channel blockers are a potential cause of the bradycardia.
- Do not give atropine to patients with high-degree atrioventricular block and wide QRS. It is ineffective and may worsen the block.
- Consider pacing in patients who are unstable, with symptomatic bradycardia refractory to drug therapies.
  - Establish early transvenous pacing in unstable patients with symptomatic bradycardia.
  - Consider transthoracic (transcutaneous) pacing as a bridge to transvenous pacing or when transvenous pacing is not readily available.
- Whenever a diagnosis of asystole is made, check the ECG carefully for the presence of P waves because, unlike true asystole, this is more likely to respond to cardiac pacing.
- If atropine is ineffective and transvenous/transcutaneous pacing is not immediately available, fist pacing can be attempted while waiting for pacing equipment (Fig. 13).

Uncontrolled organ donation after circulatory death

- When there is no ROSC, consider uncontrolled organ donation after circulatory death in settings where there is an established programme, and in accordance with local protocols and legislation

Adult special circumstances in resuscitation

The ERC Guidelines 2025 Special Circumstances in Resuscitaiton in adults cover modifications required to BLS and ALS for the prevention and treatment of cardiac arrest in special circumstances and when deviations from standard algorithms are needed.[67] (Fig. 14).

General recommendation

- Initiate resuscitation following the standard ALS algorithm in cardiac arrest.
- Always address hypoxia, hypovolaemia, electrolyte disorders, hypothermia, cardiac tamponade, tension pneumothorax, thrombosis, and toxic agents.
- Where appropriate, prioritise treating reversible causes, even if chest compressions are briefly interrupted.

Special causes

Management and prevention of cardiac arrest due to anaphylaxis

- Prompt recognition of anaphylaxis is crucial.
- Recognise anaphylaxis by the presence of airway, breathing, or circulation problems with or without skin and mucosal changes.
- Remove or stop the trigger if immediately feasible.
- Immediately inject intramuscular adrenaline 0.5 mg at first suspicion of anaphylaxis and repeat if no improvement occurs within 5 min.
- Give an IV crystalloid fluid bolus early and monitor the response.

Hyper/hypokalaemia and other electrolyte disorders

Hyperkalaemia.

- Shift potassium into cells.
  - Give 10 units soluble insulin and 25 g glucose IV for treatment of moderate and severe hyperkalaemia; follow with 10 % glucose infusion at 50 ml/hr for 5 h if pre-treatment blood glucose < 7 mmol/l.
  - Give nebulised salbutamol (10–20 mg) for moderate and severe hyperkalaemia, as an adjunct to Insulin-glucose therapy.
- Antagonise the effect of hyperkalaemia.
  - Use IV 30 mL 10 % calcium gluconate for patients with severe hyperkalaemia with ECG changes.
  - Administer IV 10 mL 10 % calcium chloride and 50 mmol sodium bicarbonate, through separate lines or with flush in between, in the treatment of hyperkalaemic cardiac arrest in all settings of severe hyperkalaemia.
- Remove potassium from the body.
  - Give sodium zirconium cyclosilicate 10 g orally.
  - Consider dialysis for patients with refractory severe hyperkalaemia.
- Consider ECPR in accordance with local protocols if initial resuscitation attempt is unsuccessful.

Hypokalaemia.

- Treatment is guided by the severity of hypokalaemia and presence of symptoms and/or ECG abnormalities.
- Where appropriate replace potassium and correct magnesium deficit concurrently.
- Give IV 20 mmol potassium chloride over 2–3 min, followed by 10 mmol over 2 min in hypokalaemia cardiac arrest then monitor K^+ level and adjust infusion rate accordingly.

Hyperthermia, malignant hyperthermia and toxin induced hyperthermia

Hyperthermia.

- Measure core temperature to guide treatment.
- Move patient to a cool environment.
- Simple external cooling may involve conductive, convective and evaporative measures.
- With heat syncope and heat exhaustion quick removal to a cool place, simple external cooling and provision of fluids are sufficient.
- With heat stroke prioritise active cooling methods that achieve the most rapid cooling rate such as application of ice, and cold-water immersion (Fig. 15).

Malignant hyperthermia.

- Stop triggering agents immediately. This includes turning off and removing vaporiser and changing the ventilator circuit.
- Give IV 2.5 mg/kg dantrolene as soon as possible.
- Start active cooling.

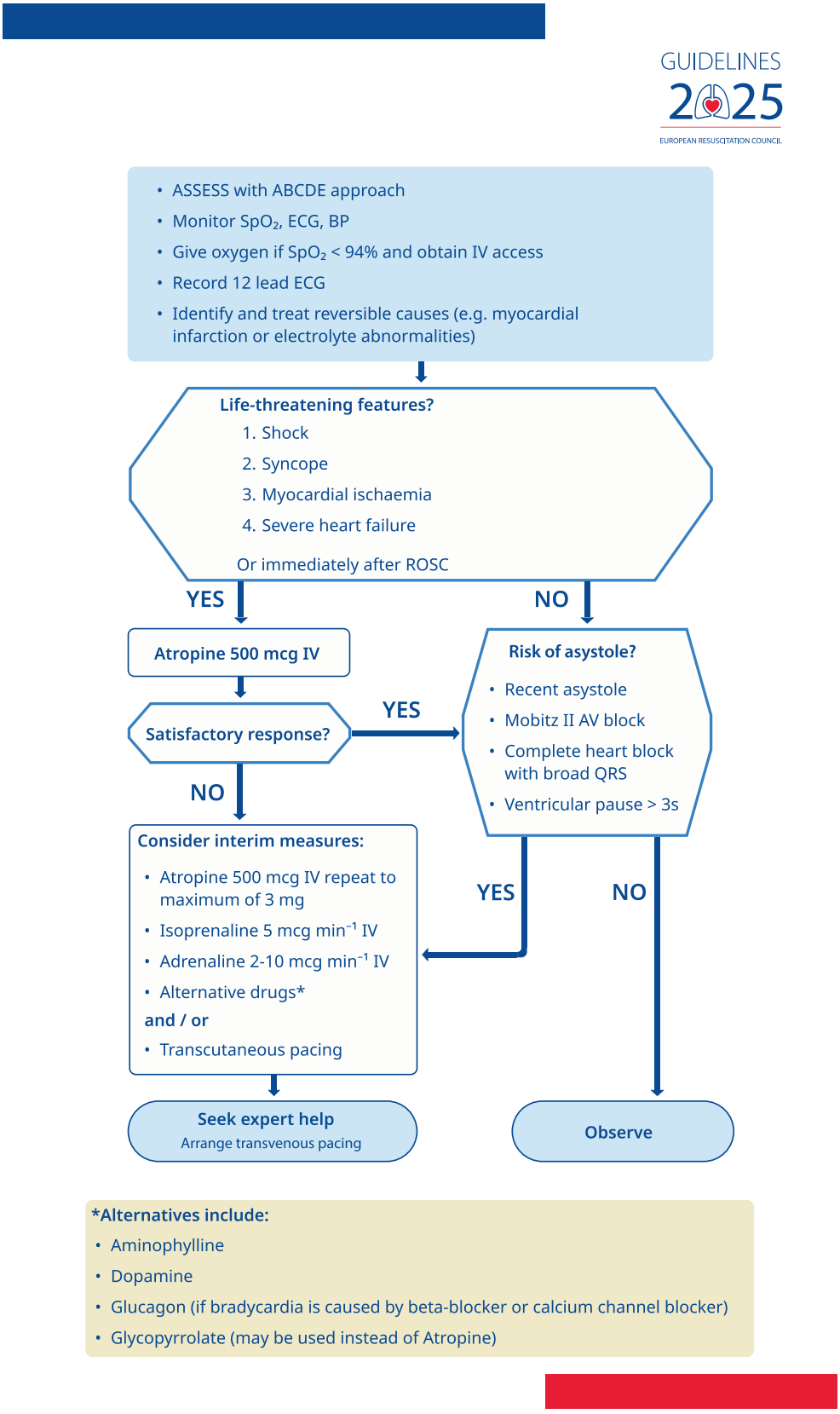


Fig. 13 – Bradycardia algorithm.

SPECIAL CIRCUMSTANCES IN ADULT RESUSCITATION
KEY MESSAGES

GUIDELINES 2025
EUROPEAN RESUSCITATION COUNCIL©

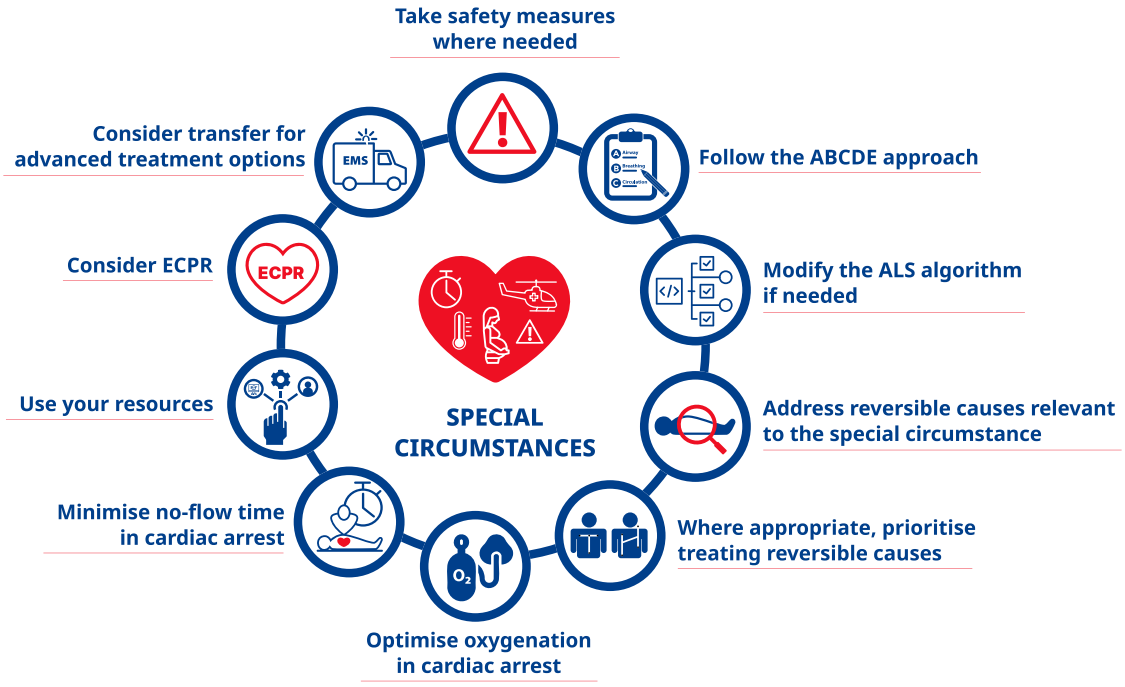


Fig. 14 – Key messages adult special circumstances.

- Give 100 % oxygen and aim for normocapnia using hyperventilation.
- Change the ventilator. If the ventilator cannot be changed, change charcoal filters.
- Contact a malignant hyperthermia centre for advice and follow-up.

Toxin-induced hyperthermia.

- Minimise exposure and absorption of the toxin.
- Use active cooling techniques. Antipyretics have no benefit as central thermoregulatory mechanisms are affected by toxins.

Accidental hypothermia and avalanche rescue
Accidental hypothermia.

- Check vital signs for up to one minute in an unconscious hypothermic patient.
- Measure core temperature with a low reading thermometer to diagnose accidental hypothermia.
- Use the Swiss Staging System if core temperature cannot be measured.
- Transfer hypothermic patients with risk factors for imminent cardiac arrest and those in cardiac arrest directly to an extracorporeal life support (ECPR) centre for rewarming.
- Delay CPR or use intermittent CPR in hypothermic arrested patients with a core temperature below 28 °C when immediate or continuous CPR is not feasible.
- Delay further defibrillation attempts if ventricular fibrillation (VF) persists after three shocks, until core temperature is >30 °C.
- Below 30 °C adrenaline will accumulate and may have more detrimental than beneficial effects. Give IV 1 mg adrenaline once to facilitate ROSC unless planning imminent initiation of ECPR. Increase administration intervals for adrenaline to 6–10 min if the core temperature is 30–35 °C.
- Consider use of a mechanical CPR device if transport is prolonged, or there are difficulties with the terrain.

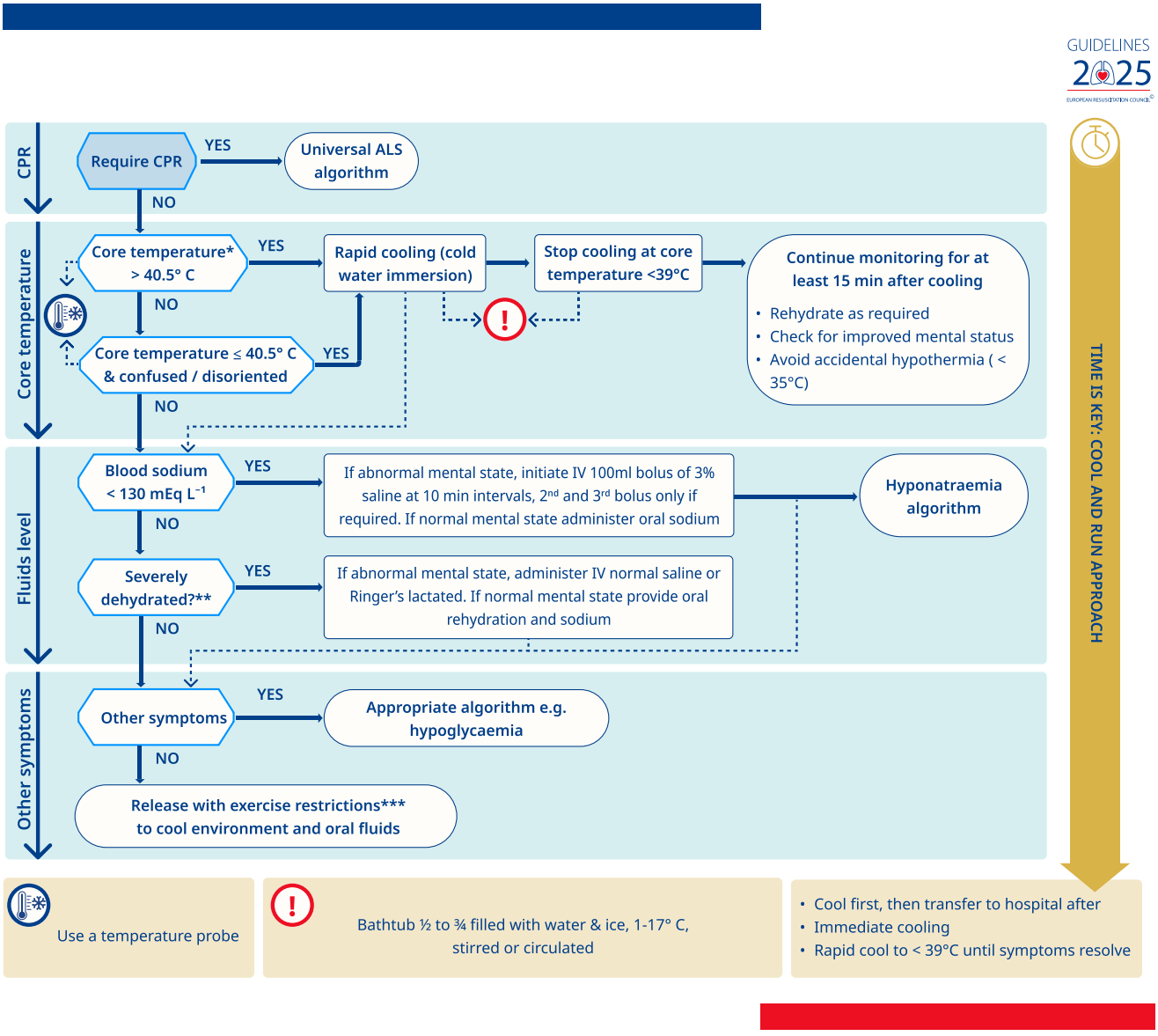


Fig. 15 – Emergency treatment of hyperthermia.

* Core temperature should be measured, e.g. tympanic, rectal, or oesophageal. ** Dry mouth, thirsty, hypotensive. *** Return to activity considerations following a diagnosis of exertional heat illness and exertional head stroke have been published recently elsewhere.

- Base in-hospital prognostication of successful rewarming on the Hypothermia Outcome Prediction after Extracorporeal Life Support (HOPE) score.
- Rewarm hypothermic arrested patients with veno-arterial extracorporeal membrane oxygenation (VA-ECMO).
- Initiate non-extracorporeal life support rewarming if an ECPR centre cannot be reached within a reasonable time (e.g. 6 h) (Fig. 16).

Avalanche rescue.

- Base initiation of CPR in cardiac arrest on core temperature, burial time, and airway patency.
- Consider proceeding according to the AvaLife algorithm, in multi-burial avalanche accidents with BLS providers only and insufficient numbers of rescuers.

Thrombosis

Pulmonary embolism.

- Consider pulmonary embolism in all patients with sudden onset of progressive dyspnoea and absence of known heart or pulmonary disease.
- Obtain 12-lead ECG (exclude acute coronary syndrome, look for right ventricle strain)
- Identify haemodynamic instability and high-risk pulmonary embolism.
- Perform bedside echocardiography.
- Initiate anticoagulation therapy (heparin 80 IU/kg IV) during diagnostic process, unless signs of bleeding or absolute contraindications.
- Confirm diagnosis with computed tomographic pulmonary angiography.

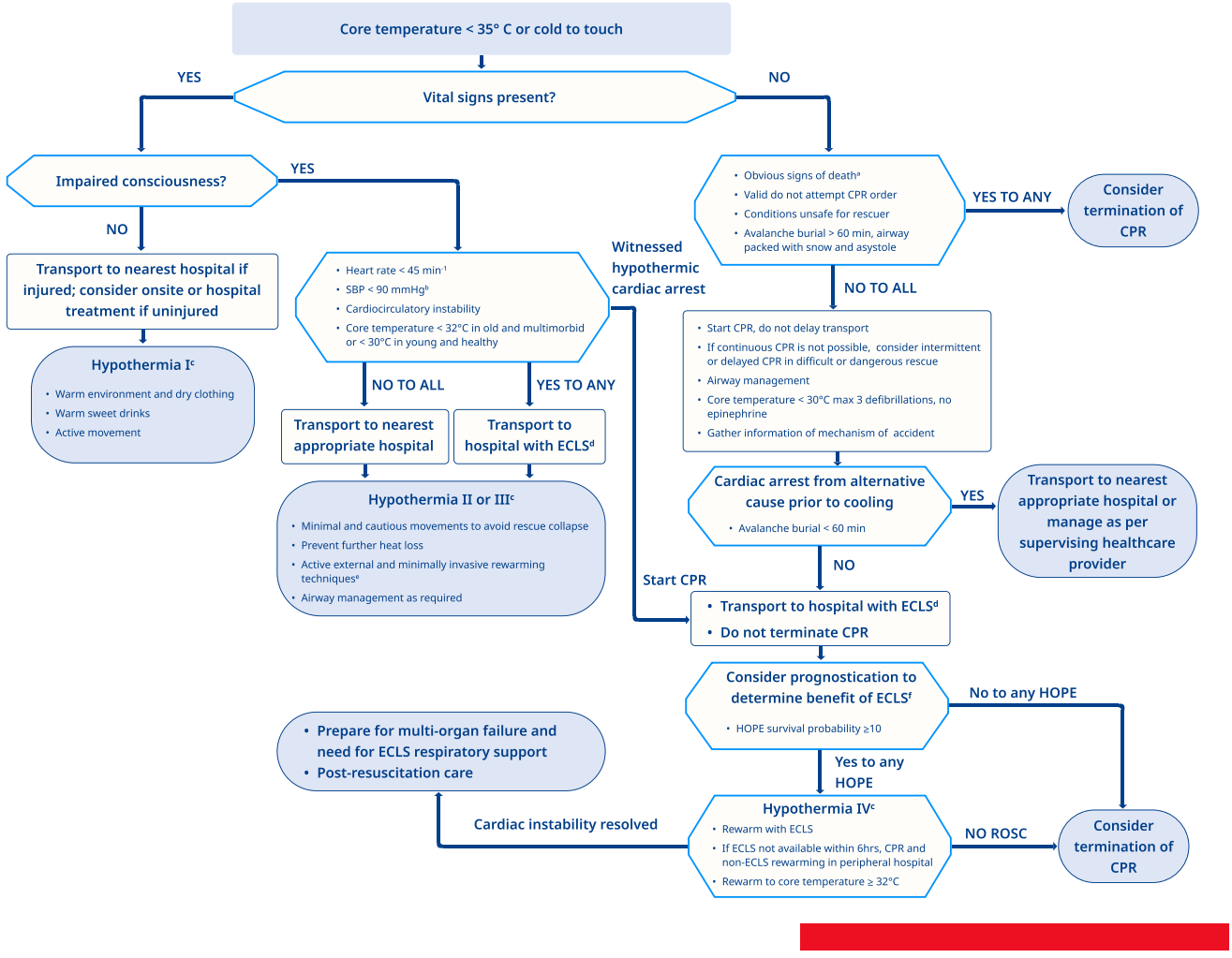


Fig. 16 – Emergency treatment of accidental hypothermia.

[a] Decapitation; truncal transection; whole body decomposed or whole body frozen solid (chest wall not compressible). [b] Systolic blood pressure <90 mmHg is a reasonable prehospital estimate of cardiocirculatory instability but for in-hospital decisions, the minimum sufficient circulation for a deeply hypothermic patient (e.g., <28 C) has not been defined. [c] Swiss staging of accidental hypothermia. [d] Direct transport to an ECLS centre is recommended in an arrested hypothermic patient. In remote areas, transport decisions should balance the risk of increased transport time with the potential benefit of treatment in an extra corporal life support centre. Transfer should be commenced if such a centre can be reached within 6 h. [e] Warm environment, chemical, electrical, or forced air heating packs or blankets, and warm IV fluids (38–42 C). In case of cardiac instability refractory to medical management, consider rewarming with extra corporal life support. [f] If the decision is made to stop at an intermediate hospital to measure serum potassium, a hospital enroute to an extra corporal life support centre should be chosen. The HOPE score should not be used in children, consider expert consultation instead.

- Consider surgical embolectomy or catheter-directed treatment as alternative to rescue fibrinolytic therapy in rapidly deteriorating patients.

Cardiac arrest due to pulmonary embolism.

- Low $ETCO_2$ values (<1.7 kPa/13 mmHg) while performing high quality chest compressions may support a diagnosis of pulmonary embolism, although it is a non-specific sign.
- Use fibrinolytic drugs for cardiac arrest when pulmonary embolism is the suspected cause of cardiac arrest.
- Use fibrinolytic drugs or surgical embolectomy or percutaneous mechanical thrombectomy for cardiac arrest when pulmonary embolism is the known cause of cardiac arrest.
- Consider ECPR as a rescue therapy for selected patients with cardiac arrest when conventional CPR is failing in settings in which it is implemented.

- Set-up a multidisciplinary team for making decisions on management of high-risk pulmonary embolism depending on local resources.

Coronary thrombosis.

- Enhance health education to recognise symptoms and minimise delays in seeking medical care.
- Promote BLS training for likely rescuers of high-risk groups.
- Strengthen regional networks to ensure timely percutaneous coronary intervention (PCI).
- Transfer the patient to a centre with PCI capability and activate existing STEMI networks in case of ST-elevation or suspected ongoing ischaemia.
- In patients with sustained ROSC and ST-elevation on ECG:
  - Perform coronary angiography (and PCI if required) within 120 min of diagnosis.
  - Consider fibrinolysis in pre-hospital and non-PCI-capable settings if greater delay is expected unless traumatic cardiac arrest, then transfer immediately to a PCI centre.
- In patients with sustained ROSC and no ST-elevation on ECG:
  - Consider immediate coronary angiography (and PCI if required) if the patient is haemodynamically unstable or shows signs of ongoing ischaemia.
  - In stable patients without ischaemic signs, emergent cardiac catheterisation laboratory evaluation should not be systematic and can be delayed if there is no estimated high probability of acute coronary occlusion.
  - Assess for non-coronary-causes if the clinical context suggests an alternative aetiology of the arrest.
  - Unless on-going resuscitation is considered futile, transfer patients without sustained ROSC with ongoing CPR, to a PCI centre for consideration for angiography or ECPR depending on available resources and team expertise.

Toxic agents

- Ensure your personal safety, as direct skin contact (e.g., mouth to mouth ventilation) might transmit toxic agents.
- Assess all patients in cardiac arrest for potential intoxication.
- Reduce absorption, consider using specific treatment measures such as antidotes, decontamination and enhanced elimination.
- Administer antidotes, where available, as soon as possible.
- Be prepared to continue resuscitation for a prolonged period of time, as the toxin concentration may fall as it is metabolised or excreted during extended resuscitation measures.
- Consult regional or national poison centres for information on treatment of the poisoned patient.

Traumatic cardiac arrest

- Traumatic cardiac arrest (TCA) is different from cardiac arrest due to medical causes; this is reflected in the treatment algorithm.
- The response to traumatic cardiac arrest is time critical and success depends on a well-established chain of survival, including focused pre-hospital and specialised trauma centre care.
- Early and aggressive management of reversible causes (e.g. haemorrhage control, airway management, chest decompression) is essential for survival.
- Ultrasound aids in identifying the cause of cardiac arrest and guides resuscitative interventions (Fig. 17).

Special settings

Cardiac arrest in the catheterisation laboratory

- Promote adequate training of the staff in technical skills and ALS, and consider periodic emergency drills.
- Ensure emergency equipment is readily available and functional.
- Plan elective procedures carefully to minimise potential complications and promote the use of safety checklists.
- Consider echocardiography in case of haemodynamic instability or suspected complication.
- Resuscitate according to the ALS algorithm, BUT modify:
  - Apply 3 consecutive shocks in case of shockable rhythm
  - Consider external or transvenous pacing for extreme bradycardia.
- Consider, in selected cases depending on clinical context, team expertise and availability:
  - Mechanical CPR, if manual compression is not feasible or safe for the provider.
  - Extracorporeal CPR in selected patients with refractory cardiac arrest, especially if it allows for critical procedures to correct reversible causes.
  - Circulatory support devices, for selected patients in cardiogenic shock after achieving ROSC (Fig. 18).

Drowning

- Rescuers and first responders should prioritise their safety and use the safest rescue technique.
- Bystanders should call for professional help and use rescue techniques with which they feel confident, based on their competencies.
- First responders should use rescue material and flotation devices they are trained to use.
- Spine immobilisation in water should not delay removing the victim from the water when resuscitation is required.
- Start with 5 ventilations using 100 % inspired oxygen when available, continue with standard CPR protocol.
- Airway and ventilation equipment can be used when the provider is trained appropriately.
- Increase ventilation pressure gradually when a high inspiration pressure is needed, in order to avoid stomach inflation.
- Consider ECPR if initial resuscitation is unsuccessful, in accordance with local protocols.
- Follow the recommendations for hypothermia.

Cardiac arrest in the operating room (OR)

- Prevent and mitigate the risk of cardiac arrest through preoperative screening and identification of high-risk patients, clear surgical communication about potential critical procedures, advanced monitoring and continuous presence of an anaesthesiologist during patient instability.
- Start chest compressions if the systolic blood pressure suddenly decreases below 50 mmHg, in association with fall in $ETCO_2$, despite appropriate interventions.
- Inform the surgeon and the operating room team of the cardiac arrest.

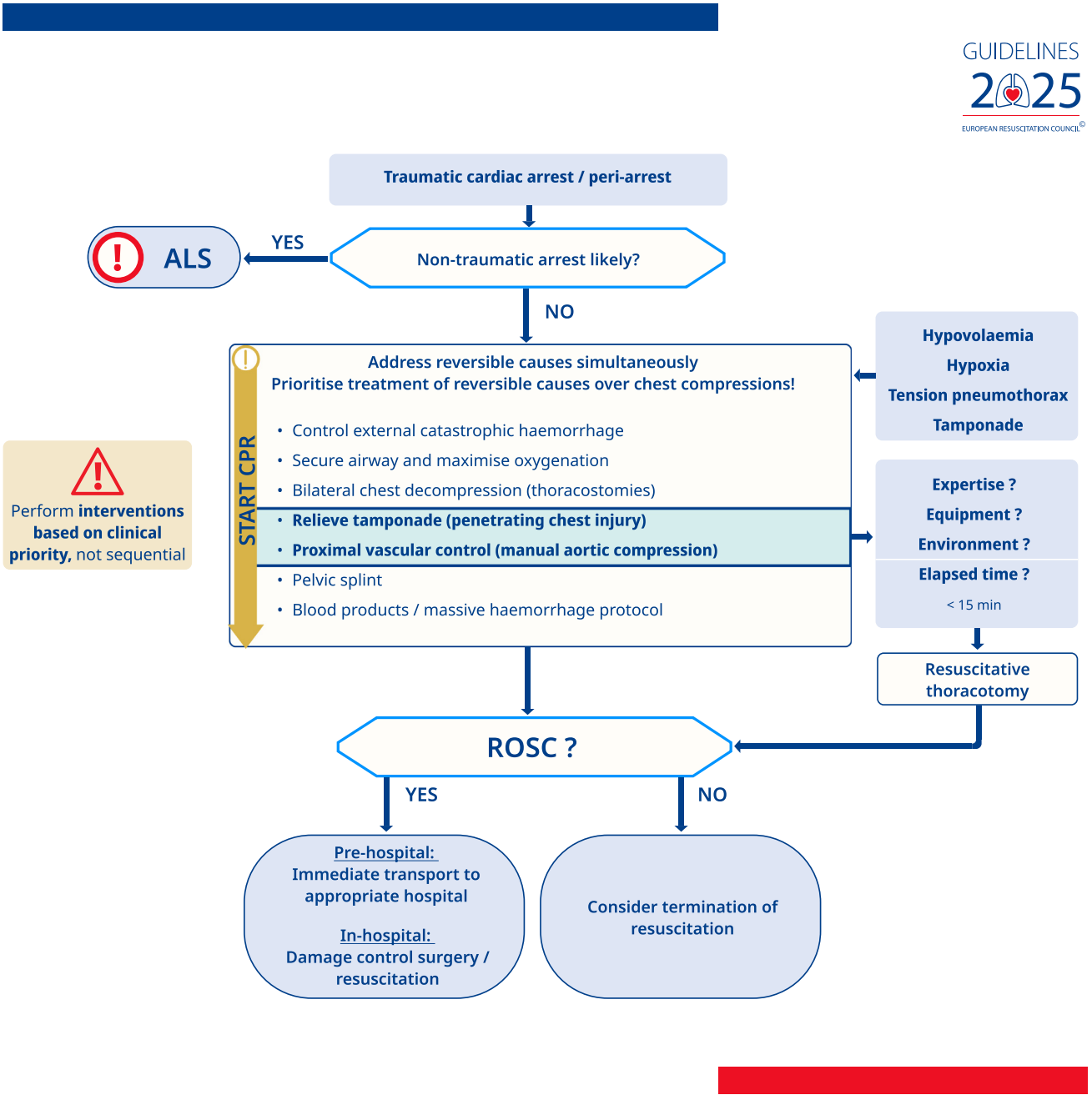


Fig. 17 – Traumatic cardiac arrest algorithm.
This algorithm should be used to guide the management of traumatic cardiac arrest and peri-arrest trauma patients with impending circulatory collapse. In contrast to the sequential ALS algorithms, it is a framework for context-sensitive decisions on clinically prioritised interventions. The aim is to treat the most urgent, reversible cause based on individualised treatment (e.g. patients with a cardiac tamponade need urgent thoracotomy; patients with pelvic fracture in haemorrhagic shock but with a stable airway may benefit more from immediate application of a pelvic binder and rapid transfer without airway intervention).

- Initiate high-quality chest compressions and adjust the height of the operating table to improve work efficiency.
- Ensure the airway is secure, review the $ETCO_2$ tracing, and deliver effective ventilation, administering 100 % oxygen. Exclude unrecognised oesophageal intubation.
- Use ultrasound to guide resuscitation addressing the reversible causes.
- Exclude tension pneumothorax.
- Consider early ECPR as therapy for selected patients when conventional CPR is failing.

GUIDELINES 2025
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1. Prevent & be prepared

Promote adequate training of the staff in technical skills & ALS

Ensure emergency equipment is functional and readily available

Plan elective procedures carefully and use safety checklists

2. Detect and react

Check patient's status and monitored vital signs regulary

Consider echocardiography if haemodynamic instability or complication

In case of cardiac arrest, call for help & activate the resuscitation team

3. Resuscitate and treat possible causes

VF / pVT cardiac arrest

↓

Defibrillate
(apply up to 3 consecutive shocks)

↓

No ROSC

↓

Asystole / PEA

↓

Consider **external or transvenous pacing** in extreme bradycardia

↓

No ROSC

↓

Continue CPR according to the ALS algorithm

- Check & correct reversible causes, including **ultrasound & angiography**
- Consider **mechanical CPR** to facilitate chest compression
- Consider **ECPR** in refractory cardiac arrest
- Consider **circulatory support devices** in case of shock after ROSC

Fig. 18 – Treatment of cardiac arrest in catheterisation laboratory.

- Trained healthcare professionals may consider open chest cardiac compression in specific cases as an alternative, if ECPR is unavailable.
- Human factors are crucial to improve survival of intraoperative cardiac arrest – ensure familiarity with equipment, assign strategies and roles during surgical team time outs and include perioperative cardiac arrest in multidisciplinary and interprofessional team training, in-situ simulation, and ALS courses.

Local anaesthetic systemic toxicity
- Stop local anaesthetic if possible.
- Hyperventilate the patient to increase plasma pH if metabolic acidosis is present
- Give a lower adrenaline dose ($\leq$1 μg kg^{-1} instead of 1 mg IV bolus).
- Give an initial IV bolus of 20 % lipid emulsion at 1.5 mL kg^{-1}over 1 min, followed by an infusion at 0.25 mL kg^{-1} min^{-1} but do not exceed a maximum cumulative dose of 12 mL kg^{-1} IV 20 % lipid emulsion.
- If ROSC has not been achieved at 5 min, double the rate of lipid infusion and give a maximum of two additional lipid boluses at 5-min intervals until ROSC has been achieved.
- Consider prolonged resuscitation (>1 h) and ECPR.
- Treat seizures by administering benzodiazepines.

Cardiac surgery
- Confirm cardiac arrest by clinical signs and pulseless pressure waveforms.
- Consider ultrasound to identify reversible causes.
- Provide up to 3 consecutive shocks in VF/pVT
- Use epicardial pacing at maximum output in asystole or extreme bradycardia.
- Perform re-sternotomy up to 10 days post-surgery within 5 min regardless of the patient's location.
- Provide internal cardiac compressions once the chest is reopened.
- Reduce IV adrenaline dose (0.05–0.1 mg).
- Consider ECPR for prolonged resuscitation or minimally invasive cases where reopening may be delayed (Fig. 19).

Left ventricular assist device (LVAD) patients.
- Immediately activate specialised teams for unresponsive LVAD patients.
- Start CPR while simultaneously attempting to restore device function if multiple rescuers are available.
- Consider delaying CPR for up to 2 min to attempt device restoration if a single rescuer is present.
- Troubleshoot device issues as a priority, following relevant protocols.

Cardiac arrest in sports
- Screening as primary prevention plays an important role but remains controversial.
- All sports and exercise facilities should undertake a risk assessment which considers the likelihood and consequence of sudden cardiac arrest and put in place mitigation strategies to reduce the risk.
- Gain immediate and safe access to the field of play.
- Awareness programs in sport events have proven to be feasible to raise awareness amongst target groups not yet involved with cardiac arrest.

Emergency medical services
- Healthcare professionals should provide resuscitation at the scene rather than undertake ambulance transport with ongoing resuscitation, unless there is an appropriate indication to justify transport (bridging to in-hospital treatment).
- Consider mechanical CPR for transport with ongoing resuscitation.
- Consider obtaining invasive arterial blood pressure to guide resuscitation and post-resuscitation care already in the prehospital setting if it is feasible.
- EMS systems should use registry and data provided from equipment data (e.g. defibrillators) for debriefing and continuous quality improvement.

Inflight cardiac arrest and microgravity resuscitation
Inflight cardiac arrest.
- Healthcare professional help should be sought (in-flight announcement).
- The rescuer should kneel in the leg-space in front of the aisle seats to perform chest compressions if the patient cannot be transferred within a few seconds to an area with adequate floor space (galley).
- Overhead-CPR is a possible option in limited space environments.
- Airway management should be based on the equipment available and the expertise of the rescuer.
- If the planned route leads over an area where no airport can be reached for a longer period of time with high possibility of ROSC during an ongoing resuscitation, consider an early diversion.
- Consider risks of diversion if ROSC is unlikely and give appropriate recommendations to the flight crew.
- If CPR is terminated (no ROSC) there is no medical need for flight diversion – follow airline policy.

Microgravity resuscitation.
- Airway management, defibrillation and IV/IO access are similar to terrestrial ALS, but only once the patient is secured.
- Consider mechanical CPR.
- Consult telemedicine support during cardiac arrest in low earth orbit if feasible and manpower allows.
- The crewmember with the highest medical qualification should decide on termination of resuscitation, consulting telemedicine support.

Cruise ship
- Use all healthcare resources immediately (personnel, equipment).
- Activate helicopter emergency medical service if close to the coastline.
- Consider early telemedicine support.
- Have all equipment needed for ALS available on board.
- In case of insufficient number of healthcare professionals to treat cardiac arrest, call for further medical staff via an on-board announcement.

GUIDELINES 2025
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1. Prevent & be prepared

- Ensure adequate training of the staff in technical skills and ALS
- Ensure availability and functioning of emergency equipment
- Use safety checklists
- Identify and manage deterioration in the post-operative cardiac patient

2. Detect cardiac arrest and activate cardiac arrest protocol

- Confirm cardiac arrest by clinical signs and pulseless waveforms
- Call for help and activate cardiac arrest protocol
- Ensure airway patency and breathing
- Deliver 100% oxygen
- Stop syringe drivers
- Consider echocardiography to early identify possible reversible causes

3. Resuscitate and treat possible reversible causes

ASSESS RHYTHM

VF/pVT	Asystole / extreme bradycardia	PEA
Defibrillate (apply up to 3 consecutive shocks)	Pace - if wires are available	Provide high-quality CPR

Start basic life support and address reversible causes

Amiodarone 300 mg IV	Consider external pacing if wires are not available	If paced, turn off pacing to exclude underlying VF

No ROSC
- Continue advanced life support
- Prepare & perform early resternotomy (<5 min)
- Consider circulatory support devices and ECPR

Fig. 19 – Post-cardiac surgery cardiac arrest algorithm.

Special patient groups

Asthma and chronic obstructive pulmonary disease

- Treat life threatening hypoxia with 100 % oxygen.
- Check for evidence of (tension) pneumothorax.
- Provide tracheal intubation (because of high inflation pressures).
- Consider manual decompression and disconnection from ventilator to manage dynamic hyperinflation.
- Consider ECPR in accordance with local protocols if initial resuscitation efforts are unsuccessful.

Cardiac arrest in haemodialysis patients

- Assign a trained dialysis nurse or technician to operate the dialysis machine.
- Stop dialysis and return the patient's blood volume with a fluid bolus.
- Disconnect from dialysis machine (unless defibrillation-proof) and beware of wet surfaces.
- Leave dialysis access open and use for drug administration.
- Dialysis may be required in the early post resuscitation period.

Table 3 – Modifications to advanced life support in obstetric patients.

ALS during pregnancy	Rationale
Detection of cardiac arrest: unconscious + abnormal breathing = suspected cardiac arrest	*No change*
Call for help – "maternal arrest team"	Consider pregnancy in any collapsed woman of childbearing age. Call maternal cardiac arrest team (including an obstetrician and neonatologist)
Manual (left) uterine displacement throughout	Relieve aortocaval compression to improve cardiac output as early as possible and maintain it throughout resuscitation. Establish manual left uterine displacement when two or more team members are available—one performing manual left uterine displacement, the other performing CPR.
Chest compression quality parameters and ventilation-compression-ratio	*No change*
Airway management	Aspiration and failed intubation risk are both increased. Use a stepwise approach (bag-mask, tracheal tube or supraglottic airway if tracheal intubation fails), according to rescuer skills. Try to achieve a ramped position. Intubation should be performed by an experienced person. Equipment considerations: – Short-handled laryngoscope for large breasts – video laryngoscope as standard for intubation – Smaller tracheal tube with guidance
Defibrillation – Shock energy	*No change*
Pad position	No change: ensure defibrillation pads are placed beneath, not over, enlarged breast tissue
Fetal monitoring	Remove internal & external fetal monitors before defibrillation
Identify common and reversible causes	4Hs, 4Ts and 4Ps – Pre-eclampsia and eclampsia; Puerperal sepsis; Placental and uterine complications; Peripartum cardiomyopathy
Medications	
Vascular access early	Consider IV/IO access above the diaphragm if possible.
Dosage and time of adrenaline, amiodarone and lidocaine	*No change*
Calcium chloride	10 ml iv calcium chloride 10 %: for Mg overdose, low calcium or hyperkalaemia
Magnesium	2 g iv: for polymorphic VT 4 g iv: for eclampsia
Tranexamic acid	1 g iv: for haemorrhage
Resuscitative Hysterotomy (Perimortem Caesarean section)	In patients >20 weeks' gestation or fundus above umbilicus. Resuscitative hysterotomy is a time-sensitive intervention. Preparation to perform should be undertaken early. Resuscitative hysterotomy should be performed as soon as possible at the site of cardiac arrest by a skilled team.
Post-resuscitation care	Stabilise mother to stabilise fetus and prepare for major obstetric haemorrhage.

Resuscitation in obese patients

- Obese patients should receive standard resuscitation treatment – no deviation from standard BLS and ALS is needed.

Resuscitation in patients with pectus excavatum

- Consider reduced chest compression depth of 3–4 cm.
- In the case of a Nuss bar correction, substantially increased force is required to deliver effective chest compressions.
- Consider early implementation of ECPR if chest compressions are ineffective.
- Use antero-posterior pad placement for defibrillation using standard energies.

Cardiac arrest in pregnancy

- Consider pregnancy in any collapsed woman of childbearing age.
- Pregnant and peripartum women can deteriorate to cardiac arrest anywhere and medical facilities and services must be prepared for such events.
- Obstetric-specific early warning systems enable early recognition of deteriorating pregnant patients.
- In obstetric cardiac arrest, follow the specific additions to the general ALS algorithm.
- Relieve aortocaval compression as early as possible and maintain it throughout resuscitation. Manual left uterine displacement in maternal cardiac arrest is suggested due to practicalities.
- Seek additional pregnancy-specific causes of cardiac arrest to the 4Hs and 4Ts: The 4Ps, which are pre-eclampsia and eclampsia, puerperal sepsis, placental and uterine complications and peripartum cardiomyopathy.
- Resuscitative hysterotomy is a time-sensitive intervention. Preparation to perform the procedure should be undertaken early.
- Resuscitative hysterotomy should be performed as soon as possible at the site of cardiac arrest by a skilled team.
- Post-resuscitation care in pregnant and postpartum women requires a multidisciplinary approach (Table 3).

Adult post resuscitation care

The European Resuscitation Council (ERC) and the European Society of Intensive Care Medicine (ESICM) have collaborated to produce these post-resuscitation care Guidelines for adults.[68] (Fig. 20)

Immediate post-resuscitation care

- Post-resuscitation care is started immediately after sustained ROSC, regardless of location.

Diagnosis of cause and complications of cardiac arrest

- Identify early non-coronary causes using transthoracic echocardiography and/or a whole body computed tomography (CT) scan (including head, neck, chest, abdomen, pelvis, and CT pulmonary angiography) at hospital admission, before or after coronary angiography if indicated.
- Prioritise immediate coronary angiography for patients with clear ST-elevation on the ECG or other high suspicion of coronary occlusion (e.g. haemodynamic and/or electrical instability). Perform a head-to-pelvis CT scan (including CT pulmonary angiography) if coronary angiography fails to identify causative lesions.
- If there are signs or symptoms pre-arrest suggesting a non-coronary cause (e.g. headache, seizures or neurological deficits, shortness of breath or documented hypoxaemia in patients with known respiratory disease, abdominal pain), perform a whole body CT-scan (including CT pulmonary angiography).

Airway and breathing

Airway management after return of spontaneous circulation

- Airway and ventilation support should continue after ROSC is achieved.
- Patients who have had a brief period of cardiac arrest and an immediate return of normal cerebral function and are breathing normally, may not require airway or ventilatory support but should be given supplemental oxygen via a facemask if their arterial blood oxygen saturation is less than 94 %.
- Patients who remain comatose following ROSC, or who have another clinical indication for sedation and mechanical ventilation, should have their trachea intubated if this has not been done already during CPR.
- Tracheal intubation (with or without drugs) should be performed only by experienced operators who have a high success rate.
- Correct placement of the tracheal tube must be confirmed with waveform capnography.
- In the absence of personnel experienced in tracheal intubation, it is reasonable to retain or insert a supraglottic airway (SGA) or maintain the airway with basic techniques until personnel skilled in drug-assisted tracheal intubation are available.
- Post ROSC patients may require drug assisted tracheal intubation – the same level of care should be provided as for any other critically ill patient with a physiologically or anatomically challenging airway in terms of skills of the provider, monitoring, and choice of drugs for induction, and maintenance of sedation.

Control of oxygenation

- Immediately after ROSC, use 100 % (or the maximum available) inspired oxygen until the arterial oxygen saturation (SpO_2) can be measured and titrated reliably with pulse oximetry or the partial pressure of arterial oxygen (PaO_2) can be measured.
- As soon as SpO_2 can be measured reliably or arterial blood gas values are obtained, titrate the inspired oxygen to achieve an arterial oxygen saturation of 94–98 % or arterial partial pressure of oxygen (PaO_2) of 10–13 kPa (75–100 mmHg). Be aware that pulse oximetry can overestimate the true oxygen saturation in people with darker skin tones and low-flow states will cause low signal quality.
- Avoid hypoxaemia (PaO_2 < 8 kPa or 60 mmHg) following ROSC.
- Avoid hyperoxaemia following ROSC.

Control of ventilation

- Obtain arterial blood gases and use end tidal CO_2 in mechanically ventilated patients.
- Target normocapnia (a partial pressure of carbon dioxide of 35–45 mm Hg or approximately 4.7–6.0 kPa) in adults with ROSC after cardiac arrest.

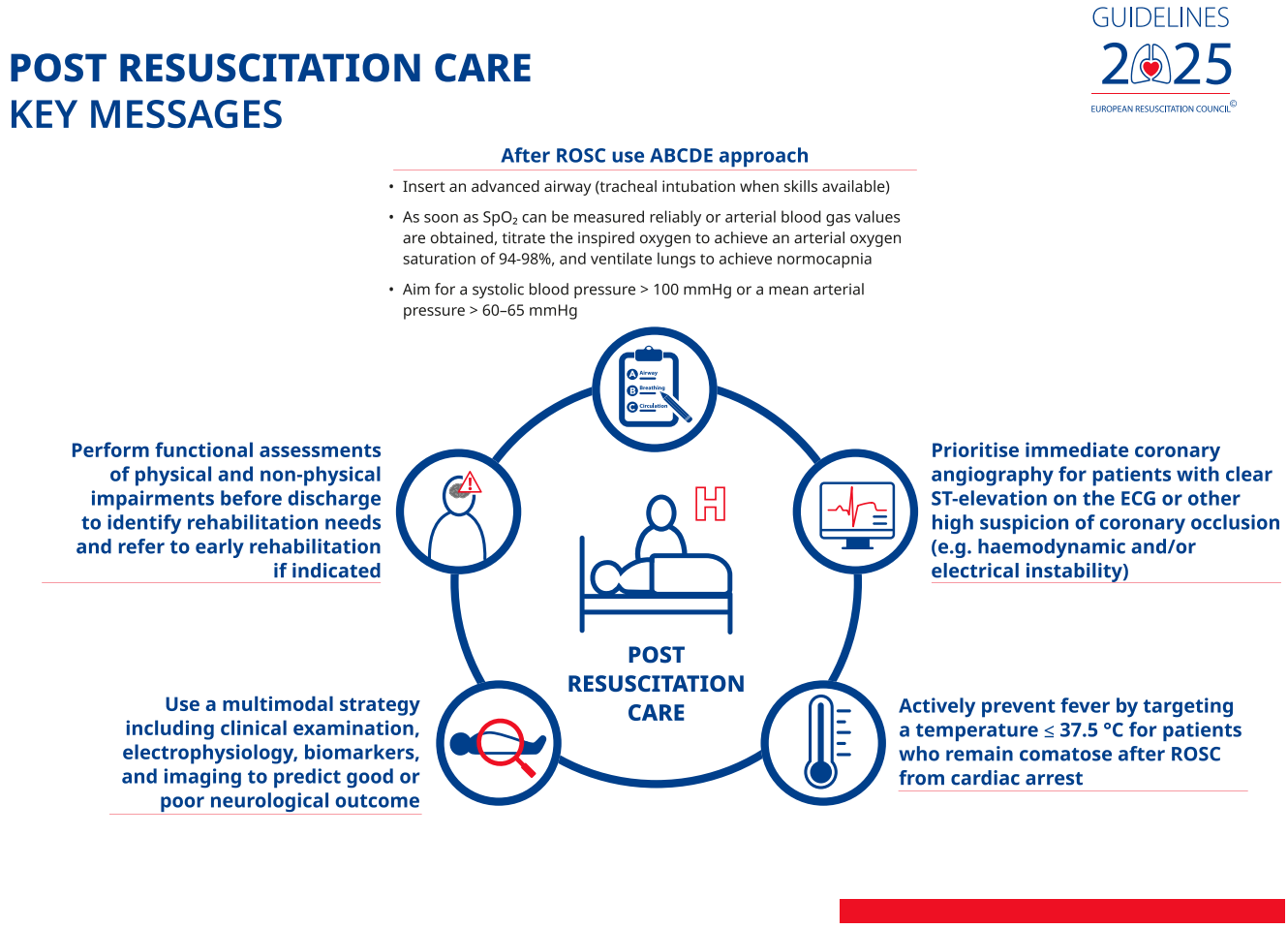


Fig. 20 – Key messages adult post resuscitation care.

- In patients with accidental hypothermia or treated with hypothermia monitor $PaCO_2$ frequently as hypocapnia may occur.
- In hypothermic patents use consistently either temperature or non-temperature corrected blood gas values.
- Use a lung protective ventilation strategy aiming for a tidal volume of 6–8 mL kg^{-1} ideal body weight.

Circulation

Coronary reperfusion

- Emergent cardiac catheterisation laboratory evaluation (and primary percutaneous coronary intervention (PPCI) if required) should be performed in adult patients with ROSC after cardiac arrest of suspected cardiac origin with persistent ST-elevation on the electrocardiogram (ECG).
- In patients with ROSC after out-of-hospital cardiac arrest (OHCA) without ST-elevation on the ECG, cardiac catheterisation laboratory evaluation should be delayed unless the clinical context suggests a high likelihood of acute coronary occlusion.

Haemodynamic monitoring and management

- All patients should be monitored with an arterial line for continuous blood pressure measurements, and it is reasonable to monitor cardiac output in haemodynamically unstable patients.
- Perform echocardiography as soon as possible in all patients to detect any underlying cardiac pathology and quantify the degree of myocardial dysfunction.
- Avoid hypotension and target a mean arterial pressure (MAP) > 60–65 mmHg after cardiac arrest.
- Maintain perfusion with fluids, noradrenaline and/or dobutamine, depending on individual patient need for intravascular volume, vasoconstriction or inotropy.
- Do not give steroids routinely after cardiac arrest.
- Avoid hypokalaemia and hyperkalaemia, which are associated with ventricular arrhythmias.
- In select patient populations (e.g. Glasgow Coma Scale score ≥8 on hospital arrival, with ST-elevation myocardial infarction (STEMI) and <10 min cardiac arrest) consider mechanical

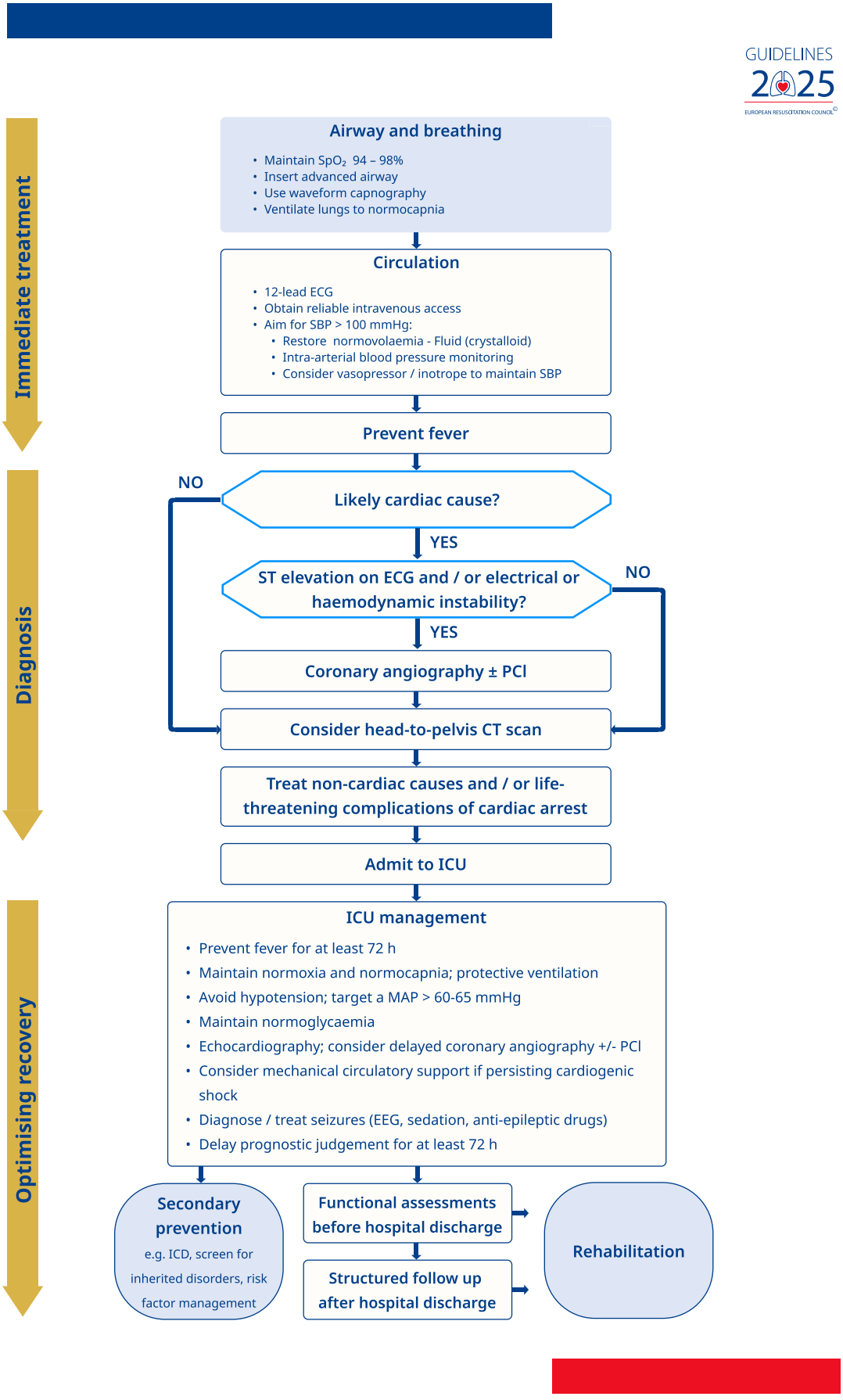


Fig. 21 – Post-resuscitation care for unconscious patients.

circulatory support (such as intra-aortic balloon pump, left-ventricular assist device or veno-arterial extra corporal membrane oxygenation) for persisting cardiogenic shock from left ventricular failure if treatment with fluid resuscitation, inotropes, and vasoactive drugs is insufficient. Left-ventricular assist devices or arterio-venous extra corporal membrane oxygenation should also be considered in haemodynamically unstable patients with acute coronary syndromes (ACS) and recurrent ventricular tachycardia (VT) or ventricular fibrillation (VF) despite optimal therapy.

Post-ROSC arrhythmias

- In patients with arrhythmia immediately after ROSC, follow the ALS Guidelines for peri-arrest arrhythmia.
- In patients with arrhythmia after ROSC, treat any potential underlying causes, such as coronary occlusion or electrolyte disorders.
- In patients with no arrhythmia after ROSC, do not routinely give anti-arrhythmic drug prophylaxis (Fig. 21).

Disability (optimising neurological recovery)

Control of seizures

- Use electroencephalography (EEG) to diagnose electrographic seizures in patients with sub-clinical convulsions and to monitor treatment effects.
- Use levetiracetam or sodium valproate as first-line antiepileptic drugs in addition to sedative drugs to treat seizures after cardiac arrest.
- Do not use seizure prophylaxis in post-cardiac arrest patients.
- Attempt a wake-up trial in patients with myoclonus and benign EEG background (days after arrest).

Temperature control

- Actively prevent fever by targeting a temperature $\leq$37.5 °C for patients who remain comatose after ROSC from cardiac arrest.
- Comatose patients with mild hypothermia (32–36 °C) after ROSC should not be actively warmed to achieve normothermia.
- We recommend against the routine use of prehospital cooling with rapid infusion of large volumes of cold intravenous fluid immediately after ROSC.
- Use surface or endovascular temperature control techniques when temperature control is used in comatose patients after ROSC.
- When a cooling device is used, we suggest using a temperature control device that includes a feedback system based on continuous temperature monitoring to maintain the target temperature.
- Prevent active fever for 36–72 h in post-cardiac arrest patients who remain comatose.

Other therapies to improve neurological outcome

- There is insufficient evidence to recommend the use of any specific drug therapy for comatose survivors of cardiac arrest.

General intensive care management

- Do not use prophylactic antibiotics routinely in patients following ROSC. However, it is reasonable to have a low threshold for giving antibiotics when there is any clinical suspicion of pneumonia.
- Use short acting sedative agents when treating post-cardiac arrest patients receiving mechanical ventilation – this may enable earlier clinical examination that is less confounded by sedation when assessing neurological recovery.
- We do not recommend systematic use of neuromuscular blocking drugs in comatose post-cardiac arrest patients.
- In patients with critical hypoxaemia and acute respiratory distress syndrome (ARDS) following cardiac arrest, the use of a neuromuscular blocker may be considered.
- Patients should be nursed 30° head-up.
- It is reasonable to start gastric feeding at low rates (trophic feeding) and increase as tolerated.
- Given the high incidence of upper gastrointestinal ulceration in post-cardiac arrest patients and the use of anticoagulant and antiplatelet drugs both pre and post arrest, use stress ulcer prophylaxis in post-cardiac arrest patients, especially in those with coagulopathy.
- Anticoagulation of post-cardiac arrest patients should be individualised and be based on general ICU recommendations.
- Use standard glucose management protocols for adults with ROSC after cardiac arrest.

Predicting neurological outcome

General recommendations

- In patients who are comatose after resuscitation from cardiac arrest, neurological prognostication should be performed using clinical examination, electrophysiology, biomarkers, and imaging, to both inform the patient's relatives and to help clinicians to target treatments based on the patient's chances of achieving a neurologically meaningful recovery.
- No single predictor is 100 % accurate. Use multimodal neuroprognostication strategies.
- When predicting poor neurological outcome, a high specificity and precision are desirable, to avoid falsely pessimistic predictions. When predicting good outcome, the aim is to identify those patients with a better potential for recovery. Since the consequence of a false prediction in this setting is less severe, the predictive performance of the test is not as critical. Both predicting good and poor outcome are important, to reduce prognostic uncertainty.
- The clinical neurological examination is central to prognostication. To avoid falsely pessimistic predictions, clinicians should exclude potential residual effects of sedatives and other drugs that may confound the results of the tests.
- Index tests for neurological prognostication are aimed at assessing the severity of hypoxic-ischaemic brain injury. Neurological prognosis is one of several aspects to consider in discussions about an individual's potential for recovery.

Clinical examination

- Perform a daily neurological examination in patients who are unconscious after cardiac arrest.
- Clinical examination is prone to interference from sedatives, opioids or neuromuscular blocking drugs. Potential confounding from residual sedation should always be considered and excluded.
- Consider neurological prognostication in patients who are not awake and obeying commands (Glasgow coma scale motor score < 6) at 72 h or later after ROSC.

- In unconscious patients at 72 h or later after ROSC, the following tests may predict a poor neurological outcome:
  - The bilateral absence of the pupillary light reflex.
  - The bilateral absence of corneal reflex.
  - The presence of myoclonus within 96 h and, in particular, status myoclonus within 72 h.
- We also suggest recording the EEG in the presence of myoclonic jerks to detect any associated epileptiform activity or to identify EEG signs such as background reactivity or continuity, suggesting a potential for neurological recovery.

Neurophysiology

- Perform EEG from day 1 after ROSC to predict outcome and detect subclinical seizure activity in comatose patients. Routine EEG or continuous EEG monitoring may be used.
- Suppressed background with or without periodic discharges and burst suppression on EEG ('highly malignant' patterns) are accurate indicators of a poor prognosis. We suggest using these EEG patterns after 24 h from ROSC.
- The bilateral absence of somatosensory evoked cortical N20 potentials indicates poor prognosis after cardiac arrest.
- Always consider the EEG and somatosensory evoked potentials (SSEPs) results in the context of clinical examination findings and other tests. Always consider using a neuromuscular blocking drug when performing SSEP.

Biomarkers

- Use serial measurements of neuron specific enolase (NSE) to predict outcome after cardiac arrest. Increasing values between 24 h and 48 h or 72 h in combination with high values at 48 h and 72 h indicate a poor prognosis.

Imaging

- Use brain imaging studies to predict poor neurological outcome after cardiac arrest. Ensure that the images are evaluated by someone with specific experience in these studies.
- Where specialist neuroradiology expertise is unavailable, consider telemedicine consultation for brain imaging interpretation.
- Use presence of generalised brain oedema, manifested by a marked reduction of the grey matter/white matter ratio on brain CT, or extensive diffusion restriction on brain MRI to predict poor neurological outcome after cardiac arrest.
- Repeat the brain CT if the patient is unconscious at the time of prognostication (72 h–96 h after ROSC) and the first brain CT does not show signs of hypoxic ischaemic brain injury (HIBI).

Multimodal prognostication

- Once major confounders have been excluded, start the prognostication assessment with an accurate clinical examination.
- In an unconscious patient at $\geq$72 h from ROSC, in the absence of confounders, poor outcome is likely when two or more of the following predictors are present: no pupillary and corneal reflexes at $\geq$72 h, bilaterally absent N20 somatosensory evoked potential (SSEP) wave at $\geq$ 24 h, highly malignant EEG at >24 h, neuron specific enolase (NSE) > 60 $\mu g\ L^{-1}$ at 48 h and/or 72 h, status myoclonus $\leq$72 h, or a diffuse and extensive anoxic injury on brain CT/MRI. Most of these signs can be recorded before 72 h from ROSC, however, conclusions on prognosis will be made only at the time of clinical prognostic assessment at $\geq$72 h.

Withdrawal of life-sustaining therapy

- Separate discussions around withdrawal of life-sustaining therapy and the assessment of prognosis for neurological recovery; withdrawal of life-sustaining therapy decisions should consider aspects other than brain injury such as age, co-morbidity, general organ function and the patients' preferences.
- Allocate sufficient time for communication around the level-of-treatment decision within the team and with the families.
- After a decision on withdrawal of life-sustaining therapy, use a structured approach to shift from curative to end-of-life palliative care and consider organ donation.

Rehabilitation and follow-up after cardiac arrest

- Implement early mobilisation, delirium management and ICU diaries during hospitalisation.
- Provide information to patients and co-survivors.
- Perform functional assessments of physical and non-physical impairments before discharge to identify rehabilitation needs and refer to early rehabilitation if indicated.
- Provide cardiac rehabilitation as indicated by the cause of the cardiac arrest.
- Organise a follow-up of cardiac arrest survivors within three months after hospital discharge; screening for cognitive, physical, emotional problems, fatigue, and impact on life roles.
- Invite co-survivors to the follow-up; ask about emotional problems and impact on life roles
- Undertake specialist referral and further rehabilitation as indicated (Fig. 22).

Organ donation

- We recommend that all patients who have restoration of circulation after CPR and who subsequently progress to death be evaluated for organ donation.
- In comatose ventilated patients who do not fulfil neurological criteria for death, if a decision to start end-of-life care and withdrawal of life support is made, organ donation should be considered for when circulatory arrest occurs.
- All decisions concerning organ donation must follow local legal and ethical requirements.
- Cardiac arrest registries should report if organ donation after initial resuscitation from cardiac arrest occurred.

Investigating unexplained cardiac arrest

- Diagnostic testing of patients with unexplained cardiac arrest includes blood sample collection for toxicology and genetic testing, data retrieval from cardiac implantable electronic devices and wearable monitors, repeated 12 lead ECG and continuous cardiac monitoring, cardiac MRI, sodium channel blocker tests, and exercise testing.
- A confirmed diagnosis of a heritable condition should prompt targeted genetic testing.
- Long-term follow-up of patients after unexplained cardiac arrest patients is recommended because of the high risk of recurrence of arrhythmia.

Cardiac arrest centres

- Adult patients with non-traumatic OHCA should be considered for transport to a cardiac arrest centre according to local protocols.
- Adult patients with non-traumatic OHCA should be cared for at a cardiac arrest centre whenever possible.

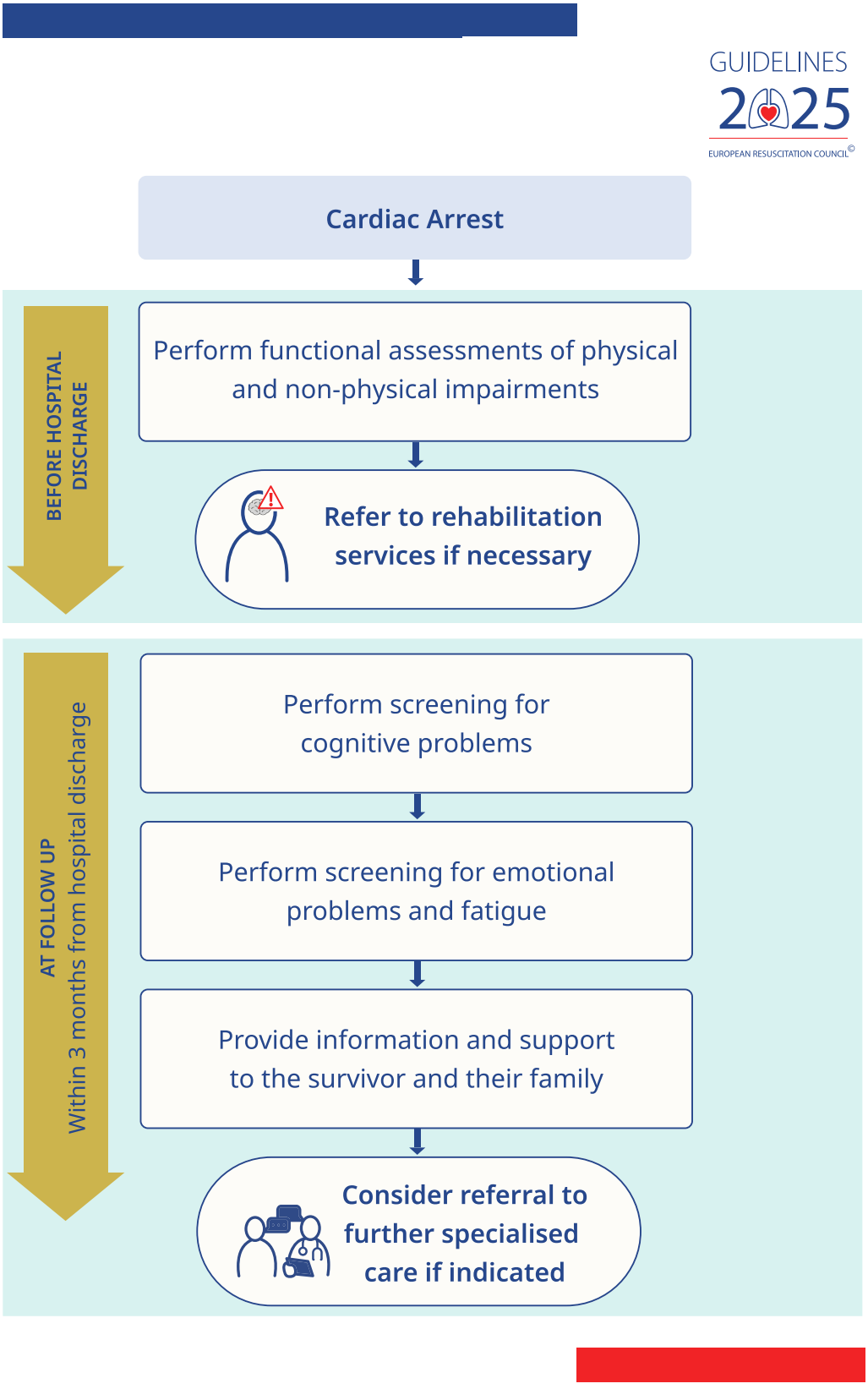


Fig. 22 – Recommendations for in-hospital functional assessments, follow-up and rehabilitation after cardiac arrest.

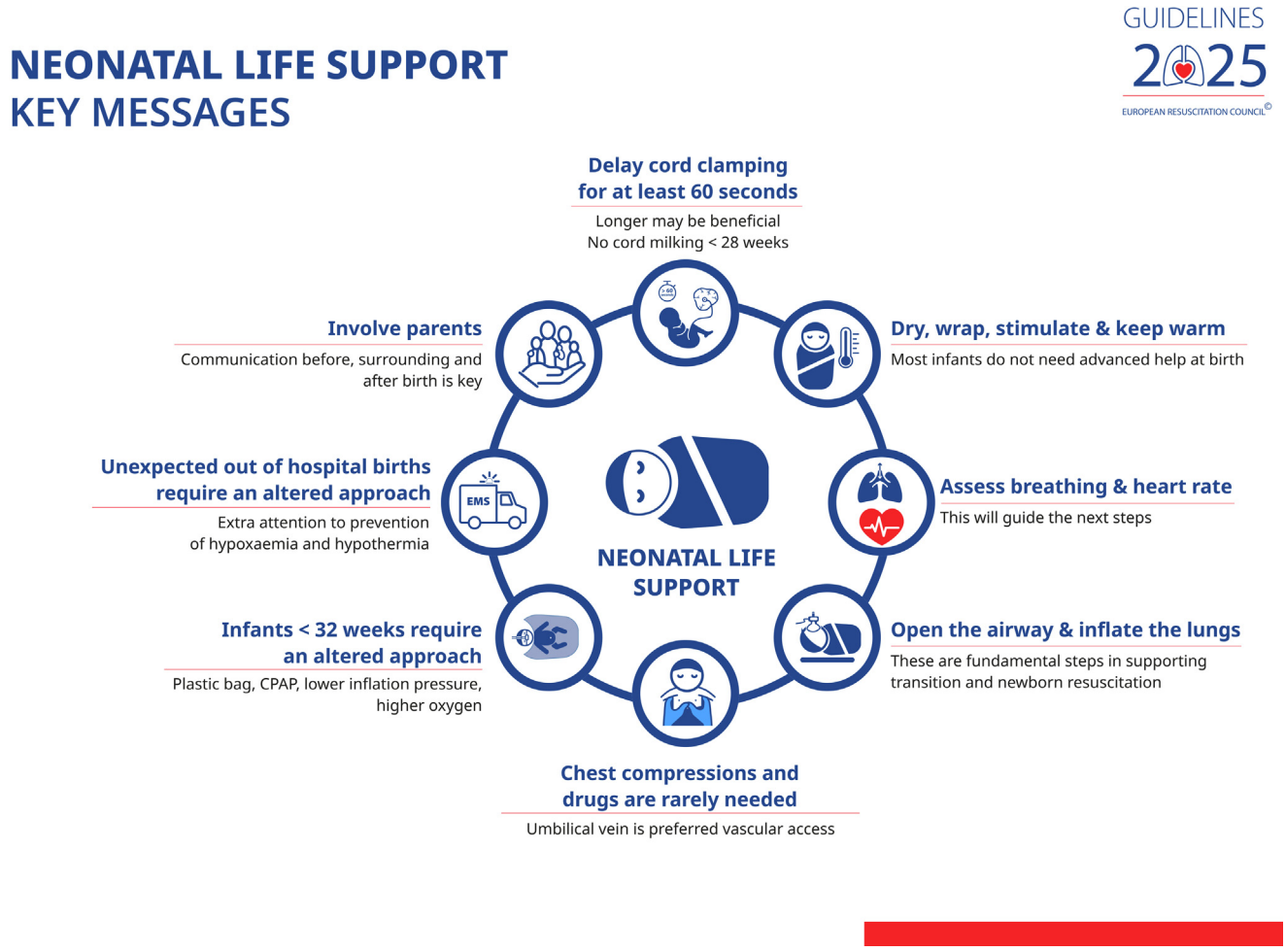


Fig. 23 – Key messages Neonatal Life Support.

- Healthcare networks should establish local protocols to develop and maintain a cardiac arrest network.

Newborn life support

The ERC Guidelines 2025 Newborn Resuscitation and Support of Transition of Infants at Birth cover the management of the term and preterm infant.[69] (Fig. 23).

Factors before birth

Staff attending births in hospitals

Any infant may develop problems during birth. Local guidelines should indicate who should attend births taking into consideration identified risk factors.

As a guide:

- An interprofessional team with appropriate experience and training in NLS proportionate to the expected risk should attend the birth.
- Neonatal staffing levels should acknowledge the potential need to deliver unexpected support in the delivery area.
- A process should be in place for rapidly mobilising extra team members with adequate resuscitation skills for any birth.

Telemedicine

- Consider the use of collaboration through telemedicine, as it facilitates providing remote advice.

Equipment and environment

- Regularly check all equipment to ensure it is ready for use.
- Ensure that equipment is easily accessible and organised in a standardised way.
- Consider human factor elements when organising equipment to maximise efficiency and minimise time delays.
- Resuscitation should take place in a warm, well-illuminated, draught-free area with a flat resuscitation surface and an external heat source, e.g. a radiant heater (see thermal control).

Briefing

- Team briefing is important and should be performed before birth.
- The purpose of briefing is to:
  - Review available clinical information.
  - Assign roles and tasks.
  - Check equipment and presence of personnel.
  - Prepare the family.
- Use a checklist and/or cognitive aid to facilitate all of the above, reduce mental load, and enhance safety.

Education

- Institutions or clinical areas where births may occur should provide sufficient opportunities and resources for healthcare professionals involved in neonatal resuscitation to receive regular training, maintaining up-to-date knowledge as well as technical and non-technical skills.
- The content and organisation of such training programmes may vary according to the needs of the providers and the local organisation.
- Undertake training at least once per year to prevent skill decay, preferably supplemented with more frequent short-duration booster sessions (e.g. every 3–6 months). For more information on training see ERC Guidelines 2025 Education for Resuscitation.

Thermal control

Standards

- Maintain the temperature of newborn infants between 36.5 °C and 37.5 °C.
- Monitor the infant's temperature regularly or continuously after birth.
- Record the admission temperature as a prognostic and quality indicator.
- Rewarm infants who are hypothermic after birth; avoid hyperthermia.
- In appropriate circumstances, therapeutic hypothermia may be considered after resuscitation (see post-resuscitation care).

Environment

- Protect the infant from draughts. Ensure windows are closed and air-conditioning appropriately programmed.
- In infants >28 weeks, keep the delivery area at 23–25 °C.
- In infants ≤28 weeks, keep the delivery area at >25 °C.

Newborn infants ≥32 weeks

- Dry the infant immediately after birth and remove wet towels.
- Cover the infant's head with a hat, and the body with dry towels.
- If no intervention is required, place the infant skin-to-skin with mother or let mother do that herself, and cover both with towels.
- Ongoing careful observation of mother and infant is required, especially in more preterm and growth-restricted infants to ensure they both remain normothermic.
- Consider the use of a plastic bag/wrap if skin-to-skin care is not possible.
- Place the infant on a warm surface using a preheated radiant warmer, if support of transition or resuscitation is required.

Newborn infants <32 weeks

- Dry the infant's head and cover with a hat.
- Put the infant's body in a plastic (polyethylene) bag or wrap without drying.
- Use a preheated radiant warmer.
- Consider the use of additional measures during delayed cord clamping to ensure thermal stability (e.g., increasing room temperature, warm blankets, and thermal mattress).
- Be careful to prevent hypothermia during skin-to-skin care during assisted transition, especially in the more preterm and/or growth restricted infants.
- Consider the use of heated humidified respiratory gases for infants receiving respiratory support.
- Be aware of the risk of hyperthermia when multiple heat-preservation interventions are used simultaneously, especially while using a thermal mattress.

Management of the umbilical cord

- Ideally, delayed cord clamping is performed in all births, after inflation of the lungs and before uterotonics are given.

Cord clamping

- Discuss the options for managing cord clamping and the rationale with parents and team before birth.
- Perform thermal management, tactile stimulation and initial assessment during delayed cord clamping.
- Newborn infants without need for support: facilitate at least 60 s of delayed cord clamping.
- Newborn infants in need of resuscitation: clamp the cord <30 s to minimise any delay to necessary interventions.
- If stabilisation with intact cord can be safely undertaken, longer delayed cord clamping is preferred, especially in infants <34 weeks.

Cord milking

- Do **not** milk the cord in preterm infants <28 weeks.
- Consider intact cord milking as an alternative in infants ≥28 weeks, but only if delayed cord clamping cannot be performed (Fig. 24).

Initial assessment

- Perform initial assessment as soon as possible after birth, ideally during delayed cord clamping, drying and wrapping to:
  - Identify the need for support and/or resuscitation.
  - Aid decisions relating to the appropriateness and duration of delayed cord clamping.
- Assess:
  - Breathing.
  - Heart rate (HR).
  - Muscle tone.
- Provide thermal management and tactile simulation during delayed cord clamping and assessment.
- Reassess breathing and HR frequently to assess any response and determine if further interventions are required.

Breathing

- Note presence or absence of breathing.
- If present, note the rate, depth, symmetry and work of breathing.

Heart rate

- Initial HR assessment can be performed with a stethoscope.
- Continuous HR assessment methods (pulse oximetry, electrocardiography (ECG)) are preferred when interventions are indicated or during stabilisation of preterm newborns.

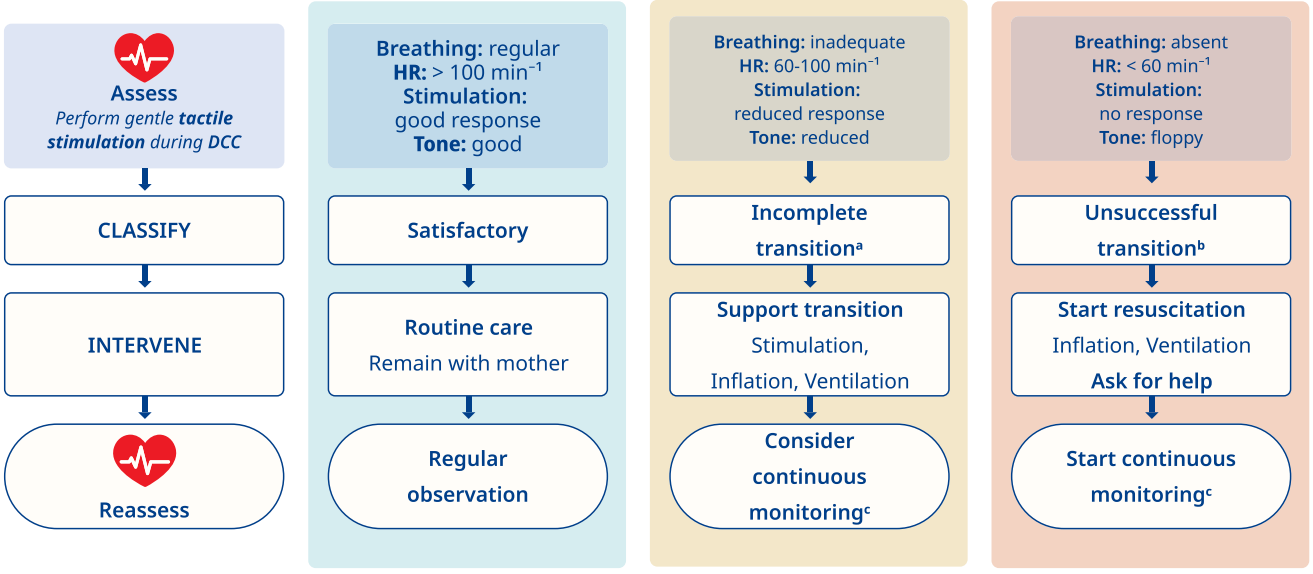


Fig. 24 – Initial assessment and interventions.
[a] Slow HR may indicate hypoxia, so airway and breathing require support. Ventilatory support will likely be adequate for a higher HR and adequate transition. [b] HR suggestive of significant hypoxia, so airway and breathing support required urgently. [c] SpO_2 +/- ECG.

- Do not interrupt resuscitation to place pulse oximetry or ECG.

Response to tactile stimulation
- Gently stimulate the newborn infant by drying them, rubbing the soles of the feet or the back.
- Avoid more vigorous methods of stimulation, especially in preterm infants.

Muscle tone & colour
- A very floppy infant is likely to need breathing support.
- Hypotonia is common in preterm infants.
- Do not use colour to assess oxygenation.
- Interpret pallor within clinical context, as it may have several causes such as acidosis, asphyxia, blood loss, or chronic anaemia.

Classification according to initial assessment
- Based on the initial assessment, further actions can be implemented guided by the NLS algorithm.

Newborn life support
- Ensure the airway is open and the lungs are inflated.
- Do not undertake subsequent interventions before the airway is open and the lungs have been inflated.
- Following initial assessment, start respiratory support if the infant is not breathing regularly or the HR is <100 min^{-1} (Fig. 25).

Airway
- Assess the effect of each airway technique by observing for chest movement and assessing HR.

Position
- Place the newborn infant on their back with the head supported in a neutral position.
- Gently push the lower jaw forwards with pressure from behind (jaw thrust) to open the airway.

Two-person method
- Use the two-person method of airway support (jaw thrust) as this approach is more effective than single person jaw thrust.

Suction
- Do not routinely suction meconium or amniotic fluid from infant's' airways because it delays initiating ventilation.
- Consider physical airway obstruction if lung inflation is unsuccessful despite alternative airway opening techniques.
- Perform suction under direct vision.

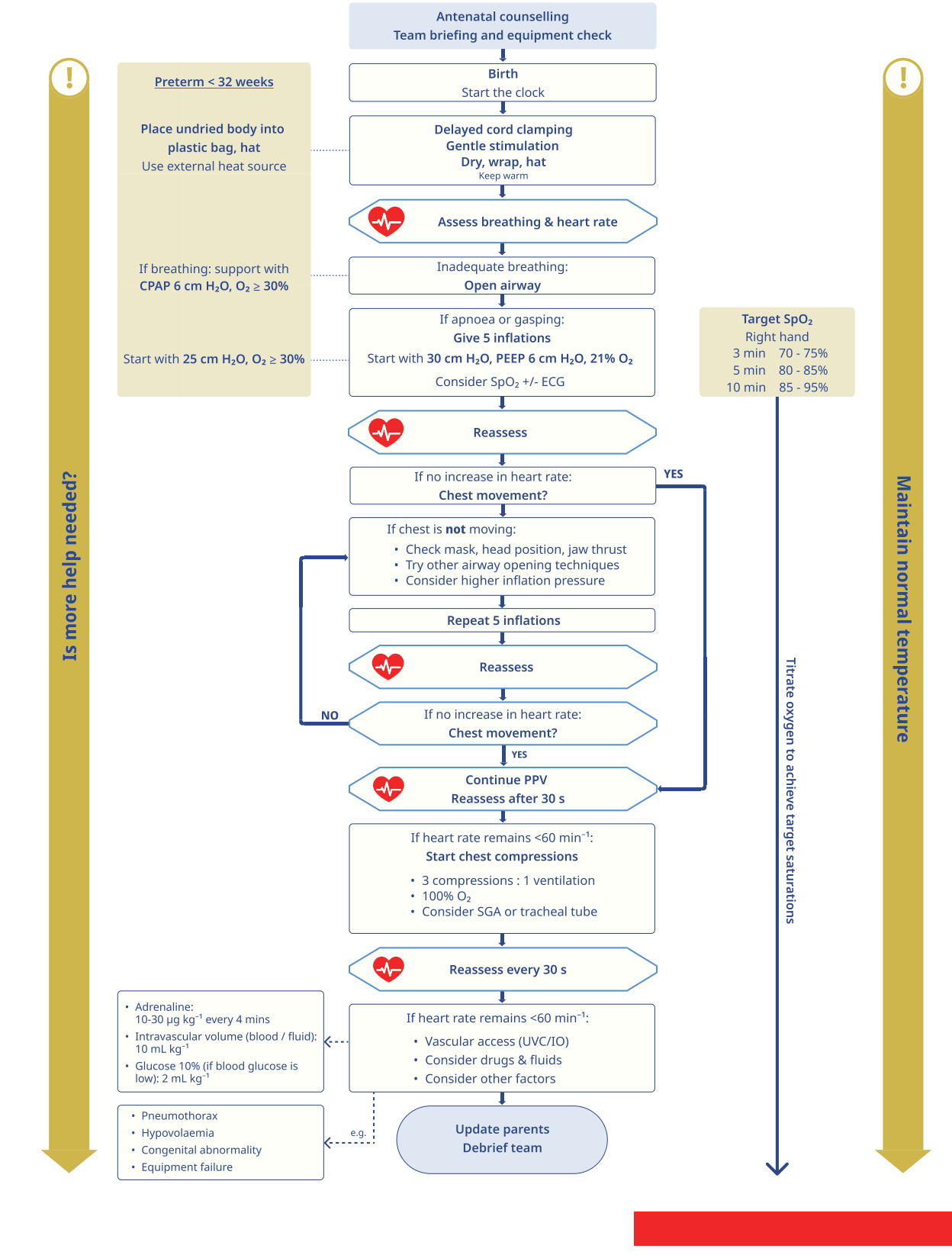


Fig. 25 – Neonatal life support algorithm.

- Rarely, with no response to inflations and no chest wall movement, an infant may require tracheal suctioning to relieve an airway obstruction below the vocal cords.

Airway devices

- Use airway devices only if competent personnel are available and trained in the appropriate equipment; if not continue with mask ventilation and call for help.

Supraglottic airway devices. Consider using an appropriate size supraglottic airway device (SGA) (see manufacturers guidelines):

- When facemask ventilation is ineffective.
- As an alternative for facemask ventilation if SGA size permits.
- When a more definitive airway is required as an alternative to tracheal intubation.
- Where tracheal intubation is not possible or deemed unsafe because of congenital abnormality, a lack of equipment, or a lack of skill.
- When chest compressions are performed.

Nasopharyngeal and oropharyngeal airway devices.

- Consider nasopharyngeal or oropharyngeal airway devices, especially when facemask ventilation may be difficult (e.g. micrognathia).
- Use oropharyngeal airway devices with caution in infants <34 weeks. They might contribute to airway obstruction.

Tracheal tube. Consider tracheal tube placement:

- When equipment and skills permit.
- When facemask or SGA ventilation are ineffective.
- With prolonged ventilation.
- When suctioning the lower airways (removal of presumed tracheal blockage).
- When chest compressions are performed.

When performing tracheal intubation:

- Have a range of different sized tubes available.
- Use video laryngoscopy or, if unable, direct laryngoscopy.
- Use exhaled CO_2 detection and clinical assessment to confirm tracheal intubation.
  - Be aware that exhaled CO_2 detection may be false negative in low or no cardiac output states at birth.
- Use appropriate imaging to confirm correct tube position.
- If available, respiratory function monitoring may be used to help confirm tube position within the airway and assist adequate ventilation (expired tidal volume 4–8 mL kg^{-1} with minimal leak).

Breathing

- Inflate the lungs when the newborn infant is not breathing using a facemask or nasal interface.
- Nasal interface used to provide positive pressure ventilation (PPV) may vary: single or binasal prongs, short or long prongs, or nasal mask.

Assisted ventilation

Lung inflation.

- If apnoeic, gasping or not breathing effectively, start PPV as soon as possible to inflate the lungs – ideally within 60 s.
- Apply appropriately fitting nasal interface or a facemask connected to a device for providing positive pressure ventilation.
- Give 5 inflations with an inflation time of up to 2–3 s:
- Infants <32 weeks: starting inflation pressure 25 cm H_2O.
- Infants ≥32 weeks: starting inflation pressure 30 cm H_2O.
- Consider pulse oximetry ± ECG.

Assessment.

- During lung inflations look for chest movement.
  - Visible chest movement during inflations indicates a patent airway and delivered volume.
  - Failure of the chest to move may indicate that the airway is not open, or that insufficient inflation pressure/volume is delivered.
- After lung inflations check HR
  - An increase in HR within 30sec of positive pressure ventilation, or a stable HR > 100 min^{-1}, usually confirms adequate ventilation/oxygenation.
  - HR < 100 min^{-1} or decreasing usually suggests continued hypoxia and almost always indicates inadequate ventilation.

If there is a HR response.

- Continue uninterrupted positive pressure ventilation until the infant begins to breathe adequately and the HR > 100 min^{-1}.
- Aim for a positive pressure ventilation rate of 30 ventilations min^{-1} with an inflation time of approximately 1 s.
- Adapt inflation pressure based on clinical observation (chest movement and HR)
- Reassess breathing and HR every 30 s, until the newborn infant is deemed stabilised.
- Consider inserting SGA or tracheal tube if apnoea continues.

If there is no HR response. If there is **no** HR response **and** the chest is not moving with inflations:

- Call for help.
- Recheck equipment.
- Perform airway opening technique of choice.
- If the airway opening techniques are ineffective in inflating the lungs, increase inflation pressure.
- Repeat inflations after every airway opening technique or after increasing inflation pressure.
- Re-assess chest movement and HR after inflations until visible chest movement **or** HR response.
- Reduce inflation pressure when chest movement is seen and there is clinical improvement.
- If being used, check with a respiratory function monitor that expired tidal volume is within target range (4–8 mL kg^{-1}, depending on gestational age).

Without adequate lung inflation, chest compressions will be ineffective:

- **Confirm effective ventilation** through observed chest movement or other measures of respiratory function.
- **Then** progress to chest compressions, if the HR remains <60 min^{-1}.

Continuous positive airway pressure and positive end-expired pressure

- Use either nasal interface or a facemask as device-patient interface to deliver continuous positive airway pressure (CPAP) or positive end-expired pressure (PEEP)
- Start with CPAP at 6 cm H_2O as initial breathing support in:
  - Spontaneously breathing infants <32 weeks with respiratory distress.

- Spontaneously breathing infants ≥32 weeks with respiratory distress requiring supplemental O_2.
- In infants needing positive pressure ventilation, start with PEEP at 6 cm H_2O.

Ventilation devices
- Use appropriately sized nasal interface or facemask to deliver CPAP or PEEP
- Ensure effective seal with minimal force on the facemask.
- Where possible, use a T-piece resuscitator capable of providing either CPAP or positive pressure ventilation + PEEP when giving ventilatory support, especially in the preterm infant.
- Self-inflating bags should be available as backup:
  - Take care not to deliver excessive volumes and pressures.
  - Be aware that CPAP might not be effectively delivered even when a PEEP valve is used.

Oxygen
- Use pulse oximetry and O_2 blenders during resuscitation or stabilisation in the delivery area.
- Check O_2 and saturations every 30 s.
- Titrate inspired O_2 to achieve target SpO_2 between the 25th and 75th percentile.
- Infants ≥32 weeks needing respiratory support:
  - Start at 21 % O_2.
- Infants <32 weeks:
  - Start at ≥30 % O_2.
  - Avoid SpO_2 < 80 % and/or bradycardia at 5 min of age.

Circulation

Chest compressions
- Start chest compressions if the HR remains <60 min^{-1} after at least 30sec of effective ventilation.
- When starting chest compressions:
  - Increase O_2 to 100 %.
  - Call for experienced help if not already summoned.
  - Anticipate the need to secure the airway and establish vascular access for medication.
- Use a 3:1 compression-to-ventilation ratio (C:V), aiming for 90 compressions and 30 ventilations (120 events) per minute.
- Use the two-thumb-hands-encircling-technique with overlapping or adjacent thumbs to deliver chest compressions.
- Compress to a depth of one-third of the anterior-posterior chest diameter.
- Allow full chest recoil between compressions.
- Re-assess HR every 30 s.
- If HR < 60 min^{-1}, secure the airway with an SGA or tracheal tube (if competent and not already done) with minimal interruptions to ongoing chest compressions.
- After tracheal intubation or, if unable, SGA placement, continue with the 3:1 C:V ratio.
- Titrate O_2 against the oxygen saturation once a reliable value is achieved.
- Discontinue chest compressions if the HR is >60 min^{-1}; check for output (e.g. auscultation, pulse check, pulse oximetry, signs of life).

Vascular access

Umbilical venous access.
- Use the umbilical vein for rapid emergency vascular access during resuscitation at birth.
- Perform emergency umbilical venous catheter placement under clean rather than sterile conditions to ensure timely vascular access is secured.
- Consider the use of emergency umbilical venous catheter until some days after birth as it may still be achievable.

Intraosseous access.
- Use intraosseous (IO) access as an alternative method of emergency vascular access for medication and fluids.
- Consider device-specific weight limitations for IO related equipment.
- Ensure there is no extravasation when administering medication and fluids.
- Do not aspirate blood; even when correctly positioned, it is often not possible.

Support of transition/post-resuscitation care.
- If venous access is required following resuscitation, peripheral access may be adequate unless multiple infusions and/or vasopressors are required in which case central access may be preferred.

Medication during resuscitation at birth

Resuscitation drugs may be considered where, despite adequate control of the airway, effective ventilation, and chest compression for at least 30sec, HR remains <60 min^{-1} and is not increasing.

Adrenaline
- Umbilical venous catheter or IO is the preferred route.
  - Give 10–30 μg kg^{-1} (0.1–0.3 mL kg^{-1} of 1:10,000 adrenaline [0.1 mg mL^{-1}]).
  - Give subsequent doses every 4 min if HR remains <60 min^{-1}.
- If no umbilical venous catheter/IO access but intubated:
  - Give intra-tracheal adrenaline at dose of 100 μg kg^{-1} (1 mL kg^{-1} of 1:10,000 adrenaline [0.1 mg mL^{-1}]).
  - If HR remains <60 min^{-1}: as soon as umbilical venous catheter/IO access is obtained, immediately give a dose via this route, irrespective of when the intra-tracheal dose was given.

Glucose
- If possible, check the blood glucose value during resuscitation.
- If blood glucose is low: give glucose 200 mg kg^{-1} (2.0 mL kg^{-1} of 10 % glucose).

Intravascular volume replacement
- Give 10 mL kg^{-1} of group O Rh-negative blood or isotonic crystalloid solution if suspected blood loss or in a newborn infant unresponsive to other resuscitative measures.

Absence of an adequate response despite appropriate resuscitation measures

- Consider other factors which may be impacting the response to resuscitation, and which require addressing such as the presence

of pneumothorax, hypovolaemia, congenital abnormalities, equipment failure.

Low resource or remote settings

- Births outside the hospital may be considered as birth in a remote or low resource setting. Moreover, not all hospitals have the same resources.
- HCPs have to adapt according to available resources. Focus needs to be on prevention or treatment of hypothermia and hypoxia within the existing possibilities.

Planned home births

- Ideally, two trained healthcare professionals (HCP) should be present at all home births.
- Have at least one HCP competent in providing inflations, PPV and CC to the newborn infant.
- Have a minimum set of equipment of an appropriate size for the newborn infant available.
- Have a clear plan of who will attend, what equipment will be available, and how transfer will be arranged if newborn support is required and agree this with parents when formulating the home birth plan.
- HCPs attending home births should have pre-defined plans for unexpected or difficult situations, including knowing how to communicate with receiving healthcare facilities for the mother and newborn infant.

Unexpected births outside the hospital

- Emergency services should be prepared and trained for such events and carry appropriate equipment, especially related to thermal care and support of airway and breathing.
- Equipment to support thermal care and oxygenation should be available.

Temperature control out of hospital

- Involved HCPs should have a heightened awareness of the increased risk of hypothermia in infants born (unexpectedly) out of hospital.
- They should perform regular temperature checks of the neonate and intervene if the temperature is too low.
- Most interventions for infants born in hospital (see temperature management) can also be applied outside the hospital.
- If possible, place compromised, preterm (<37 weeks), and/or growth restricted infants in a preheated incubator for thermal control and transport.

Post-resuscitation care

- Once effective ventilation and circulation are established, the infant should be cared for in or transferred to an environment in which close monitoring and anticipatory care can be provided.

Glucose management

- Measure blood glucose values early and regularly until they have stabilised in the normal range; especially in newborns resuscitated at birth, those at risk of hypoxic-ischaemic encephalopathy (HIE), and/or receiving intravenous glucose.
- Avoid hypoglycaemia, hyperglycaemia, and large swings in blood glucose value.

Thermal care

- Monitor the infant's temperature frequently or continuously after resuscitation.
- Maintain temperature between 36.5 °C and 37.5 °C and rewarm if the temperature is below this.

Therapeutic hypothermia

- Consider inducing therapeutic hypothermia (33–34 °C) *after* completion of resuscitation and detailed assessment of potentially eligible infants with clinical, biochemical, and (if available) neurophysiological evidence of HIE.
- Use appropriate eligibility criteria and strictly defined protocols to guide the cooling process; inappropriate application of therapeutic hypothermia may be harmful.
- Arrange safe transfer to an appropriately equipped facility where monitoring and treatment can be continued.
- Monitor (rectal) temperature during transport and, if available, apply active cooling with a servo-controlled device while transferring the infant.

Oxygenation and ventilation

- Consider additional monitoring of post-ductal oxygen saturation to identify pulmonary hypertension.
- Avoid hypoxia and hyperoxia.
- Avoid inadvertent hypocapnia during mechanical ventilation.

Documentation and prognostication

- Keep an accurate time-based record of the infant's clinical state, interventions and responses during resuscitation to facilitate retrospective review.
- Record APGAR scores.

Clinical team debriefing

- Use performance-focused, interdisciplinary/interprofessional team debriefings following resuscitation or other non-routine situations to optimise individual and team performance as well as systems issues (e.g., emergency supplies, equipment).

Communication with parents

Where intervention is anticipated

- The decision to attempt resuscitation of an extremely preterm or clinically complex infant should be taken in close consultation with the parents and senior paediatricians, midwifes, and obstetricians.
- Discuss the options, including the potential need and magnitude of resuscitation and the likely prognosis before birth, so that an individualised management plan can be agreed.
- Ensure concise and factual documentation of discussions is recorded in mother's notes before birth and in the infant's notes after birth.

For every birth

- If parents want and resources allow, enable parents to be present during the stabilisation or resuscitation.
- Consider the views of the resuscitation team, parents and circumstances.
- Ensure that parents are fully informed about the progress of the care provided to their infant.

- Identify a member of healthcare staff to support parents and be aware that witnessing the resuscitation of their infant will be distressing for them.
- Encourage parents to hold or touch their infant as soon as possible after resuscitation; this should be facilitated especially when the resuscitation was unsuccessful.
- Ensure an accurate record is kept of the resuscitation and of any subsequent parental communication.
- Provide an explanation of any procedures and why they were required.
- Facilitate further discussions later to enable parents to reflect and to aid their understanding of events.
- Provide additional support to parents following resuscitation at birth.

Discontinuing or withholding resuscitation

- Use national or regional outcomes and guidelines to interpret these recommendations
- When discontinuing, withdrawing or withholding resuscitation, care should be focused on the comfort and dignity of the infant and family and should ideally involve senior paediatric/neonatal staff.

Discontinuing resuscitation

- If the HR remains absent despite ongoing resuscitation, review clinical factors (for example potential reversible factors, gestation of the infant), effectiveness of resuscitation, and the views of other members of the clinical team about continuing resuscitation.
- If the HR of a newborn infant remains absent for more than 20 min after birth despite the provision of all recommended steps and exclusion of reversible causes, consider stopping resuscitation.
- For preterm infants (particularly extremely preterm), it may be appropriate to discontinue resuscitation earlier than 20 min. The decision should be individualised.
- Where there is partial or incomplete HR improvement despite apparently adequate resuscitative efforts, the choice is much less clear. It may be appropriate to take the infant to the intensive care unit and later consider withdrawing life sustaining treatment.
- Where life-sustaining treatment is withheld or withdrawn, infants should be provided with appropriate palliative (comfort focused) care.

Withholding resuscitation

- Decisions to withhold life sustaining treatment should be made in advance of birth together with parents in the light of regional/national evidence on outcome if resuscitation and active (survival focused) treatment is attempted.
- In situations where there is extremely high (e.g. >90 %) predicted neonatal mortality and unacceptably high morbidity in surviving infants, attempted resuscitation and active (survival focused) management is usually not appropriate.
- Resuscitation is nearly always indicated in conditions associated with lower (e.g. <50 %) neonatal mortality and what is deemed to be acceptable morbidity. This will include most infants with congenital malformations and most infants >24 weeks or above in high resource settings with access to neonatal intensive care.
- Resuscitation should usually be commenced in situations where there is uncertainty about the outcome and there has been no chance to have prior discussions with parents.
- In situations where there is high mortality (e.g. >50 %) and/or a high rate of morbidity, and where the anticipated burden of medical treatment for the child is high, parental wishes regarding resuscitation are usually supported. It may be appropriate to provide full resuscitation, to provide some measures (but withhold other interventions) or to provide comfort focused care. Provision of antenatal palliative care support can be beneficial to parents in the face of certain or uncertain poor outcomes.

Paediatric life support

The ERC Paediatric Life Support (PLS) Guidelines cover the management of critically ill infants and children, before, during and after cardiac arrest, and includes special circumstances of cardiac arrest in children.[70] (Fig. 26).

Prevention of cardiac arrest

Cardiac arrest in infants, children and adolescents is often secondary to progressive respiratory or circulatory failure or to neurological emergencies. Therefore, the recognition and proper management of critically ill children remains the best way to prevent cardiac arrest.

Recommendations for caregivers and other untrained rescuers

- All parents and caregivers should be encouraged to learn basic recognition of critical illness and trauma and basic first-aid life-saving procedures.
- Simple recognition using triage tools and basic first-aid life-saving procedures should be taught to professional caregivers for children, including child minders, schoolteachers, first responders, lifeguards and coaches/trainers of children and adolescents.
- Immediately call for medical help or call the emergency medical service (EMS) if a child has signs or symptoms that might indicate critical illness such as those described in the BBB-tool namely:
- **Behaviour**: A child who:
  - is not fully conscious or is difficult to rouse, floppy or rigid,
  - is having a seizure,
  - is confused, agitated, or interacting abnormally with the parents/caregivers,
  - is crying inconsolably,
  - is not able to move one or more limbs, and/or
  - has severe pain or is unable to speak or walk, if previously able to do.
- **Breathing:** A child who has difficulty breathing, such that they:
  - are unable to take a deep breath,
  - are working hard to take each breath (breathing fast, grunting, flaring of the nostrils, and indrawing between or under the ribs),
  - are making additional noises while breathing,
  - are breathing too fast, too slowly or irregularly, stops breathing, and/or
  - adopt an abnormal posture to aid breathing.

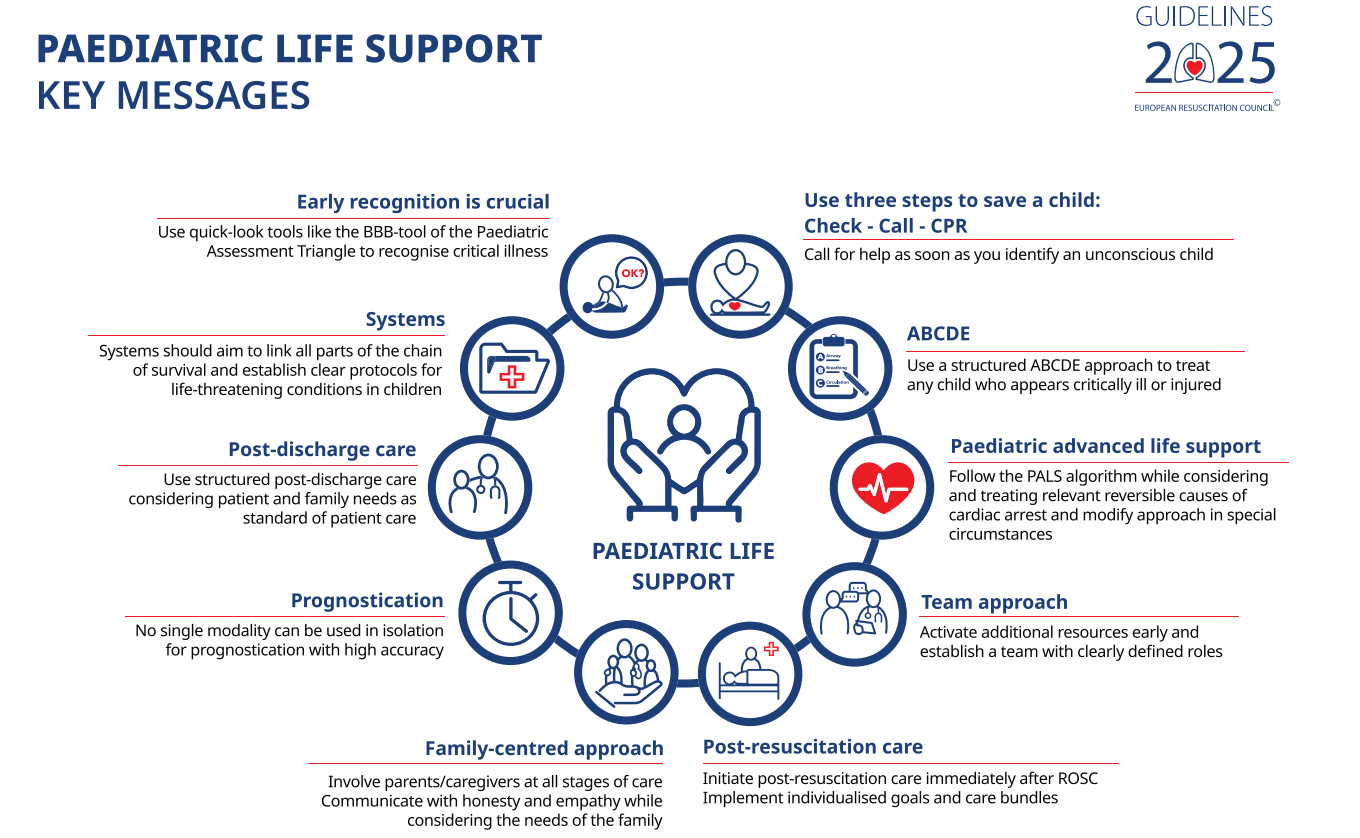


Fig. 26 – Key messages Paediatric Life Support.

- **Body colour**:
  - The child's skin is cyanosed (blue), mottled, abnormally pale or greyish. Look at the hand palms, soles of the feet and mucosal membranes especially in children with darker skin tones.
- Parents/caregivers of children with specific chronic conditions (e.g. children who are dependent on medical equipment, who have a tracheostomy, cardiac conditions, malignancy, or who were born with a very low birth weight) should have an emergency plan available for any sudden deterioration and caregivers should be familiar with this and trained in initial life-saving procedures.

Recommendations for healthcare professionals

- Identify children with an increased risk of cardiac arrest and formulate a care plan for these children.
- Use a dedicated quick-look tool (e.g. the above-mentioned BBB-tool or the paediatric assessment triangle) for the early recognition of a potentially critically ill child.
- Consider your own safety. Use appropriate personal protection equipment when indicated.
- Immediately perform an initial ABCDE assessment in any child who appears to be critically ill or severely injured. Initiate life-saving interventions as soon as a problem is identified.
- Activate additional resources (e.g. personnel, equipment) and establish a team with clearly defined individual roles and responsibilities as soon as possible.
- Use cognitive aids such as displayed algorithms and checklists to decrease cognitive load.
- Reassess the child after any intervention or when in doubt.
- Ask caregivers for an estimate of the child's weight or estimate this using length-based methods, which should ideally be corrected for body-habitus.
- Use an individualised approach or modify interventions for children with chronic medical conditions or specific medical needs. Ask a parent/caregiver for relevant information about the condition if they have this.
- At all times allow parents/caregivers to stay with the child if they wish, and if this does not preclude their safety or the safety of the child or personnel.
- Include parents and those with parental responsibility in discussions and decision-making.

- Assign a dedicated team member to the care of parents or caregivers, and ensure they are fully informed at all stages.

Recognition of the critically ill or injured child.

Airway

- Check the patency of the airway and the presence of air flow using the look-listen-feel method.
- Consider stridor or snoring to be a sign of partial airway obstruction.
- Allow a conscious child to adopt the most comfortable position, do not force them to lie down.

Breathing

- Check for signs of respiratory insufficiency. Assess:
  - Work of breathing (respiratory rate, recession, grunting, nasal flaring, tracheal tug, positioning).
  - Effectiveness of breathing (chest expansion, character and strength of crying/speaking, auscultation (reduced air entry, symmetry, wheeze or crepitations), skin colour (cyanosis), arterial oxygen saturation.
  - Systemic signs (heart rate, conscious level).
- Monitor arterial oxygen saturation by pulse oximetry (SpO_2) continuously. Be aware that a pulse oximeter can be less reliable in children with a darker skin tones or poor peripheral perfusion.
- Monitor capnography (end-tidal carbon dioxide, ($ETCO_2$)) in all patients with an advanced airway (i.e. a tracheal tube or supraglottic airway device (SGA)). Consider capnography in patients with non-invasive ventilation.
- Consider point of care ultrasound (POCUS) of the lungs and blood gas analysis.
- Use multiple variables to recognise respiratory failure as no single sign in isolation is indicative of this. Trends are more important than a single value.

Circulation

- Check for signs of cardiovascular insufficiency (Tables 2 and 3).
  - Cardiovascular signs (heart rate, pulse volume (peripheral and central), blood pressure, preload (jugular veins, liver span, crepitations).
  - Organ perfusion (capillary refill time, skin colour and temperature, urinary output, level of consciousness).
- Attach an ECG-monitor, to assess the rhythm, and a non-invasive blood pressure (NIBP) monitor/device.
- Consider serial lactate measurements if signs of shock are present.
- Consider POCUS which might help to distinguish the cause and type of shock.
- Consider a 12-lead ECG.
- Use multiple variables to recognise circulatory failure (shock) and the type of shock; no single sign in isolation is indicative of shock. Trends are more important than a single value.

Disability

- Check conscious level using the AVPU (Alert-Verbal-Pain-Unresponsive) scale, (paediatric) Glasgow Coma Scale (GCS) total score, or the GCS motor score, pupil size, symmetry, and reactivity to light and the presence of posturing or focal neurological signs.
- Recognise seizures as a neurological emergency.
- Check blood glucose.
- Consider urgent brain imaging if neurological symptoms persist after ABC resuscitation.

Exposure

- Check body temperature.
- Undress the child and look for rashes, injuries and signs of physical child abuse and neglect.
- Look for signs and symptoms of potentially life-threatening conditions as described further below (e.g. anaphylaxis, sepsis).
- Try to identify any underlying conditions that might require a specific approach (e.g. intoxication, underlying chronic conditions).
- Use AMPLE (Allergy-Medication-Past History-Last Meal-Events) to quickly establish a basic medical history.
- Be alert to conditions in which cardiac arrest is imminent such as airway obstruction, flail chest, silent chest, tension pneumothorax, massive haemorrhage, cardiac tamponade, intracranial hypertension, hypoglycaemia with coma, hypothermia, severe trauma and thrombosis (Fig. 27).

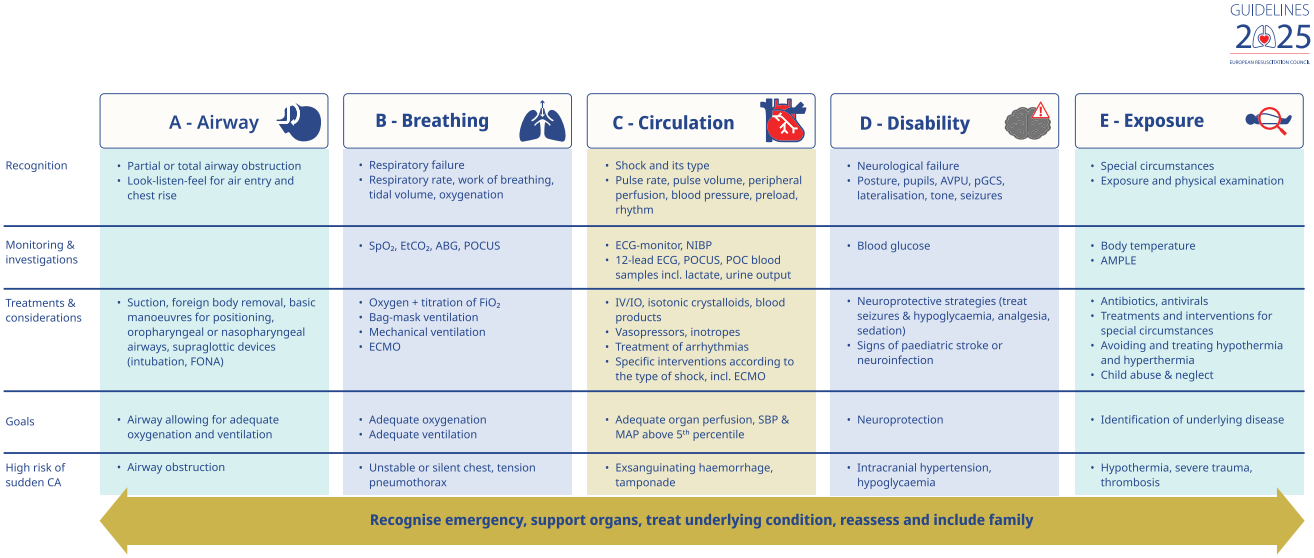


Fig. 27 – Management of critically ill/injured child using the ABCDE approach.

Principles of the management of the critically ill or injured child.

Airway

- Establish airway patency to enable adequate oxygenation and ventilation.
- Open the airway and keep it open. Use adequate positioning of the head and body alignment (head tilt and chin lift or jaw thrust), remove secretions and other obstructing materials by careful suctioning if necessary.
- Consider a nasopharyngeal or oropharyngeal airway of the appropriate size in children with a decreased level of consciousness.
- Use a supraglottic airway device (laryngeal mask, i-gel), when indicated, only if you are competent in its use.
- Intubate the trachea of a child or use a SGA, when indicated, only if you are competent and experienced and have the necessary materials and drugs immediately available and use a well-defined operating procedure.
  - Always have a plan for difficulties with the airway (e.g. SGA-insertion, additional expertise).
  - Preoxygenate the child before induction of anaesthesia, avoid distending the stomach.
  - Use sedative and neuromuscular blocking drugs with a rapid onset of action, unless the child is deeply comatose.
  - Do not use atropine as premedication routinely.
  - The oral route for tracheal intubation is preferable during emergencies.
  - Use video or direct laryngoscopy for tracheal intubation depending on local protocols and rescuer experience.
  - Provide oxygen during airway management (apnoeic oxygenation, high-flow nasal oxygen or oral) to avoid hypoxia during the procedure.
  - Do not attempt intubation more than twice and limit each attempt to 30–60 s. Monitor SpO_2, heart rate and blood pressure during intubation and stop the attempt immediately in case of bradycardia or oxygen desaturation. Immediately recommence bag-mask ventilation or insert an SGA to restore oxygenation.
  - Use cuffed tracheal tubes for all children. Monitor and limit cuff inflation pressure according to the manufacturer's recommendations.
  - Provide adequate analgosedation during and after intubation.
  - Confirm tube placement clinically and using $ETCO_2$ monitoring (providers with expertise may use POCUS in addition). Monitor SpO_2 and $ETCO_2$ continuously in all children with an advanced airway. Confirm the tube position with X-ray as soon as practicable.
- Use a front-of-neck airway only as a last resort option in cannot-ventilate-cannot-oxygenate situations. This should be performed by an individual trained in invasive airway techniques.
- In children with tracheostomies, who develop difficulty breathing, suspect an obstruction of the tracheostomy tube.
  - Try to relieve the obstruction by suctioning the tracheostomy tube.
  - If a suction catheter cannot be passed, the tracheostomy tube should be removed immediately and replaced.
  - If a clean tube is not available, provide oxygen and ventilation via bag valve mask until the tube is cleaned and replaced.
  - If the child's upper airway is patent, it may be possible to provide oxygen and bag and mask ventilation via the mouth and nose whilst the tracheal stoma site is occluded.
  - If the upper airway is not patent it may be possible to provide oxygen and bag-mask ventilation at the tracheostomy stoma site using a small face mask (or the end of an LMA used as a mask) over the stoma site.
  - In an emergency, tracheal intubation via the tracheostomy or upper airway (if patent) with a tracheal tube may be needed.

Breathing

- Aim for adequate oxygenation and ventilation.
- Initially give 100 % oxygen for all children with respiratory, circulatory, or neurological failure.
- Titrate the fraction of inspired oxygen (FiO_2) as soon as the SpO_2 can be monitored and avoid sustained readings of 100 % (except in special circumstances, e.g. carbon monoxide intoxication, methaemoglobinaemia, cyanide poisoning or severe anaemia).
- In previously healthy children aim for an SpO_2 of 94–98 %. The goal is to achieve an SpO_2 of at least 94 % with the lowest possible FiO_2.
- Consider individualised targets for SpO_2 and $ETCO_2$ in children with specific conditions (e.g. cyanotic congenital heart defects, chronic respiratory failure).
- Consider high-flow nasal oxygenation or non-invasive ventilation in children with hypoxaemia not responding adequately to conventional oxygen therapy.
- Support inadequate spontaneous ventilation, using bag-mask ventilation as the first-line method.
  - Ensure correct head positioning, mask size and proper seal between the mask and the face.
  - Use a two-person approach (using both hands to hold the mask and keep the airway open), especially if ventilation is difficult or when there is a risk of disease transmission. Consider airway adjuncts (e.g. oropharyngeal device).
  - Use an appropriately sized bag and sufficiently long inspiratory times to make the chest visibly rise (mild chest movements). Avoid hyperinflation and high peak inspiratory pressure.
  - Aim for a normal respiratory rate for the child's age (pragmatically use the following rates per minute: 25 in infants, 20 in children >1 y, 15 in children >8 y, 10 in children >12 y).
- Consider the early insertion of an SGA or tracheal tube in cases when bag-mask ventilation does not improve oxygenation or ventilation or when prolonged respiratory support is anticipated.
- Check air leak, signs of aspiration, efficacy of ventilation in patients with SGA or tracheal tube.
- In mechanically ventilated children:
  - Use tidal volumes of 6–8 ml kg^{-1} of ideal body weight and a respiratory rate at a low-normal range for the child's age.
  - Start with a positive end expiratory pressure (PEEP) of 5 cm H_2O and adjust PEEP and FiO_2 to improve oxygenation, always titrating these to the minimum support needed to achieve the desired targets.
  - Individualise ventilator settings in specific conditions, seek the advice of a paediatric intensivist early if possible.
  - Minimise apparatus dead space, especially in infants.
  - Avoid both hyperventilation and hypoventilation. Monitor $ETCO_2$ and aim for normocapnia. Check partial pressure of carbon dioxide in arterial blood ($PaCO_2$) as soon as practicable to assess its relationship to $ETCO_2$.

- Use DOPES to help identify the cause of a sudden rapid deterioration in a ventilated child (bag-mask ventilation or mechanical ventilation):
  - Displacement (mask, SGA, tracheal tube)
  - Obstruction (secretions, tube, circuit, airway – head position)
  - Pneumothorax or other pulmonary pathology
  - Equipment (disconnection, oxygen supply, tubing, valves, ventilator)
  - Stomach/stacking/sedation (abdominal distention, stacked breaths or insufficient sedation).

Circulation

- Aim for adequate organ perfusion.
- In the case of circulatory failure (shock), do not spend more than 5 min (or 2 attempts) to establish intravenous (IV) access. Competent providers should use POCUS to guide IV cannulation.
- Establish intraosseous (IO) access as a rescue alternative if IV access fails or when the chances for a successful IV-cannulation are considered minimal.
  - Use an IO-needle of appropriate size.
  - Provide effective analgesia (e.g. intranasal ketamine) unless the child is deeply comatose.
  - Use manual infusion or a high-pressure bag for fluid infusion.
  - Monitor for signs of extravasation and displacement.
- Give one or more fluid boluses of 10 ml kg^{-1} in children in hypovolaemic, obstructive or distributive shock.
  - Use balanced isotonic crystalloids as the first line choice of fluids. If unavailable, use normal saline, which may be the preferred fluid in diabetic ketoacidosis and severe traumatic brain injury.
  - Give repeated 10 ml kg^{-1} boluses, as necessary. A total of 40–60 ml kg^{-1} may be needed during the first hour of treatment of hypovolemic or distributive shock.
  - Reassess the child after each bolus looking for signs of fluid overload or cardiac failure (e.g. lung crepitations, increasing liver edge, raised jugular venous pressure).
  - If the signs of shock recede, continue maintenance fluids and rehydration at a slower pace.
  - Consider vasoactive drugs and respiratory support if repeated fluid boluses are required.
- Consider the need for fluids in cardiogenic shock on an individual basis. Fluids might still be needed but should be given more cautiously e.g., 5 ml kg^{-1} fluid bolus.
- Assess the type of shock; hypovolaemic, cardiogenic, obstructive, distributive, or dissociative (POCUS may be of value for this).
- Start vasoactive drugs (inotropes and/or vasopressors depending on the type of shock) early, as a continuous infusion via a central or peripheral line, and not later than after three to four fluid boluses (30–40 ml kg^{-1}):
  - Pay attention to the proper composition, dilution, and dosing of fluids.
  - Use a dedicated line for vasoactive drug infusion whenever possible.
  - Titrate the infusion rate according to clinical and other signs (pulse, capillary refill time, urine output), not solely based on blood pressure targets which may differ according to the pathology, age and response. Aim for the 5th percentile as a minimum.
  - Use noradrenaline as a first line vasopressor and adrenaline as a first line inotrope. Use milrinone as first-line inodilator.
  - Consider the use of POCUS, echocardiography, lactate and mixed venous oxygen saturation (SvO_2) to further guide clinical decision making, if the expertise is available.
- Treat arrhythmias if present (see below).
- Initiate other specific treatments according to the type of shock (see below).
- Seek expert advice on extracorporeal support (e.g. ECMO) in children with refractory shock or specific conditions (e.g. congenital heart disease).

Disability

- Aim for neuroprotection (see the section on post-resuscitation care).
- Ensure adequate oxygenation, ventilation, and circulation.
- Treat clinical and electroencephalographic seizures. Follow a time-critical protocol for the management of status epilepticus.
- Treat hypoglycaemia, orally, if possible, with 0.3 g kg^{-1} glucose as soon as this is detected. If oral intake is not possible, give an IV bolus of 0.2 g kg^{-1} glucose (2 ml kg^{-1} 10 % glucose) and re-check blood glucose after 5–10 min and repeat if necessary.
- When IV glucose is not available, give glucagon as a temporary rescue measure: glucagon IM or SC, 0.03 mg kg^{-1} (or 1 mg if >25 kg or 0.5 mg if <25 kg) OR intranasally 3 mg if 4–16 yr.
- Ensure (preferably continuous) analgosedation in children with discomfort or pain. Anticipate and prevent hypotension.
- Consider the possibility of paediatric stroke or neuroinfection and quickly seek expert help.

Exposure

- Avoid hypothermia and hyperthermia and start specific measures if present.
- Consider antibiotics and/or antiviral medication if a bacterial or viral cause of critical illness is likely (e.g. in sepsis, encephalomeningitis, severe pneumonia).
- Protect the best interests of the child according to the local ethical and legal policies in case of a suspicion of inflicted trauma (child abuse and neglect).

Additional recommendations for time-critical interventions.

In children with **severe acute asthma** (critical asthma syndrome):

- Give 100 % oxygen.
- Give (intermittent or continuous) short acting $beta_2$-adrenergic agonists via pressurised metered-dose inhalers with spacer or by nebulisation (e.g. salbutamol 100 μg/dose at 4–10 puffs every 20 min or by nebulisation with 100 % oxygen 2.5–5 mg in sterile 0.9 % sodium chloride in a volume suitable for the type of nebuliser run until empty)
- Give inhaled ipratropium with $beta_2$-adrenergic agonists as required in the following doses: children aged from 1 month to 5 years 125–250 μg (max 1 mg day^{-1}), from 6 to 11 years 250 μg (max 1 mg day^{-1}) and from 12 to 17 years 500 μg (max 2 mg day^{-1}).
- Give prednisolone 1–2 mg kg^{-1} orally or IV (max. 40 mg) or dexamethasone 0.3–0.6 mg kg^{-1} (max. 16 mg) within the first hour.
- Consider adding high dose inhaled corticosteroids in a severe crisis.
- Consider IV magnesium sulphate 40 mg kg^{-1} (max 2 g) over 20 min in children who fail to respond to initial treatment.
- Consider a loading dose of IV short-acting $beta_2$-adrenergic agonists (e.g. 5–15 μg kg^{-1} salbutamol over 10 min, max. doses of 250–750 μg have been used) which may be followed by an infu-

sion depending on clinical severity (e.g. salbutamol 1–2 μg kg^{-1} min^{-1}). Monitor potassium levels, lactate, blood glucose and ECG.
- Consider a trial of non-invasive ventilation provided the child still has sufficient respiratory drive.
- Consider tracheal intubation and invasive ventilation (and anticipate potential serious side effects), or extracorporeal life-support in near fatal asthma (e.g. exhaustion, severe hypoxia despite high flow oxygen and adequate medication).

In children with **septic shock**:
- Obtain blood samples for blood culture and polymerase chain reaction (PCR) if possible and start broad-spectrum antibiotics as soon as possible (within 1 h) after initial ABCDE management.
- Consider hydrocortisone 1–2 mg kg^{-1} if the child is not responding to fluids and vasoactive support, and in children with specific pathologies (e.g. adrenal insufficiency) or who are receiving specific medications.

In children with **cardiogenic shock**:
- Seek the advice of paediatric cardiologist early. Use echocardiography to guide treatment.
- Start inotropic support and consider mechanical ventilation. Anticipate possible cardiac arrest during tracheal intubation, use medication with minimal cardiovascular side effects (e.g. use ketamine and avoid propofol).
- Consider IV furosemide only in children without concomitant hypovolaemia.
- Consider extracorporeal life support in refractory cardiogenic shock.

In children with **haemorrhagic shock**:
- Activate local protocols for massive haemorrhage and control bleeding using pressure and tourniquets as indicated.
- Minimise the use of IV crystalloid boluses (max. 20 ml kg^{-1}). Give blood products or full blood as soon as these are available.
- Use vasoactive drugs in fluid-refractory shock, especially when there is also a loss of sympathetic drive (e.g. during anaesthesia or analgosedation), or in children with concomitant traumatic brain injury. Target MAP to above the 50th percentile to attain sufficient cerebral perfusion pressure in traumatic brain injury. Support cardiac function if this is necessary to achieve MAP above the threshold.
- Use a strategy that focuses on improving coagulation in children with severe blood loss.
- Use tranexamic acid as soon as possible (at least within 3 h) in all children requiring transfusion after trauma or with life-threatening haemorrhage. Give a loading dose of 15–20 mg kg^{-1} (max. 1 g) IV over 10 min, followed by an infusion of 2 mg kg^{-1} h^{-1} (max. 1 g) for at least 8 h or until the bleeding stops.

In children with **circulatory failure due to bradycardia**:
- Seek the advice of a paediatric cardiologist early.
- Improve oxygenation, ventilation, and circulation.
- In patients with bradycardia and poor perfusion not responding to oxygenation and ventilation, start chest compressions.
- Consider adrenaline as small IV bolus doses (e.g. 1–2 μg kg^{-1}) or as a continuous infusion.
- Consider transthoracic pacing only in specific cases of bradycardia (e.g. complete heart block, sick sinus syndrome).
- Consider atropine *only* in specific cases of bradycardia (e.g. induced by increased vagal tone or by a cardiac conduction disease); dose IV atropine 20 μg kg^{-1} (max. 0.5 mg).

In children with **circulatory failure due to tachydysrhythmia**
- Seek the advice of a paediatric cardiologist early.
- In patients with decompensated circulatory failure regardless of the origin of tachycardia (supraventricular or ventricular), perform immediate synchronised cardioversion starting with 1 J kg^{-1}, doubling the energy with each subsequent attempt up to a maximum of 4 J kg^{-1}. Have a 12-lead ECG running during the cardioversion attempt. If the child is not comatose, ensure adequate analgosedation according to local protocols. Reassess signs of life and pulse after each attempt. While waiting for anaesthesia and the defibrillator, chemical cardioversion (see below) can be attempted but it should not delay the cardioversion attempt.
- In patients with narrow complex supraventricular tachycardia (SVT) who are not in decompensated circulatory failure:
- Consider vagal manoeuvres (e.g. modified Valsalva or ice pack to the face)
  - Consider IV adenosine as a rapid flush of 0.1–0.2 mg kg^{-1} (max. 6 mg) via a large vein. Ensure a 12-lead ECG is running during the administration of adenosine. If the SVT persists, give a second dose of 0.3 mg kg^{-1} (max. 12–18 mg) after at least 1 min. If the SVT persists after the second dose, consider further doses of IV adenosine every 1–2 min increasing the dose in steps of 0.05–0.1 mg kg^{-1} until a maximum single dose of 0.5 mg kg^{-1} has been given.
  - Seek the advice of a paediatric cardiologist. Consider cardioversion or alternative medications (e.g. amiodarone), especially in children with sinus node disease, pre-excited atrial arrhythmias, a history of heart transplant or severe asthma.
- In patients with a wide QRS tachycardia who are not in decompensated circulatory failure:
  - Try vagal manoeuvres which might provide diagnostic insight (e.g. into an SVT with abnormal conduction).
  - Seek the advice of a paediatric cardiologist. Pharmacological treatment options include amiodarone, lidocaine, esmolol, magnesium sulphate, and procainamide.
  - In torsade-de-pointes VT, give IV magnesium sulphate 50 mg kg^{-1} (max. 2 g).

In children with generalized **seizures**:
- Monitor the time from the start of the seizures closely. Manage ABC, monitor vital functions and ECG. Consider possible causes for seizures (e.g. infection, intoxication, metabolic disorders, hypoxia, hypoglycaemia, hyperthermia, intracranial hypertension, channelopathies) and treat these appropriately. Anticipation is important when treating seizures as several interventions may be necessary.
- Any seizure lasting 5 min or longer (status epilepticus) requires treatment with a benzodiazepine (first-line medication). Use the intravenous (IV) route if available. If an IV/IO access has not yet been established, use an alternative route (e.g. buccal, nasal, IM).
- If the seizures continue, give a second dose of a benzodiazepine IV or IO after 5–10 min and prepare to administer a second-line medication.

- If the seizures persist after two doses of the first-line medication (<15–20 min from the start of the seizures) give levetiracetam IV or IO 40–60 mg kg^{-1} (max. 4.5 g) over 5 min (second-line medication). If levetiracetam is not available, give phenytoin IV 20 mg kg^{-1} over 20 min, or phenobarbital IV 20 mg kg^{-1} (max 1 g) by slow injection at a maximum rate of 1 mg kg^{-1} min^{-1}, or valproic acid IV 20 mg kg^{-1} over 4 min as a second choice instead. Do not use valproic acid where there is the potential for pregnancy.
- If the seizures continue for ≥30 min despite the administration of a second-line drug (refractory status epilepticus), prepare for intubation and refer the child to the paediatric intensive care team. If you are not ready for intubation and anaesthesia, then giving another, different second line drug is an alternative.
- Start anaesthesia (e.g. with midazolam, ketamine, phenobarbital, thiopental, or propofol) within 40 min of the onset of seizures, with intubation and mechanical ventilation. Aim for termination of clinical seizures and burst suppression on electroencephalography (EEG). Monitor for respiratory and haemodynamic instability, metabolic disturbances, renal failure, rhabdomyolysis, and adverse drug effects.
- Seek the advice of a paediatric neurologist.
- Consider continuous EEG monitoring and brain imaging.

Other important *peri*-arrest situations are described below in the dedicated subchapter on Special Circumstances.

Paediatric basic life support (PBLS)

Recommendations for untrained rescuers and dispatcher-assisted CPR

- If you encounter a child who appears to be unresponsive and you have no training in PBLS, ensure your own safety and that of the child and follow the **3 steps to save a life** (see Fig. 8):
  - **Check** if the child reacts to non-painful stimulus.
  - **Call** the EMS immediately If the child does not react and follow the dispatcher's advice.
  - **CPR**: Start CPR immediately following the instructions of the dispatcher.
- Dispatchers should encourage bystanders to perform both ventilation and chest compressions in children of all ages. They should actively ask about signs confirming that the ventilations are effective (e.g. whether the chest is moving).
- Dispatchers should use a 30:2 ratio for CPR instructions with 5 initial rescue breaths for untrained bystanders or bystanders trained only in adult BLS.
- If the bystanders are not willing or able to perform rescue breathing, dispatchers should encourage compression-only CPR in all children.
- Dispatchers should instruct bystanders to use age-specific techniques for chest compressions and breathing in infants, children and adolescents (see below).

Recommendations for those trained in PBLS (Fig. 9)

- Ensure safety for you and the child.
- Use verbal and tactile stimulation to assess responsiveness. Do not use painful stimuli.
- Call, or have someone call, the EMS immediately, using speaker function of your mobile phone with video when possible. Follow the advice of the dispatcher who can help you to recognise if you need to start CPR. If you are trained in PBLS, check the breathing as described below, while waiting for the connection with the dispatcher.
- Use the head tilt chin lift manoeuvre to open the airway and assess breathing and look for signs of life for no longer than 10 s.
- Give five initial rescue breaths.
- Immediately proceed with 15 chest compressions.
- Continue CPR in a 15:2 compression-to-ventilation ratio if you are specifically trained in PBLS to the level of the ERC PBLS-course or equivalent, otherwise use a ratio of 30:2.
- Focus on consistently high-quality compressions and effective ventilations. Minimise chest compression pauses.
- If a second rescuer is available, they should call the EMS while the first rescuer starts CPR, and then bring and attach an automated external defibrillator (AED) as soon as possible for children of all ages. Once attached, follow the instructions of the AED.
- If there is only a single rescuer, calling the EMS and starting CPR should be prioritised over fetching and attaching an AED.
- Do not interrupt CPR unless there are clear signs of life, or you are instructed to do so by the AED.
- In an unresponsive child who is clearly breathing effectively, keep the airway open by continued head tilt chin lift or positioning the child in a recovery position, especially if there is a risk of vomiting, but not in trauma.
- Check the breathing continuously or at least every minute if the child is placed in the recovery position. If in doubt about the stability of the position or the quality of the breathing, turn the child onto their back and open the airway with the head tilt chin lift manoeuvre.
- **Airway** and assessment of breathing:
  - Keep the head in the neutral position in infants by slightly tilting the head and lifting the chin with two fingers on the chin bone without pressing on the soft tissues (head tilt chin lift manoeuvre). In older children, more head tilt will be needed. In adolescents, full extension of the head is needed as in adults.
  - Look for chest movement, listen and feel for the flow of air from the nose and/or mouth. If the chest is moving but there is no air flow, the airway is not open. Immediately try to improve the airway opening manoeuvre.
  - If you have any doubt whether breathing is normal, act as if it were not normal.
- **Rescue breaths** without equipment**:**
  - Ensure the airway is open and blow steadily into the child's mouth (or infant's mouth and nose) for about 1 s, sufficient to make the chest visibly rise and then allow the chest to fall back passively while you take your next breath.
  - If the chest does not rise, the airway may be obstructed:
  - Remove any visible obstruction in the mouth if it is easy to do so. Do not perform a blind finger sweep.
  - Reposition the head or adjust the airway opening method by further lifting the chin or tilting the head.
- **Chest compressions**:
  - Perform chest compressions on a firm surface if immediately available. Remove clothes only if they hinder chest compressions.
  - Perform chest compressions over the lower half of the sternum (breastbone) in all age groups.
  - Use the two-thumb encircling method for chest compressions in infants.
  - Use the one-hand or two-hand technique in children older than 1 year, or when unable to give high-quality chest compressions with the two-thumb-encircling technique.

- Deliver high quality chest compressions as defined by:
- Rate of 100–120 min^{-1}.
- Depress the chest by *at least* one third of the anteroposterior dimension. Use the adult depth recommendation of 5–6 cm in adolescents and do not exceed a depth of 6 cm at any age.
- Avoid leaning by releasing all pressure between compressions and allow the chest to rise again completely (chest recoil).
- Do not interrupt chest compressions except when giving ventilations, or if you are instructed to do so by the AED.

- **Using an automated external defibrillator**:
  - Follow the instructions of the AED.
  - Apply the defibrillation pads with minimal interruptions in CPR (one person applying the pads, a second performing CPR).
  - Activate the paediatric mode, if available, in all infants and children weighing less than 25 kg (i.e. approximately 8 years of age). In larger children and adolescents, use the AED in standard adult mode. If the AED does not have instruction for children, use it in standard adult mode.
  - Place adult size defibrillation as follows:
  - Use the antero-posterior position in infants and children weighing less than 25 kg: the anterior pad is placed mid-chest immediately left of the sternum and the posterior on the back placing the centre of the pad between the scapulae (shoulder blades).
  - Use either the antero-lateral for the antero-posterior or the anteroposterior position in children weighing more than 25 kg and adolescents. In the antero-lateral position one pad is placed bellow the right clavicle and the other in the left axilla. If the antero-posterior position is used in adolescents, avoid placing the defibrillation pads over breast tissue.
  - Do not touch the patient while the AED is analysing the rhythm.
  - Restart chest compressions immediately after shock delivery.

Additional considerations for PBLS

- In hospital, healthcare professionals should call for help as soon as deterioration is detected and not wait for cardiac arrest.
- They should then check for breathing and other signs of life.
- If they suspect a cardiac arrest or a critical situation, one person should call the resuscitation or emergency medical team, while the other person starts CPR as described above, using a compression-to-ventilation ratio of 15:2.
- Competent providers should use bag-mask ventilation with oxygen.
- If starting ventilations is not immediately possible (e.g. bag-mask ventilation is not immediately available and there is a contraindication to mouth-to-mouth ventilation), start chest compressions immediately and add ventilations as soon as possible.
- Competent providers can also use a pocket mask for rescue breaths to ventilate larger children when a bag and mask is not available.
- Activate the CPR mode on the bed to increase stiffness of the mattress (if the bed is equipped with this function).
- Over-the-head chest compressions can be used in certain specific situations such as limited space or limited personnel.
- The anterolateral pad position can be used by competent providers in children $\leq$25 kg when using paediatric pads provided these do not touch each other.
- A single rescuer without a mobile phone, should perform CPR for 1 min before going to seek help.

Foreign body airway obstruction

- Suspect choking due to a foreign body if the child is unable to speak (children and adolescents) or cry aloud (infants or smaller children), especially during feeding, eating, or playing unsupervised.
- Call or have someone call the EMS as soon as possible.
- Encourage an older child or adolescent to cough.
- Give up to 5 back blows if coughing is not possible or becoming ineffective:
  - Turn the infant face-down on your forearm with your forearm resting on your leg. Support the head of the infant with your hand. Try to hold the head below the level of the thorax (use gravity). Give a sharp blow between the shoulder blades. Repeat up to 5 times or until the obstruction is relieved.
  - Lean children and adolescents forward and give blows between the shoulder blades. Repeat up to 5 times.
- Give up to 5 chest/abdominal thrusts if back blows are not effective:
  - In infants:
  - Turn the infant onto their back and lay them on your knees.
  - Use the two-thumbs encircling technique to perform chest thrusts as advised for chest compressions but compressing the sternum more sharply. Repeat up to 5 times or until the obstruction is relieved.
  - In children and adolescents:
  - Stand behind the child and put your arms around the upper part of their abdomen.
  - Lean them forward.
  - Clench your fist and place it between the navel (umbilicus) and the end of the breastbone (xiphoid).
  - Grasp your fist with the other hand and pull sharply inwards and upwards.
  - Repeat up to 5 times or until the obstruction is relieved.
  - If the child is still conscious, repeat the back blows up to 5 times alternating these with up to 5 chest/abdominal thrusts.
  - Stop back blows or chest/abdominal thrusts immediately if at any time there are signs of relief of the obstruction (coughing, loud breathing or crying).
- Do not use blind sweeps to clear the obstruction from the mouth but use a single sweep to remove a clearly visible obstruction.
- Call for help and the EMS as soon as practical (if not already done so), at the latest when the child loses consciousness.
- Start CPR immediately with 5 rescue breaths as soon as the child becomes unconscious.
- The ERC is unable to make a recommendation for or against the use of suction-based devices advertised and marketed for clearing a foreign body airway obstruction, because no high-certainty scientific evidence exists (Fig. 28).

Paediatric advanced life support (PALS)

- Use a team approach, define clear roles for each team member, consider and practice the choreography (i.e. the best way for your own team to resuscitate a child including roles and sequences of action).
- Commence or continue with high quality chest compressions and ventilations.
- Recognise cardiac arrest on clinical grounds (e.g. no signs of life) or based on monitored vital signs (e.g. ECG, loss of SpO_2 and/or $ETCO_2$, loss of intra-arterial blood pressure trace).

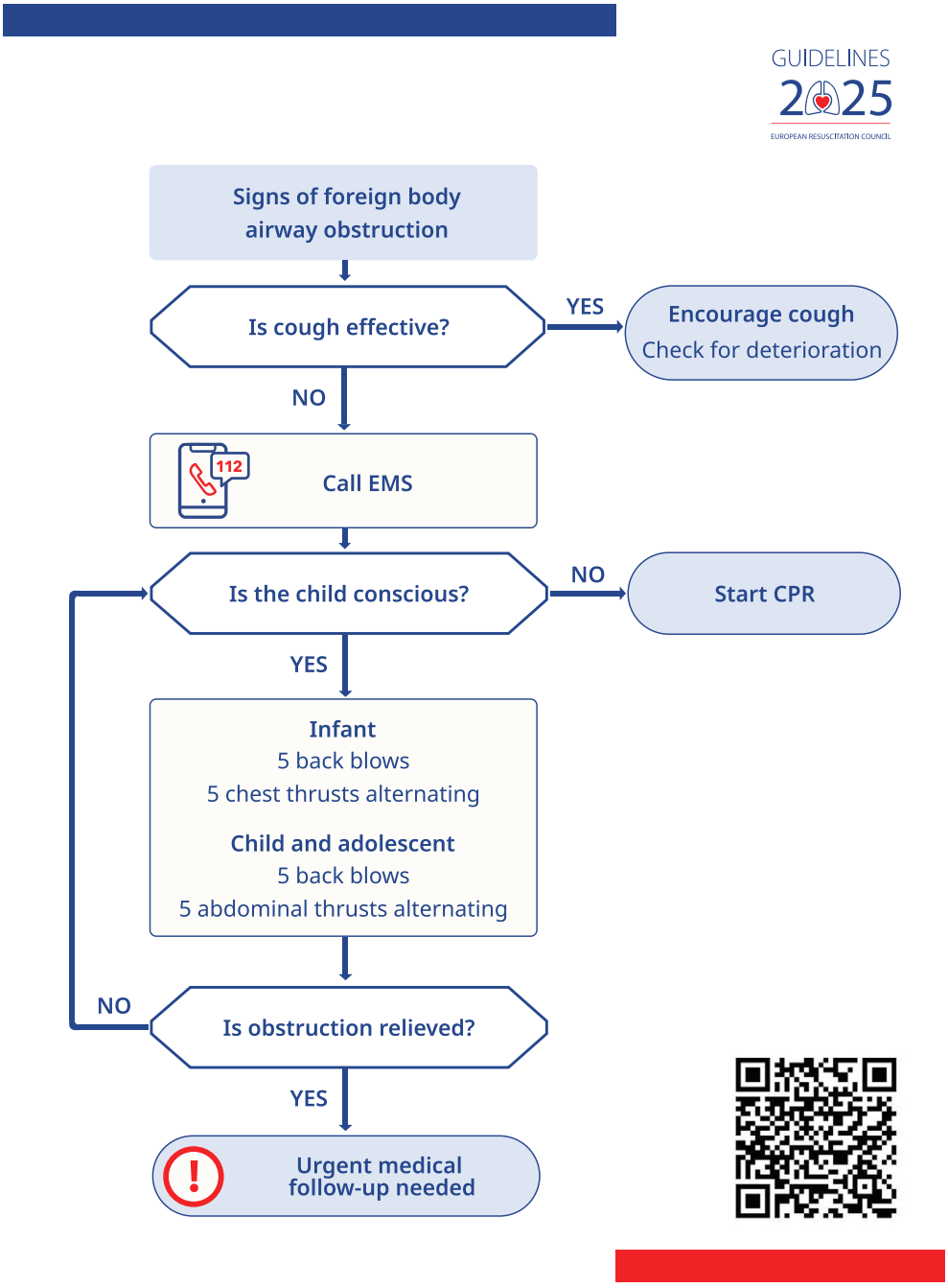


Fig. 28 – Algorithm for paediatric foreign body airway obstruction.

- Importantly, chest compressions should also be started in children who become bradycardic (<60 per min) with signs of poor perfusion despite adequate respiratory support, even if there is still a detectable pulse.
- Apply cardiac monitoring as soon as possible, if not already in place, using self-adhesive defibrillator pads as the first choice as this allows for a shorter time to defibrillation in children who require it.
- Differentiate between shockable and non-shockable cardiac rhythms (Fig. 29).

Non-shockable rhythms are bradycardia (with poor perfusion), pulseless electrical activity (PEA) and asystole.

- Obtain vascular access and give adrenaline IV/IO (10 microg kg^{-1}, max 1 mg) *as soon as possible* followed by a flush to facilitate drug delivery. Immediately attempt IO access if IV access is likely to be difficult.
- Repeat adrenaline IV/IO every 4 min (i.e. *every other* 2 min cycle) unless being guided by intra-arterial blood pressure monitoring and the haemodynamic response.
- Reassess the cardiac rhythm every 2 min (<5 s). If the rhythm has changed to an organised rhythm which could produce cardiac output, check for signs of life and feel for a central pulse (max. 5 sec).

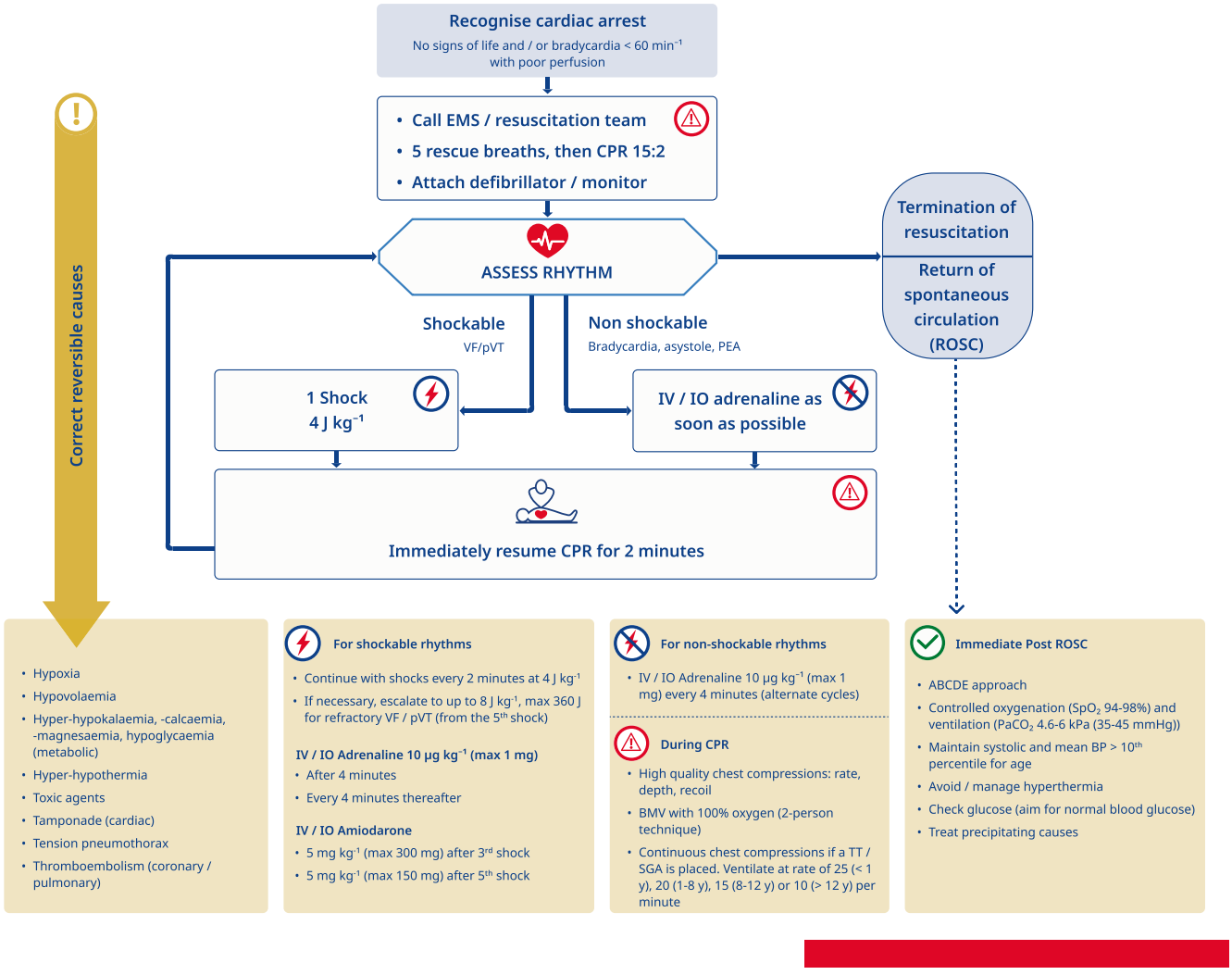


Fig. 29 – Paediatric Advanced Life Support algorithm.

- Change the person doing chest compressions at least every 2 min. Watch for fatigue and/or suboptimal chest compressions and switch rescuers earlier if necessary.

Shockable rhythms are pulseless ventricular tachycardia (pVT) and ventricular fibrillation (VF).

- As soon as identified, give one defibrillation shock (regardless of the ECG amplitude). If in doubt, consider the rhythm to be shockable.
- If using self-adhesive pads, continue chest compressions while the defibrillator is charging.
- Ensure that there is no leakage of oxygen around the chest during defibrillation. In small children the self-inflating bag may be very close to defibrillation pads; direct the oxygen exhaust away from the chest or disconnect the bag, if necessary, before charging the defibrillator. Do not disconnect the tracheal tube if a closed circuit is being used e.g. during mechanical ventilation.
- Once charged, pause chest compressions, briefly check that the rhythm is still shockable (<5 s) and ensure *all* persons are clear of the child before giving a single shock.
- Minimise pauses between stopping chest compressions, delivery of the shock and restarting chest compressions (<5 s).
- Give one shock (4 J kg^{-1}, max. 120–200 J) and *immediately* resume CPR for 2 min.
- Reassess the cardiac rhythm:
  - o If the rhythm changes to an organised rhythm which could produce cardiac output, check signs of life and feel for a central pulse (<5 s)

  OR

  - o If a shockable rhythm persists, give a 2nd shock (4 J kg^{-1}) and immediately resume CPR for 2 min, then reassess and continue to repeat this cycle.

- Give adrenaline (10 μg kg^{-1}, max. 1 mg) and amiodarone (5 mg kg^{-1}, max. 300 mg) IV/IO immediately after the 3rd shock. Flush after each drug. Lidocaine IV (1 mg kg^{-1}) might be used as an alternative if amiodarone is not available or a local decision has been made to use lidocaine instead of amiodarone.
- Give a second dose of adrenaline (10 μg kg^{-1}, max 1 mg) and amiodarone (5 mg kg^{-1}, max 150 mg) IV/IO immediately after the 5th shock.
- Unless there are clear signs of life adrenaline IV/IO should be repeated every 4 min (i.e., *every other* 2 min cycle) unless being guided by intra-arterial blood pressure monitoring and the haemodynamic response.
- Change the person doing compressions at least every 2 min. Watch for fatigue and/or suboptimal compressions and switch rescuers earlier if necessary.

CPR should be continued unless:

- An organised rhythm is recognised at a rhythm check and is accompanied by signs of return of spontaneous circulation (ROSC), identified clinically (e.g. eye opening, movement, normal breathing) and/or by monitoring (e.g. ETCO2, SpO2, blood pressure, echocardiogram) and/or presence of a palpable central pulse.
- Perfusion is restored by ECPR.
- Criteria for withdrawing resuscitation are met.

Defibrillation during PALS

- Manual defibrillation is the recommended method for PALS. If this is not immediately available an AED can be used.
- Proper planning before each defibrillation will minimise hands-off time.
- Defibrillation pads should be positioned either in the antero-lateral or the antero-posterior position.
  - Avoid contact between defibrillation pads as this can cause charge arcing.
  - In the antero-lateral position, one pad is placed below the right clavicle and the other in the left axilla.
  - In the antero-posterior position the anterior pad is placed mid-chest immediately left of the sternum and the posterior in the middle of the back between the scapulae.
  - Use the antero-posterior position in infants and children who can easily be turned onto their side for pad placement and in whom the antero-lateral position is more difficult to achieve without contact between the defibrillation pads.
  - Use the antero-lateral position in larger children as this leads to less interruption of chest compressions than the antero-posterior position. Avoid breast tissue in adolescents.
- Defibrillation with self-adhesive pads is standard, use it if available, if not, use paddles with preformed gel pads (this demands specific choreography of defibrillation).
- Use 4 J kg^{-1} as the standard energy dose for the initial shocks. It seems reasonable not to use doses above those suggested for adults (120–200 J, depending on the type of defibrillator).
- Increase the energy dose – stepwise increasing up to 8 J kg^{-1} (max. 360 J) for refractory VF/pVT (i.e. more than 5 shocks are needed).
- Charge the defibrillator with the defibrillation pads or paddles on the chest. Continue chest compressions while the defibrillator is charging when using defibrillation pads.
- If any period of ROSC is achieved and the child goes back into a shockable rhythm, use the defibrillation energy dose that was previously successful.

Oxygenation and ventilation during PALS

- Effective oxygenation and ventilation combined with high quality chest compressions are essential during CPR to generate sufficient coronary perfusion to restart the heart.
- Oxygenate and ventilate with a bag and mask, using 100 % oxygen. Do not titrate FiO_2 during CPR.
- Intubate the child only if you are experienced and competent and have all the necessary equipment. If not, continue to ventilate using a bag and mask or insert an SGA. Ensure the chest moves during ventilation. If not, adjust the airway or ventilation technique.
- Use a tracheal tube or SGA if CPR is required during transport; when prolonged resuscitation is anticipated or when it is impossible to ventilate with a bag and mask. Call for expert help if this is not already present.
- Do not interrupt chest compressions during airway management. Use $ETCO_2$ monitoring to ensure correct ventilation when a tracheal tube or SGA is in place.
- Avoid hypo- or hyperventilation.
- Give continuous chest compressions when the airway is secured with a tracheal tube or SGA and ventilate without pausing chest compressions. Pausing only briefly for each rhythm check.
- Ventilate at the lower limit of the normal rate for age e.g. pragmatically use breaths/min: 25 (infants), 20 (>1 y), 15 (>8 y), 10 (>12 y).
- If there is doubt about the effectiveness of ventilation (e.g. high air leak, diminished air entry into lungs) during continuous chest compressions return to a chest compression to ventilation ratio of 15:2.
- For children who go into cardiac arrest on a mechanical ventilator, either disconnect the ventilator and ventilate with a self-inflating bag/anaesthetic bag (depending on expertise) or continue to ventilate with the mechanical ventilator (ensuring the child is adequately ventilated). In the latter case, ensure that the ventilator is in a volume-controlled mode, that triggers and limits are disabled, and that the ventilation rate, tidal volume and FiO2 are appropriate for CPR. There is no evidence to support any specific level of PEEP during CPR. Always consider ventilator dysfunction as a possible cause of cardiac arrest
- Titrate FiO_2 to an SpO_2 of 94–98 % after ROSC.

Measurable factors during PALS

- **Capnography:** Use $ETCO_2$ monitoring once a tracheal tube or an SGA is in place to assess the quality of chest compressions and to help verify ROSC.
- **Invasive blood pressure:** If an intra-arterial line is in situ during CPR, monitor the diastolic blood pressure values in response to chest compressions and drugs (adrenaline). Aim for an intra-arrest diastolic blood pressure of at least 25 mmHg for infants and at least 30 mmHg for children and adolescents.
- **Point of care ultrasound:** Use POCUS only if you are competent in its use during CPR and if it does not compromise the quality of chest compressions.

Table 4 – Reversible causes of cardiac arrest in PALS.

Consider	Identification	Treatment in cardiac arrest
Hypoxia	History/clinical exam/SpO_2 and/or PaO_2 pre-arrest or intra-arrest.	Ventilate with 100 % oxygen. Insert an advanced airway if bag-mask ventilation is inadequate. Ensure adequate chest movement. Check for leaks, air entry, abdominal distention, or stacked breaths if an advanced airway is in situ.
Hypovolaemia	History (sepsis, haemorrhage, diarrhoea, anaphylaxis) POCUS.	Fluid bolus 10 ml kg^{-1} isotonic crystalloid or blood products for major haemorrhage.
Hyper-/hypo-kalaemia, calcaemia, magnesaemia and hypoglycaemia (metabolic derangements)	***Hyperkalaemia*** History (massive haemolysis, tumour lysis syndrome, crush syndrome, acute or chronic renal failure, malignant hyperthermia, specific intoxications).Blood gas analysis with electrolytes.	In cardiac arrest with severe hyperkalaemia (>6.5–7 mmol/L), give 0.1 unit kg^{-1} short acting insulin (max 10 units) with 5 ml kg^{-1} 10 % glucose (max 250 ml) as an IV bolus and an IV/IO infusion of a short acting $beta_2$-adrenergic agonist (e.g. salbutamol 5 μ kg^{-1}). Consider extracorporeal potassium removal.
	Hypokalaemia History (diarrhoea, vomiting, diabetes insipidus, specific medications, hyperaldosteronism). Blood gas analysis with electrolytes.	In cardiac arrest associated with severe hypokalaemia (<2.5 mmol/L), give 1 mmol kg^{-1} (max 30 mmol) potassium at 2 mmol/min for 10 min followed by the rest of the dose (if necessary) in 5–10 min. Repeat, if necessary, until the serum potassium is >2.5 mmol/L. Consider magnesium for concomitant hypomagnesaemia.
	Hypoglycaemia History and blood analysis.	Give an IV bolus of 0.2 g kg^{-1} glucose (e.g. 2 ml kg^{-1} 10 % glucose) and re-check blood glucose after 5–10 min. Repeat if necessary.
	Other metabolic derangements History and blood analysis.	Correct calcium, magnesium and other metabolic derangements.
Hypo-or hyperthermia	***Hypothermia*** History/situation and core temperature.	Modify the PALS algorithm: • <30 °C: give a single dose of adrenaline unless planning immediate initiation of extracorporeal life support. • Give a maximum of three shocks if a shockable rhythm is present; if this is ineffective, delay further attempts until core temperature >30 °C. • 30–35 °C: adrenaline IV/IO every 8 min (6–10 min), second dose amiodarone IV/IO after 8 min, normal interval of defibrillation (every 2 min). • >35 °C: normal algorithm. • Consider transport to a centre for extracorporeal life support. • >32 °C: warm using external rewarming methods (hypothermia is unlikely to be the primary cause of cardiac arrest). • <32 °C: use active external and internal rewarming methods including extracorporeal techniques.
	Hyperthermia History and core temperature.	External cooling. If drug mediated, consider antidotes or other treatments.

(*continued on next page*)

Table 4 (continued)

Consider	Identification	Treatment in cardiac arrest
Thromboembolism	History (children with indwelling central lines, cardiac conditions, cancer, recent trauma, recent surgery) and POCUS.	Consider IV thrombolysis.
Tension pneumothorax	History (trauma, positive pressure ventilation, acute severe asthma exacerbation) Examine for symmetrical air entry and POCUS.	Needle thoracocentesis/thoracostomy (trauma).
Tamponade	History (cardiac surgery, penetrating chest trauma, acute viral pericarditis) and POCUS.	Pericardiocentesis/thoracotomy (trauma).
Toxic agents	History. Pre-arrest ECG, blood gas analysis, electrolytes.	Specific measures (safety, antidotes, decontamination, enhanced elimination). Consider ECPR.

- **Point of care blood analysis:** Check at least glucose, potassium, haemoglobin, lactate and blood gas analysis, and treat as appropriate.

Extracorporeal CPR

- Consider extracorporeal CPR (ECPR) as an *early* intervention for selected infants and children with IHCA (e.g. children with cardiac conditions in the paediatric intensive care unit, perioperative children) and OHCA (e.g. a refractory shockable rhythm) in settings where resources allow ECPR.

Reversible causes of paediatric cardiac arrest

- Seek and identify any reversible cause for cardiac arrest early and treat appropriately.
- Use the mnemonic '4H4T' (Table 4).

Cardiac arrest and its prevention in special circumstances

The recommendations in this section are primarily aimed at healthcare professionals.

Anaphylaxis

- Identify and treat anaphylaxis as soon as possible to prevent cardiac arrest – typically an acute onset of cutaneous, respiratory, circulatory and/or severe gastrointestinal symptoms.
- Discontinue administration of any potential allergen, if possible.
- Immediately administer 0.01 mg kg^{-1} = 10 microg kg^{-1} (max. 0.5 mg) adrenaline (1 mg/ml) *intramuscularly* (IM) into the anterolateral mid-thigh.
- Pragmatically one can use the following doses of adrenaline according to the child's age:
  - 0.15 mg at 1–5 years,
  - 0.3 mg at 6–12 years and
  - 0.5 mg if older than 12 years.

  An age-appropriate autoinjector can also be used.
- Repeat this dose of IM adrenaline every 5 min if symptoms persist.
- Assess ABCDE and position the child according to the presenting features (supine for shock, but the sitting position may optimise respiratory effort). Reassess ABCDE frequently.
- Give 100 % oxygen to children with respiratory distress and those receiving more than one dose of adrenaline.
- Consider early tracheal intubation in case of respiratory compromise and in anticipation of airway oedema. Airway management can be difficult, and the early involvement of a competent practitioner is mandatory.
- Establish vascular access and give crystalloid fluids 10 ml kg^{-1} as required to treat shock.
- Give inhaled short-acting beta$_2$ agonists for bronchospasm *in addition* to intramuscular adrenaline.
- After treatment, observe the child for at least 6–12 h.
- Consider second-line medications, such as antihistamines (for cutaneous symptoms) and steroids (only if there is concurrent asthma), when the initial reaction is under control.
- Seek expert advice (e.g. of a paediatric intensivist) if the child requires more than two doses of adrenaline with ongoing symptoms.
- Try to identify the allergen and take blood for serum tryptase analysis.

Traumatic cardiac arrest

- Identify and treat reversible causes to prevent cardiac arrest.
- Ensure proper team collaboration.
- *Additional recommendations for PBLS in traumatic cardiac arrest*
  - Follow standard CPR, start opening the airway and ventilate.
  - Competent providers open the upper airway with a jaw thrust and minimise spinal movement without hampering CPR.
  - Stop significant external bleeding immediately with manual pressure, haemostatic dressing or tourniquet.
  - Use an AED only if there is a high likelihood of a shockable rhythm (e.g. following electrocution).
- *PALS in trauma*
  - Professional rescuers should look for and treat reversible causes.
  - Use the acronym 'HOTT' to identify reversible causes: **H**ypotension, **O**xygenation (hypoxia), **T**ension pneumothorax and cardiac **T**amponade). In cardiac arrest, treating these has priority, or should run concurrently with, chest compressions and the administration of adrenaline IV/IO.
  - Use POCUS where available to diagnose reversible causes.
  - The optimal sequence of action will depend upon the setting and the number of rescuers, but consider:

- Correct hypoxia. Open the airway using a jaw thrust manoeuvre and minimise spinal movement, without hampering CPR. Ensure adequate ventilation and intubate the child as soon as the expertise and equipment are available. Intubate the child's trachea if the expertise and equipment are available. Use an SGA if intubation is not possible.
- Correct hypovolemia with intravascular fluid replacement, including early use of blood products in haemorrhagic shock.
- Relieve a suspected tension pneumothorax with a bilateral finger thoracostomy prior to chest drain placement.
- Perform a resuscitative thoracotomy, if competent, for a cardiac tamponade. Otherwise perform pericardiocentesis via a mini-thoracotomy or insert a wide-bore drain, preferably guided by POCUS.

- Attach an AED directly if there is a high likelihood of a shockable underlying rhythm such as following electrocution or in cardiac contusion. Otherwise, HOTT has priority over the AED.
- Consider a resuscitative thoracotomy (e.g. for penetrating chest injuries) provided the expertise, equipment and systems are in place.
- High-quality resuscitation is the standard in cardiac arrest due to a medical cause coincidental to the trauma or to a non-hypovolemic, non-obstructive aetiology (e.g. isolated traumatic brain injury, cardiac contusion, or asphyxia) or due to electrocution.

Drowning

- Reverse hypoxia and treat respiratory failure early to prevent cardiac arrest following drowning.
- Manage cardiac arrest following drowning with standard PALS with additional attention to reversing hypoxia and hypothermia.
- Remove the child as quickly and safely as possible from the water.
- Do not enter the water unless you are trained to rescue a person from the water.
- Try to reach the child from the land and provide a flotation device such as a lifebuoy or other rescue equipment.
- Start ventilation in the water if you are trained to do so and have a floatation device and the child is unconscious and not breathing.
- Start standard PBLS with 5 rescue breaths as soon as it is safe to do so (e.g. on land or on a boat).
- Give 100 % oxygen as soon as it is available. Intubate the child if the expertise and equipment are available.
- Attach an AED after drying the chest. Uninterrupted CPR and oxygenation take priority over the AED.
- Assess ABCDE and stabilise the child if not in cardiac arrest. Prevent cardiac arrest by identifying and treating respiratory insufficiency and hypothermia.
- Rewarm a hypothermic child immediately and simultaneously with the stabilisation. Treat hypothermia in a child with an intact circulation as follows:
  - Monitor the core temperature with a thermometer suitable for low temperatures.
  - Handle the child gently in a horizontal position to reduce the risk of cardiac arrest (especially VF).
  - Start rewarming if <35 °C and rewarm at a rate of at least 1 °C h^{-1}. Aim for normothermia but stop active rewarming at 35 °C to avoid overshoot hyperthermia.
  - Use active external rewarming applied to the trunk (chest, abdomen, back and axillae – not the extremities) with e.g. a hot-air blanket, radiant warmer, warmed blankets or hot packs, applied according to the manufacturers' instructions.
  - Do not place warm devices directly on the skin to prevent burns. Avoid rubbing and massaging of the extremities.
  - Do not use a warm shower or warm water immersion for rewarming a child with a decreased level of consciousness.
  - Give warmed and humidified 100 % oxygen and warmed IV/IO fluids (39–42 °C) to prevent further heat loss and to compensate for the vasodilatation during rewarming but avoid fluid overload by careful haemodynamic monitoring.
- Look for and treat a possible underlying cause of drowning (e.g. arrhythmia, epilepsy, intoxication, or trauma).
- Check blood glucose and electrolytes.
- Follow the PALS algorithm modified for hypothermic arrest if cardiac arrest occurs (see below).
- Consider ECPR if conventional CPR is failing.

Hypothermic cardiac arrest

- Individualise approaches depending on the cause of cardiac arrest: accidental hypothermia, or other possible causes such as drowning, suffocation, intoxication.
- Start standard CPR in every case of hypothermic cardiac arrest as soon as possible (e.g. before full extrication from an avalanche or in the water).
- If standard CPR is not possible and the child is deeply hypothermic (<28 °C) consider delayed or intermittent CPR.
- Modify the standard PALS-algorithm according to the core temperature. The revised Swiss Staging for Hypothermia can be used when the core temperature cannot be measured.
- Start rewarming the child as rapidly as possible while monitoring the core-temperature as soon as this is practicable.
- Below 30 °C give a single dose of adrenaline unless planning immediate initiation of extracorporeal life support. Do not give amiodarone until the temperature is above 30 °C. Prolong the administration intervals of resuscitation drugs while the core temperature remains between 30 and 35 °C (i.e. adrenaline every 8 min, second dose of amiodarone after 8 min).
- Attempt defibrillation a maximum of 3 times if a shockable rhythm is present under 30 °C. If this is ineffective, delay further attempts until the core temperature exceeds 30 °C. Then use the standard sequence of defibrillation (every two minutes).
- Transport a child considered to have a chance of a favourable outcome from hypothermic cardiac arrest as soon as possible to an appropriate centre for extracorporeal life support.
- Extracorporeal life support is potentially indicated in all children with hypothermic cardiac arrest who do not achieve ROSC in the field.
- Hypothermic patients with risks factors for imminent cardiac arrest (e.g. P or U on the AVPU scale, associated trauma, ventricular arrhythmia, or hypotension) should be transported to an extracorporeal life support centre.
- Stop resuscitation if ROSC is not achieved within 30 min when cardiac arrest is due to trauma or asphyxia (i.e. avalanche burial for >60 min, core temperature $\geq$30 °C and an obstructed airway).

Hyperthermia/heat stroke

- Identify patients with exertional or environmental hyperthermia or heat stroke (core temperature above 40 °C, not due to fever) as soon as possible. Look for an elevated body temperature associated with confusion, agitation or disorientation which can progress to coma and/or seizures.
- Remove the child from the heat source and/or stop exercise and loosen or remove clothing.
- If the temperature is above 40 °C, start cooling aggressively preferably using immersion up to the neck in cold water.
- Activate the EMS at the same time as initiating cooling.
- Monitor the core temperature to prevent overcooling. Aim to reduce this by about 0.1–0.2 °C min^{-1}. If the core temperature cannot be measured, cool for 15 min or until neurological symptoms subside.
- Hydrate orally if possible, or intravenously. Give room-temperature intravenous fluids as an adjunct to cooling and avoid fluid overload.
- Monitor symptoms and vital signs including mental status.
- Start resuscitation if circulatory collapse supervenes (often around 41 °C) and follow the standard PALS algorithm while continuing cooling.
- Stop aggressive cooling (e.g. cold-water immersion) when core temperature reaches 39 °C. Stop all active cooling at 38 °C but continue to monitor core temperature.
- Stabilise the child according to the ABCDE-method.
- All children with heat stroke should be admitted to a paediatric intensive care unit for continued monitoring in anticipation of sequalae and complications.

In the case of malignant hyperthermia (MH) stop all potential triggering agents immediately (e.g. anaesthetics), replace ventilation tubing and the ventilator, cool the child actively, ensure adequate oxygenation and ventilation, correct severe acidosis and hyperkalaemia, and administer dantrolene.

Tension pneumothorax

- Suspect tension pneumothorax especially in trauma, following central venous cannulation and during positive pressure ventilation.
- Use clinical signs to diagnose a tension pneumothorax. POCUS is helpful but is not necessary to make the diagnosis.
- Perform a needle thoracocentesis in the 4th or 5th intercostal space in the anterior axillary line or 2nd intercostal space in mid clavicular line; followed by chest drain insertion usually in the axilla.
- In trauma perform a finger thoracostomy in the 4th or 5th intercostal space in the anterior axillary line, followed by emergency chest drain insertion.
- Perform bilateral thoracostomies in traumatic cardiac arrest with or without signs of a tension pneumothorax.

Cardiac tamponade

- Suspect cardiac tamponade especially after cardiac surgery, in penetrating chest trauma and pericarditis.
- Use clinical signs and POCUS to recognise cardiac tamponade which is most common post cardiac surgery and in penetrating chest trauma and some viral illnesses.
- Perform urgent pericardiocentesis, mini-thoracotomy, resuscitative thoracotomy or re-sternotomy depending on the setting and available expertise.

Pulmonary thromboembolism

- Suspect PE in case of tachycardia, tachypnoea and hypoxia, especially in children with central lines, cardiac conditions, cancer, unilateral limb swelling, recent trauma/surgery, prior thromboembolism, anaemia and/or leucocytosis.
- Consider echocardiography if the expertise (e.g. a paediatric cardiologist) is available.
- For thrombolytic therapy refer to local protocols and call for expert help. Consider systemic or catheter-directed administration of thrombolysis which is more effective than systemic anticoagulation.
- Consider extracorporeal life support and surgical embolectomy when thrombolysis fails, or the child progresses towards cardiac arrest.
- In cardiac arrest due to pulmonary thromboembolism, consider thrombolysis, e.g. IV alteplase 0.3–0.5 mg kg^{-1} (max 50 mg) over 2 min, which may be repeated after 15 min.

Toxic agents

Prevention of cardiac arrest

- Provide supportive care based on the ABCDE approach to prevent cardiorespiratory arrest whilst awaiting toxin elimination. Look for evidence of non-accidental trauma.
- Provide early advanced airway management if decreased conscious level.
- Administer IV boluses of 10 ml kg^{-1} isotonic crystalloids for hypotension. Noradrenaline may be required if hypotension persists.
- Perform a 12-lead ECG in certain poisonings (e.g. antipsychotics, 3,4-methylenedioxymethamphetamine (MDMA) and other amphetamines) or in children with altered consciousness, abnormal heart rate or blood pressure. Cardiovert life-threatening tachyarrhythmias
- Take blood for electrolytes, blood glucose and blood gas analysis and correct any abnormalities. Take blood and urine for toxicological analysis.
- Check for and correct hyperthermia (ecstasy, cocaine, salicylates) and hypothermia (ethanol, barbiturates).
- Take a thorough history (families, friends, EMS crew) and perform a complete physical examination to identify diagnostic clues (e.g. odours, needle puncture marks, pupils, tablet residues).
- Administer antidotes, where available.
- Consult a regional or national poisons centre for information on treatment.

Cardiac arrest

- Suspect toxic agents as an infrequent cause of cardiac arrest after more common causes have been excluded.
- Provide standard PBLS and PALS.
- Do not use mouth-to-mouth ventilation in the presence of chemicals such as cyanide, hydrogen sulphide, corrosives and organophosphates.
- Exclude all reversible causes of cardiac arrest, including electrolyte abnormalities which can be indirectly caused by a toxic agent.
- Be prepared to continue resuscitation for a prolonged period while the toxin concentration falls.
- Consult regional or national poison centres for information on treatment.

- Consider ECPR for selected patients when conventional CPR is failing.

Hyperkalaemia

- Suspect hyperkalaemia in children with massive haemolysis (neonates), cellular lysis (tumour lysis syndrome, crush syndrome), in acute or chronic renal failure, malignant hyperthermia, or specific intoxications.
- Stop all exogenous sources of potassium including fluids containing potassium when hyperkalaemia is detected. Use normal saline if fluids are needed.
- If severe hyperkalaemia is confirmed (>6.5 $mmol^{-1}$ or >7.0 mmol L^{-1} in neonates younger than 96 h):
  - Treat the underlying cause if possible.
  - Administer rapidly acting insulin with glucose 0.1 U kg^{-1} (max. 10 U) with 10 % glucose at 5 ml kg^{-1} (max. 250 ml) over 30 min followed by a glucose containing infusion. Check potassium and glucose every 15 min for 4 h.
  - Administer short acting $beta_2$-adrenergic agonists preferably as inhalation/nebulisation (e.g. salbutamol 2.5–5 mg, repeat up to 5 times).
  - If inhalation is not possible, give short-acting $beta_2$-adrenergic agonists IV (e.g. salbutamol 5 microg kg^{-1} over 5 min). Repeat if insufficient effect is seen within 15 min, up to a maximum total dose of 15 μg kg^{-1}.
  - In patients with conduction abnormalities on the ECG consider 10 % calcium gluconate, 0.5 ml kg^{-1}, max. 20 ml.
  - Prepare a potassium removal strategy (e.g. binding agents, furosemide in well hydrated children with preserved kidney functions, dialysis).
- For cardiac arrest caused by severe hyperkalaemia (usually above 6.5–7 mmol L^{-1}):
  - Give 0.1 unit kg^{-1} short acting insulin (max 10 units) with 5 mL kg^{-1} 10 % glucose (max 250 ml) as an IV bolus, followed by blood potassium and glucose monitoring and a glucose containing infusion as needed. Higher concentrations of glucose solutions may be used via a central line (e.g. 2.5 ml kg^{-1} 20 % glucose or 1 ml kg^{-1} 50 % glucose).
  - Do not use calcium in children in cardiac arrest.
  - Continue high quality PALS and consider ECPR.

Other metabolic derangements

- Hypokalaemia: give 1 mmol kg^{-1} (max 30 mmol) potassium at 2 mmol min^{-1} for 10 min followed by the rest of the dose (if necessary) in 5–10 min in children with severe hypokalaemia (<2.5 mmol L^{-1}) with life-threatening symptoms or in cardiac arrest. Repeat, if necessary, until the serum potassium is >2.5 mmol L^{-1}. Follow this with an IV infusion (e.g. 0.5–1 mmol kg^{-1} h^{-1}, maximum 20 mmol h^{-1}, depending on the potassium level for 1–2 h). Consider magnesium sulphate 30–50 mg kg^{-1} IV for concurrent hypomagnesaemia.
- Hypoglycaemia: Treat hypoglycaemia < 3.9 mmol L^{-1} with symptoms, or <3.0 mmol L^{-1} if asymptomatic. Give a bolus of 0.2 g kg^{-1} glucose (e.g. 2 ml kg^{-1} 10 % glucose) and re-check the glucose after 5–10 min. Repeat as needed.
- In other metabolic derangements (hypocalcaemia, hypercalcaemia, hypomagnesaemia, hypermagnesaemia): Correct the metabolic derangement during cardiac arrest, while continuing high-quality CPR. Consider extracorporeal life support.

Cardiac arrest in children with congenital heart disease

- Follow the standard PALS algorithm with additional considerations for pulmonary hypertension, obstructed cardiac shunt or if the child is attached to a defibrillator and has a witnessed shockable rhythm.

Pulmonary hypertension

- Suspect pulmonary hypertension in children with congenital heart disease or chronic lung disease but also as a primary disease.
- Anticipate and prevent pulmonary hypertensive crises by avoiding triggers such as pain, anxiety, excessive tracheal tube suctioning, hypoxia, hypercapnia, and metabolic acidosis.
- Treat pulmonary hypertensive crises with a high concentration of oxygen, adequate ventilation, analgesia and sedation and with muscle relaxation as necessary.
- Search for and treat other possible reversible causes of increased pulmonary vascular resistance: inadvertent interruption of pulmonary hypertensive therapy, arrhythmia, cardiac tamponade, or drug toxicity.
- Consider inotropic and or vasopressor therapy to avoid or treat right ventricle ischaemia caused by systemic hypotension.
- Additional therapies, which are indicated if the crisis does not rapidly resolve or in the case of cardiac arrest, are inhaled nitric oxide and/or intravenous prostacyclin.
- Consider ECPR if medical management is ineffective.

Cardiac arrest due to obstruction of a cardiac shunt

- Suspect acute obstruction due to thrombosis or mechanical kinking of connections between the systemic and pulmonary circulation in children with aortopulmonary shunts or patent ductus arteriosus stents as a cause of cardiac arrest.
- Give 100 % oxygen to maximise alveolar oxygenation.
- Consider hypovolaemia and treat this with IV or IO fluids if necessary.
- Ensure an adequate systemic blood pressure to optimise shunt and coronary perfusion pressure with vasoactive agents and inotropes.
- Ensure adequate anticoagulation e.g. with a bolus of heparin 50–100 U kg^{-1} followed by a titrated continuous infusion.
- Call for immediate expert help and consider interventional catheterisation or surgery. In the direct post-operative period immediate re-sternotomy may improve shunt perfusion.

Cardiac arrest in an ECG-monitored child attached to a defibrillator with a witnessed shockable rhythm

- As soon as a shockable rhythm is detected, give up to three quickly successive (stacked) shocks using the standard energy doses for the child's weight.
- Recharge the defibrillator and rapidly check for a rhythm change and signs of life after each defibrillation attempt and, if necessary, immediately give a further shock.
- Start chest compressions after the third defibrillation attempt and continue CPR for 2 min.
- Start chest compression and give amiodarone after if the third stacked defibrillation attempt is unsuccessful and continue CPR for 2 min.
- Give adrenaline after 4 min.
- The subsequent resuscitation follows the standard sequence of actions, i.e. giving a single shock every 2 min, adrenaline every 4 min and a second dose of amiodarone after the 5th shock.

Cardiac arrest in the operating room

- Clarify roles and procedures during the team briefing before high-risk cases to enable co-ordinated actions should cardiac arrest occur.
- Treat pre-arrest states such as hypoxia and hypotension aggressively. Ventilate with 100 % oxygen and give intravascular fluid and vasoactive agents.
- Recognise cardiac arrest early by continuous monitoring and a high index of suspicion, particularly during difficult airway management and massive bleeding.
- Start chest compressions if extreme bradycardia or hypotension (<5th percentile for age) occurs suddenly despite interventions, or the waveform capnography suddenly decreases.
- Inform the whole OR-team of the cardiac arrest.
- Call for help and for the defibrillator.
- Optimise the child's position and the height of the operating table to facilitate high-quality chest compressions.
- Ensure the airway is secure, review the $ETCO_2$ tracing, and deliver effective ventilation with 100 % oxygen.
- Follow the general PALS algorithm and focus initially on the most likely reversible causes: hypovolaemia (haemorrhage, anaphylaxis), hypoxia, tension pneumothorax, thrombosis (pulmonary embolism) and toxic agents (medication).
- Use POCUS, when the equipment and expertise are available, to help identify the cause and guide resuscitation, provided this does not compromise the quality of the resuscitation.
- Also consider causes specific to the operating room such as: gas embolism, bradycardia from axial nerve blocks, malignant hyperthermia, local anaesthetic overdose, and other drug errors.
- For hypotensive and/or bradycardic children in a pre-arrest state, give smaller incremental bolus doses of IV adrenaline initially (e.g. 1–2 $\mu g\ kg^{-1}$ intravenously). If the child progresses to cardiac arrest give adrenaline according to the standard PALS-algorithm.
- If the facilities and expertise are available and conventional CPR is failing, consider early ECPR or open chest cardiac compressions as an alternative if ECPR is unavailable.

Post-resuscitation care

Post-resuscitation care starts immediately after return of spontaneous circulation (ROSC) is achieved.

Recommendations for healthcare providers in the pre-hospital setting and limited-resource healthcare

- The general ABCDE principles described in the section on the prevention of cardiac arrest also apply to post-resuscitation care.
- Ensure adequate oxygenation and ventilation.
- Intubate the trachea only if you are competent and equipped to do so safely.
- Always use analgosedation and muscle relaxants for intubation unless the child is deeply comatose (GCS 3). Provide 100 % oxygen during intubation.
- Monitor $ETCO_2$ continuously if an advanced airway is in place.
- Titrate FiO_2 to achieve a peripheral oxygen saturation of 94–98 % as soon as reliable measurement is available. When ABG-analysis is available aim for normoxaemia.
- In the absence of ABG analysis, aim for a normal respiratory frequency for the child's age and mild chest movements.
- Monitor capnography and aim for normocapnia. When ABG-analysis is available confirm normocapnia.
- Use tidal volumes of 6–8 ml kg^{-1} of ideal body weight, and PEEP of 5 cm of H_2O for mechanical ventilation in previously healthy children.
- Use the minimum airway pressures needed to achieve oxygenation and ventilation goals, adjusting these in special circumstances (e.g. chronic lung disease).
- Check for signs of shock and treat it immediately if present. Treat shock with fluids, vasoactive drugs or inotropes or combinations of these.
- Aim for a systolic and mean arterial blood pressure above 10th percentile for child's age.
- Treat seizures immediately if they emerge.
- Check blood glucose after cardiac arrest and treat hypoglycaemia.
- Use analgesia and sedation to treat pain and discomfort after cardiac arrest in children of all ages. Avoid bolus medications that can cause sudden drops or rises in blood pressure.
- Always treat hyperthermia or fever with active cooling.
- Try to establish the cause of cardiac arrest and treat it to avoid re-arrest.
- Enable parental or caregiver presence during the pre-hospital care or transport whenever this can be done safely (Fig. 30).

Recommendations for healthcare providers in a hospital

- Use individualised goals and bundles of care rather than specific single targets during post-resuscitation care. Treat underlying disease(s) as well as post-cardiac arrest syndrome.
- Establish invasive arterial blood pressure monitoring and central venous access with SvO_2 measurement as a minimum in all sedated or comatose children.
- If no individualisation is needed, continue targeting normoxaemia, normocapnia, and maintain systolic and mean arterial blood pressure above 10th percentile for at least 24 h after cardiac arrest.
- Use available non-invasive or invasive techniques to diagnose the probable cause of cardiac arrest as well as to make individualised decisions in the management of post-cardiac arrest syndrome.
- Diagnose, monitor, and treat pain, discomfort and delirium.
- Keep temperature control management as an integral part of post-resuscitation care for at least 24 h after cardiac arrest. Avoid fever for at least 72 h.
- Prevent, diagnose, and treat acute kidney injury or renal failure.
- Optimise nutrition.
- Start rehabilitation early.
- Allow unrestricted access of primary caregivers to the child as a part of family-centred care. Be sensitive to cultural and religious issues.
- Communicate clearly and honestly with parents/caregivers while also paying attention to their understanding and needs; decision making should be shared. Involve concerned stakeholders (e.g. extended family, religious support) in the communication.
- Seek the assistance of specialised multidisciplinary teams early (e.g. paediatric neurologists, psychologists, paediatric palliative care team, social workers, and, if necessary, an interpreter) to address the needs and concerns of the child, parents, family and other caregivers.
- In case of cardiac arrest, whether fatal or not, use a standardised diagnostic protocol to identify the cause. If the cardiac arrest might have been due to an inherited condition, such as certain arrhythmias and cardiomyopathies, ensure appropriate screening of family members to prevent cardiac arrest in future patients.

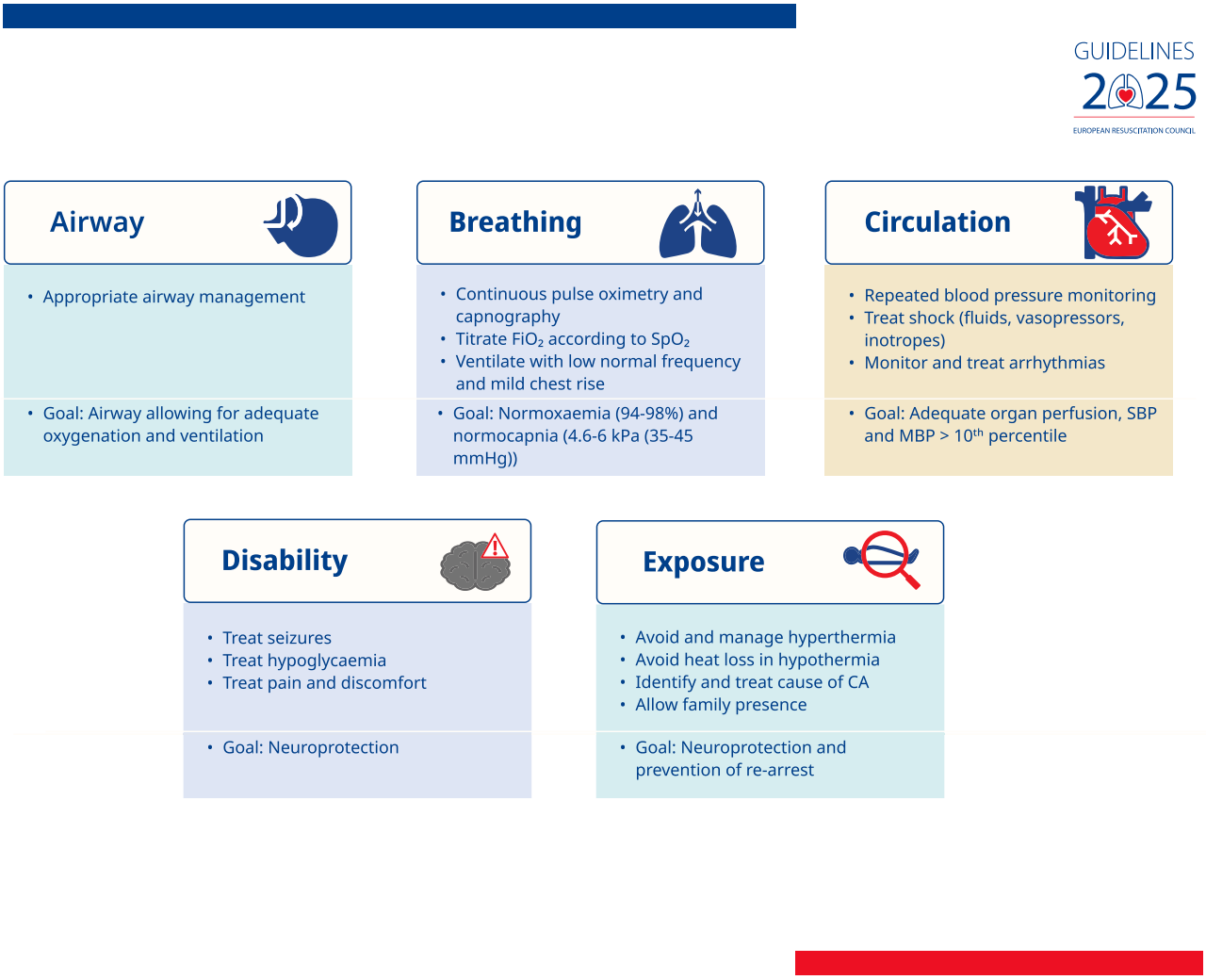


Fig. 30 – Immediate paediatric post-resuscitation care.

Prognostication after cardiac arrest

- Avoid both false optimism and false pessimism, and prevent individual suffering, increased healthcare costs, impaired daily skills and reduced ability to participate in society (education, labour).

Recommendations for healthcare professionals

- Delay prognostication in children with a decreased level of consciousness or who are sedated for at least 72 h following cardiac arrest.
- Use a multimodal approach to prognostication. Accurate prognostication for both good and poor outcomes involves:
  - o Pre-arrest: knowledge of the child's baseline health and neurological status
  - o The context of the cardiac arrest: e.g. location of the cardiac arrest, bystander BLS, first rhythm, cause of cardiac arrest and duration of the cardiac arrest.
  - o Post-cardiac arrest care: a comprehensive assessment supplemented with repeated evaluations.
- Combinations and timing of investigations and signs predicting good outcomes differ from those predicting poor outcomes. No single modality can be used in isolation for prognostication with high accuracy.
- Use the suggested standardised minimal set of diagnostic modalities for better comparability and research.
- Visual aids and presentations might help parents/caregivers to understand certain specifics of prognostication enabling them to participate better in the decision making.

Post-discharge care

- Assess outcomes with standardised measurements using validated instruments and involve paediatric psychologists, neurologists, rehabilitation physicians and/or intensivists in post-discharge care.
- Plan and discuss the post-discharge care with caregivers before hospital discharge.
- Organise multidisciplinary post-discharge care to minimise the number of hospital visits for the child and family.
- Consider a virtual consultation when an on-site visit to an outpatient clinic is challenging due to financial, travel or work limitations.
- Screen patients, parents/caregivers, and family members for symptoms of post-intensive care syndrome regularly and refer to a professional (e.g. psychologist) as soon as any physical or mental health issues arise.

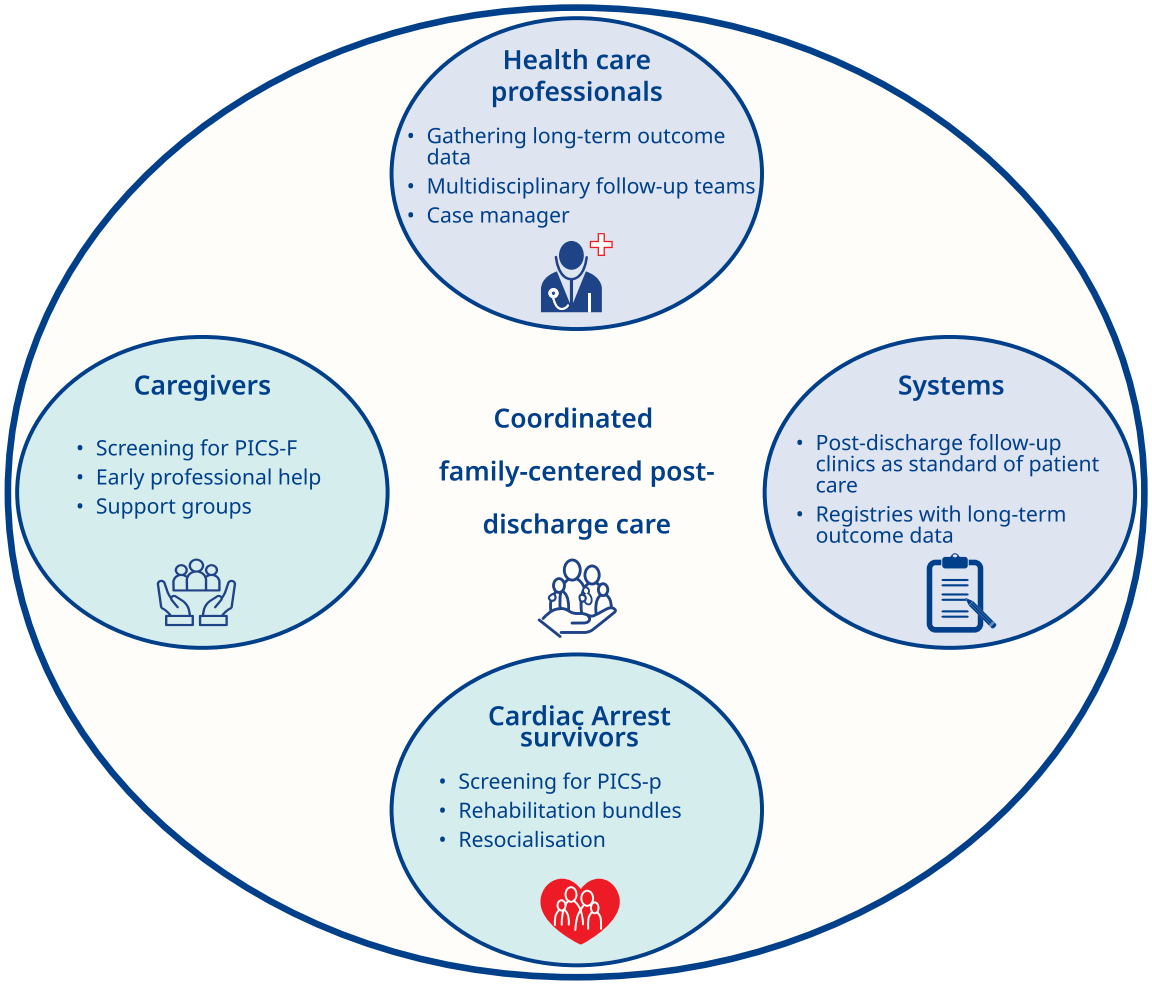


Fig. 31 – Paediatric post-discharge care.

- Seek and signpost supportive structures for patients and parents/caregivers, such as parent groups, cardiac arrest survivors' groups and bereavement groups (Fig. 31).

System-level recommendations and recommendations for implementation

Recommendations for the general public

- All parents and caregivers should be encouraged to learn the basic recognition of signs and symptoms of critical illness and trauma in children, basic first-aid life-saving procedures and PBLS.
- PBLS, simple recognition triage tools and basic first-aid life-saving procedures for paediatric emergencies should be part of training for professional caregivers of children (e.g. child minders, schoolteachers, first responders, lifeguards, and coaches/trainers of children and adolescents). Priority should be given to the training of those who take care of children with an increased risk of an acute life-threatening event.
- Facilities should be in place to manage acute life-threatening events in children, including trauma, in settings in which there is an increased risk of these events, such as sporting events, swimming pools and other areas of open water. These facilities must include equipment, protocols, systems, and trained personnel.

- Children who live near water should be taught to swim before they are allowed to play unsupervised.
- In settings where heat stroke might occur, e.g. sports events in a warm climate, facilities for the management of hyperthermia, including a method for rapid cooling should be available.
- Every child who has had an anaphylactic reaction should carry an adrenaline auto-injector of the appropriate dose which the caregivers and the child, if old enough, should be able to use.

Recommendations for all healthcare systems

- All systems caring for children should aim to link all parts of the chain of survival (prevention of cardiac arrest, early call for help, PBLS, PALS, post-resuscitation care and post-discharge care).
- As well as individual technical and non-technical skills, the safe and effective management of an acute life-threatening event or cardiac arrest requires an institutional safety culture embedded in everyday practice through continuous education, training, and multidisciplinary cooperation.
- All systems should promote the use of protocols and bundles of care for life-threatening conditions (e.g. for cardiac arrest, sepsis, anaphylaxis, status epilepticus) and should evaluate protocol adherence aiming for improvements in care.
- All systems caring for children should adopt standardised drug calculations and provide cognitive aids (algorithms, tapes, posters, applications) and standardised drug and equipment labelling and handling to avoid medical errors. All personnel should be trained accordingly. Cognitive aids used should be easily accessible.
- All systems should aim to identify children who may be at increased risk of cardiac arrest such as very small and preterm infants, children with a sudden unexplained death in the family, siblings of children who died from sudden infant death syndrome (SIDS) and children with specific congenital abnormalities, primary arrhythmia syndromes, cardiomyopathies, channelopathies and coronary artery abnormalities. Systems should ensure that a plan is in place to care for these children.

Recommendations for emergency medical systems and dispatch systems

- Dispatch systems should implement instructions for dispatcher-assisted CPR specific for children.
- Ensure clear and effective communication so that emergency personnel are dispatched promptly to a critically ill or injured child or a child in cardiac arrest.
- Pre-hospital emergency medical systems should train all professionals in the recognition and initial management of critically ill and injured children to prevent cardiac arrest, including field triage.
- Pre-hospital emergency medical systems should train all professionals in PBLS.
- Emergency healthcare responders should be available at all times and must be trained in PALS and suitably equipped to respond to a paediatric cardiac arrest.
- Emergency responders' PALS skills should include bag-mask ventilation, IV/IO access, administration of adrenaline, rhythm recognition, use of a defibrillator/AED and knowledge and understanding of the PBLS and PALS algorithms including choking. Training should also include communication with parents/caregivers.
- Emergency medical systems should have set training schemes to improve skill retention and teamwork. They should develop clear protocols and communication plans to facilitate the transportation of children with a cardiac arrest.
- There should be systems, including protocols, to guide communication between pre-hospital teams and hospital teams to prepare them to receive the child.
- There should be systems, including protocols, to guide the transport of parents/caregivers when possible.
- Children sustaining a cardiac arrest should be transported to a hospital with a paediatric intensive care unit.
- Certain specific subgroups of patients should be transported directly to specialised paediatric intensive care units with facilities for extracorporeal life support.
- Consultation with specialists (e.g. via telemedicine) should be encouraged when there are uncertainties regarding the management or transport of a child.

Recommendations for hospital departments and resuscitation teams

- Emergency departments treating children should implement triage systems specific for, or adapted to children and should train personnel in their use. They should monitor and evaluate the effectiveness of their triage protocols.
- Hospitals should train all healthcare professionals who are involved in the care of children (including those who only occasionally treat them) in the recognition and initial management of critically ill or injured children.
- All healthcare professionals involved in the care of children should be able to perform PBLS.
- Systems should exist to activate personnel skilled to establish IO access in less than 5 min.
- Use paediatric early warning systems as part of an overall in-hospital response system, not as a stand-alone measure.
- Each hospital caring for children should have a resuscitation team (and/or clinical emergency team) trained in PALS. Its members should have pre-designated roles. These individual roles should cover all the required interventions and competencies to resuscitate a child effectively and efficiently. Shared leadership should be considered.
- Each hospital should set training requirements for members of the resuscitation team to improve skill retention and teamwork.
- Each hospital should have a designated method of summoning the resuscitation team which can be audited.
- Ideally, members of the resuscitation team should meet once or twice a day at the beginning of each shift (team huddle) to get to know each other, discuss role allocation and any patients of concern in the hospital.
- Members of the resuscitation team should be given time to debrief after critical events both to support staff and to enhance performance.
- Standardise resuscitation trolleys across the hospital and train staff in their contents and use of equipment. Trolleys should be checked frequently.
- Provide easy bedside access to cardiac arrest algorithms both electronically and on paper, and display these on the resuscitation trolley and in all areas where cardiac arrest might occur. Provide handheld cards and/or electronic tools for staff.

- Every child who has a reduced level of consciousness after cardiac arrest should be admitted to a paediatric intensive care unit, if possible, for post-resuscitation care.
- Hospitals offering extracorporeal life support, should establish institution-specific protocols for cardiac arrest in children during or after cardiothoracic surgery, and other children with cardiac arrest or *peri*-arrest conditions.
- There should be a clear protocol, based on these recommendations, for the management of perioperative cardiac arrest in every operating room.
- Hospitals, department and paediatric intensive care units should investigate and employ ethical, guideline-based and reliable prognostication methods.
- Allow sufficient dedicated time for physicians to talk with parents/-caregivers about care and prognostication.
- Family-centred care and a shared approach to decision making should be considered the standard of care in the best interest for the child.
- Include all cardiac arrest survivors and their families in post-discharge care. Offer specific care to families of non-survivors, including bereavement care and psychological support.
- Aim for well-coordinated family-centred post-discharge care, using e.g. family liaison staff to limit the burden for cardiac arrest survivors and their families.

Recommendations for manufacturers of medical devices

- Manufacturers of AEDs and defibrillation pads should standardise pictograms for positioning the defibrillation for infants and children so that they are in line with current resuscitation guidelines.
- Manufacturers of public access defibrillators should aim for the simplest and quickest possible ways to attenuate energy levels in case the AED is used in younger children (preferably a paediatric button with only one size of defibrillation pads).

Recommendations for low resource settings

- Aim for the highest possible level of care within the specific context.
- Prioritise implementation of recommendations according to the expected benefit for the overall outcomes (e.g. training many in simple procedures rather than buying expensive advanced equipment).
- Modify recommendations taking the availability of personnel and equipment into account.
- Adjust recommendations to the typical patient-population and specific setting.
- Where possible, critically ill and injured children should receive specific *paediatric* care, as recommended in these Guidelines. Where this is not possible, arrange for the most appropriate care, considering the child's age, condition and circumstances.

Education of resuscitation

The ERC Guidelines in Education of Resuscitation 2025 provide guidance to citizens and healthcare professionals on how to teach knowledge, skills and attitudes of resuscitation with the goal of teaching effective resuscitation measures that will improve patient survival after cardiac arrest.[71] (Fig. 32).

Resuscitation education tailored for specific groups of life-saving rescuers

- Educate all members of the community about cardiac arrest awareness and cardiac arrest treatment and consider the diversity of the target group.
- Introduce early resuscitation training starting in early childhood education (around 4–6 years of age) and incorporate annual resuscitation training into school curricula.
- Provide all health care professionals with accredited resuscitation training.
- Tailor the required CPR training to the provider's role, their specific setting, and/or specific patient populations.
- Train emergency medical services dispatchers in cardiac arrest recognition and telephone-assisted CPR guidance.

Educational methods to teach high-quality resuscitation competencies

- Use blended and self-directed learning to provide flexibility and accessibility for all learners of resuscitation.
- Consider gamified learning as a component of resuscitation training for all types of basic and advanced life support courses.
- Use real-time CPR feedback devices to improve chest compression skill acquisition and accuracy.
- Use rapid cycle deliberate practice as an effective learning strategy to master skills rapidly.
- Use spaced learning to improve acquisition and retention of competencies.
- Use stepwise approaches for structured skill acquisition. Strict adherence to a four-step approach is not always necessary.
- HCPs should consider using cognitive aids during resuscitation training to enhance protocol adherence. Bystanders should not use them as this may delay critical actions.
- Integrate ethical training into HCP resuscitation education.
- Regardless of the rescuer's background, basic life support education should include effective chest compressions, safe use of an AED, and ventilation of the lungs.
- Teach two-person ventilation when using a self-inflating bag and mask.
- Address in BLS training barriers that rescuers might experience in performing CPR and factors increasing rescuers' willingness to perform CPR.
- Include training of team competencies in all life support courses (incl. non-technical skills and human factors during resuscitation) (Fig. 33).

Technology-enhanced learning for resuscitation

- Use online learning modalities (e.g. podcasts, videos, social media) to provide flexibility in time and location for learners and to promote asynchronous learning.
- Use augmented reality for life support training as it possibly adds value to the learning process.
- Consider applications and artificial intelligence, which might facilitate assessment and teaching during resuscitation courses.

Simulation-based resuscitation education

- Use high-fidelity manikins when training centres/organisations have the infrastructure, trained personnel, and resources available. Use low-fidelity manikins for standard advanced life support training where high-fidelity manikins are not available.

EDUCATION FOR RESUSCITATION
KEY MESSAGES

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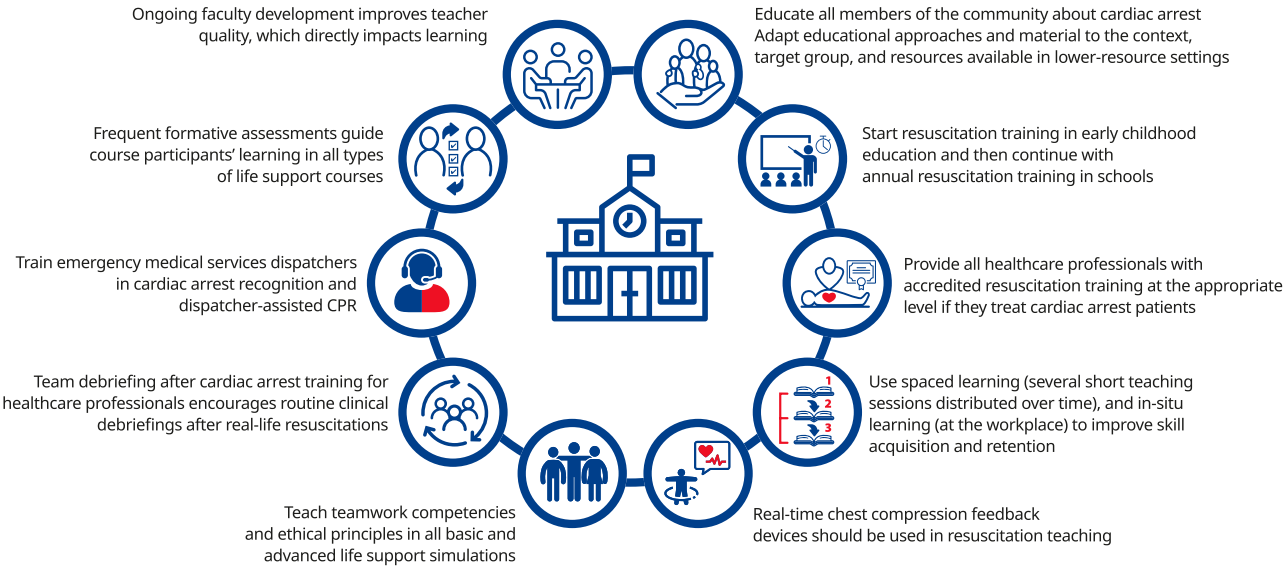


Fig. 32 – Key messages education for resuscitation.

- Use in-situ simulation (at the workplace) as an option for CPR training where resources are readily available.
- Include the teaching of teamwork competencies in basic and advanced life support simulations.
- Consider the inclusion of a CPR coach as a member of the resuscitation team during CPR simulation.
- Use debriefing scripts to support instructors during debriefing after simulation.

Assessment in resuscitation education

- Use frequent formative assessments in all life support courses to provide instructors with information for targeted feedback, to support learning, and to facilitate a summative assessment.
- Use checklists to support assessment decisions.

Feedback and debriefing in life support courses

- Ensure feedback is a two-way discussion between the giver and the recipient, driven by an authentic interest in the learner's improvement.
- Consider using a concise team debriefing after cardiac arrest training for HCPs to encourage routine clinical debriefings after real-life resuscitations.

Faculty development

- The ERC recommends faculty development programs for all instructors teaching life support courses.
- Select trainers with medical education expertise to conduct faculty development programmes.
- Implement faculty development programs that enable participants to establish a positive learning climate, practice effective educative leadership, communicate learning goals, implement robust assessment and feedback strategies, and evaluate course programs for continuous improvement.

Effect of resuscitation education on outcome

- HCPs providing advanced life support to adults should attend accredited adult advanced life support training.
- HCPs providing advanced life support for newborns and babies should attend accredited neonatal resuscitation training (NRT) courses such as Newborn Life Support.
- For HCPs providing care for newborns and babies in out-of-hospital low-resource settings, we recommend participation in the Helping Babies Breathe (HBB) support program.

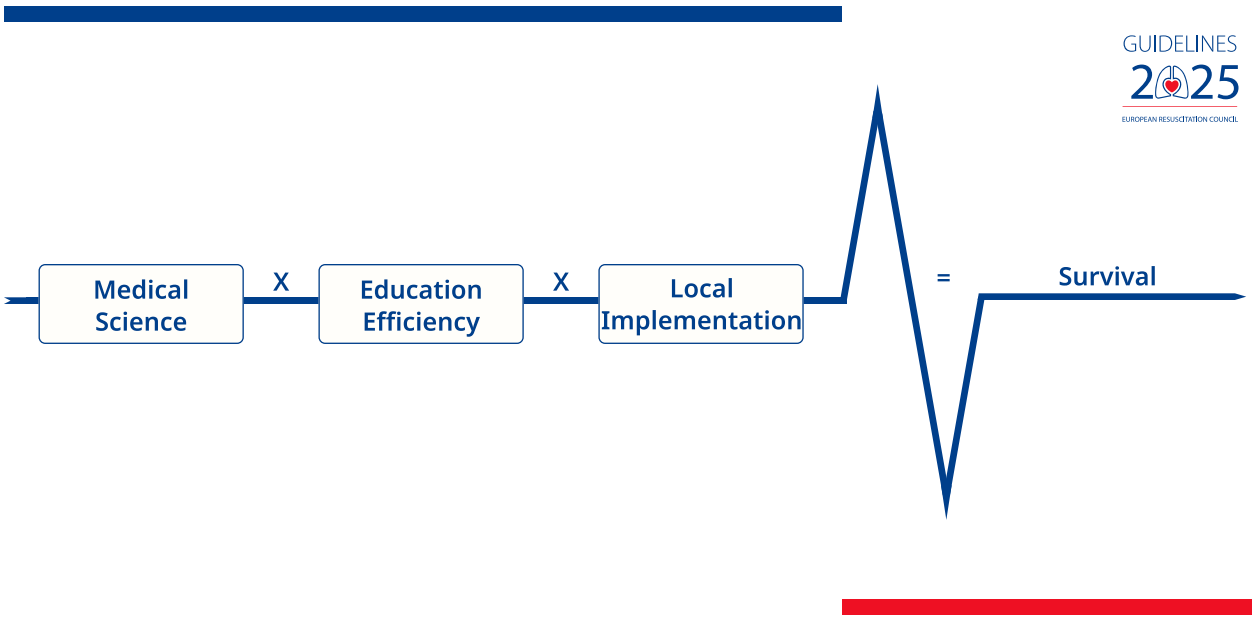


Fig. 33 – The Utstein formula of survival.

- Other accredited life support courses (e.g., paediatric life support) are recommended, even though less evidence on the effect on patient outcomes is available.

Resuscitation education in low-resource settings and remote areas

- Adapt educational approaches and materials, and awareness campaigns to the context and available resources.
- Consider distance learning, technology-enhanced learning, hybrid resuscitation training, and the use of low-cost (self-made) manikins.

Ethics in resuscitation

The ERC Ethics in Resuscitation Guidelines 2025 provide evidence-informed recommendations for the ethical, routine practice of resuscitation and end-of-life care of adults and children.[72] (Fig. 34).

Advance care planning

- Healthcare systems should offer advance care planning to all patients expressing wishes to discuss goals of care.
- Decisions of do not attempt CPR (DNACPR) are best made in the broader context of advance care planning.
- Anticipatory decisions, whether to attempt cardiopulmonary resuscitation (CPR) or not, should be taken regardless of the time of the day in all patients with a significant risk of cardiac arrest. For patients not under imminent risk, it is appropriate to plan for the discussion and decision-making to take place at daytime.
- Document decisions of DNACPR and on which of the three different grounds the decision is based: (1) CPR will not be appropriate since death is expected; (2) CPR not in a beneficial balance between the medical assessment and the patient's values; (3) or the patient does not wish to receive CPR.
- For patients with cognitive impairment, invite a substitute decision maker to ensure concordance in goals of care over time.
- Offer patient-centred education about advance care planning to patients before discussions on this topic.
- Document advance care plans in a consistent manner that is available in emergency care settings (e.g. electronic registries, standardised documentation templates).
- Use advance care planning to identify treatments and interventions that should be avoided upon hospital admission at the end of life.
- Reassess advance care plans regularly and when a patient's situation changes.
- Facilitate patient and family caregivers' understanding of their preferences, as mutual understanding can optimise the decision-making process for all involved.
- Organise local educational hubs focusing on skills and competencies when undertaking goals of care discussions.
- Communication skill training should be part of the continuous professional development of healthcare providers involved in advance care planning and end-of-life care.

Ethics of bystander and first responder involvement

- Ensure that bystanders are not forced or unduly compelled into performing CPR, respecting their personal autonomy in resuscitation decision-making, while acknowledging the 'duty to help'.
- Mitigate moral distress among bystanders and first responders by offering ethical guidance for navigating situations involving difficult or distressing interventions.

ETHICS IN RESUSCITATION
KEY MESSAGES

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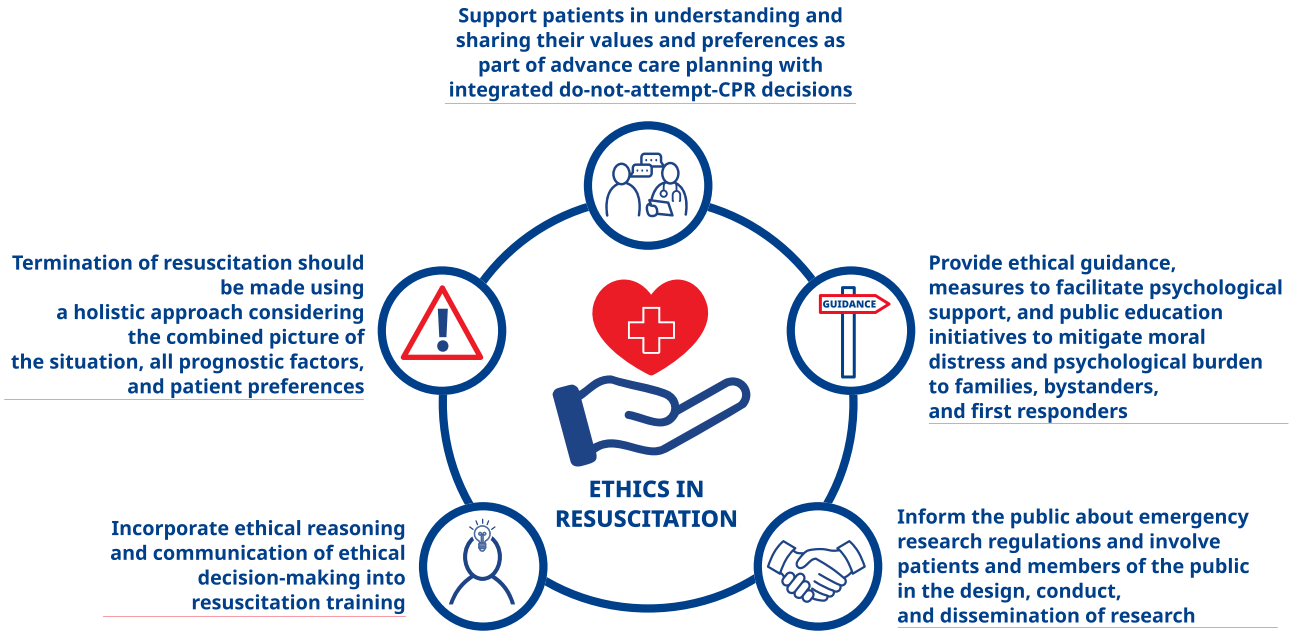


Fig. 34 – Key messages ethics in resuscitation.

- Health care systems should implement measures to facilitate psychological support for bystanders and first responders following out-of-hospital cardiac arrest (OHCA), e.g. through surveys or defusing to identify people in need of additional support and/or by providing contact information for further psychological support.
- Clarify legal and ethical protection for bystanders to reduce hesitation due to fear of liability or moral responsibility.
- Implement strategies to minimise the impact of biases in bystander intervention, ensuring that factors such as gender, cultural background, or the patient's social identity do not influence resuscitation decisions.
- Clearly articulate the ethical boundaries of bystander responsibility in OHCA response, carefully distinguishing between moral obligations and legal or medical duties and delineating how these distinctions can be navigated effectively within the context of the legal-moral duty to assist.
- Implement safeguards in bystander alert systems to protect patient autonomy and prevent unwanted or inappropriate resuscitation attempts, while also ensuring that the bystanders' autonomy is respected in their decision to intervene.

Family presence

- Resuscitation teams should offer the family of cardiac arrest patients the choice of being present during the resuscitation attempt.
- Healthcare systems should establish clear, contextualised, and culturally sensitive procedures for the involvement of family members.
- Healthcare systems should specifically train their teams to support family members during resuscitation.
- As far as reasonably practicable, healthcare systems should have a trained team member who can be designated to this task as part of the overall CPR strategy and choreography.

Termination of resuscitation (TOR)

- Make a team-based decision to terminate resuscitation based on a holistic approach considering patient values and preferences and the combined picture of prognostic factors including duration of CPR, the absence of reversible causes, and the absence of response to advanced life support.

- TOR should be carried out in a planned manner and all team members should have the opportunity to weigh in before termination.
- The team should conduct a debriefing immediately following termination.
- TOR may be considered when the patient has persistent asystole despite 20 min of advanced life support in the absence of any reversible cause when no other clinical factors suggest against.
- TOR rules may be used to aid decision-making for adult patients with OHCA following local validation and considering local values and preferences.
- TOR rules should not be used for IHCA and for paediatric patients in any setting due to insufficient evidence.
- Persistently low $ETCO_2$ is a strong prognostic marker that may be used to aid decision making in addition to other factors but should not be used in isolation.
- Other factors such as cardiac ultrasound, blood gases, and pupil reactiveness are not valid factors for termination of resuscitation (Fig. 35).

Uncontrolled organ donation after circulatory death

- Healthcare systems should assess their current policies and strategies regarding organ donation to improve organ availability while considering their sociocultural and religious context.
- Healthcare systems should invest in education and communication for both citizens and healthcare professionals.
- In healthcare systems that offer uncontrolled donation after circulatory determination of death, transparent procedures should be accessible to all those involved. These procedures should cover aspects such as donor identification, consent, organ preservation, and procurement.
- Moreover, TOR practices within these systems should be reviewed and adjusted to ensure they do not conflict with the possibility of uncontrolled organ donation after circulatory death.

Ethics of education and systems

- Establish ethical reasoning as a core competency in resuscitation education to strengthen critical thinking, ethical judgment, and decision-making that respects patient autonomy, follows medical best practices, and aligns with societal values.
- Implement simulation-based ethics training to provide healthcare professionals with hands-on experience in ethically complex resuscitation scenarios, including cases involving communication and decision-making regarding advance care planning, DNACPR decisions and TOR decisions.
- Introduce ethical preparedness education for resuscitation providers to develop strategies for managing moral distress, addressing ethical dilemmas, and overcoming institutional constraints that impact decision-making in high-pressure situations.
- Standardise institutional policies on advance care planning, DNACPR decisions, and TOR by embedding structured ethical frameworks that provide clear, legally and professionally aligned guidance for resuscitation decisions.
- Develop formal education programs to equip healthcare professionals with the skills to navigate institutional constraints, legal uncertainties, and policy inconsistencies in ethically complex resuscitation cases.
- Establish ethical oversight mechanisms within resuscitation policies to promote patient-centred, transparent, and ethically sound decision-making at institutional levels.

Cardiac arrest as a result of a suicide attempt

- In making decisions about withholding or withdrawing resuscitation in patients after attempted suicide, teams should consider various factors, such as context, patient motivations, and competing rights.
- If there is an advance directive, we still suggest initiating resuscitation until the context and background – clinical and ethical – of that advance directive is fully known.
- The response to the clinical situation should be tailored to the individual patient and not be dogmatic.
- If resuscitation likely results in significantly more harm than benefit, then the cause (being suicide) becomes irrelevant.

Resuscitation research ethics

- Systems should support the delivery of high-quality emergency research, as an essential component of optimising patient-centred cardiac arrest outcomes.
- Regulatory and procedural barriers to high-quality emergency research related to consent models should be minimised by legal improvements. For example, clear legal support for deferred consent may be extended to non-drug investigational interventions to minimise any pertinent ambiguity, while still maintaining adequate safeguards for patient and family autonomy, dignity and privacy.
- For observational research (e.g. in the context of registry data collection and/or DNA biobank data sampling and analyses) we suggest consideration of a deferred consent model, with concurrent implementation of appropriate safeguards aimed at preventing data breaches and patient reidentification.
- Researchers should involve patients, and members of the public as community advisors, throughout the research process, including design, delivery and research dissemination.
- Systems should promote education of the public regarding applicable regulations and the necessity of using deferred consent for emergency research. This initiative may enhance willingness for research participation.
- The use of a core outcome set, along with standardised corresponding terminology, should be harmonised across trials investigating clinical effectiveness.
- Communities or populations in which research is undertaken and who bear the risk of research-related adverse events, should be given the opportunity to benefit from its results.
- Researchers should comply with best practice guidance to ensure integrity and transparency of research, including study protocol registration, prompt reporting of results, allocation of authorship according to international criteria for authorship, and data sharing.
- Policies of governments, public health bodies, international societies, and non-profit organisations should aim to ensure that funding for cardiac arrest research is sufficient to effectively address the high societal burden caused by cardiac arrest-associated morbidity and mortality.
- Health authorities should augment systems' resilience to pandemic-associated (or other calamity-induced) disruption of resuscitation research by cost-effective use of available computer and telecommunication/telemedicine technology and

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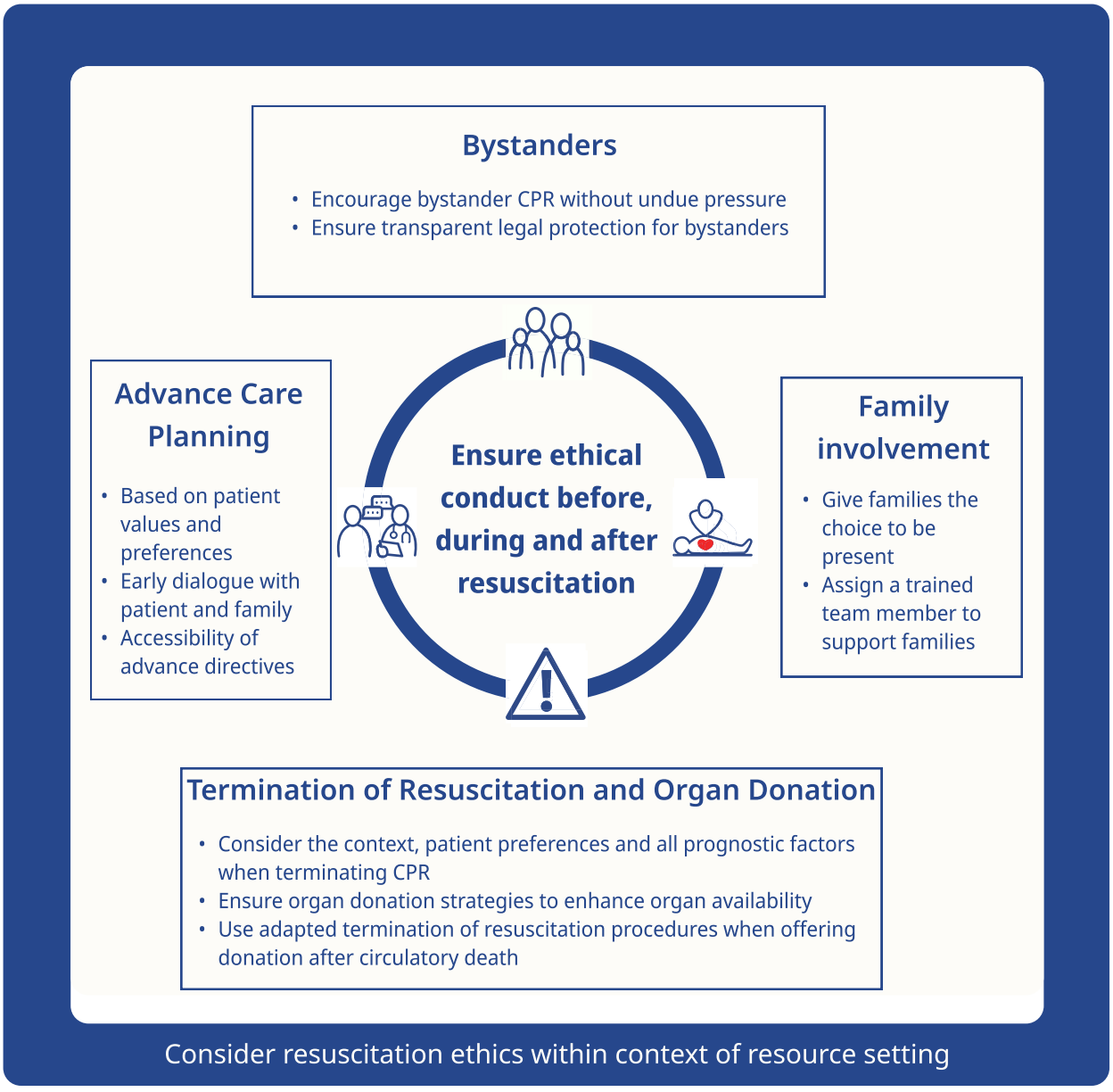


Fig. 35 – Ethical considerations before, during and after resuscitation.

infrastructure, and other occasion-specific measures, such as personal protection and widespread/prompt vaccination.

- Use of AI in research should be regulated according to rigorous ethical and scientific safeguards for beneficence, autonomy/privacy and justice. As an example, development of new AI algorithms should be based on broad datasets from the general population, rather than datasets from socioeconomically privileged groups.

First aid

The ERC First Aid Guidelines 2025 include evidence-informed first aid management of emergency medicine and trauma related to resuscitation and prevention of cardiac arrest.[73] (Fig. 36).

Implementation of first aid guidelines and considerations for different settings

Considering differences across these four essential domains will support guideline implementation:

- First aid recipient (e.g. age, sex, gender, health status, capacity to provide consent).
- First aid provider (e.g. knowledge, training/education, preparedness, familiarity, duty to respond, professional scope, capability).
- Treatment (e.g. invasiveness, skills required, technology, efficacy and effectiveness, cost).
- Setting and environment (e.g. low- or high-resource, safety, cultural norms and values, urban or remote).

Expectations of a first aid provider

As a first aid provider, you may minimise further injury, improve health and prevent death by following these three key principles:

- Check for scene safety.
- Call your local emergency number as soon as possible.
- Only use available equipment or medications you have been trained to use.

First aid courses

- First aid courses should be accessible to the widest possible audience and promote equal opportunities in both providing and receiving first aid.
- Course providers should tailor content based on the needs of participants, their context (low-resource settings, rural areas), sociocultural appropriateness and feasibility.
- Courses should teach awareness of the regional Good Samaritan laws.

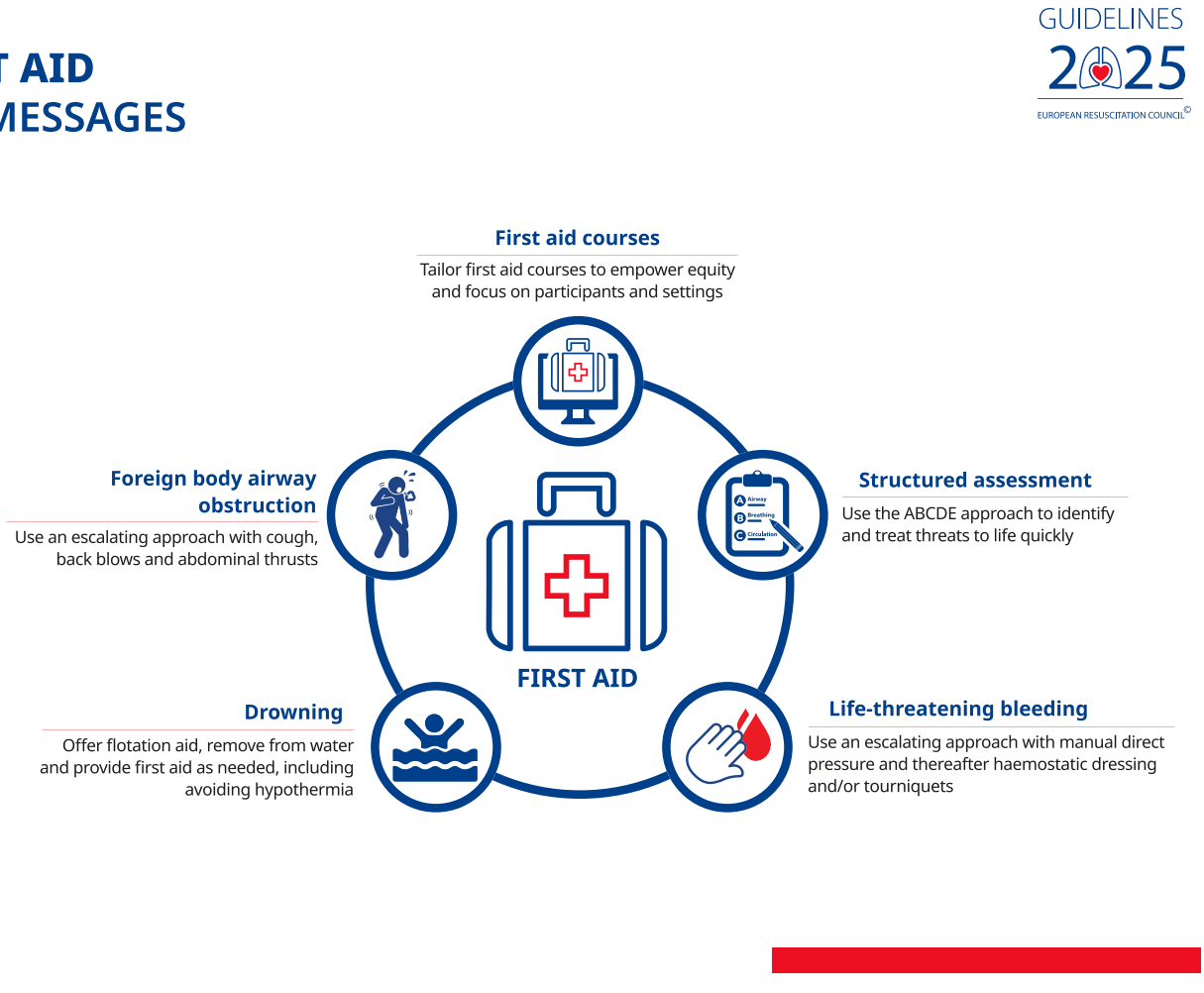


Fig. 36 – Key messages first aid.

- Courses should include measures to help bystanders, lay rescuers and professional first aid providers to overcome fear, anxiety and moral distress during and after providing first aid.

First aid kits

- All workplaces, leisure centres, public buildings, homes and cars should have first aid kits.
- Public first aid kits should meet local legal requirements, be clearly marked and readily accessible.
- The content of the kits should be based on the setting, expected risks and the users.
- All first aid kits should be inspected regularly and properly maintained.

Cardiac arrest

- If you suspect a cardiac arrest, call the emergency number (112) and follow the dispatcher instructions on how to perform cardiopulmonary resuscitation (CPR).
- Start CPR without worrying about accidentally hurting the person. It is more important to try to save their life than causing an injury.
- Continue CPR until professional help arrives and takes over or tells you to stop.

Structured first aid assessment of a person appearing ill, injured or in shock (ABCDE)

- Pay immediate attention to safety, responsiveness of the victim, and catastrophic bleeding.
- Use the ABCDE framework to structure your assessment of a person in need.

Recovery position

- Place adults and children with decreased level of responsiveness who do NOT meet the criteria for CPR into a lateral (side-lying) recovery position.
- In situations such as agonal breathing or trauma, do NOT move the person into the recovery position.

Use of a pulse oximetry and use of oxygen for acute difficulty breathing

- Give oxygen to a person with difficulty breathing and looking cyanosed (blue tinged) but only if you are trained in its use.
- Use a pulse oximeter to titrate the administered oxygen.
- Give oxygen via a simple facemask or non-rebreathing mask. Titrate flow rate to maintain an oxygen saturation of 94–98 %.
- If the person has chronic obstructive pulmonary disease, titrate the oxygen flow to maintain an oxygen saturation between 88 % and 92 %.
- In the presence of life-threatening hypoxaemia (oxygen saturation <88 %) give oxygen with a higher flow to everyone, including persons with chronic obstructive pulmonary disease having difficulty in breathing in the out-of-hospital setting.

Medical emergencies

Anaphylaxis

- Suspect anaphylaxis if someone has:
  - Stridor (which could be due to upper airway swelling), wheezing (which could be due to lower airway obstruction) or breathing difficulties.
  - Flushing, rash (hives), cold or clammy skin or is feeling faint.
  - Abdominal pain, vomiting, or diarrhoea.
  - A recent exposure to known food allergens or insect stings.
- Call your emergency number (112).
- Ensure that the person remains in a sitting or lying position.
- Give intramuscular adrenaline as soon as possible via autoinjector into the outer thigh in the recommended dose (self-administered or given by trained individuals).
  - 0.15 mg for children aged 1–5 years.
  - 0.3 mg for children aged 6–12 years.
  - 0.5 mg for adults.
- If an autoinjector is not available, use a device for intranasal administration.
- Give a second dose of adrenaline, if symptoms persist 5 min after administration.

Choking in an adult

- Suspect choking if a person is suddenly unable to speak or talk, particularly if eating.
- Ask the person – "Are you choking?"
- Encourage the person to cough.
- If unable to cough or the cough becomes ineffective, give up to 5 back blows.
- If back blows are ineffective, give up to 5 abdominal thrusts.
- If choking has not been relieved after 5 abdominal thrusts, continue alternating 5 back blows with 5 abdominal thrusts until choking is relieved, or the person becomes unresponsive.
- Call your emergency number (112).
- Do NOT use blind finger sweeps to try and remove a foreign body from the mouth or airway.
- If the person becomes unresponsive, start CPR.
- Any person successfully treated for choking with abdominal thrusts or chest compressions should be evaluated by a healthcare practitioner since complications and injuries may occur.

Asthma

- Assist persons with asthma who are having problems in using their own bronchodilator device.

Chest pain *in a responsive adult*

- Reassure the person and sit or lie them in a comfortable position.
- Encourage and assist a person with cardiac sounding chest pain in self-administering 150–500 mg of chewable aspirin as soon as possible whilst awaiting transport to hospital (but not to adults with known aspirin allergy).
- Assist a person with known angina to self-administer their own nitro-glycerine spray or tablets.
- Stay with the person until help arrives.

Hypoglycaemia (low blood sugar value)

- Suspect hypoglycaemia in someone with diabetes or chronic malnutrition and sudden impaired responsiveness or behavioural change.
- Give glucose or dextrose tablets (15–20 g), by mouth if the person is awake and able to swallow.
- If feasible, measure capillary blood sugar using a blood glucose meter and treat if low (a value less than 4.0 mmol L^{-1} or 70 mg dL^{-1}) and repeat measurement after treatment.

- If glucose or dextrose tablets are not available give other dietary sugars, such as a handful of sugary sweets or 50–100 mL of fruit juice or sugar containing soda
- If oral glucose is not available, give a glucose gel (partially held in the cheek, and partially swallowed).
- Repeat giving oral glucose if the symptoms are still present and not improving after 15 min.
- If the person has a prescribed glucagon autoinjector, this could be administered under the skin in the outer thigh (self-administered or by trained individuals). Some diabetics may have glucagon syringes for nasal use.
- For children, consider administering half a teaspoon of table sugar (2.5 g) under the child's tongue, if they are uncooperative with swallowing oral glucose.
- Call your emergency number (112) if the person is/or becomes unresponsive or the condition does not improve.
- Following recovery from symptoms (5–10 min after sugar intake) encourage the person to eat a light snack.
- For unresponsive persons, do not give oral sugar due to the risk of aspiration, instead call your local emergency number (112).

Opioid overdose

- Suspect an opioid overdose if the person is breathing is slowly, irregularly or not at all, is extremely drowsy or unresponsive, or has pinpoint (very small) pupils.
- If the person is unresponsive and not breathing normally, start CPR CPR and call your local emergency number (112).
- Administer intra-nasal naloxone, or if you are trained, use an intramuscular naloxone autoinjector.
- Reassess the person according to ABCDE.
- Follow package instructions on when to give another dose of naloxone.

The management of general intoxications and opioid overdose has been described in the ERC Guidelines 2025 Special Circumstances in Resuscitation (Fig. 37).

Stroke

- Use a stroke assessment scale to decrease the time to recognition and call for help.
- Give oxygen only if you are trained in its use and the person is showing signs of hypoxia (bluish lips and rapid breathing).

Suicidal thoughts

If you think a person might harm themselves;

- Ask the individual "Are you alright?" "How do you feel and why"?
- Ask if the person has suicidal thoughts and plans (how? where? when?).
- Summarise to the person your understanding of how and why they have certain feelings.
- If the person has made concrete threats or plans for suicide, tell them you are going to ask for help, and call your emergency number (112).
- Give hope.

Trauma emergencies

Cervical spinal motion restriction

- Suspect a cervical spine injury in a person who fell or dived from a height, was crushed by machinery or a heavy object, was involved in a road traffic, or a sporting accident.
- Minimise movement of the neck if the person is awake and alert and encourage them to self-maintain their neck in a comfortable stable position.
- Never force an uncooperative person into any position, as this may exacerbate an injury.
- In unresponsive persons lying on their back, kneel behind their head and immobilise their head and neck using head or trapezius squeeze.
- Consider the need to open the person's airway using the 'jaw-thrust' technique.
- If the person is unresponsive and is lying face-down, check if their airway is open and hold their neck in a stable position
- If you need to open their airway, ask others to help you carefully roll them as a unit onto their back whilst keeping their neck in line with their body and as stable as possible. Then apply the head or trapezius squeeze.
- First aid responders with specialised training (e.g. ski patrol, lifeguard) may consider the selective use of spinal motion restriction using their existing protocols.

Control of life-threatening bleeding

- Apply firm direct manual pressure to the bleeding injury.
- Apply a standard or haemostatic dressing directly to the bleeding injury and then apply firm direct manual pressure on top of the dressing.
- Once bleeding is under control, apply a pressure dressing.
- Apply a tourniquet as soon as possible for life-threatening extremity bleeding that is not controlled by direct manual pressure.
- Write the time of application on the tourniquet.

Open chest wounds

- Leave an open chest wound exposed to freely communicate with the external environment.
- Do not apply a dressing or cover the wound.
- If necessary, control localised bleeding with direct pressure.
- If you are trained and the equipment is available, apply a specialised non-occlusive or vented dressing, ensuring a free outflow of air when breathing out.
- Observe the wound for air flow obstruction due to bleeding or clotted blood.

Concussion

- Suspect concussion if a person has difficulties with thinking/remembering, displays physical symptoms (headache, change in vision, dizziness, nausea or vomiting, seizures, sensitivity to light/noise), emotional changes or changes in behaviour (increased sleepiness, reduction in normal activities, loss of responsiveness, confusion).
- Remove the person from physical activities.
- Refer to a healthcare professional for further advice and assessment.

Preservation of an amputated body part

- Manage any severe bleeding first (see 'Control of life-threatening bleeding').
- Retrieve the body part as quickly as possible and keep it cold without freezing.
  - Wrap the part in a sterile dressing or a clean cloth moistened with saline or water.

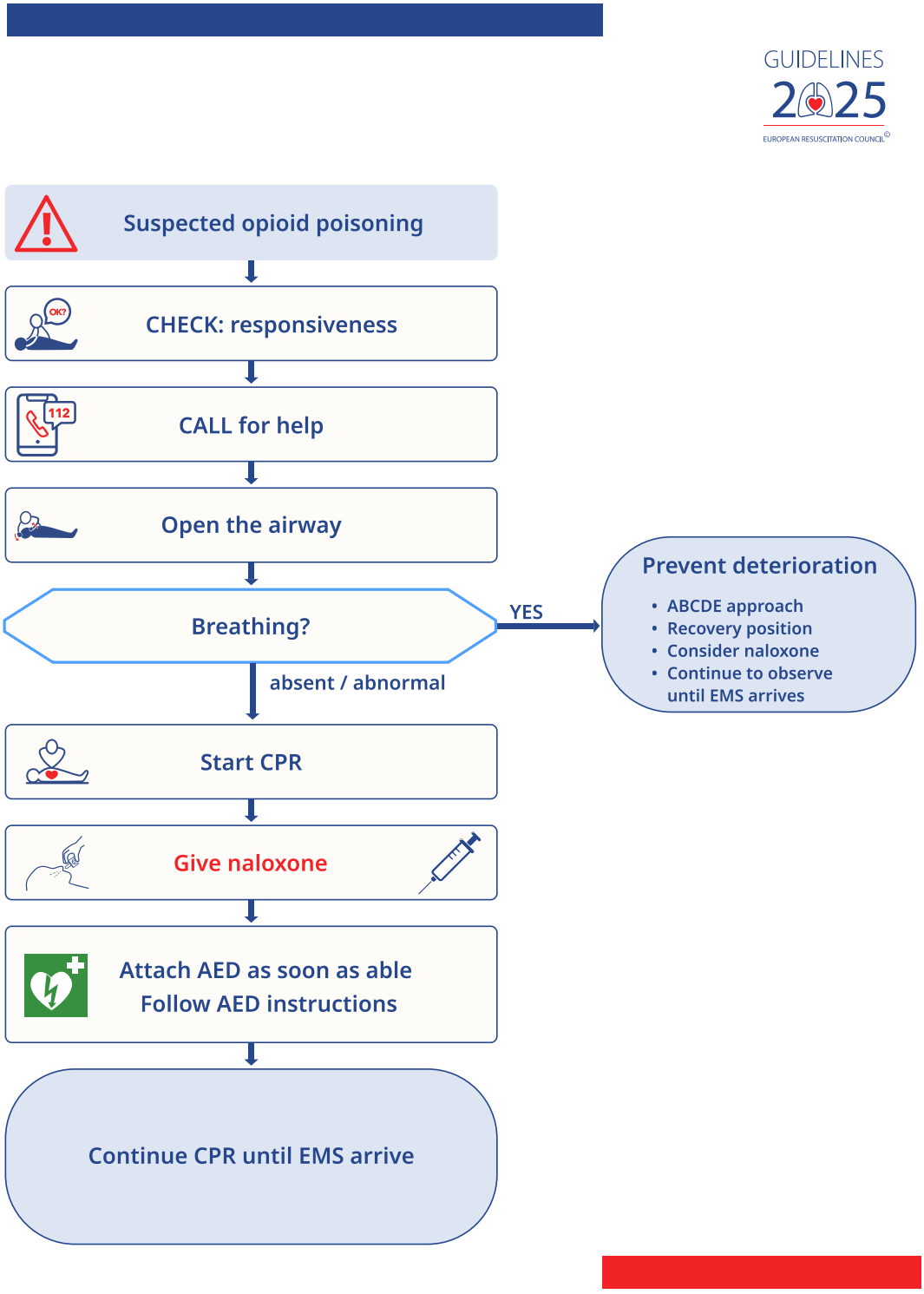


Fig. 37 – Order of actions for opioid overdose.

- o Place the wrapped part in a clean watertight plastic bag or container.
- o Put the watertight bag or container holding the body part, inside another bag containing ice or ice-water. If ice is unavailable, you can use a cooler with instant cold packs.
- Keep the part always cooled. Avoid direct contact with ice or freezing. Label the container with the person's name and time the part was stored.
- Transport the part with the injured person to the same hospital as quickly as possible.

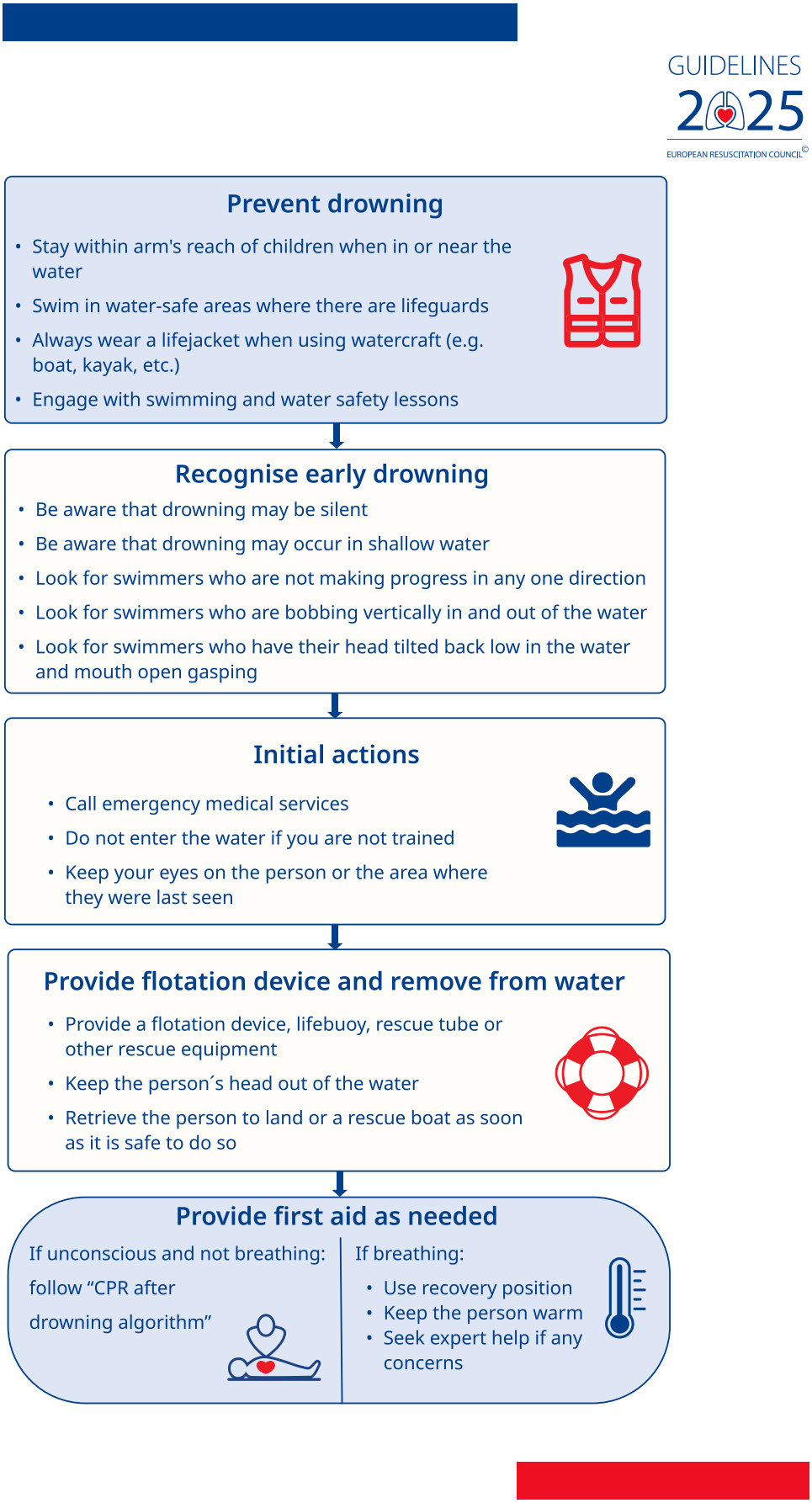


Fig. 38 – First aid in drowning.

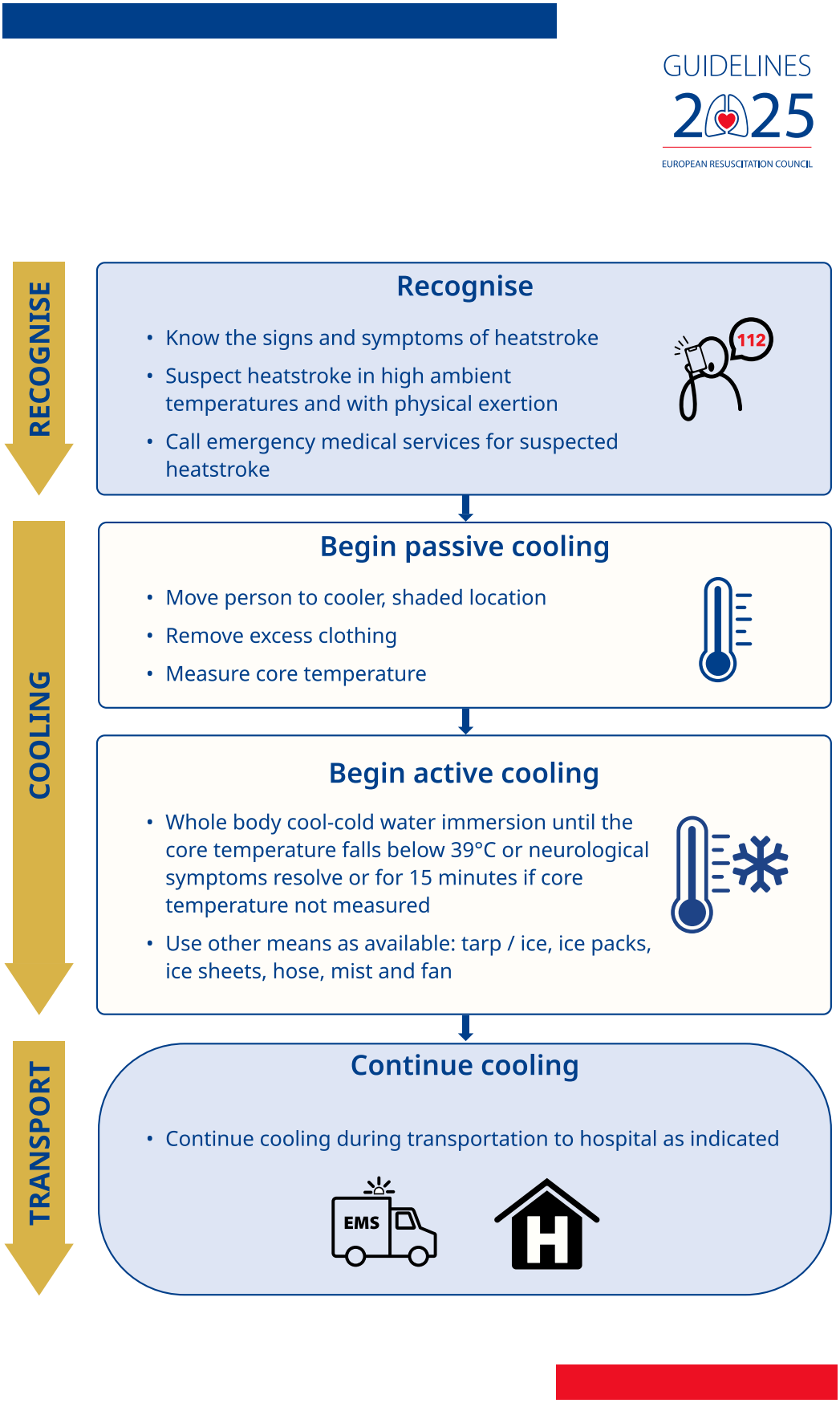


Fig. 39 – Management of heatstroke and exertional hyperthermia.

Environmental emergencies

Drowning

- Do not enter the water as you might risk drowning yourself if you are not trained in water rescue.
- If the person is awake and responsive, stay on land and reach out to the person through floatation devices, lifebuoy, rescue tube or other rescue equipment.

Trained first aiders or lifeguards in the water or on a boat:

- Call for help before you enter the water.
- Provide a flotation device, lifebuoy, rescue tube or other rescue equipment.
- Keep the person´s head out of the water.
- Assess if the person is unresponsive and not breathing. If feasible and safe (with an effective flotation device), provide 5 rescue breaths in the water as soon as possible.
- Retrieve the person to land or a rescue boat as soon as possible.
- Once out of the water, provide 5 rescue breaths if the person is not breathing, if necessary, start standard CPR.
- Attach an AED, if available and after drying the chest, and follow the instructions (Fig. 38).

On land, if the person has drowned and is unresponsive and not breathing:

- If feasible and safe, provide 5 rescue breaths and start standard CPR.
- Attach an AED, if available and after drying the chest, and follow the instructions.

Prevention of hypothermia

- Insulation: Cover the individual with dry blankets or clothing to minimise heat loss.
- Wind protection: Shield the person from wind using barriers or by moving them to a sheltered area.
- Wet clothing removal: Gently remove wet clothing and replace it with dry garments to prevent further cooling.
- Ground isolation: Place insulating materials, such as blankets or pads, between the individual and the cold ground.
- In settings where hypothermia might be common, implement tailored prevention plans and training for first aid providers.

Heat stroke

- Consider symptoms of heat stroke with high ambient temperature, like elevated core body temperature, confusion, agitation, disorientation, seizures or unresponsiveness.
- Prevent exertional heat stroke (i.e. during long-distance sport events in a hot climate) by adequate preparation and provide tools for diagnosis (e.g.: rectal temperature probes) and cooling (e.g. immersion ice-water baths).
- With suspected heat stroke remove the person from the heat source and commence passive cooling by removing excess clothing and placing the person in a cooler/shaded location.
- Use any technique immediately available to provide active cooling, if core temperature >40 °C.
- Use whole body (neck down) cold water (1 to 26 °C) immersion until the core temperature falls below 39 °C, alternatives are: tarp-assisted cooling oscillation (TACO) ice sheets, commercial ice packs, fan alone, cold shower, hand cooling devices, cooling vests and jackets or evaporative cooling (mist and fan).
- Where possible monitor core temperature (rectal thermometer).
- If a core temperature cannot be obtained, continue cooling for 15 min or until neurological symptoms resolve, whichever is first.
- Remember: cool first, transfer second.
- Continue cooling as needed during transportation to a medical facility for further evaluation (Fig. 39).

Snake bite

The only indigenous highly venomous snake in Europe is the European Viper, which has a haemolytic toxic venom.

- Call your local emergency number (112).
- Keep the person calm and at rest.
- Keep the bitten body part still and immobilise the affected limb as this may slow venom spread.
- Remove tight clothes, rings or watches from the affected limb.
- Avoid harmful actions:
  - Do not apply a pressure dressing, ice, heat, or use tourniquets.
  - Do not cut the wound and never try to suck out the venom.

Declaration of competing interest

Declarations of competing interests for all ERC Guidelines authors are displayed in a COI table which can be found online at https://doi.org/10.1016/j.resuscitation.2025.110770.

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Practice Guideline

European Resuscitation Council Guidelines 2025 Epidemiology in Resuscitation

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Abstract

These European Resuscitation Council Guidelines 2025 on epidemiology of resuscitation provides key information about incidence, patients' characteristics, system organisation and outcomes for both out-of-hospital and in-hospital cardiac arrest in Europe and beyond. Information regarding patients' post survival experience and causes of cardiac arrest, including genetic factors, are also reported. Recommendations are provided to support the development of cardiac arrest registries, and improve out-of-hospital cardiac arrest (OHCA) follow-up with an emphasis on quality of life, and perform autopsy including genetic analysis in young individuals.

Keywords: Cardiac arrest, Epidemiology, Incidence of cardiac arrest, Genetics, OHCA, IHCA, Registries

Introduction

Cardiac arrest is one of the leading causes of death worldwide.[1,2] Whether cardiac arrest occurs outside the hospital (i.e. out-of-hospital cardiac arrest – OHCA) or inside the hospital (in-hospital cardiac arrest – IHCA), differences in incidence and outcome have been reported over the years across countries.[3–5] These differences are due to several reasons, including variations in population characteristics (e.g. age, socio-economic status, co-morbidities), in system organisation (e.g. different emergency medical services (EMS) systems or differences in teams responding to IHCA; geographical variation; implementation of first responders network), and treatment provided by the system of care (e.g. quality of CPR, interventions, decisions on when initiate or terminate resuscitation, post-resuscitation care).[6] Differences also arise from variation in data collection practices (e.g. case definition, ascertainment methods and outcome verification).

For these reasons, since the early 1990s, the Utstein recommendations on outcome reports for OHCA and IHCA have been published and periodically updated to provide researchers with a single template to facilitate and harmonise data collection.[7–9] This enables inter-system and intra-system comparisons to identify gaps in knowledge, and to support clinical research.[8,9] Understanding the epidemiology of cardiac arrest as accurately as possible is a step towards understanding its causes, improving treatments and patients' outcomes.[10] This chapter provides an overview of incidence, patient characteristics, system organisation and outcomes of OHCA and IHCA. It also focuses on post-survival recovery and underlying causes of cardiac arrest (SCA), including genetic factors (Fig. 1).

The chapter focuses mainly on epidemiology in European countries; however, reference is also made to non-European countries. A section on epidemiology in lower resourced countries and remote areas is also included.

Individual search strategies were constructed for each section of these Guidelines. Searches were conducted using PubMed,

Abbreviations: AED, Automated External Defibrillator, COSCA, Core Outcome Set for Cardiac Arrest, CPC, Cerebral Performance Category, CPR, cardiopulmonary resuscitation, EDTA, Ethylenediaminetetraacetic acid, EMS, emergency medical services, ERC, European Resuscitation Council, IHCA, in-hospital cardiac arrest, ILCOR, International Liaison Committee on Resuscitation, OHCA, out-of-hospital cardiac arrest, ROSC, Return of spontaneous circulation, VF, ventricular fibrillation

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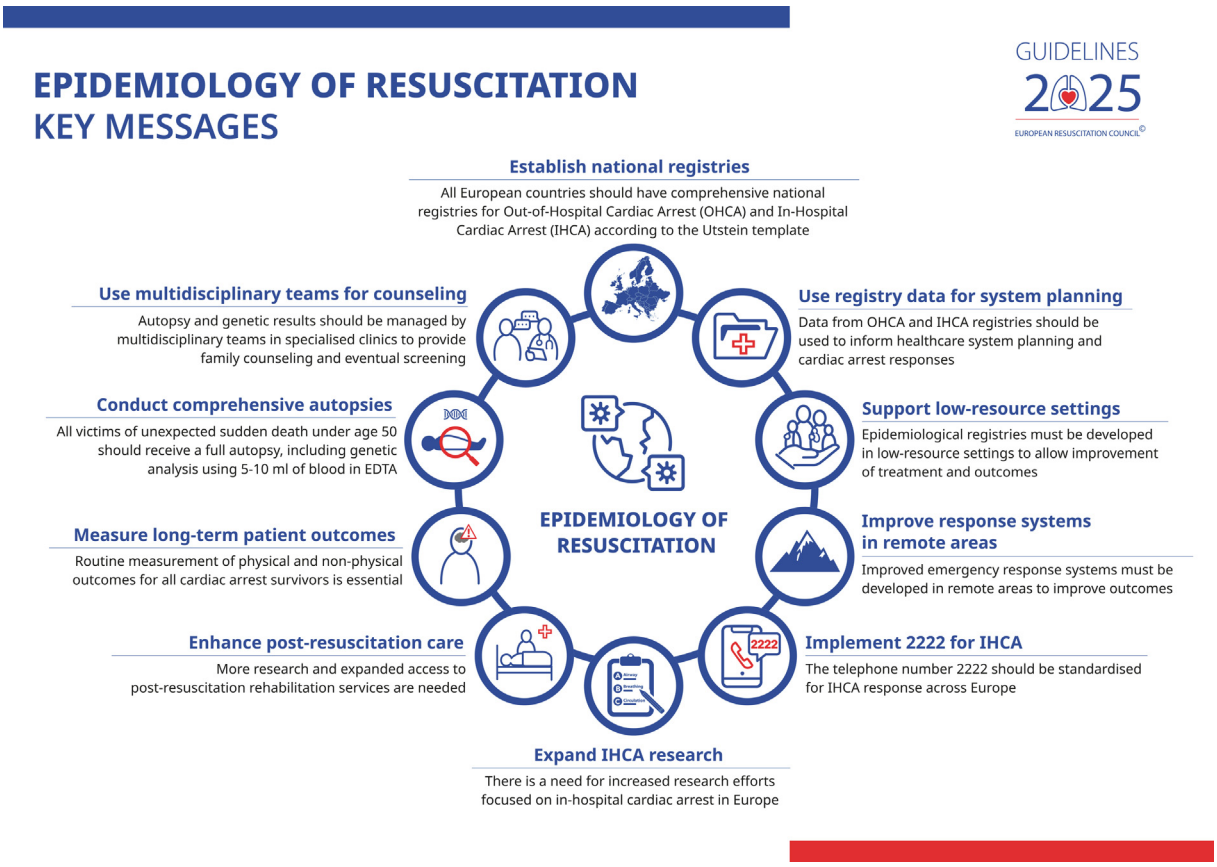


Fig. 1 – Epidemiology of resuscitation – key messages.

Embase and Cochrane. Only publications in English from the last 10 years were included, unless there was limited literature available or in the case of particularly relevant articles (i.e. articles with key information not included in subsequent studies). Abstracts were reviewed by at least two authors and relevant articles were read in full-text.

These Guidelines were drafted, discussed and agreed upon by the European Resuscitation Council (ERC) Epidemiology in Resuscitation Writing Group and the ERC Guidelines 2025 Steering Committee. This Guideline was posted for public comment between 5 and 30. May 2025. A total of 21 individuals submitted 22 comments, leading to 10 changes in the final version. Subsequently, the feedback was reviewed by the writing group, and the Guideline was then updated where relevant. The Guideline was presented to and approved by the ERC Board and the ERC General Assembly in June 2025. The methodology used for guideline development is presented in the executive summary.[11]

Summary of facts on epidemiology in resuscitation

Out-of-hospital cardiac arrest

- The annual incidence of EMS-treated OHCA in Europe is 55 per 100,000 inhabitants.
- The mean age of patients is of 67.2 ± 17.3 years.
- Male subjects account for 65 %.
- Seventy percent occur in private locations.
- A shockable rhythm is the initial presentation in 20 % of cardiac arrests; 91 % have a medical aetiology.
- Nine European countries have an OHCA registry with full population coverage and 17 countries have a first responder system at least at a local level.
- The bystander CPR rate in Europe is 58 % with significant regional variations (from 13 % to 82 %).
- The use of an AED before EMS arrival varies from 2.6 % to 59 % in different European countries.
- Survival after OHCA in Europe is 7.5 % with a range in European countries from 3.1 % to 35 %.

In-hospital cardiac arrest

- The annual incidence of IHCA in Europe is 1.5 to 2.8 per 1000 hospital admissions.
- The proposed standard internal telephone number to alert the emergency team (2222) for IHCA in Europe is implemented in 2 % of countries only.

Long term survival and return to societal participation

- In European countries where withdrawal of life sustaining treatment is practised, poor neurological outcomes occur in less than 10 % of cardiac arrest survivors, whilst in situations where withdrawal of life sustaining treatment is not practised survival with poor neurological outcome is more common.
- The majority of OHCA survivors indicate the need for post-discharge follow-up with access to a multi-disciplinary team.

- One out of three OHCA survivors receive cardiac rehabilitation and only one out of ten receive brain injury rehabilitation.

Genetic variants and autopsy in cardiac arrest patients

- A clinically actionable pathogenic or likely pathogenic variant in a gene potentially related to the cause of sudden cardiac arrest is identified in up to 25 % of OHCA cases younger than 50 years.
- Autopsy in young sudden cardiac arrest victims is currently not routinely performed in many European countries.

Low-resource settings and remote areas

- The rate of bystander CPR and AED use is lower in low-resource settings compared to high-resource settings.
- Lower resourced countries tend to lack OHCA registries according to the Utstein template and based on a reference territory
- Early BLS and rapid response by an EMS are crucial and determines the prognosis of an OHCA patient also in remote areas.

Evidence informed guideline

Out-of-hospital cardiac arrest

Incidence

The incidence of OHCA has been reported in multiple studies including the three major EuReCa studies.[2,12 5] Across all EuReCa studies, the incidence of cardiac arrest per 100,000 inhabitants demonstrated significant inter-country variation. In the 2022 three-month EuReCa-3 study, the annualised incidence ranged from 31 to 243 per 100,000 inhabitants, with an overall average of 82 per 100,000. Similarly, the incidence of EMS-treated OHCAs varied significantly with an overall incidence of 55 per 100,000 (range from 17 per 100,000 to 104 per 100,000).[5] The mean incidence of cardiac arrest remained consistent throughout the 8 years of the EuReCa studies. (Table 1).[2,5,12]

Accurately estimating the true incidence of OHCA remains challenging because of reporting limitations—most notably, the restriction to cases treated by emergency medical services (EMS), which likely underestimates the overall burden of disease. The proportion of patients with cardiac arrest where no resuscitation was started may differ systematically because of cultural norms or religious beliefs, bystanders' willingness to start CPR and variations in how and when the EMS are alerted.[13] As highlighted by the EuReCa THREE study, only EMS-treated OHCAs are reported in many European countries, meaning the reasons for not initiating CPR are missing from a significant portion of the population.[5] Given that dispatch centres serve a gatekeeping role for ambulance services and that most use a standardised dispatch protocol,[14] it should be feasible in the future to systematically collect data on true incidence of cardiac arrest. This aligns with the recent Utstein update on data collection from dispatch centres.[8]

The number of reported OHCAs in Europe has increased in recent years when compared with one or two decades ago.[5,12,15] Whether these differences reflect an increased number of OHCAs or simply a more comprehensive reporting is unclear. It is unknown if this can be partly explained by improved case ascertainment methods and increased coverage by regional and national registries or by an increase in intervention initiated before EMS arrival.

European OHCA incidence appears consistent with non-European settings. EMS-treated OHCA rates range from 44 to 56 per 100,000 population in Australia, New Zealand, Singapore, and South Korea, to 62–76 in the United States, and up to 97–100 in Japan—illustrating a similar degree of international variation.[16–18]

The incidence of OHCA was impacted by the COVID-19 pandemic. During the early stages of the outbreak, regions severely affected by the virus, such as Northern Italy and the Paris region in France, reported an increase in OHCA incidence of up to 187 % compared with the same period in the previous year.[19,20] Further analysis confirmed that OHCA incidence increased significantly in regions with high weekly COVID-19 incidence, returning to previous values after the end of the outbreak.[21,22]

Patients' characteristics and presenting rhythms

Patient characteristics,[23–26] event circumstances,[27–30] underlying aetiology and presenting rhythms significantly influence survival outcomes.[31] Therefore, differences in these characteristics across European countries must be considered to understand regional variation in outcomes and opportunities for improvement.

The mean age of EMS-treated OHCA was reported as 67.6 ± 17.5 year.[2] This aligns with findings from the third ILCOR report on OHCA, where the mean age ranged from 62 to 76 years, across different countries.[18] These patterns mirror the mean age of the general population in Europe [32] with similar trend in the United States, Australia and New Zealand.[17,33] Global comparisons reveal wider variability, patients from the middle east and Asia tend to be younger with a mean age of 50 years in United Arab Emirates and 57 years in

Table 1 – The mean incidence of OHCAs in the three EuReCa surveys.

	Overall OHCAs		EMS-treated OHCAs	
	Mean incidence per 100,000	Range of incidence per 100,000 across countries	Mean incidence per 100,000	Range of incidence per 100,000 across countries
EuReCa ONE[12]	84	28–160	49	19–104
EuReCa TWO[2]	89	53–166	56	27–91
EuReCa THREE[5]	82	31–243	55	17–104

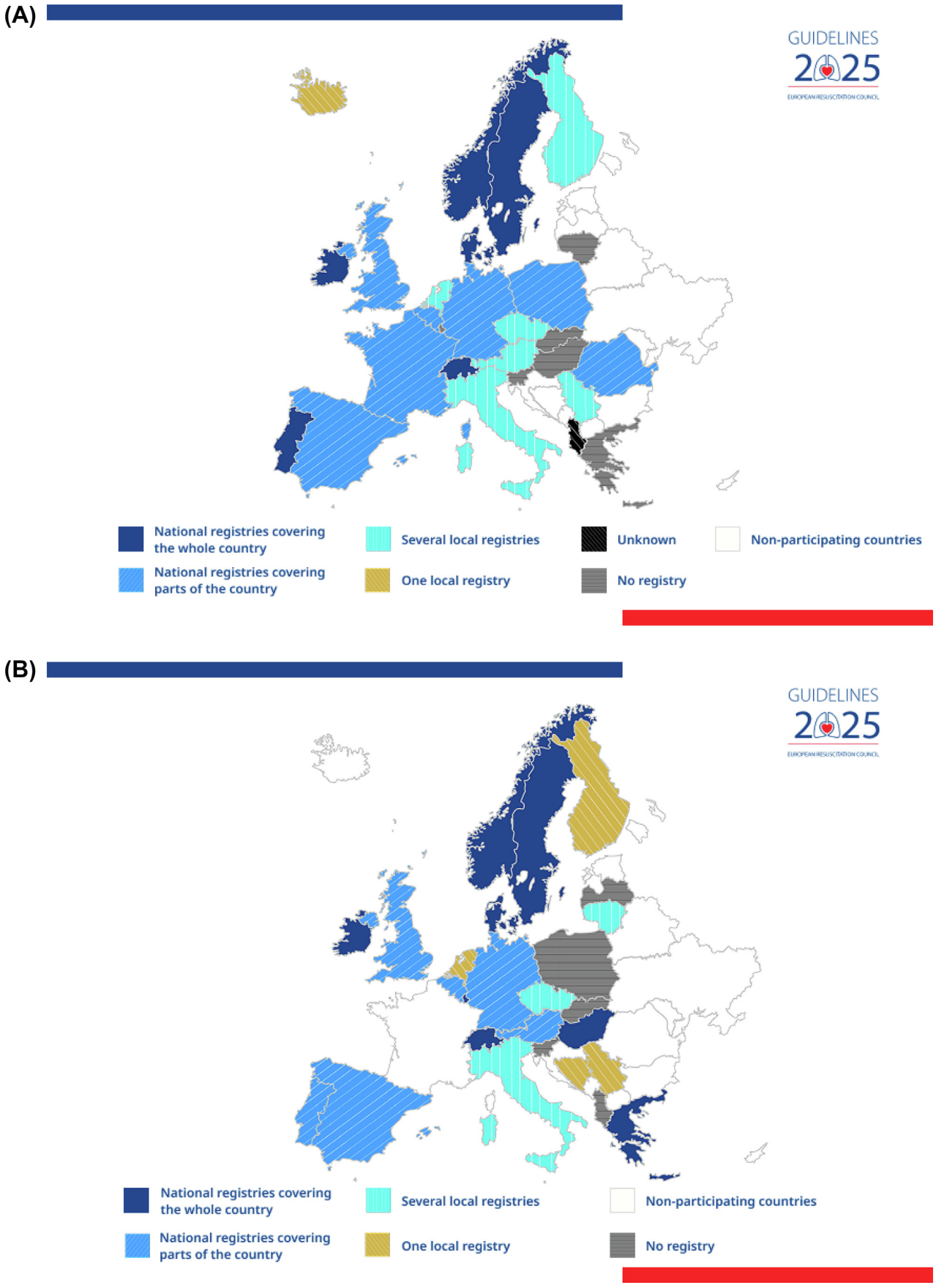


Fig. 2 – Coverage of OHCA registries in European countries in 2019 (2A) and in 2025 (2B). Countries not participating are left white.



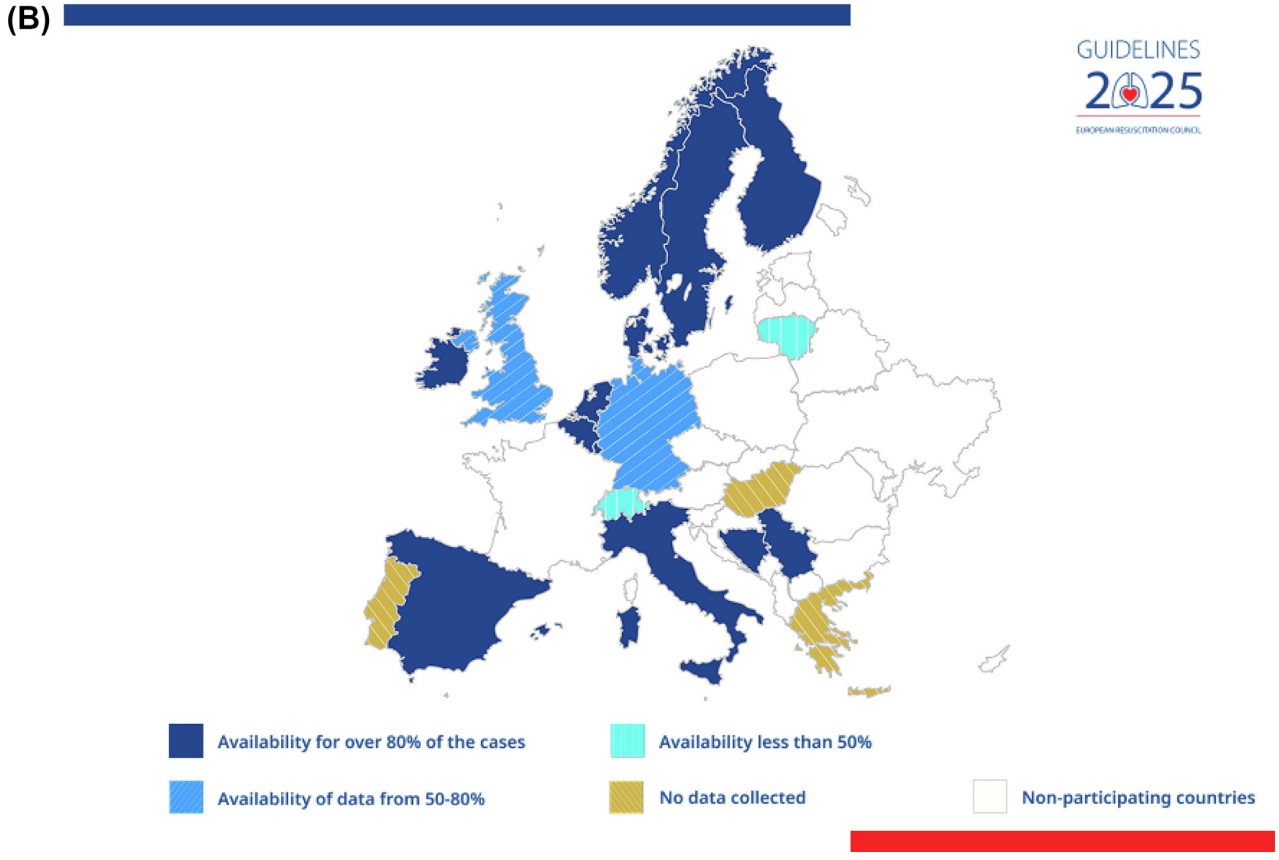


Fig. 3 – Availability of data in out-of-hospital cardiac arrest registries in Europe. Fig. 3A is ambulance data, Fig. 3B is hospital data and Fig. 3C is patient-reported quality of life data. Countries not participating are left white.

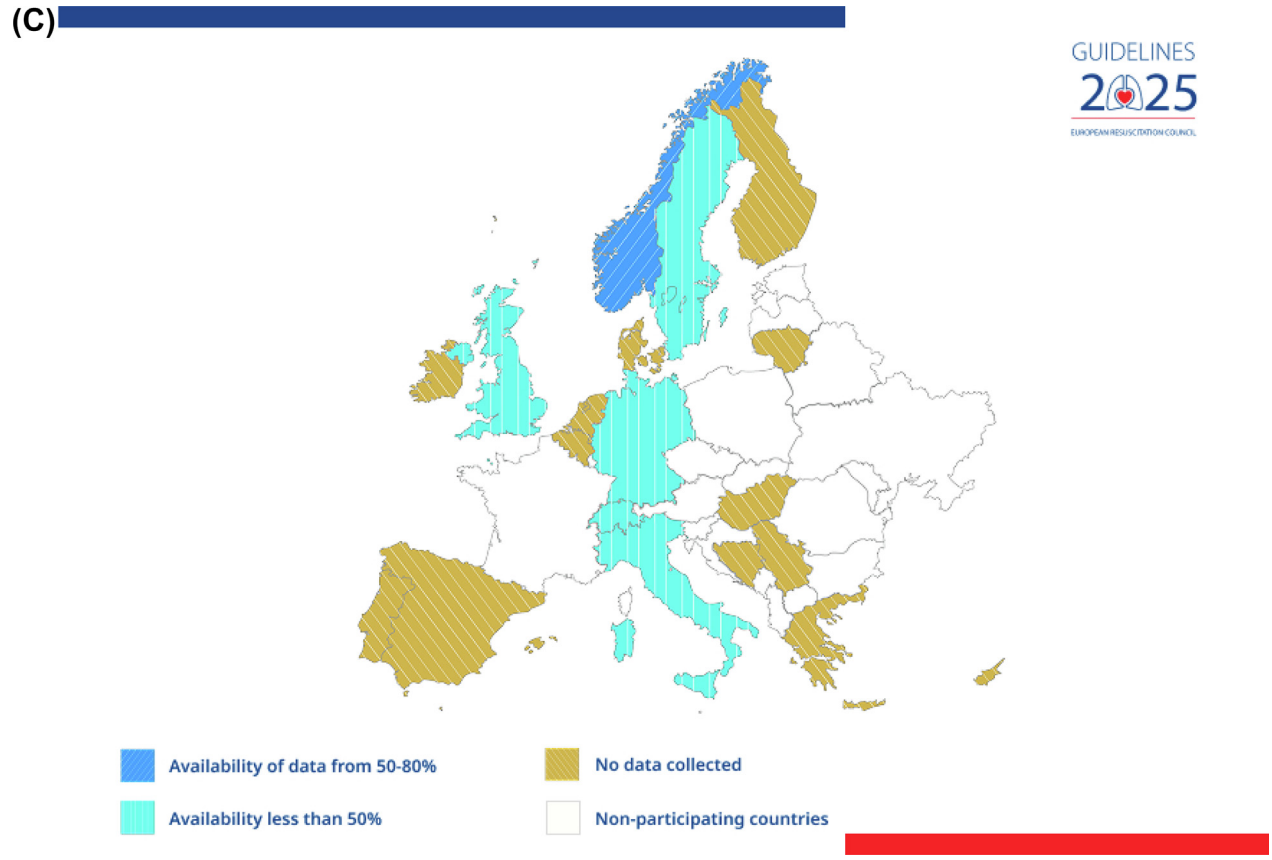


Fig 3. (continued)

Thailand. Conversely older ages have been reported in Japan (75 years) and Taiwan (76 years).[34] Interestingly, the mean age of the OHCA patients in whom the resuscitation was not started was higher than in patients in whom CPR was started (71.5 ± 17.4 years versus 67.6 ± 17.5 year).[2]

Sex distribution among OHCA patients is similar across Europe, with males representing about 65 % of patients overall,[2] e.g. 68 % in Norway and France, and just under 60 %, in Italy. [17,18] This pattern is largely in line with international data,[33,35] although lower in some countries, e.g. 57 % in Japan[17,18,34] and higher in others, e.g. 82.7 % in the United Arab Emirates.[34]

Approximately one-third of OHCA cases in Europe are unwitnessed OHCA, ranging from 17.3 % in France to 46 % in Denmark.[17] Bystanders represent the largest group of witnesses, ranging from 44 % in Germany and Denmark to 69 % in France. EMS personnel are present at the time of arrest less frequently, ranging from 8 % in Ireland to 16 % in Switzerland.[17] Outside Europe, unwitnessed OHCA exceed 50 % in the United States, Canada, Japan, South Korea, Singapore, Taiwan and United Arab Emirates,[17,18,34] whilst EMS-witnessed events seem to be similar globally.[17,33,34]

In Europe, the majority (70 %) of OHCAs occur in private residences such as the patient's home with reported rates ranging from 61.5 % in Switzerland to 76.3 % in Italy.[2] The proportion of cardiac arrests which occurred in a private residence increased during the COVID-19 pandemic.[21,36] Around 10 % of OHCAs occur in public places or in nursing homes, with fewer cases occurring in schools, sport facilities and workplaces.[17,18] These findings are consistent with data reported from United States, Australia and Japan,[16] although OHCAs in nursing homes are less common in some Asian countries (about 2–5 %).[16,18,34]

The initial rhythm of arrest is one of the most important prognostic factors for short- and long-term survival. In Europe, approximately one in five patients with an EMS-attempted resuscitation experience a 'shockable rhythm' (ventricular fibrillation (VF) or pulseless ventricular tachycardia) as the first monitored rhythm of cardiac arrest.[2] However, the rate of first monitored shockable rhythms varies three-fold across European countries from 11.4 % to 36.8 %. This may partly explain regional differences in outcomes.[2] Similar variability has been reported in other continents, such as Asia (from 4.1 % to 19.8 % in different regional areas) and Australia (22.9–44.0 %).[33,34] Emerging data suggest that the proportion of first monitored shockable rhythms may be declining over time, giving rise to a higher proportion of OHCA with initial asystole and pulseless electrical activity.[37–41] For example, in Sweden, the proportion of OHCA with an initial shockable rhythm declined from 39.5 % in 1990 to 17.4 % in 2020, with a larger difference in women (35.9 % in 1990 to 11.4 % in 2020).[38] Similar findings have been reported in other regions.[39–41]

An important consideration is that the initial rhythm reported depends on the time interval between the cardiac arrest and the first rhythm analysis. Large population studies highlighted that the odds of a shockable first monitored rhythm declined with each additional minute of no-flow time as VF degenerates into a non-shockable rhythm, and that bystander CPR significantly mitigates the degradation of shockable rhythms over time.[42–44]

Arrest aetiology strongly correlates with the initial rhythm and patient age. Medical causes precipitated 91.1 % of OHCA, while trauma, asphyxia, drug overdose, drowning and electrocution made up the remaining cases.[2] The leading cause of medical-related OHCAs include underlying cardiac aetiologies. In Sweden, the proportion of cardiac arrests caused by heart disease have declined for both men and women, from 80.5 % in 1990 to 58.7 % in 2020,[38] with similar declines observed in other high resource countries.[41] The German Resuscitation Registry reported increasing OHCA of presumed cardiac aetiology between 2006 and 2020, but with values that have risen from just below to just over 60 %.[39] Most OHCAs in adults $\geq$ 40 years are from cardiac cause.[38] Drug overdose and suicide represents the leading cause in young adults and adolescents, and this is an increasing trend in some parts of Europe (e.g. in Sweden).[45]

EMS organisation

A 2025 survey of EMS system characteristics gathered data from 27 European countries about EMS dispatch, on scene management, and coverage by cardiac arrest registries.[14] Compared with a previous survey in 2019,[46] there were changes in the countries reporting a median EMS response interval of less than ten minutes in urban areas. Austria, Cyprus, the Netherlands, Slovakia and Slovenia reported improvement, whilst Belgium, Italy, Luxembourg, Norway, Poland and Switzerland reported a deterioration.[14] Variation was noted in how response intervals are calculated according to start (e.g. starting of the call, ambulance alerting) and end points.

Early recognition and early initiation of CPR is crucial to improve survival. [47] To achieve that, several first responder systems have been established. [48,49] Only 17 countries reported having established first responder system without changes over time.[14,46]

Several countries established a new OHCA registry or expanded an already existing OHCA registry in the last five years (Fig. 2). [14,46] Currently, nine countries report having an OHCA registry with national coverage (Cyprus, Denmark, Greece, Hungary, Ireland, Luxembourg, Norway, Sweden, Switzerland).[14]

Case ascertainment and data completeness are key drivers of how representative a registry is of the population it covers.[50,51] As can be seen in Fig. 3, data completeness levels are high for EMS treatments and survival to hospital (>80 % data completeness). By contrast, data are less complete for hospital treatments. For health-related quality of life only one registry manages to capture information from more than 50 % of the survivors (Norway). Healthcare systems need reliable and accurate information if they are to be used for quality improvement purposes.[8] This highlights that there is still much room for improvement across Europe.[14]

Community response

Dispatching community first responders to cardiac arrest

A systematic review identified that eight mobile phone systems from seven countries in Europe are used to alert community first responders for OHCA.[48] This includes text messages or specially designed smartphone applications.[52] Activation radii (i.e. the distance from the scene that first responders are activated), prioritising volunteers to reach the scene, exclusion criteria (e.g. unsafe environment, patient's age) and methods for retrieval of AEDs tend to vary between systems. A recent survey of EMS systems suggests there are more systems being used across Europe than have been published in recent literature.[46]

A meta-analysis on the impact of dispatching community first responders to cardiac arrest including six European countries, reported higher CPR and AED use with community first responders compared with the conventional emergency response.[49] The activation of community first responders also improved the rate of defibrillation before EMS arrival, particularly in private homes.[53]

Risks for dispatched community first responders are rarely reported.[54] In Denmark, the rate of injury was only 26/7334 (0.35 %), with one ankle fracture reported.[55] The psychological impact of a volunteer responding to cardiac arrest was also investigated; 24.7 %, 5.5 % and 1.2 % of 5395 respondents reported low, moderate, or severe impact, respectively.[56] More severe impact was associated with lack of CPR training, younger age and female sex. Dispatching first responders seems to be equally safe in both public and private locations.[57] Taking care in terms of psychological safety, continuing motivation and standardised debriefing needs to be included in first responder systems.[58]

Bystander CPR and defibrillation rates

Bystander CPR rates vary across Europe with a mean bystander CPR rate of 58 %, but with a very wide range (13 % to 82 %). [2,59] A common barrier to starting bystander CPR is a lack of knowledge (29.9 %). In a survey, even among those who reported that they knew what to do during an OHCA and how an AED works, few were able to mention specific actions required.[60] A meta-analysis including 23 studies (10 from European countries) reported advanced age, lower socioeconomic and educational status, and marginalisation groups (due to race or language differences) were barriers to lay persons participating in resuscitation training.[61] Enablers identified were having previously witnessed a collapse, awareness of AEDs locations, certain occupations, and legal requirements for training.[61] The rate of bystander CPR appears to be influenced by the population awareness about OHCA. Community interventions such as 'Restart a Heart' may contribute to improved bystander CPR rates.[62]

Database analyses suggests that bystanders are more likely to perform chest compression-only CPR than standard CPR, but with a wide variability across European countries.[15,63] Socioeconomic status affects the probability of receiving bystander CPR and socially deprived areas in a country have a lower probability of bystander CPR.[64] A review of 29 studies across 35 countries (including 9 studies from Europe) also reported higher rates of bystander CPR in countries with a higher Gross Domestic Product per capita.[65,66]

Unwitnessed OHCA at home and among older people are less often resuscitated by bystanders.[67] In contrast, in the case of exercise-related cardiac arrest, although representing a minority of all OHCAs, there is a much higher rate of bystander CPR reported than for other OHCAs (95 % vs 77.4 % in Denmark).[68] Similarly, bystander AED use was higher for exercise-related OHCA compared with the general OHCA population (38.3 % vs 7.5 % in a Danish population).[68]

The rate of AED use remains variable in European countries, ranging from 2.6 % to 59 % of cases, although an increase has been observed in some countries in the last decade.[69] Bystander defibrillation is reported as less likely in urban settings, at home, and in women.[70]

Community response during COVID-19 pandemic

According to a meta-analysis including approximately 50,000 OHCAs from around the world, the reduction in bystander CPR rate was directly related to the weekly COVID-19 incidence in each area.[21] Bystander CPR and bystander AED use rates fell during

the COVID-19 period, particularly in public places, and particularly during the first COVID-19 wave in different European areas.[71,72] European first responder systems reacted differently to the COVID-19 pandemic and this led to different results in different countries.[73] Community first responder engagement and bystander defibrillation rates did not differ significantly during lockdown and non-lockdown periods in two Danish regions. However, compression-only CPR was more often performed during the lockdown period then previously (79 % versus 59 %).[74] Similar findings were observed in a worldwide registry-based study that included data from several European countries[75,76] and in a large study in the UK.[77] There was a reduction in CPR initiated by first responders during the pandemic in Switzerland (45.3 % during pandemic vs 62.2 % before pandemic), but no difference in defibrillation rates by first responders (15.9 % during pandemic vs 23.9 % after pandemic), probably because alerting for community first responders was deactivated, but maintained for on-duty first responders.[78]

Outcome

The ERC recommends registries report outcomes according to the Utstein template to improve comparability between health systems. Registries should prioritise collecting information about survived event, ROSC, transport to hospital, survival and neurological outcome at discharge or at 30 days.[8]

There is substantial international variation in survival rates and neurological outcomes. ILCOR reported survival to hospital discharge or 30-day survival ranged from 3.4 % to 15.6 %.[18] Some areas reported even lower values (e.g. China 2.8 %).[79,80] Unfortunately, resuscitation outcome is unknown in many countries particularly among those with developing emergency systems.[81,82]

Prognostic factors for cardiac arrest outcome are age,[23,24] gender,[83,84] aetiology, initial arrest rhythm,[27,85–87] previous and existing comorbidities, [88,89] location of the cardiac arrest,[90,91] whether the arrest was witnessed,[27,28] socioeconomic status,[92,93] and ethnicity.[94] Also the way health systems are organised,[95] available post-resuscitation care facilities (e.g. percutaneous coronary intervention,[96–99] temperature control,[98,100–102] cardiac arrest centres[103,104]) are contributing factors on the variability in patient survival. Furthermore, a significant variability in OHCA outcome may be observed in the same region or country, despite the same health system organisation, because of differences in demographics and the community response,[105–108] which can change over time.[109] Differences in decisions on when to terminate resuscitation in the field will influence the denominator, which will affect outcome rate.[110]

Unfortunately, these aspects are not always captured by current data collection systems.[111] However, despite their inaccuracies and limitations, data from registries constitute the standard for knowing the outcomes from OHCA. These registries should enable annual updates that describe trends in outcomes and compare different areas of the world. For example, in 2024 the US Cardiac Arrest Registry to Enhance Survival (CARES) documented a survival to hospital discharge rate of 10.2 % for all EMS-treated non-traumatic adult OHCA cardiac arrests and 8.1 % for survival with good neurological function.[1] The Australian Aus-ROC Epistry captures data from Australia and New Zealand and reported survival to hospital discharge/30-days as 13 % with a range across different EMS from 9.9 % to 20.7 %.[33] The Swedish OHCA Registry has reported on the evolution in the treatment of OHCA during more than 30 years.[38]

In Europe, the European Registry of Cardiac Arrest (EuReCa) has performed 3-monthly cross-sectional studies including about 30 countries, providing the data source on OHCA for the Atlas of Cardiovascular Diseases in Europe.[112] Over the years of these studies the average survival has changed from 10.3 % [range 1.1–30.8 %] in 2014 to 8 % [0–18 %] in 2017, and 7.5 % [3.1–35 %] in 2022.[5] These results correlate well with annual reports from national registries. [113–119] (Table 2).

The Utstein comparator group (bystander witnessed OHCA with a first monitored shockable rhythm) represents the recommended subgroup for system comparison on survival. Reported survival rates are higher than the general population of OHCA patients: 20 % in England,[113] 27.1 % in Spain,[115] and 30 % in Europe in 2022.[5] Several European countries (Denmark, the Netherlands, Sweden, Czech

Table 2 – Outcome reported for OHCAs in different European countries.

Country	Type of outcome	Rate
England	Survival at hospital discharge	7.9 %
France	Survival at hospital discharge	4.9 %
Spain	Survival at hospital discharge	11.5 %
Ireland	Survival at hospital discharge	6 %
Spain	Survival at hospital discharge with CPC 1 or 2	9.8 %
Germany	Survival at hospital discharge with CPC 1 or 2	10.5 % (males) −7.1 % (females)
Sweden	Survival at 30 days	12.3 %
Denmark	Survival at 30 days	14.4 %
Norway	Survival at 30 days	15 %

Republic and Norway) exceeded 40 % survival for this benchmark in 2022.[5]

A peculiar sub-group of patients are those with a traumatic cardiac arrest, for whom resuscitation was considered futile in the past.[120] However, recent data suggest that a good outcome can also be achieved in these patients, as the reported good neurological status at discharge ranged between 2.0 % in Germany [121] and 6.6 % in Spain.[122]

During the first wave of the COVID-19 pandemic, the outcome of OHCA patients was worse regardless of known predictors of outcome and regardless of the incidence of COVID-19 in a region.[21] This highlights how the pandemic profoundly affected the management and survival of cardiac arrest patients worldwide.

Scientific consensus[8] and policies from the European Parliament[123] have highlighted the importance of knowing local outcome data about OHCA in each country to issues guidance how to improve the response system and to enhance survival. The ERC recommends that maintenance of registries with high-quality data and adhering to the Utstein template should be an integrated part of each EMS service. This will help to improve their services and their patients' outcome.

Diversity, equity, equality & inclusion (DEEI) discrepancies on outcome

Studies show that racial, gender, and socioeconomic disparities influence cardiac arrest outcomes. Women receive 27 % less bystander CPR than men and survival is lower for women compared with men.[124–127] Black and Hispanic patients in the USA tend to have lower survival rates and to receive fewer interventions before EMS arrival.[128,129] Hispanic patients in the USA had poorer survival outcomes, even after accounting for medical history.[130,131] Lower-income and rural areas have longer EMS response times, fewer public AEDs and lower survival rates.[108,132–134] These disparities among these groups are reflected by their under-representation in resuscitation science.[124,135] Ethnicity, gender, socioeconomic status, geographic location, sexual orientation, and disability are all characteristics that contribute to differences in healthcare outcomes.[136] Equitable resuscitation science requires mitigating barriers that contribute to survival rates, training accessibility, and clinical decision-making. This includes ensuring diverse representation among authors and researchers who can then create culturally competent approaches to guideline development. Recently, the Women's International Group to Inspire, Support, and Empower Women in Resuscitation (WISER) was founded to promote gender equality within resuscitation research community.[137]

Epidemiology of paediatric resuscitation

Resuscitation in children is rare and most challenging presentation in OHCA. Most of the data on paediatric OHCA comes from North America and Asia.[138] While age-definitions and eligibility criteria differ across reports, data from Italy, Spain, Sweden, Norway, Germany, Denmark and the Netherlands indicates that the incidence of EMS-treated paediatric OHCA varies between 3.1 and 9.0 cases per 100,000 person-years.[139–145] The incidence of paediatric OHCA has a U-shaped relationship with age, with the highest incidence observed in infancy and adolescence.[139,141,142,144] The aetiology of OHCA also correlates with age: sudden infant death syndrome (SIDS) is the leading cause of death in children under 12 months of age, while hypoxia, trauma and cardiac causes are more prevalent in adolescent children.[45,140,142,145,146] Recent data from Sweden indicate that overdose and suicide are common in adolescent children and may be increasing.[45] The vast majority of cases, particularly in young children, are unwitnessed, occur in the home and have an initial non-shockable rhythm.[140–143,147] In adolescents, initial shockable rhythms are common and a third of all events are precipitated by physical activity.[144] Bystander CPR occurs in 41 % to 88 % of cases, although the provision of defibrillation before EMS arrival remains infrequent (<10 %).[140–142,144,147,148] Rates of survival and neurologically favourable survival are low in paediatric OHCA, but these outcomes may also be influenced by age, aetiology and initial rhythm.[141,143,146] Overall survival to hospital discharge or 30-day survival varies between 7 % and 40 %, while neurologically favourable survival varies between 4 % and 15 %.[141,142,144,145,147,148]

Treatment by bystanders using public access defibrillation can result in survival rates exceeding 80 %.[141] Data from Sweden and Netherlands also indicates that both short-term survival outcomes and neurologically favourable survival are increasing over time.[45,143,148] Despite limited reports from Europe examining the long-term quality-of-life and functional recovery of children survivors of OHCA, the available data suggests survivors maintain good neurological outcomes at longer-term follow-up.[145,149]

Although synthesised data on the incidence and outcomes of paediatric OHCA are lacking, existing reports indicate some differences and similarities across regions. In Australia, the incidence of EMS-treated paediatric OHCA was 4.9 cases per 100,000 person-years (6.7 per 100,000 in EMS-treated cases) and 8.1 % of patients survived to hospital discharge.[150] In North American regions contributing to the Resuscitation Outcomes Consortium, the incidence of EMS-treated paediatric cases was 6.8 cases per 100,000 person-years (8.3 per 100,000 in EMS attended cases) with 10.2 % surviving to hospital discharge.[151] In comparison, Asian regions contributing to the Pan Asian Resuscitation Outcomes Study reported a pooled survival to hospital discharge rate of 8.6 %, although the incidence was not reported.[152] A recent systematic review exploring the influence of sociodemographic factors on paediatric OHCA indicates that the incidence of paediatric OHCA and the presence of bystander CPR were strongly associated with race and ethnicity, with minority populations being disproportionately impacted.[153] These factors may contribute to global differences in the outcome of paediatric OHCA.

In-hospital cardiac arrest (IHCA)

Incidence

There is wide variation in the incidence of treated IHCA in Europe.[154,155] The ERC continues to recommend the adoption across Europe of the Utstein recommendations for reporting in-hospital cardiac arrest.[9] The Utstein recommendations advocate reporting incidence as the number of treated in-hospital cardiac arrests per 1000 hospital admissions (excluding cardiac arrests which occur in the emergency department). A few studies on this topic have been published recently (Table 3 and Supplementary Table 1).[3,4,91,156–161] They confirm previous European studies, which showed an incidence of 1.5 to 2.8 per 1000 admissions.[162–166] Patients are aged 67 to 75 years and most are male (60 %-69 %), which is very consistent across different studies and countries.[3,4,156–158,160,161] However, outcome data show significant variations

Table 3 – IHCA incidence, characteristics and outcome in published studies from 2020 to 2024.

Reviewed published studies (2020-2024) focusing on IHCA	IHCA Utstein's Core Elements* reported	Age (Mean)	Sex (Male)	Number of treated IHCA per year	Incidence ofIHCA per 1000admission per year**	Location in hospital	Monitored (M)/ non-monitored (NM) area	AnyROSC%	Survival to discharge%	30-day survival%	Neurological outcome CPC 1-2%	DNAR reported
Adielsson – 2020 – Sweden[3]	Yes	72.6	61.4	23,950	N/A	All	M/NM	N/A	N/A	32.5%	N/A	No
Albert - 2023- Sweden[156]	Yes	74	63.1	4,324[A]	N/A	All	M/NM	65.3/49.9%[A]	N/A	48.4/ 18.7%[B]	89.8/ 72.8%[B]	No
Andersson – 2022 – Sweden[91]	No	N/A	N/A	245	N/A	All	M/NM	N/A	N/A	49.8%	40%	Yes
Bruchfeld – 2024 – Sweden[157]	No	75	60	5,788[C]	N/A	All	M/NM	45%	21%	N/A	16%	No
Creutzburg - 2021 – Denmark[158]	Yes	67	69	444/494[D]	1.13/1.11[D]	General ward	NM	N/A	N/A	N/A	N/A	No
Flam – 2024 - Sweden [159]	No	N/A	N/A	3,737	16.1[E]	ICU	M	N/A	N/A	N/A	N/A	No
Silverplats - 2024 – Sweden [160]	Yes	73	65	745/254[F]	2.9/12.4[G]	All	M/NM	63/72%[F]	N/A	40/ 39%[F]	92/ 91%[F]	Yes
Yonis -2020 – Denmark [4]	No	74	65	1,892	N/A	All	M/NM	N/A	N/A	27.3%	N/A	No
Yonis - 2022 – Denmark [161]	No	74	63.1	8,727	N/A	All	M/NM	53.1%	N/A	62%[H]	N/A	No

DNAR: Do Not Attempt Resuscitation.

* Hospital/Patient/Pre-event/Cardiac Arrest Process/Postresuscitation Process/Outcome.

** Non-Utstein Core Elements.

[A] Cardiac/non-cardiac cause.

[B] Cardiac/non-cardiac group.

[C] Non-shockable IHCA.

[D] Pre-Implementation Early Warning Score/Post-Implementation Early Warning Score group.

[E] Intensive Care Unit (ICU) cardiac arrest events.

[F] Prospectively/retrospectively registered.

[G] Total/ICU admissions.

[H] <5 min resuscitation duration.

between the different studies, also depending on differences in the denominator, but ranging between 27.3 % and 62 %.[3,4,91,156,160,161] (Table 3).[3,4,91,156–161]

Response organization

The ERC was a key stakeholder in the development of the 10 steps toward improving IHCA quality of care and outcomes recommenda-

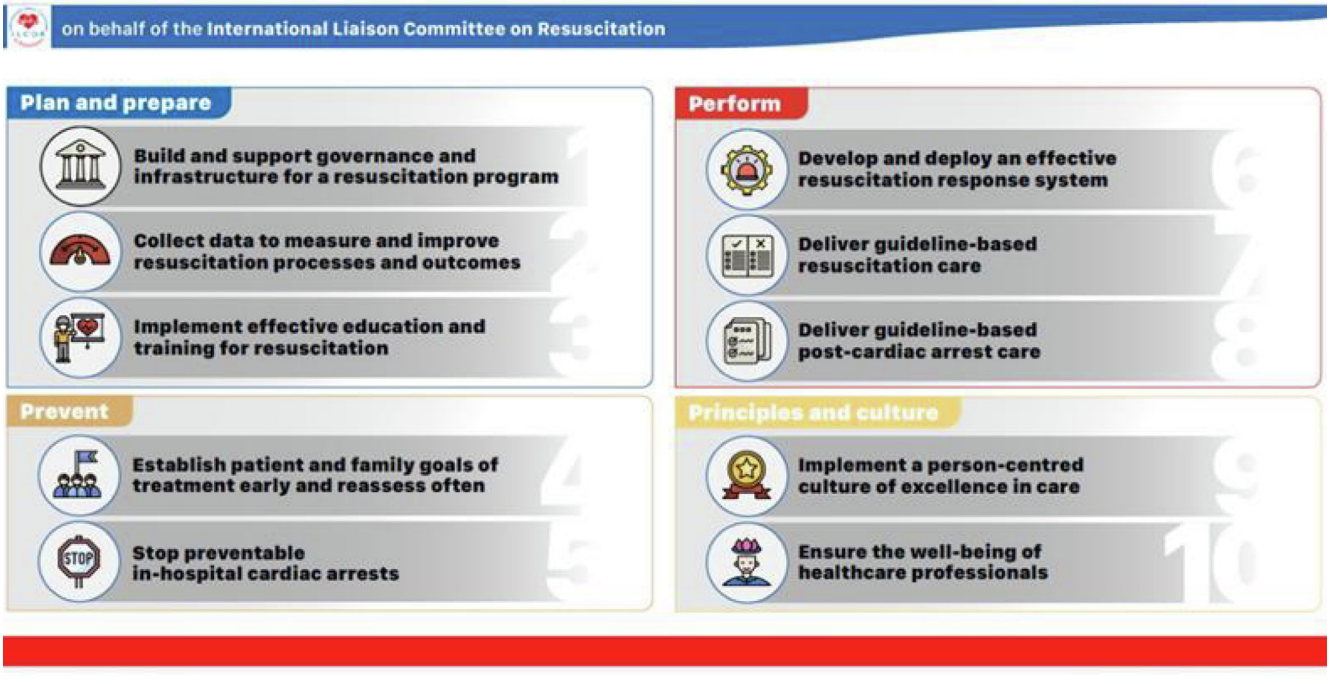


Fig. 4 – 10 Steps to improve in-hospital cardiac arrest quality of care and outcomes.

Table 4 – Summary of use of 2222 emergency call number for IHCA in European Countries.

Country	Survey date	Hospitals	Use of 2222 (%)
Belgium	2021	Flemish Hospitals	2/19 (11 %)
Denmark	2017	Hospitals	9/40 (29 %)
France	2019	Military Hospitals	2/8 (25 %)
Ireland	2019	Public and Private Hospitals	52/67 (78 %)
ERC guideline survey	2025	14 countries	2/14 (13 %)

tions from ILCOR.[167] The programme highlights the importance of planning and preparation, systems to prevent IHCA and inappropriate resuscitation, optimal organisation of the emergency response to IHCA including delivery of guideline-based care and principles of person-centred culture (Fig. 4).

Develop and deploy an effective resuscitation response system

Step 6 of the ILCOR initiative on improving IHCA describes the importance of a hospital-wide resuscitation response system that is easily and rapidly activated. It highlights the importance of a high-quality resuscitation team that includes preassigned, experienced, and interdisciplinary health care professionals.[167] A survey amongst guideline writing group authors ($n = 14$, 100 % response) covering 14 countries (Austria, Croatia, Denmark, France, Germany, Greece, Italy, Netherlands, Norway, Serbia, Spain, Sweden, Switzerland, United Kingdom) explored the characteristics of the response to IHCA. Most countries used a designated cardiac arrest team (78 %). Team roles were pre-assigned before cardiac arrest in nine countries (60 %), at the time of the cardiac arrest in two (20 %), and there was no consistent approach in two (20 %). The use of multi-professional teams was almost universal (93 %) – just one country included physicians only. Some form of standardised advanced life support training was provided in all but one country. The ERC Advanced Life Support Course was used in 6 countries (40 %), local advanced life support courses in 6 countries (40 %) or no consistent approach in 2 countries (13 %). Use of a defibrillator was permitted by physicians (all countries) and nurses in ten countries (73 %).

The ERC continues to recommend the use of a standard internal telephone number (2222) for IHCA in Europe.[168] Despite these recommendations being made in 2016, penetration across Europe is limited. (Table 4) Forward citation tracking of the publications recommending implementation of 2222 as the standard number to alert the in-hospital resuscitation team demonstrates variable penetration across Europe.[169–172]

Outcome

Outcome data should be reported consistently to enable comparisons. Core outcome data should include reasons for CPR termination, ROSC, survival and neurological outcome at discharge and/or at 30-days.[9]

There are far fewer studies reporting outcomes from IHCA compared with those reporting outcomes from OHCA. Data identified by the ERC writing group are summarised in Table 3 and show that varying rates of ROSC (range 45–72 %), survival (range 27.3–62 %) and neurological outcome (range 16–92 %). There is also evidence that IHCAs in monitored areas, younger age, shockable rhythm, with less comorbidity are associated with best outcomes,[9] whilst IHCAs occurring early in the morning are associated with worse outcomes.[173] The ERC therefore strongly advocates for the roll out of IHCA registries in accordance with Utstein recommendations.

Long term survival and return to societal participation

Measurement of outcome and recovery

Long term survival and outcome

Severe hypoxic-ischaemic brain injury is a devastating outcome for cardiac arrest survivors. In most European countries where withdrawal of life sustaining treatment is routinely practiced, a poor neurological outcome is seen in less than 10 % of cardiac arrest survivors.[174] In situations where withdrawal of life sustaining treatment is not applied, survivors with severe hypoxic-ischaemic brain injury are substantially more common. Even among survivors classified with a good outcome, the effects of hypoxic-ischaemic brain injury may impact everyday life. The most frequently reported neurological sequela is neurocognitive impairment, affecting most survivors in the early phase and up to 50 % over the longer term, where it is mostly mild-to-moderate.[174,175]

When assessed at group level, the use of generic measures of health-related quality-of-life suggests comparable levels of health with the general population.[175,176] However, more nuanced analyses reveal that several health-related quality-of-life sub-domains are poorer in cardiac arrest survivors, and that cognitive, physical, emotional problems and fatigue are common.[174,177–180]

Families of cardiac arrest patients (also known as ‘co-survivors’) are also at significant risk of emotional problems including anxiety, increased care-giver burden, and post-traumatic stress.[181–183] Being a witness to a relation’s cardiac arrest increased the risk for emotional problems,[181] and cognitive impairment in the survivor was associated with increased caregiver strain.[183,184] Logistical and ethical challenges with collecting detailed information beyond hospital

discharge remains a critical issue for long-term recovery reporting.[8,175]

A recent review of recovery and survivorship following paediatric cardiac arrest describes the commonality of cognitive impairment, including difficulties with memory, language, attention, communication, and executive functioning, impaired physical functioning, and activities of daily living.[185] Emotional problems, such as anxiety, depression, or behavioural problems, may manifest as somatic complaints or attention difficulties. Changes in family social functioning are also described. Few studies capture long-term outcomes beyond 2–3 years post hospital discharge.[185]

Registries

The Utstein template defines core and supplementary outcome variables and recoding methodologies to be collected in the event of OHCA.[8] Since its introduction, patient survival and neurological status have received increasing focus. Utstein guidance directs that neurological outcome is reported using the Cerebral Performance Category (CPC) and/or modified Rankin Scale (mRS) for adults and the Paediatric Cerebral Performance Category for children at hospital discharge or at 30 days.[8] Because the collection of post-discharge survival status and health-related quality-of-life data requires extensive resources they are identified as supplementary outcomes. Recommended health-related quality-of-life assessments are in line with the Core Outcome Set for Cardiac Arrest (COSCA) outcome reporting recommendations: that is, the Short-Form 36-item Health Status Survey (SF-36), EuroQoL EQ-5D-5L, or the Health Utility Index version 3 (HUI3) for adult survivors at 90-days[186] and the Pediatric Quality of Life Scale (PEdsQL) for children at 6-months.[187] However, a recent review of studies citing Utstein guidance found that the supplementary outcomes were rarely used, with fewer than 3.3 % assessing health-related quality-of-life.[8]

Research

The introduction of the COSCA guidance has contributed to an improvement in outcome reporting:[188] 82 % (45/55) of recent trials reported neurological function, of which 19 of 45 adopted the modified Rankin Scale as a measure of functional outcome; 33 % (18/55) of trials reported health-related quality-of-life, with most (16 of 18) including recommended assessments. The EuroQoL EQ-5D-5L was most frequently used. However, continued heterogeneity in the reporting of health-related quality-of-life is hindering data synthesis.[176,179]

Recognising the limitation of generic assessments, COSCA highlights the complementarity of domain-specific assessment, for example, of cognition, fatigue, anxiety, and participation. However, without specific assessment guidance, further heterogeneity in domain-based outcome reporting has been described.[177–180] For example, a review of 43 studies described more than 50 measures and a range of different cut-points used to assess neurocognitive function following OHCA.[177] Similarly, 16 different measures of anxiety or depression across 32 studies of cardiac arrest survivors were reported in another review.[180] Variation in measurement choice and cut points impacts prevalence reporting; standardisation is urgently required to support greater transparency in the assessment of symptom incidence.

Recent evidence suggests that the Montreal Cognitive Assessment (MoCA) is an acceptable measure of cognitive screening following cardiac arrest,[189,190] further underpinning recommendations for its use in this population.[191] The measure is usually administered face-to-face or via a digital meeting. Whilst a telephone version is available, the psychometric properties are less known, and hence this version should be applied with caution.[192]

Despite the Hospital Anxiety and Depression Scale (HADS) being widely used as a measure of anxiety and depression in cardiac arrest survivors,[180] there are few psychometric evaluations of its use with this population.[193] However, there is strong evidence supporting its use in the general population and in patients with cardiac disease. For example, evidence from a large Danish population of cardiac patients suggests acceptable evidence of essential measurement properties, in keeping with earlier studies.[194]

Fatigue assessment guidance following cardiac arrest is not available. Whilst the most widely used measures in cardiac arrest are the Fatigue Severity Scale (FSS)[195–197] and the Modified Fatigue Impact Scale (MFIS),[197–199] information of psychometric properties is limited in this population. Evidence from other patient groups (e.g. multiple sclerosis) suggest they are comparable when measuring physical aspects of fatigue in populations with mild to moderate fatigue.[200] However, where both physical and cognitive aspects are important, and where higher levels of fatigue might be anticipated, the somewhat longer Modified Fatigue Impact Scale is preferable.[200]

Guidance for the assessment of activities and participation following cardiac arrest does not exist. However, functional outcome scales and health-related quality-of-life assessments, such as the modified Rankin Scale and Short-Form 36-item Health Status Survey, commonly include these domains; the value of reporting health-related quality-of-life outcomes at a domain-level has been demonstrated.[201] Whilst overall physical and mental component summary scores on the Short-Form 36-item Health Status Survey suggested health status comparable to the general population, at the domain level impairment was substantial. This was particularly noted where people experienced difficulties engaging in roles related to work and other activities due to physical (50 % impaired) and emotional (35 %) limitations.[201]

Variation in outcome assessment following paediatric cardiac arrest (what is assessed, when, and by whom) is described, which may further contribute to the reported heterogeneity in post-arrest problems described and our understanding of long-term outcomes.[185] Moreover, the widespread use of blunt global assessments such as the Paediatric Cerebral Performance Category (PCPC) may inadequately capture change in patient and family important outcomes such as ability to engage with friends, school, and society. Introduction of the Paediatric-COSCA guidance in 2020[187] is expected to contribute to improvements in outcome reporting and our understanding of the long-term recovery and survival of children.[185]

Routine practice

Measures to use during follow-up in clinical practice are detailed in the ERC Guidelines 2025 Post-resuscitation care, and includes guidance for screening of cognitive, emotional challenges, and fatigue and exploring limitations in physical activity and physical function.[202]

Rehabilitation and return to societal participation

Follow-up and screening

The 2021 ERC Post-resuscitation Guidelines recommended the assessment of physical and non-physical impairments both before and within 3-months of hospital discharge to identify rehabilitation needs and the provision of timely and targeted care through appro-

priate referrals.[191] An early follow-up assessment, including screening for cognitive and emotional challenges, is supported by an RCT from the Netherlands.[203–205] This cost-effective intervention contributed to a positive impact on mental health and an earlier return to work at one year.[205,206] Several European national guidelines and quality standards now recommend early follow-up following cardiac arrest – for example, Sweden,[207] France,[208] United Kingdom,[209,210] Scotland,[211] and the Netherlands.[212] To what extent cardiac arrest survivors in Europe are assessed before discharge and/or at follow-up is unknown.

Most cardiac arrest survivors who responded to a UK survey (95 of 123 (77 %); median 2 yrs since cardiac arrest) reported being followed-up, typically by a cardiologist (62 %). The majority (99 %) indicated the need for post-discharge follow-up with access to a multi-disciplinary team; more than half (61 %) preferring early follow-up within one month of discharge. Prioritised topics included: medical issues (as the cause of the cardiac arrest and heart disease), mental fatigue/sleep and screening for emotional and cognitive challenges.[213]

Almost all respondents to a survey of French ICUs reported providing oral information to cardiac arrest survivors prior to discharge (136/145, 94 %).[208] However, just half noted the OHCA survivors' neurological and functional outcome in medical records or organized a post ICU follow-up which included cognitive and emotional screening. Described barriers to provision of follow-up appointments included: lack of awareness and knowledge; limited resources, including limited interdisciplinary collaboration; limited evidence to justify the cost; and an absence of practical recommendations.[208,212]

Informed by previous experiences[203–206] and European guidelines[214] the Essex Cardiothoracic centre started the UK's first dedicated follow-up clinic for cardiac arrest.[215] Cardiac arrest survivors (approximately 70 per year) are assessed by an ICU nurse and cardiologist before discharge and provided with multiple information sources, ranging from contact details to a peer support group. A post-discharge telephone call is organized within 48-hours, with follow-ups at 2-, 6- and 12-months for survivors and their carers.[215] A hub-and-spoke sub-regional model with a single lead cardiac arrest centre performing patients' assessment both in-person and remotely is being implemented in Italy. Such an approach may reduce disparities in care allowing this type of follow-up even in hospitals with limited resources.[216]

The 'Copenhagen Framework'[217] provides a further example of guideline translation[191,214] into clinical practice. A stepwise multidisciplinary approach to organise and manage follow-up and rehabilitation, implemented through two high-volume cardiac arrest centres (approximately 200 survivors a year), it includes: in-patient assessments; early follow-up 1–2 weeks post-discharge; and a more extensive follow-up at 2-months for both survivors and their family members.

Rehabilitation

The 2021 guidelines recommend that, where indicated, cardiac arrest survivors should be referred for specialist rehabilitation.[191] However, there remains a lack evidence for rehabilitation after cardiac arrest.[218] Current evidence based clinical practice recommendations for rehabilitation after cardiac arrest are discussed in the ERC Guidelines 2025 Post-resuscitation care.[202] Here we explore and describe available European rehabilitation pathways for cardiac arrest survivors. Participants in a large trial including mainly European OHCA survivors described their experience of rehabilitation within the first six-months post-arrest.[192] Just 29 % out of 836 patients participated in cardiac rehabilitation, with fewer than 12 % receiving brain injury rehabilitation (in-hospital: 12 %; outpatient: 5 %).[192] In a smaller Danish study of OHCA survivors who had been in employment before their arrest ($n = 38$), 100 % had a rehabilitation plan at time of discharge.[219] The most frequently accessed rehabilitation interventions involved psychologists addressing psychological issues (78 %) and physiotherapists supporting exercise capacity (68 %). Although rehabilitation participation was high, almost half of survivors reported unmet rehabilitation needs at 6-months, including support for existential issues, speech problems, return to work, fatigue and energy management.[219]

Whilst many cardiac arrest survivors are eligible for cardiac rehabilitation, engaging in these programmes alongside other patients who have experienced an acute cardiac/coronary event, those survivors whose cardiac arrest was idiopathic or due to non-ischaemic causes are generally excluded.[174,175,215] A survey of Danish cardiac rehabilitation facilities suggests that cardiac arrest survivors received less specialised cardiac rehabilitation than myocardial infarction patients. This included less patient education, exercise training, screening for anxiety and depression and nutritional counselling.[220]

Commencing at three-months post-arrest for survivors who had been discharged to home, a small Danish pilot study tested a combination of residential and home-based rehabilitation including education, physical activity training, and psychosocial support.[198] Carers were invited to attend the residential group sessions. Whilst this small pilot study is unable to provide sufficient evidence to support a change in practice, patient and clinician satisfaction was high. However, the specialised residential component may not be feasible in many settings.

Due to the prevalence of cognitive impairment in cardiac arrest survivors, a potential knowledge gap in care delivery by cardiology-based healthcare professionals has been described,[212,221] with a greater need for interdisciplinary collaboration proposed.[215,221,222] By example, a combined cardiac and cognitive rehabilitation programme is provided to cardiac arrest survivors at a single centre in the Netherlands.[223] More specifically, whilst those without cognitive impairment follow a traditional cardiac rehabilitation programme, those with impairment participate in smaller cardiac rehabilitation groups with the addition of a cognitive rehabilitation programme. This pathway has not been evaluated, but 23 % of cardiac arrest survivors referred for cardiac rehabilitation had cognitive problems.[224]

Brain injury rehabilitation is often provided to cardiac arrest survivors with severe hypoxic-ischaemic brain injury, with care provided alongside other patients with acquired brain injury – e.g., traumatic brain injury.[225] Whilst guidance on brain injury rehabilitation following cardiac arrest is not available in the European context, insight can be gained from several retrospective studies (e.g., patient records) from the last decade. A retrospective review of patients admitted to a Turkish brain injury in-patient rehabilitation facility between 2011 and 2015, reported anoxic brain injury following cardiac arrest in 5 % of patients.[225] Patients with anoxic brain injury received the same intense rehabilitation programme as patients with traumatic brain injury, including physiotherapy, occupational therapy, cognitive rehabilitation and speech-language therapy for 5 h a day, for 20 days. In a small Dutch study of patients hospitalised and institutionalised because of unresponsive wakefulness syndrome (most due to cardiac arrest), more than half (54 %) had not received any rehabilitation.[226] By contrast, a larger German study on 93 patients describes early, daily interdisciplinary neurological rehabilitation for patients with severe hypoxic-ischaemic brain injury (34 % of cardiac causation), which

continued until improvement ceased or complications were observed (including death).[227] Following a mean duration of 109 days, 41 % were discharged to a nursing facility, 23 % were referred for additional rehabilitation, 18 % returned home, 10 % needed further acute-care and 8 % died. Of those comatose at admission, 82 % remained comatose at discharge. A single French centre describes a six-month therapeutic intervention for institutionalised patients with anoxic brain injury ($n = 11/20$ caused by cardiac arrest; mean 8-years post-event).[228] Consisting of medication, psychotherapy, support group, and physical, cultural and/or artistic therapeutic activities, it positively impacted quality of life and social participation.

Genetic variants and autopsy in cardiac arrest patients

The cause of cardiac arrest is known to be different according to the age of the victim. Coronary artery disease indeed represents the cause of cardiac arrest in most people over 50 years, but it explains only a minority of cases in young people. In young victims, most of the sudden cardiac deaths are attributable to other diseases, of which the majority are genetically determined structural or arrhythmogenic myocardial pathologies.[229,230] Differences in the cause of cardiac arrest become more pronounced at younger ages.[231,232] In young victims of sudden cardiac disease, the most common causes are hypertrophic cardiomyopathy—which is particularly prevalent in athletes—and arrhythmogenic cardiomyopathy. Other significant contributors include dilated cardiomyopathy and primary arrhythmogenic disorders, such as familial long-QT syndrome, catecholaminergic polymorphic ventricular tachycardia, and Brugada syndrome.[231,232] The identification of such an aetiology in the deceased may have important implications for families, allowing their arrhythmic risk to be defined and potentially preventing further sudden death events. In concordance with other European Societies the ERC recommends that a full post-mortem examination, including heart dissection, sampling for genetic and toxicological analysis, should be done in all the young sudden cardiac disease victims. However, although this recommendation is endorsed by numerous scientific societies in Europe and beyond, the post-mortem examination of young sudden cardiac disease victims is currently not routinely performed in many European countries.[233,234]

Genetic post-mortem analysis (so-called 'molecular autopsy') is important because about one third of the sudden cardiac disease remains unexplained after autopsy.[235–237] For this reason, the collection of 5–10 mL of blood in Ethylenediaminetetraacetic acid (EDTA) is recommended during post-mortem examination or whenever possible, even on the OHCA scene.[235,238,239] Modern techniques of DNA evaluation (e.g. multi-gene panels using next-generation sequencing) enable identification of a clinically actionable pathogenic or likely pathogenic variant in a gene potentially related to the cause of sudden cardiac death in up to 25 % of cases, with significant implications for the care of their families.[231,240–247] Considering genetic data together with the phenotype provides much more informative data at a clinical level than using genetic data alone. Molecular and familial analysis together enable increased diagnostic yield.[248] The clinical data, including information about the deceased, the context and the triggers of the event, and the families, are all important.[249–251] Modern DNA analysis techniques enable the identification of a considerable percentage of variants of uncertain significance (VUS) on genes of interest. However, unlike pathogenic or likely pathogenic variants, these types of variants present significant challenges when explaining their significance to family members of the deceased and, if still alive, to the patients themselves.[250] The ERC recommends that genetic and clinical testing should be undertaken only by multidisciplinary teams including professionals with skills to counsel on the implications and the uncertainty of results and to decide about the appropriateness of extending the screening to the first-degree relatives of the victims, and experienced cardiologists able to direct testing to the correct phenotype.[252] These teams should ideally be based in tertiary centres that offer comprehensive professional expertise and can receive patient referrals from a wide region. These centres should also be capable of periodically reanalysing and reclassifying variants as new data on pathogenicity become available.[247,253] There has been consensus that the autopsy and genetic testing should be performed in those under the age of 40 years;[250,254] however, other studies suggest that the age range should be extended up to 50 years.[255,236,251,256] This wider age range is supported by two recent expert consensus statements on genetic evaluation of patients with unexplained sudden cardiac arrest.[252,257] These statements represent the official views of the European Society of Cardiology (ESC) and numerous arrhythmia scientific societies worldwide (European Heart Rhythm Association, Heart Rhythm Society, Asia Pacific Heart Rhythm Society and Latin American Heart Rhythm Society). Therefore, the ERC strongly recommends performing a comprehensive post-mortem examination (including heart dissection and toxicological analysis) and a molecular autopsy on all victims of unexpected sudden death under 50 years old.

Low-resource settings and remote areas

Out-of-hospital cardiac arrest and IHCA occur worldwide, regardless of a country's available resources, population density, or remoteness. Although responding to cardiac arrest may not be a primary focus of emergency services in lower-resourced countries, the fundamental principles of resuscitation still apply. However, the epidemiology, organisation of response and treatment, and both short- and long-term outcomes differ significantly in these settings and in remote areas. Therefore, it is important to consider the treatment of OHCA and IHCA in less-resourced countries and remote regions separately. The response to OHCA in remote areas of high-resourced countries involves entirely different strategies and resource allocation compared to those in lower-resourced settings.

Low-resource settings

The only available data on OHCA in low-resourced countries in Europe concern Serbia and Bosnia and Herzegovina,[258,259] two of the most low-resourced countries in Europe, where an incidence of OHCA of 85.6 per 100,000 and 54 per 100,000 inhabitants/year respectively is reported, which aligns with the median reported incidence of 55 per 100,000 inhabitants/year in Europe.[5] Some characteristics of OHCAs in those countries are similar to other European countries, such as the majority of events occurring at home, but other aspects are significantly different. In particular, the rate of first monitored shockable rhythm reported in Bosnia and Herzegovina is consistently higher than in other European countries, representing

45.6 % of OHCAs.[258,259] The rate of bystander CPR (15.3 % among bystander witnessed in Serbia and 3.3 % among all OHCAs in Bosnia and Herzegovina) and AED use (0 % in Bosnia and Herzegovina) is lower compared with the European average value.[258,259] This reflects on the outcome, as the ROSC and survival rates in both countries are lower than the median value in Europe.[2,5]

The differences between low– and high-resourced countries become even more apparent outside Europe, where there is a reporting bias because of a lack of OHCA registries adapted to the Utstein template and based on a reference territory,[260] both of which are essential for reliably understanding the phenomenon. Most reports are derived from hospital-based registries that do not follow the Utstein template, and often describe cases where patients in cardiac arrest are transported to the Emergency Department without EMS activation,[261–265] leading to clear delays in treatment, compromised care, and poorer outcomes.

Estimating the incidence of OHCA is only feasible in a few countries with functioning registries, such as South Africa and Argentina—both classified as 'upper-middle income' countries. Reported incidence rates are 23.2 per 100,000 inhabitants per year in Cape Town and 53 per 100,000 inhabitants per year in the city of Bariloche, although the latter figure includes all OHCAs, not just those treated by EMS.[266,267] No incidence data are available from other countries.

The available data suggest that the mean age of OHCA patients in low-resourced countries is lower than in high-resourced settings, ranging from 55 years in Pakistan[265] to 63 years in South Africa.[266] This likely reflects both a younger general population and differing attitudes toward resuscitation in elderly individuals. The location of OHCA, though difficult to interpret because of reporting limitations, varies considerably. The proportion of OHCAs occurring at home ranges from 56.1 % in China[80] to 79.7 % in South Africa.[266]

A first monitored shockable rhythm is found in only a small fraction of patients—approximately 1 % in both Pakistan[263] and South Africa.[266] Bystander intervention is also rare, with CPR rates ranging from 2.3 % in Pakistan and 5.1 % in Iran,[263,268] to 18.7 % in China and 22 % in Vietnam,[80,269] underscoring the strong correlation between bystander CPR and gross domestic product.[65] Outcomes for OHCA patients in these settings are generally poor: in cohorts with presumed lower reporting bias, ROSC is about 1 %,[266] and survival to hospital discharge ranges from 0 % to 4 %.[263,265,266,268] There are no data on IHCA in low-resourced countries in Europe. Existing data from non-European countries are limited and typically based on small patient cohorts. The reported incidence in Egypt is 1.77 per 1000 patients discharged,[270] while the median age in Uganda is 40 years.[271] ROSC rates range from 49.3 %[272] to 62.2 %,[271] and survival rates from 14.9 %[271] to 35.5 %,[272] with improved outcomes reported following the implementation of in-hospital Rapid Response Teams.[270,273] In summary, for both OHCA and IHCA in low-resourced countries, the establishment of robust registries is of paramount importance to accurately define the epidemiology and to monitor progress in treatment and patient outcomes.

Remote areas

Regarding OHCAs in remote areas, available European data are limited to mountain regions, which represent the most remote settings within the European context. Studies from the French,[274] Polish,[275] and Austrian Alps[276] reveal some common features—such as a mean age of OHCA victims around 60 years and a predominance of male patients—but also highlight significant differences in bystander intervention and outcomes. French data suggest a key reason for this variation: OHCAs that occur on ski slopes are more likely to receive bystander CPR and AED use, leading to better survival rates, compared with those that occur off the slopes or in other mountain settings, including typical Utstein-defined locations such as homes, public spaces, or workplaces.[274] This emphasises that the response to the arrest, rather than the location itself, is the critical factor in determining patient outcomes. Remote areas are more widespread outside Europe, and informative data on OHCA in these contexts come from Canada,[277] the United States,[278] and Australia.[279,280] In these countries, OHCA patients in rural and remote settings tend to be younger, and bystander CPR and AED use are more common than in urban areas. However, significantly longer EMS response times in remote regions consistently reduce the likelihood of ROSC and survival in all three countries, underlining the particular challenges of managing OHCA in geographically isolated areas.

Declaration of competing interest

Declarations of competing interests for all ERC Guidelines authors are displayed in a COI table which can be found online at https://doi.org/10.1016/j.resuscitation.2025.110733.

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Appendix A. Supplementary material

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Practice Guideline

European Resuscitation Council Guidelines 2025 System Saving Lives

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Abstract

The European Resuscitation Council (ERC) developed the Systems Saving Lives Guidelines, based on the 2025 ILCOR Consensus on Science with Treatment Recommendations (CoSTR). These Guidelines addresses various topics including the Chain of Survival, advocacy, CPR awareness campaigns, Kids Save Lives, resuscitation in low-resource settings, social media, first responders, EMS organisation for cardiac arrest, in-hospital cardiac arrest management, cardiac arrest centres, system performance improvement, survivors and co-survivors, and new technologies and artificial intelligence.

Keywords: Cardiac arrest, Systems saving lives, Emergency medical service, First responders, Awareness campaign, Advocacy, Survivors, Co-survivors, Kids save lives, World restart a heart, Low resource settings, In-hospital cardiac arrest, Cardiac arrest centres, Social media, Artificial intelligence

Introduction

These ERC Guidelines 2025 on Systems Saving Lives explain how various factors can work together to improve the care of cardiac arrest patients, not through isolated actions, but via a comprehensive, system-level strategy. This chapter aims to present the best practice based on the highest quality evidence available, regarding interventions that healthcare systems can implement to improve outcomes from cardiac arrests occurring both outside and inside hospital settings (Fig. 1).

The intended audience includes governments, stakeholders in health and education systems, healthcare professionals, educators, students, laypeople, and communities affected by cardiac arrest.

The importance of the Systems Saving Lives approach to cardiac arrest is highlighted within the chain of survival. Key components include cardiac arrest centres, rapid response teams to prevent in-hospital cardiac arrest (IHCA), and the collaboration among community, Emergency Medical Services (EMS), and hospital healthcare professionals. This system involves everyone, from schoolchildren learning CPR to citizens, ready to initiate resuscitation after receiving alerts on their mobile phones. The latest ERC guidelines extend their relevance to low-resource settings, recognising the need for adaptable solutions beyond high-resource healthcare environments (Table 1).

These Guidelines are derived from the previous Consensus on Science with Treatment Recommendations (CoSTR) provided by the International Liaison Committee on Resuscitation (ILCOR).[1] The ERC Systems Saving Lives writing group has used published systematic reviews and scoping reviews, alongside the CoSTR document. This process includes thorough consideration of evidence-to-decision tables, narrative reviews, task force discussions, and

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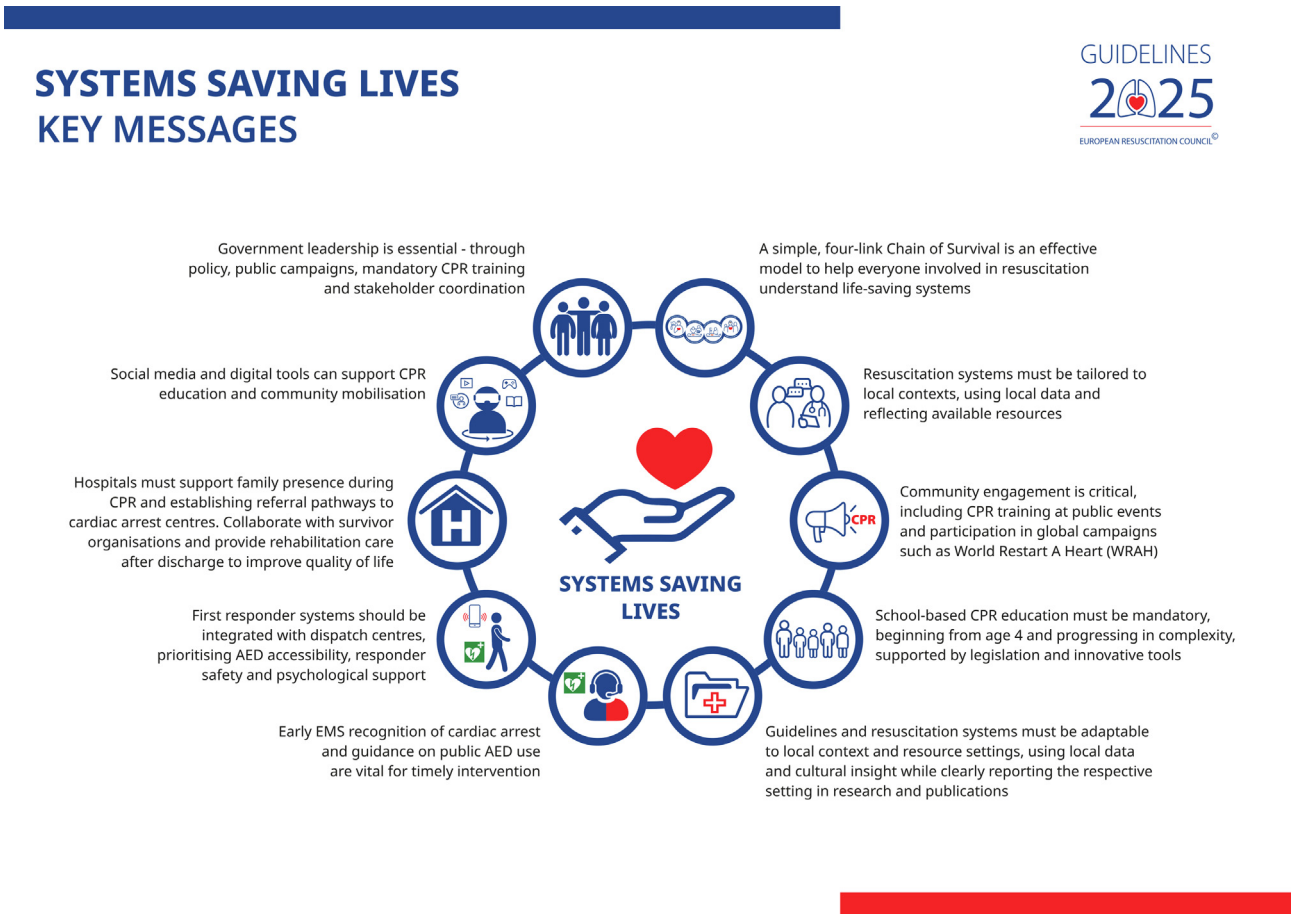


Fig. 1 – Systems Saving Lives – key messages.

justifications during the development of these Guidelines. For topics not reviewed by ILCOR, other reviews, single studies, surveys, or expert consensus from the writing group members have been used to inform these Guidelines.

The methodology used for the guideline development is presented in the Executive Summary.[2] The Guidelines were posted for public comment between 5. and 30. May 2025. A total of 31 individuals submitted 31 comments, leading to five changes in the final version. Feedback was reviewed by the writing group and updates were made where relevant. The Guidelines was presented and approved by the ERC Board and the ERC General Assembly in June 2025.

The term cardiopulmonary resuscitation (CPR) in these Systems Saving Lives Guidelines refers to the entire resuscitation procedure, not just chest compression and ventilation. The term "co-survivors" includes family members, significant others, close friends, or next of kin.

Concise guidelines for clinical practice

The chain of survival

- The chain of survival is a concept that summarises the complex Systems Saving Lives approach. It is intended for everyone involved in resuscitation care, including lay persons, healthcare professionals, educators, and stakeholders. The concept can be used for a variety of purposes, ranging from raising awareness to inclusion in educational materials.
- For simplicity and consistency, the four-link format is used by the ERC.
- For specific situations or target audiences, a multifaceted chain system (i.e., the basic chain of survival plus additional elements) may be applied.

The formula of survival

- The formula of survival depicts the overarching system behind a successful chain of survival and its underlying factors. It can be used to highlight the complex interaction of science, education and implementation to achieve optimal outcomes.
- The three interactive factors are: Science (referring to the continuous evaluation of evidence by ILCOR and the development of evidence-informed guidelines by the ERC); Education (referring to resuscitation training for those who may potentially, or actually take care of cardiac arrest patients—training that must be effective and up to date); and Implementation (referring to a well-functioning chain of survival at both regional and local levels, potentially adapted to various resource settings).

Table 1 – The major changes in the ERC Guidelines 2025 for Systems Saving Lives.

ERC Guidelines 2021	ERC Guidelines 2025
The chain of survival and formula of survival Both describe a series of actions linking a person who experienced sudden cardiac arrest to survival. Emphasis was placed on combining high-quality science with effective education for both laypeople and healthcare professionals. These Guidelines highlighted the importance of implementing resource-efficient systems of care that could improve survival rates following cardiac arrest within healthcare systems.	**The chain of survival and formula of survival** Expansion of the concept, presenting the chain of survival as part of a broader Systems Saving Lives approach. It is designed for all stakeholders, lay persons, healthcare professionals, educators, and policymakers. The preservation of a four-link chain format provides consistency, while also enabling an expanded, multifaceted concept tailored to specific situations or target audiences. The focus is on integrating the chain into public awareness, education, and system-wide resuscitation efforts.
	Advocacy This new recommendation emphasises advocacy by encouraging governments, local authorities, and NRCs to promote policies that improve survival and quality of life following cardiac arrest. Key actions include public awareness campaigns (e.g., World Restart a Heart – WRAH), mandatory CPR education in schools and for drivers (e.g., Kids Save Lives), and enhancing workplace emergency preparedness (e.g., Alliance for Workplace Awareness & Response to Emergencies – AWARE). Collaboration with stakeholders aims to promote engagement with EU legislative bodies and local governments to support cardiovascular health and harmonise CPR policies (e.g., the European Alliance for Cardiovascular Health). Major sporting events and public gatherings serve as key platforms for promoting CPR education to diverse and large audiences.
Community initiatives to promote CPR implementation European Restart a Heart Day (ERHD) & World Restart a Heart (WRAH). Awareness efforts were divided into two distinct areas: European Restart a Heart Day (ERHD) and World Restart a Heart (WRAH), and community initiatives. National Resuscitation Councils, governments, and local authorities were encouraged to engage in WRAH, raise public awareness about bystander CPR and automated external defibrillator (AED) use, train large numbers of citizens, and develop life-saving systems and policies. Separately, healthcare systems were urged to implement widespread community CPR training programmes at various levels, from local neighbourhoods to entire nations.	**Awareness campaigns and initiatives to promote CPR** The former topics were merged under a unified focus. NRCs, governments, and local authorities are encouraged to support community CPR education initiatives and actively participate in WRAH. The aim is to raise public awareness of bystander CPR and the use of automated external defibrillators (AEDs) to efficiently train as many people as possible, and to develop innovative policies and systems to improve survival outcomes.
Kids Save Lives The Kids Save Lives initiative recommended annual CPR training for all schoolchildren, focusing on the Check–Call–Compress method. It encouraged children to teach at least ten others within two weeks, creating a multiplier effect. CPR training was also promoted for students in higher education, particularly those in healthcare and teaching fields. These Guidelines called for Ministries of Education and political leaders to implement mandatory CPR education by law across Europe and beyond.	**Kids Save Lives** The initiative has been expanded and made more structured. Cardiopulmonary resuscitation education is to start as early as age four. Training progresses gradually, introducing more complex skills as children mature. Children are encouraged to train family and friends using take-home training CPR kits. Technology-enhanced learning (e.g. virtual reality, serious games, apps) has been introduced to complement traditional education. Mandatory CPR education is reinforced through legislation, funding, and national public awareness campaigns.
Low-resource settings The focus was on the need for more research into cardiac arrest in low-resource settings, emphasising the importance of understanding different populations, aetiologies, and outcomes while following the Utstein guidelines, and of considering psychological and sociocultural factors. Experts from diverse settings were to be consulted to ensure that guidelines were acceptable and applicable locally. Additionally, the development of a list of essential resuscitation resources specifically tailored for low-resource environments was recommended, in collaboration with local stakeholders.	**Resuscitation in low-resource settings** The approach is now more streamlined and practical. It continues to promote research on populations, causes, and outcomes of cardiac arrest, with adherence to reporting standards (e.g. Utstein approach), and highlights the importance of including information about the respective resource setting (e.g., income classification) in publications. Cultural considerations should ensure that guidelines are regionally acceptable and implementable. Adaptations of the guidelines for specific resource settings—such as remote areas or alpine regions—are suggested when standard guidelines are not feasible.

(*continued on next page*)

Table 1 (continued)

ERC Guidelines 2021	ERC Guidelines 2025
Social media and smartphones apps for engaging the community The focus was on encouraging European countries to implement smartphone applications or text alert systems to notify trained and untrained first responders—including lay persons, police, firefighters, and off-duty healthcare professionals—of nearby out-of-hospital cardiac arrests (OHCA). The goals were to increase bystander CPR rates, reduce the time to first chest compressions and shock delivery, and improve survival with good neurological outcomes.	**Social media** New recommendations highlight social media platforms to be used to enhance public awareness, education, and community engagement in CPR and cardiac arrest. Schools, universities, and healthcare institutions are encouraged to integrate short videos, interactive content, and live sessions into CPR training programmes. Such content should be validated by experts to ensure alignment with international guidelines. Additionally, the effectiveness of social media initiatives should be continuously monitored to assess their impact on CPR training outcomes, bystander CPR rates, and hopefully patient survival.
	First Responders The approach is now more structured and comprehensive. All healthcare systems are advised to implement first responder programmes dispatched by EMS and linked to AED registries, covering both public places and private residences. New emphasis is placed on ensuring the physical safety and psychological support of first responders. Additionally, cardiac arrest events should be reported using standardised methods to monitor system performance and drive continuous quality improvement.
Role of dispatcher The focus was primarily on the role of dispatchers in the early recognition of cardiac arrest and the delivery of dispatcher-assisted CPR instructions. Dispatch centres were encouraged to use standardised algorithms to quickly identify cardiac arrest during emergency calls and to continuously monitor and improve their ability to recognise these cases. There was a strong emphasis on ensuring that call handlers provided clear instructions for chest compression-only CPR to callers dealing with unresponsive adults who were not breathing normally, reinforcing the importance of immediate bystander intervention guided by dispatchers.	**EMS organisation in response to cardiac arrest** The scope has expanded beyond dispatcher roles to encompass a more comprehensive approach involving the entire EMS system. Standardised algorithms for cardiac arrest recognition remain important, but there is an added focus on public-access AED deployment, ensuring AEDs are easily accessible, and equipping all OHCA ambulances with defibrillators. EMS organisations are encouraged to establish prehospital critical care teams, including strategies to maintain team members' resuscitation skills. Additionally, systems are advised to implement structured decision-making processes, including termination of resuscitation (TOR) protocols, to improve patient outcomes and optimise care during cardiac arrest responses.
Early warning scores, rapid response systems, and medical emergency teams The focus was mainly on recommending the introduction of Rapid Response Systems (RRS) to reduce in-hospital cardiac arrests and related mortality. These Guidelines highlighted the importance of early recognition and intervention but provided limited detail on additional strategies.	**In-hospital cardiac arrest management** The recommendations have expanded significantly. While Rapid Response Systems remain central, the updated Guidelines places a greater emphasis on broader strategies for improving system-wide performance.
Cardiac arrest centres The recommendation was that adult patients with non-traumatic out-of-hospital cardiac arrest (OHCA) should be considered for transport to a cardiac arrest centre, based on existing local protocols. The emphasis was on following established procedures to determine whether patients would benefit from being taken to specialised centres; however, there was limited guidance on broader system organisation or the development of networks to support these decisions.	**Cardiac arrest centres** The guidance has evolved to strongly advocate that adult patients with non-traumatic OHCA should be cared for at a dedicated cardiac arrest centre whenever possible, reinforcing the importance of specialised post-arrest care. Additionally, there is an emphasis on healthcare systems establishing and maintaining formal cardiac arrest networks with clear local protocols. This is a shift from only recommending transport decisions to encouraging the development of structured regional systems aimed at improving outcomes through coordinated care.
Measuring the performance of resuscitation systems The focus was on encouraging organisations and communities that manage cardiac arrest to evaluate their system performance and identify key areas for improvement. The emphasis was on assessment and measurement, aiming to understand how effectively resuscitation systems were functioning and to use that information to guide improvements in performance.	**System performance improvement** The Guidelines now emphasise the proactive implementation of system improvement strategies designed to optimize patient outcomes in cardiac arrest care. The language has shifted from simply evaluating performance to implementing structured, proactive approaches. This reflected a broader, more outcome-driven focus on ensuring resuscitation systems not only measure their effectiveness but also systematically apply strategies to optimise care and survival rates.

Table 1 (continued)

ERC Guidelines 2021	ERC Guidelines 2025
	Survivorship and co-survivorship New recommendations emphasise the importance of survivorship and co-survivorship in cardiac arrest care, promoting a shift towards holistic, patient- and family-centred care beyond the initial resuscitation phase. Healthcare systems should develop multidisciplinary policies to support survivors and their co-survivors from pre-discharge through long-term follow-up. Educate healthcare professionals to address these needs, fostering collaboration with survivor organisations, and involving survivors, co-survivors, and the public in policy development and research are also highlighted.
	New technologies and Artificial Intelligence This new recommendation highlights the emerging role of artificial intelligence (AI) and digital health technologies in improving outcomes after cardiac arrest. While these innovations show significant potential to enhance early recognition, optimise resuscitation efforts, and support post-resuscitation care, they are not yet ready for widespread, routine clinical implementation. Their current use should be restricted to research projects or controlled environments, where safety, effectiveness, and ethical considerations can be carefully evaluated. Ongoing studies and pilot programmes are encouraged to further assess their impact and guide future integration into clinical practice.

Advocacy

- Multi-national collaborative bodies, national governments, local authorities, and National Resuscitation Councils (NRC) should advocate for policies that increase survival rates and improve the quality of life for cardiac arrest patients through the following actions:
  - Promotion of comprehensive policies / legislation: Advocate for policies that increase survival rates and enhance the quality of life for cardiac arrest patients.
  - Public awareness campaigns: Increase public awareness through initiatives such as World Restart a Heart and Get Trained Save Lives.
  - Mandatory CPR education: Implement mandatory CPR education for children, students (e.g., Kids Save Lives), and drivers (e.g., Learn to Drive Learn CPR).
  - Enhanced workplace preparedness: Strengthen policies for workplace preparedness (e.g., Alliance for Workplace Awareness and Response to Emergencies – AWARE).
  - Stakeholder engagement: Collaborate with stakeholders to support cardiovascular health and harmonise CPR policies (e.g., the European Alliance for Cardiovascular Health).
  - CPR training at major sporting and large-scale events: Offer free short CPR training sessions at major sporting events and other large-scale gatherings to raise awareness and increase knowledge among attendees.

Awareness campaigns and initiatives to promote CPR

- Community initiatives to promote the implementation of BLS should be endorsed and supported.
- Multi-national collaborative bodies, national governments, local authorities, and National Resuscitation Councils should actively participate in World Restart a Heart (WRAH) to raise awareness of bystander CPR and the use of automated external defibrillators (AEDs), train as many citizens as possible, and develop new and innovative systems and policies.

Kids Save Lives (KSL)

- All schoolchildren should receive CPR training every year, with an emphasis on the Check–Call–Compress approach.
- CPR education should start at an early age (around 4 years of age), progressing to comprehensive training that includes chest compressions by ages 10–12, ventilation by age 14, and AED usage by ages 13–16.
- Children who have been trained should be encouraged to educate family members and friends, aiming to teach at least ten others within two weeks. Take-home CPR training kits should be distributed to maximise the multiplier effect.
- CPR education should also be extended to higher education, particularly for healthcare and teaching students.
- Technology-enhanced learning (e.g., extended reality (XR), serious games, smartphone apps) should be incorporated to engage schoolchildren effectively and supplement traditional training methods.
- Ministries of Education and policymakers should mandate CPR education in schools by law across Europe and beyond, supported by legislation, funding, and public awareness campaigns in every country.

Resuscitation in low-resource settings

- Experts from all resource settings are encouraged to investigate and report on populations, aetiologies, and outcomes of resuscitation, following established reporting standards such as the Utstein reporting template.

- Experts from all resource settings should be consulted regarding cultural differences and the regional and local acceptability, applicability, and implementation of guidelines and recommendations.
- All reports and research on resuscitation should include a brief section on the respective resource setting, for example the income classification of the country.
- In situations where standard guidelines are not applicable, specific recommendations may be developed for low-resource settings (such as areas with limited funding, ships, alpine regions, or remote areas) concerning essential equipment, education, and procedures for managing cardiac arrest both during and after the event.

Social media

- Social media (SoMe) platforms could be used as research tools for data collection, analysis, education, awareness campaigns, communication, and information sharing on sudden cardiac arrest.
- SoMe platforms should be leveraged to support public awareness campaigns, disseminate knowledge on CPR for any age group, foster community participation, and further the mission of the ERC.
- SoMe platforms should be incorporated into CPR training programmes. Educational and healthcare institutions are encouraged to use concise, engaging videos and interactive materials to reinforce learning and retention.
- Real-time engagement should be encouraged. Live question-and-answer sessions, interactive posts, and gamified learning should be used to increase engagement and knowledge retention in CPR training.
- The validation of SoMe content by experts should be promoted. Institutions are encouraged to ensure that educational materials shared on social media align with international CPR guidelines to prevent the spread of misinformation.
- SoMe-driven initiatives should be monitored and evaluated. Further research is needed to determine their impact on CPR training efficacy, bystander CPR rates, and patient survival outcomes.

First responders

- Every healthcare system should implement a first responder programme.
- Registered first responders who are near a suspected out-of-hospital cardiac arrest (OHCA) should be notified by the dispatch centre and dispatched to both public locations and private residences, in order to reduce the time to first chest compression and shock delivery, and to improve survival rates with favourable neurological outcomes.
- Systems that dispatch first responders should be linked to AED registries and should prioritise both the physical safety and psychological support of first responders.
- Cardiac arrest events should be reported in a standardised manner to monitor system performance and support continuous quality improvement.

EMS organization in response to cardiac arrest

- EMS should use standardised algorithms or criteria to identify cardiac arrest promptly.
- EMS should teach, monitor, and improve OHCA recognition in dispatch centres.
- EMS should implement and evaluate dispatcher-assisted public-access AED systems, including linkage to AED registries.
- Dispatch centres should implement systems allowing call handlers to deliver CPR instructions for cardiac arrest patients
- The use of locked or inaccessible AED cabinets is discouraged.
- All ambulances responding to OHCA should be equipped with a defibrillator.
- EMS should organise prehospital critical care teams for adult and paediatric OHCA.
- EMS should monitor and address low resuscitation exposure among personnel to ensure teams include members with recent experience and implement proper training to overcome low exposure.
- EMS systems treating OHCA should implement system improvement strategies to enhance patient outcomes.
- EMS systems may implement termination of resuscitation (TOR) rules to determine whether to stop resuscitation or continue during transport following local validation of the TOR criteria and considering specific local legal, organisational and cultural context.

In-hospital cardiac arrest management

- Hospitals should consider introducing a rapid response system (RRS).
- Hospitals should use system improvement strategies to enhance patient outcomes.
- Hospitals should implement protocols for managing family presence during CPR and provide respective education for healthcare teams
- Hospitals are encouraged to use the “Ten Steps Toward Improving In-Hospital Cardiac Arrest Quality of Care and Outcomes” framework to guide structured, system-wide improvements in resuscitation quality, outcomes, and team well-being.

Cardiac arrest centres (CAC)

- Adult patients with non-traumatic OHCA should be cared for at a CAC whenever possible.
- Healthcare systems should establish local protocols to develop and maintain a cardiac arrest network.

System performance improvement

- Organisations or communities that treat cardiac arrest should implement system improvement strategies to enhance patient outcomes.

Survivorship and co-survivorship

- Healthcare systems should create and implement policies for the care of cardiac arrest survivors and their co-survivors (e.g., families, close friends, and partners also impacted by the event) from

pre-discharge to long-term follow-up. These policies should adopt a multidisciplinary approach, responsive to the needs of both survivors and co-survivors. Healthcare professionals should receive adequate education to support both the identification of needs and the provision of appropriate care.

- National Resuscitation Councils (NRCs) should connect with and support cardiac arrest survivor organisations within their countries, strengthening ties with healthcare systems, survivors, and co-survivors.
- Engaging in partnerships among NRCs, and with organisations that have broader missions—such as cardiovascular healthcare organisations—can help address the diverse needs of survivors and co-survivors and optimise resource utilisation.
- Healthcare systems should actively engage cardiac arrest survivors, co-survivors, and the public as partners in policy development and research to enhance the quality, relevance, and integrity of outcomes.

New technologies and artificial intelligence

- Artificial intelligence (AI) and digital health technologies show potential to improve cardiac arrest outcomes but are not yet ready for routine clinical use, and their application should be limited to research or controlled settings.

The evidence informing the Systems Saving Lives Guidelines

Chain of survival

The chain of survival for victims of cardiac arrest dates back to concepts proposed by Friedrich Wilhelm Ahnefeld and Peter Safar, and emphasises the time-sensitive interventions, represented as links, that maximise the chance of survival.[3,4] This foundational concept has been expanded in subsequent years, with contributions from various organisations and academics, involving significant modifications in 1991.[5] Over time, designs depicting the chain of survival have evolved; however, the core messages behind each link have largely remained unchanged.

The ERC first published the chain of survival in its four-link format in the 2005 ERC Guidelines, summarising the vital links needed for successful resuscitation, including early recognition and call for help, early bystander CPR, early defibrillation, and early ALS and standardised post-resuscitation care. Each of these links highlights the interconnection and urgency of effective actions, emphasising the importance of a prompt response to optimise the chances of survival.[6] The term “chain of survival” is now used internationally in resuscitation awareness building, education, and science. A large and heterogenous body of literature on the chain of survival has emerged. An ILCOR scoping review found several novel versions and adaptations, partly expanding into other medical fields beyond resuscitation.[7] Adaptations addressed different situations or target audiences, but inconsistent in design and without an underlying system. Any chain link should be evidence-based and contribute to improved patient, education, or implementation outcomes.[8,9] The ILCOR scoping review proposed a six-link chain comprising: 1) Prevention and recognition, 2) Early call for help, 3) High-quality CPR, 4) Early defibrillation and ALS, 5) Post-cardiac arrest care, and 6) Recovery and rehabilitation.[6,7] In contrast, the ERC Guidelines 2025 now still recommends a four-link chain of survival for clarity and consistency. However, the original messages and links of the chain have been expanded and rearranged (Fig. 2). This basic chain should be used for all cardiac arrest aetiologies and locations, and all patient age groups.

Interestingly, only a few studies have so far formally assessed the impact of the chain of survival on clinical and educational outcomes. Findings suggest increased survival rates and better neurological outcomes have occurred following the introduction of new components to the chain, underscoring its potential effectiveness as a framework for improving practice.[7,8]

Apart from the basic chain of survival, individuals or organisations may require adaptations for specific situations or target audiences. The ERC follows ILCOR with an adaptive approach: an adapted ‘one-size-fits-all’ concept as a multifaceted system can be used when the basic chain of survival is not sufficient.[7,8] The basic chain of survival serves as the foundation; the chainmail of survival can be used with a multitude of additional links, depicting different situations and factors and highlighting the complexity of the system. Specific versions of the chain of survival can also be used for specific situations and audiences (e.g., trauma, drowning).[7,8] This adaptive concept is particularly important in the context of low-resource settings, where high-resource links in the basic chain may not be applicable or may need to be replaced.[10]

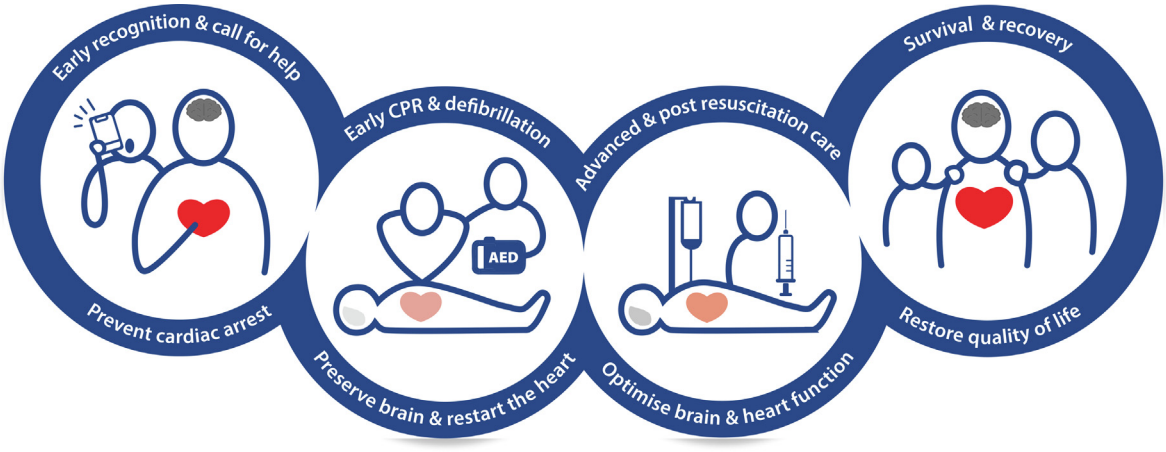


Fig. 2 – Chain of survival.

The formula of survival

The formula of survival combines scientific treatment, effective education, and local implementation to improve cardiac arrest survival rates.[11,12] These elements are multiplicands and are essential for a strong chain of survival.[12] Resuscitation guidelines are updated through the ILCOR evidence evaluation process and annual CoSTR publications. The ERC courses provide effective education. Local champions play a key role in putting resuscitation practices into action, overcoming challenges, using facilitators, and incorporating feedback systems.[8,13,14].

Advocacy

Advocacy is a civil endeavour in which individuals or groups support policies across various social, economic, or legislative domains to influence the allocation of both human and financial resources.[15] Advocacy is essential in addressing the multifaceted needs of cardiac arrest patients and their families.[16] This paragraph explores the definitions, actions, and impacts of such efforts, emphasising the ERC role in promoting comprehensive policies, public awareness, and support systems to improve outcomes and quality of life for cardiac arrest survivors and their co-survivors.

Advocacy role of scientific societies in the field of resuscitation

Advocacy is crucial for strengthening emergency care systems. Some initiatives advocate for new regulations, while others focus on educating hospital staff and frontline physicians locally. These programs improve emergency care for various traumas and life-threatening conditions, including cardiac arrest. Advocacy aims to bridge gaps, enhance outcomes, and make life-saving treatments more effective and accessible.[17]

The ERC plays a leading role at the European level in advocating for increased survival following cardiac arrest and improved quality of life through comprehensive policies and public awareness campaigns. One outcome of this advocacy was the establishment of European Cardiac Arrest Awareness Week by the European Parliament. This initiative encouraged member states to implement AED programmes, adapt legislation to enable CPR by non-medical individuals, collect data for quality management, support national CPR strategies, and provide legal immunity for non-medical first responders.[18]

The ERC has launched several key initiatives, including European Restart a Heart in 2013, Kids Save Lives in 2015, and broader campaigns to promote CPR training and AED accessibility across Europe.[18–20] Current ERC advocacy priorities include mandating CPR training for new drivers, strengthening CPR education among young people, harmonising CPR-related legislation, improving workplace emergency preparedness, and increasing public awareness and engagement. The “Learn to Drive Learn CPR” initiative, developed jointly by the ERC and the European Driving Schools Association (EFA), aims to integrate BLS training into driver education programmes across Europe.[19,21] Currently, fewer than half of European countries require such training (Fig. 3). This project aims to equip new drivers with life-saving skills, significantly increasing the number of potential responders. In 2025, the European Union formally adopted new minimum requirements for new drivers in the Driving License Directive. Thanks to ERC advocacy, the Parliament, Council, and Commission agreed to mandate knowledge of first aid, including CPR, in the theory exam. Applicants with certified practical training may be exempted from theory questions. Formal adoption is expected mid-2025, with Member States implementing the rules within four years.[22]

The Alliance for Workplace Awareness and Response to Emergencies (AWARE) seeks to enhance preparedness for cardiac arrest in the workplace. The coalition advocates for widespread CPR and first aid training, as well as broad availability of AEDs in European workplaces—areas not currently addressed by unified EU policy. AWARE calls on the EU to reopen the Health and Safety at Work Framework Directive (89/391/EEC) to strengthen these regulations, underlining the importance of explicitly supporting CPR and AED training, as both interventions are proven to significantly increase survival rates.[23]

The ERC also collaborates with the European Alliance for Cardiovascular Health to promote cardiovascular disease prevention and rehabilitation.[24] This collaboration includes developing a Cardiovascular Health Knowledge Centre and Observatory, co-creating national action plans, and supporting digital health policies.

Finally, the ERC hosted the EU Resuscitate Workshop: CPR Harmony for a Healthier Europe at the European Parliament. The event brought together Members of the European Parliament for hands-on CPR training. Its goals were to equip participants with life-saving skills, raise awareness of cardiac arrest statistics, and underscore the urgency of harmonising CPR training policies across member states to improve survival outcomes.[25]

Get trained save lives

The Get Trained Save Lives (GTSL) campaign is a public health initiative collaboratively developed between the Union of European Football Associations (UEFA) and the ERC (Fig. 4). This initiative aims to increase public awareness and engagement in CPR and AED training across Europe by leveraging the widespread influence of football and the expertise of resuscitation professionals. This campaign seeks to empower lay persons with essential life-saving skills to improve bystander intervention rates in OHCA. Through accessible, standardised training programmes and high-visibility events, the GTSL campaign aspires to foster a culture of preparedness, ultimately contributing to enhanced survival outcomes and strengthening the chain of survival in the community.[26,27]

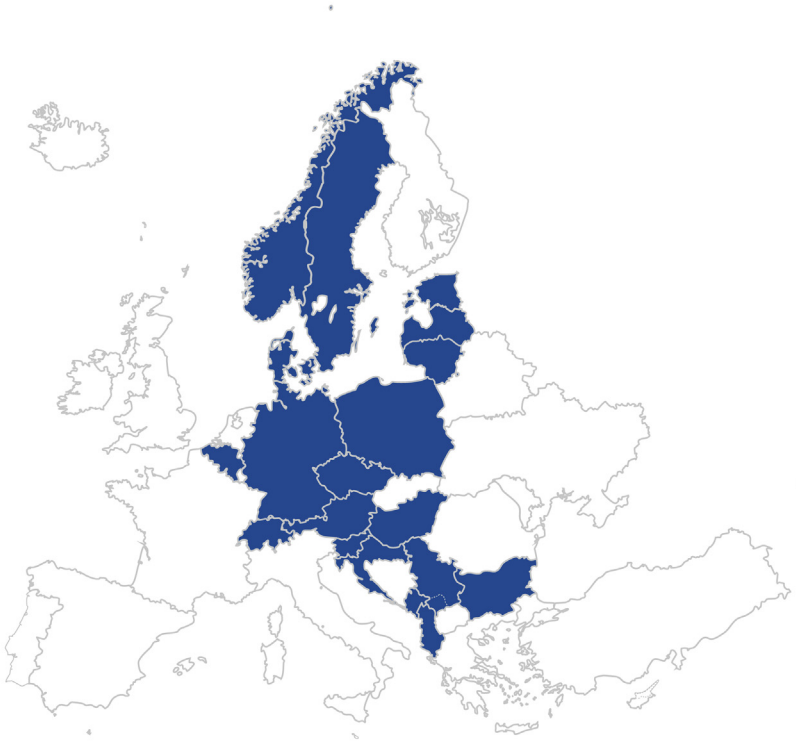
Awareness campaign and initiatives to promote CPR

Community initiatives to promote CPR implementation

A scoping review by ILCOR in 2024, identified 21 new studies[28–48] that focused on adult OHCA, with community interventions implemented in workplaces, schools, government offices, public events, and shared community spaces,[49] and were grouped into three categories:

1. Community CPR training programmes ($n = 11$)[28–30,39–46]
2. Mass-media campaigns ($n = 1$),[38] focusing on public awareness through media outlets.
3. Bundle interventions ($n = 9$)[31–37,47,48]: efforts to combine CPR training with other community-based strategies (e.g., public awareness campaigns, guideline implementation, legislative changes, and mandatory training for driver’s licence applicants).

The bystander CPR rate was the outcome consistently evaluated across nearly all included studies. Most reported improvements following community initiatives,[49] and six studies reported an increase in the number of people trained.[33,34,47,48,50,51] These results suggest that community initiatives are effective in improving the response to



Is Basic Life Support (BLS) training mandatory to obtain a category B* driving license?	
Yes	No
Albania +	Andorra
Austria +	Armenia
Belgium +	Azerbaijan
Bulgaria +	Bosnia Herzegovina
Croatia +	Cyprus
Czech Republic +	Finland
Denmark	France
Estonia +	Georgia
Germany +	Greece
Hungary +	Iceland
Latvia +	Italy
Liechtenstein +	Kazakhstan
Lithuania +	Kosovo
Monaco +	Luxembourg
Montenegro +	Malta
Norway +	Moldova
Poland +	Netherlands
Serbia +	North Macedonia
Slovenia +	Portugal
Sweden +	Romania
Switzerland +	San Marino
	Slovakia
	Spain
	Turkey
	Ukraine
	United Kingdom

*Category B driving license allows an individual to drive a motor vehicle with a maximum authorised mass not exceeding 3500 kg and designed and constructed for the carriage of no more than eight passengers in addition to the driver.

+ The BLS is often part of a broader first aid course.

Fig. 3 – CPR Training included in driving license courses.

OHCA. However, the effect on patient outcomes (survival and neurological recovery) was less conclusive without favouring interventions. Based on expert consensus, community initiatives should be endorsed and supported that promote BLS implementation.

European Restart a Heart & World Restart A Heart

Following an ERC campaign, the European Parliament adopted a Written Declaration calling for improved CPR and AED training across all EU member states. The Declaration also urged legislative changes to ensure equal access to high-quality CPR and defibrillation for all Europeans, and proposed the establishment of a European Cardiac Arrest Awareness Week,[18] recognising that national resuscitation policies can increase citizens' willingness to perform bystander CPR. To promote these policies, the ERC established European Restart a Heart Day on 16 October to raise awareness.[18,52,53] This initiative later evolved into World Restart a Heart (WRAH), endorsed by ILCOR with the motto: "All people of the world can save a life—all that is needed is two hands (Check, Call, Compress)" (Fig. 5).

As a result, between 2018 and 2023, more than 12.6 million people have been trained, and 570.7 million individuals have been reached through WRAH messaging.[20] The initiative has showcased a wide variety of campaigns tailored to each country's specific context and culture. Its success lies in annual collaboration among nations, organisations, and communities, reinforcing its global significance and reach. The adaptability of WRAH makes it an accessible and effective response to one of the world's most critical health challenges—saving lives through bystander CPR.

Based on expert consensus, national resuscitation councils, governments, and local authorities engaging in WRAH should aim to



Fig. 4 – UEFA and ERC Get Trained Save Lives campaign.

train as many people as possible, raise public awareness of the importance of bystander CPR and AEDs, establish protective legislation for lay rescuers, and develop innovative systems and policies to further improve survival outcomes.

Kids Save Lifes (KSL)

The Kids Save Lives initiative aims to introduce CPR education early and reinforce it throughout the school years. Implementing mandatory, nationwide CPR training for schoolchildren has been shown to have the greatest long-term impact on bystander CPR rates. Scandinavian countries, where CPR training has been compulsory for decades, report some of the highest bystander CPR rates globally.

The World Health Organization (WHO) endorses the ERC's Kids Save Lives initiative and recommends that children receive at least two hours of CPR training annually, starting at the age of 12—an age considered optimal for learning and retaining these skills.[20]

An ILCOR scientific statement titled Basic Life Support Education for Schoolchildren outlines best practices for teaching these essential life-saving skills, advocating for the integration of CPR training into school curricula worldwide.[54] This comprehensive review of the literature identifies the most effective strategies for educating children and adolescents in CPR. For details on educational approaches, consult the section on Tailored Resuscitation Education in ERC Guidelines 2025 – Education for Resuscitation (Fig. 6).[54]

Multiplication effect and social impact

Teaching CPR to children creates a multiplier effect, as they often pass on their skills to others. Studies show that each trained child educates between 1.8 and 4.9 people, helping to improve bystander



Fig. 5 – International World Restart a Heart poster.

CPR rates, especially in underserved areas. In one study, students from a predominantly low-income community trained an average of 4.9 others after learning CPR, highlighting its potential to spread CPR knowledge where formal training is limited.[54,55]

Legislative support and public campaigns

Legislative support is crucial for large-scale CPR education. ILCOR advocates making CPR education mandatory in schools, with government funding for materials and teacher education in resuscitation.

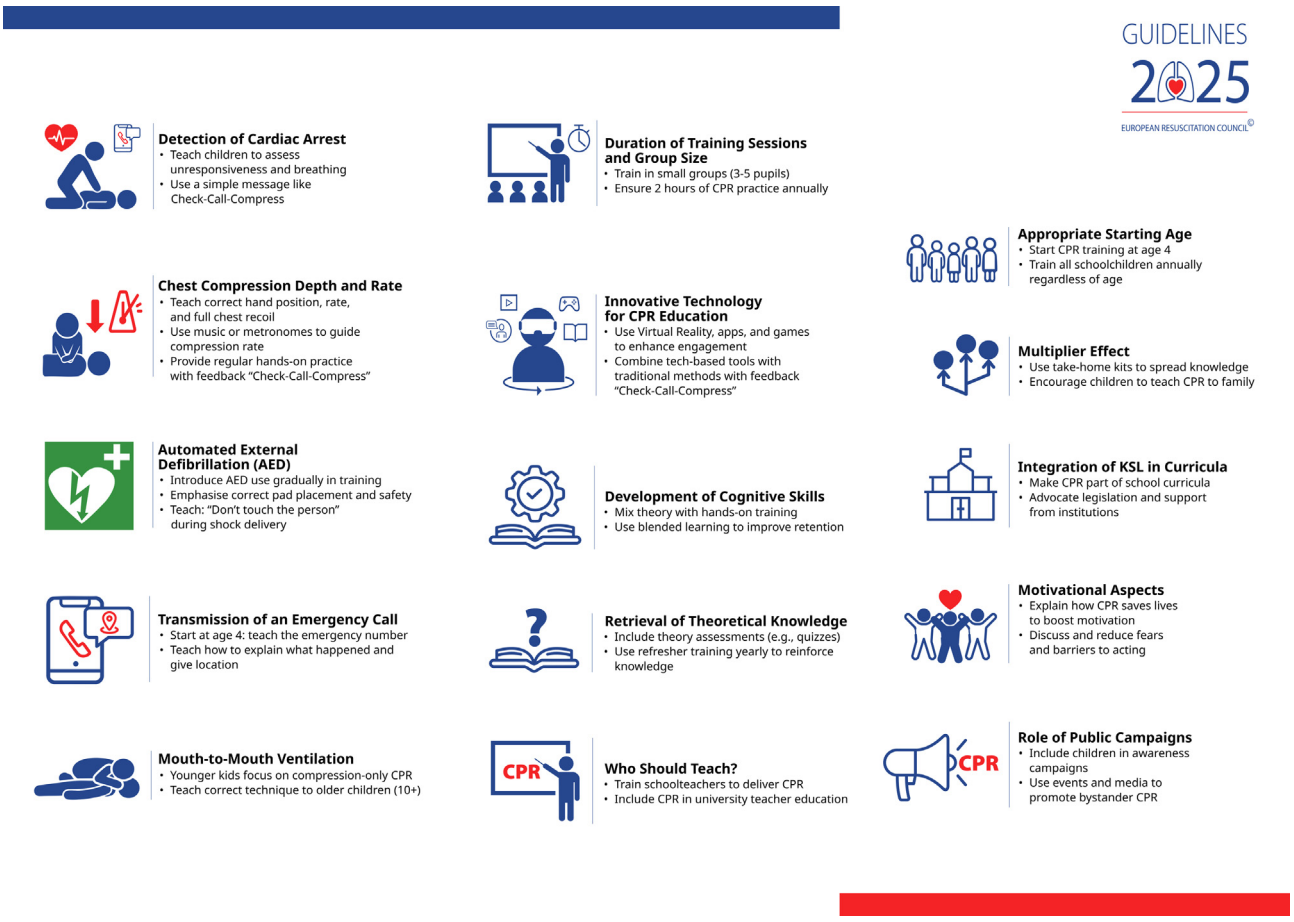


Fig. 6 – Summary of the Kids Save Lives ILCOR statement suggestions.

The 2023 ILCOR statement outlines a global framework for integrating CPR into school curricula.

European Kids Save Lives survey

A survey assessed the implementation of the Kids Save Lives initiative to evaluate the status of CPR education across Europe, examining whether it is mandated, recommended, or absent in school curricula.[56] The findings revealed significant disparities: six countries—Belgium, Denmark, France, Italy, Portugal, and the UK—have national laws mandating CPR training in schools, reflecting strong political and educational commitment. Others, such as Germany, Poland, and Sweden, recommend CPR training without mandating it, resulting in inconsistent implementation. Countries like Albania, Azerbaijan, and Moldova lack formal policies and rely on sporadic local or international efforts. Even in countries with mandates, implementation is challenged by limited funding, inadequate teacher education, and regional disparities. Public awareness campaigns also vary widely, underscoring the need for a more unified approach to CPR education across Europe (Fig. 7).

Resuscitation in low-resource settings

A 2020 ILCOR scoping review on clinical outcomes of resuscitation in low-resource settings highlighted the scarcity and heterogeneity of available literature.[57] This prompted discussions about the applicability of global resuscitation guidelines—often developed from a high-resource perspective by experts in high-income countries—as a one-size-fits-all model.[57–59]

Initially, low-resource settings were equated with low-income countries, as defined by the World Bank.[60] While this holds true in many cases, and outcomes remain poor in such contexts, resource availability can vary significantly across locations and over time.[61] For example, a major city in a low-income country might offer high-level cardiac arrest care, whereas an offshore facility or alpine region in a high-income country might lack essential resources. Moreover, resource conditions can shift due to infrastructural changes, environmental factors, or events such as natural disasters, pandemics, or armed conflicts.

In a 2023 ILCOR task force statement, the limitations of prior, exclusionary guideline approaches were acknowledged, and a more inclusive perspective was adopted (Fig. 8).[9] Drawing from existing emergency care networks—such as the World Health Organization (WHO) emergency care system framework, first aid guidelines from the International Federation and regional Red Cross and Red Crescent Societies, and the Helping Babies Breathe initiative—the task force identified enablers and barriers to implementing an effective chain (or 'chainmail') of survival.[62–65]

Most links in the chain require further research in low-resource contexts, ideally in collaboration with organisations experienced in such environments—e.g., resuscitation societies in low-income countries or groups focused on mountain, expedition, wilderness,

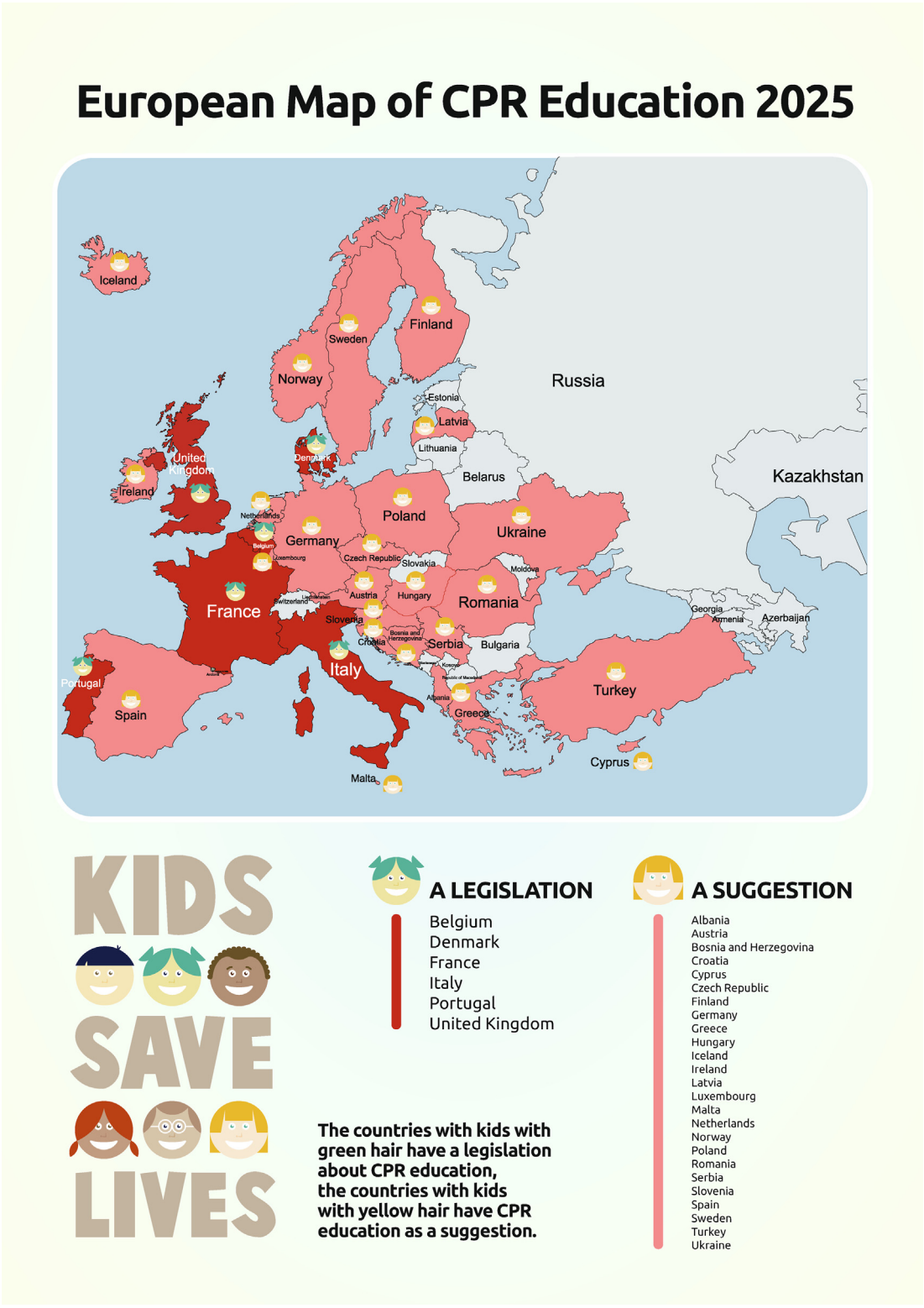


Fig. 7 – Map 2025 of schoolchildren CPR training in Europe.

or military medicine. A uniform approach will never fully address the diversity of these settings. Instead, existing guidelines can serve as a flexible foundation. ILCOR is currently working on evidence-informed expert opinions addressing specific subtopics relevant to low-resource environments.[10,63,66,67]

Alongside proposed action points—including the examination of ethical questions (e.g., is it appropriate to initiate advanced life support when no ICU or hospital is available?), the involvement of experts in the field, and support for research and registries—a list of essential basic and advanced resuscitation resources has been

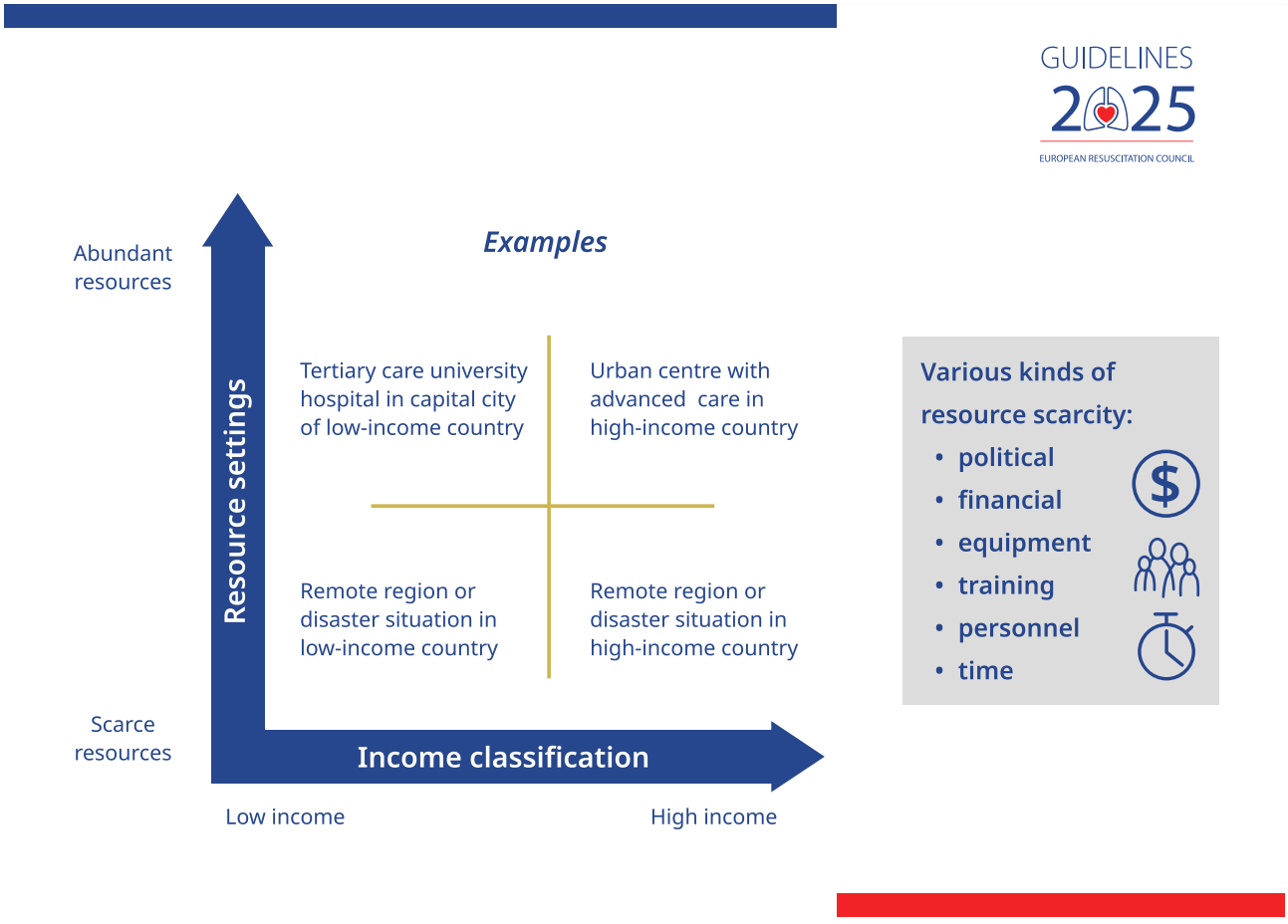


Fig. 8 – Low resource setting scheme.

suggested. However, this list still requires validation before it can be universally recommended.[10,68] Cost-effectiveness must also be considered in all related initiatives (Fig. 8).[69]

Social media

The growing use of social media (SoMe) in healthcare education has created new opportunities to promote adult CPR training. A recent scoping review examined SoMe applications in CPR, highlighting its effectiveness as a tool for data analysis, collection, education, awareness campaigns, communication, and information sharing on cardiac arrest.[70]

With around five billion users worldwide as of 2024, SoMe is a powerful platform for public health interventions. In adult CPR research, YouTube and X (formerly Twitter) were the most commonly used platforms for content dissemination, followed by WhatsApp and Instagram.[71] The main applications of SoMe in CPR include:

- Data analysis (41 %) – used to evaluate public sentiment, trends in CPR training, emotional responses to cardiac arrest events, and knowledge gaps.
- Data collection (36 %) – enabling large-scale surveys and real-time engagement studies on CPR knowledge and bystander behaviour.
- Teaching (10 %) – leveraging videos, infographics, and interactive content to improve knowledge retention among lay persons and healthcare students.
- Campaign promotion (7 %) – supporting initiatives like *World Restart a Heart*[20] that significantly increased engagement, though long-term behavioral impact remains unclear.
- Communication (4 %) – facilitating direct interaction between trainers and the public.
- Content sharing (2 %) – encouraging peer-to-peer learning and spreading awareness through viral posts.[70]

As another example, the widely-used 'emojis' in social media, and especially in text messaging, could be used for spreading awareness about CPR. Since there are barriers in introducing official CPR emojis, 'stickers' have been proposed instead.[72]

Despite its benefits, SoMe-based CPR education faces several challenges. A significant portion of CPR-related content does not align with guidelines from accredited bodies, raising concerns about quality and misinformation, and highlighting the need for expert validation.[71,73–76] Selection bias is another limitation, as users are more likely to engage with content aligned with their existing interests, which can affect generalizability. Additionally, access inequality due to socioeconomic disparities and inconsistent internet access

may limit the reach of SoMe-based CPR training.[77,78] Furthermore, while SoMe enables rapid information dissemination, its effect on long-term knowledge retention remains uncertain. To maximise SoMe's benefits in CPR education, standardised frameworks are needed to assess impact and ensure consistent training outcomes. Public health organisations and policymakers are encouraged to integrate SoMe strategies into national resuscitation programs to extend their reach.[79]

Future research should explore the role of emerging platforms—such as TikTok and Bilibili for education and awareness, LinkedIn, Bluesky, and Mastodon for professional communication and advocacy, and Instagram and Snapchat for public engagement—while considering demographic diversity and income disparities across countries. Implementing AI-driven content moderation and fact-checking tools is also recommended to reduce misinformation and improve content quality.

Integrating SoMe into CPR education has significant potential to boost public knowledge, increase bystander CPR rates, and improve survival outcomes in out-of-hospital cardiac arrest (OHCA). By leveraging digital platforms, healthcare professionals can create more effective, scalable, and engaging training programs tailored to diverse populations. Future work should focus on optimising SoMe content, standardizing evaluation metrics, and addressing barriers to digital education access.

First responders

CPR, defibrillation and survival

First responders (FRs) may be either community FRs or on-duty FRs.[80,81] Community FRs are volunteers who receive alerts about nearby emergencies and may choose whether to respond. On-duty FRs are professionals such as firefighters or police officers who are dispatched while on duty but are typically unable to transport patients. A recent survey found that 19 countries, including 15 in Europe, currently operate community FR systems.[82] Cost-effectiveness of FR systems has been suggested.[83]

The current recommendation is based on a 2019 ILCOR systematic review.[84] Only one randomised controlled trial (RCT) has directly assessed the impact of community FR systems (dispatched vs. not

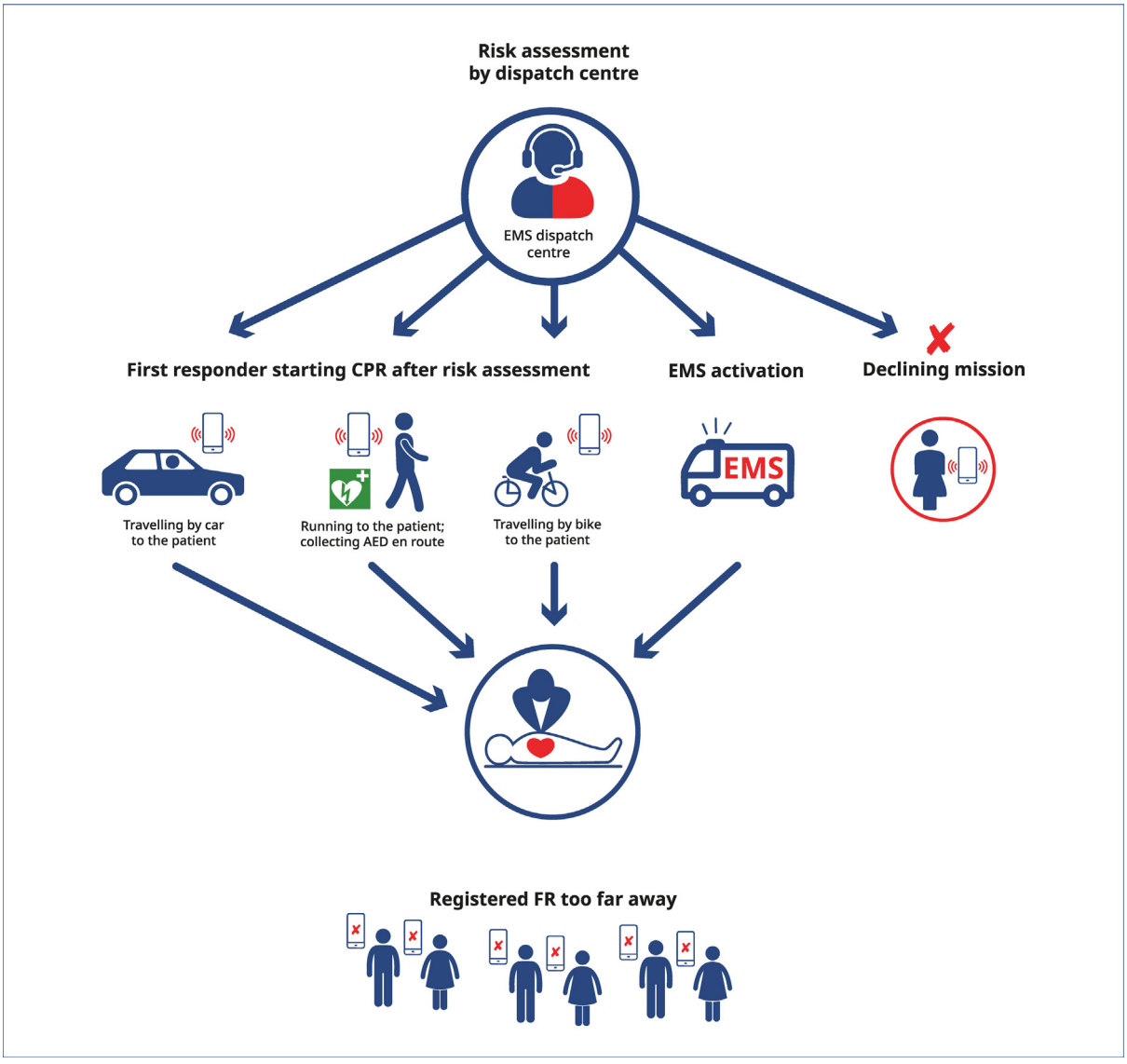


Fig. 9 – First Responder scheme.

dispatched) on bystander-initiated CPR.[85] In this trial, 5989 lay volunteers were randomly allocated via a text-message system. Bystander-initiated CPR was significantly higher in the intervention group than the control group (62 % vs 48 %, $p < 0.001$).

A separate non-randomised stepped-wedge cluster intervention study enrolled 5735 text-alerted volunteer responders directed to retrieve AEDs.[86] The study found survival after OHCA increased from 26 % to 39 % [adjusted relative risk (RR) 1.5, 95 % confidence interval (CI): 1.03–2.0]. The RR for neurologically favourable survival was 1.4 (95 % CI: 0.99–2.0). Several observational studies have reported that FR system implementation is associated with higher rates of bystander CPR and defibrillation, shorter time to defibrillation, and improved survival with favourable neurological outcomes.[86–91] Although RCT data on the effect of FR programmes on defibrillation and survival are limited, several trials are currently underway to address this gap.[37,92–95] The existing evidence is drawn from heterogeneous studies across various systems—differing in FR type (community vs professional), activation methods, activation radius, number of responders, and study designs (population, outcomes, etc.)—which limits generalisability.[96–102]

In line with ILCOR, the ERC recommends that individuals located near a suspected OHCA and willing to be engaged by a healthcare system should be alerted.[1]

Activation systems

First responder systems can operate via text messages, but most now use app-based platforms. App-based systems appear to reduce the time to FR arrival.[103] Using true-line distances rather than radial estimates may improve the accuracy of distance calculations, although further evidence is needed to determine whether this leads to better outcomes. FR systems should be integrated with AED registries and provide directions to nearby devices.[102,105] To ensure FR safety and appropriate support from EMS, activations should be managed through dispatch centres.[106,107] Protocols for FR activation must prioritise both physical and psychological safety (Fig. 9).[86,107,108]

Follow up after missions

Current evidence indicates a low risk of psychological distress and physical harm among dispatched first responders (FRs). Studies from the Netherlands, Denmark, Sweden, Australia, and New Zealand have reported low levels of post-traumatic stress symptoms at 3–6 weeks following deployment, and one study found minimal psychological distress just days after a mission.[109–112] However, one study noted that in rural OHCAs, FRs are more likely to know the patient or their families, which may present emotional challenges.[113] In a survey of FRs in Australia and New Zealand, most participants found debriefing to be beneficial.[111]

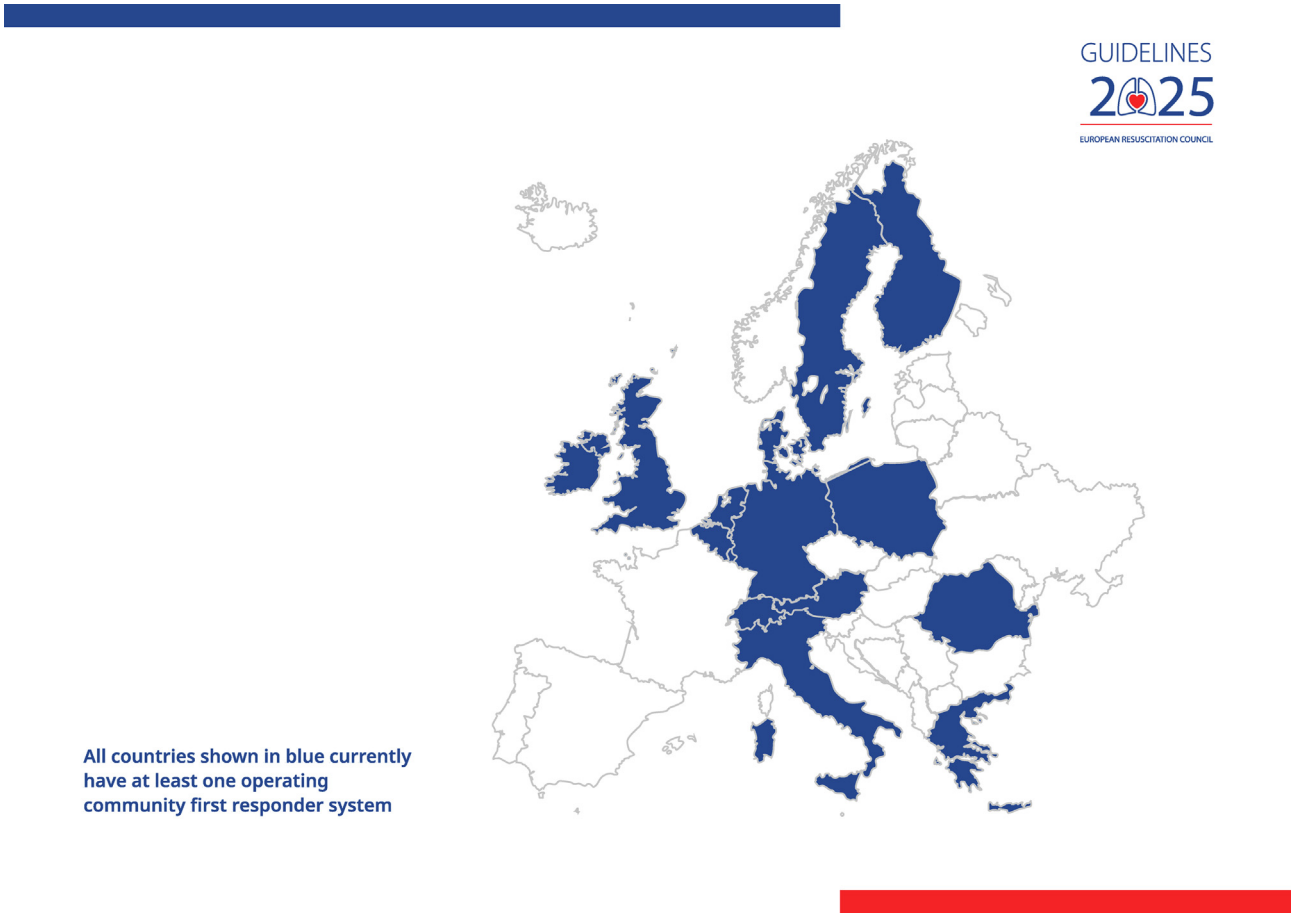


Fig. 10 – Map 2025 of First Responder activities in Europe.

Based on available evidence and expert consensus, FR systems are encouraged to implement systematic follow-up procedures to identify those who may have experienced physical harm or require defusing or psychological support.[114–118] Feedback and psychological support are considered essential for sustaining volunteer well-being and ongoing engagement.[112,119] Various follow-up models have been described, but further research is needed to determine the most effective approach. [104,108]

Customisation

The optimal activation radius or number of FRs dispatched per mission remains unclear and varies widely between systems.[104] First responder systems are encouraged to tailor activation protocols based on regional and EMS characteristics, such as population density and the number of available responders.[119,120]

Dispatching FRs to private residences appears reasonable because: (i) most OHCAs occur at home; (ii) survival rates for home OHCAs are lower; and (iii) automated external defibrillators (AEDs) are less accessible in residential areas.[88,111,121–123] Studies from Sweden and Denmark have reported a higher likelihood of bystander defibrillation when FRs are dispatched to home OHCAs.[88] A retrospective study from the Netherlands found improved survival in patients with ventricular fibrillation following implementation of a residential FR system.[86] Similarly, a US study showed increased CPR rates, defibrillation, and survival to hospital discharge for patients who received professional FR assistance at home.[39] The impact of FR systems may be even greater in rural areas, where observational studies show a higher proportion of FRs arrive before EMS and initiate resuscitation.[39,106,124–126] Systems are encouraged to prioritise FR recruitment in less densely populated regions.[127]

Qualification requirements for community FRs vary across systems (Fig. 10). A recent survey found that 69 % of FR systems require at least some level of CPR training.[128] A retrospective analysis reported higher survival to hospital discharge when CPR was performed by medically trained bystanders, compared to lay responders.[129] In a study assessing anaesthesiologists' perceptions of dispatched FRs, 84 % 'strongly agreed' that FRs had adequate CPR skills, despite no mandatory CPR training within the programme.[130]

Restrictive qualification criteria may reduce the pool of available FRs. However, a higher number of FRs arriving before EMS has been associated with increased rates of bystander CPR and defibrillation.[123,131] A survey also showed that FRs who had completed CPR training within the past 12 months were more likely to respond to a mission.[111] Additionally, FRs with prior CPR training or a professional background reported lower self-perceived psychological impact.[132]

Currently, there is a lack of studies evaluating system efficiency and patient outcomes based on FR proficiency levels. FR systems should routinely assess mission data, including patient outcomes and FR safety, ideally using a standardised reporting template to enable comparisons across systems.[115]

EMS organization in response to cardiac arrest

Optimisation of dispatcher assisted recognition of OHCA

A 2020 ILCOR diagnostic systematic review included 47 observational studies and reported wide variability in dispatchers' ability to recognise OHCA (sensitivities and specificities varied from 0.46 to 0.98 and 0.32 to 1.00, respectively). There were no differences between dispatching criteria/algorithms or level of education of dispatchers although comparisons were hampered by heterogeneity across studies.[133,134]

A recent ILCOR scoping review identified 62 studies on dispatcher-assisted (DA) recognition of OHCA, using qualitative, mixed-methods, observational, and randomised clinical trial approaches. Research focused on four key areas: caller-dispatcher communication, new technologies, patient characteristics, and quality improvement initiatives. Most studies were retrospective, assessing OHCA recognition rates and influencing factors. A major challenge was distinguishing normal from abnormal breathing. Various strategies were tested, but none outperformed the standard two-question method: (1) "Is the person awake and alert?" and (2) "Is (s) he breathing normally?". Only one RCT examined AI-assisted recognition and found no significant improvement because of a high rate of false positives. Overall, no new evidence supports changes to current OHCA recognition protocols.[1,135]

Consistent with ILCOR, the ERC recommends that dispatch centres implement standardised algorithms or criteria to quickly identify OHCA during emergency calls. Additionally, dispatch centres should monitor their diagnostic accuracy to ensure effective recognition but also seek ways to optimise sensitivity and minimise false negatives.

Optimization of dispatcher-assisted CPR

A 2020 ILCOR systematic review and *meta*-analysis evaluated the impact of dispatcher-assisted CPR (DA-CPR) programmes, including 33 observational studies. It found that the provision of DA-CPR was consistently associated with improved outcomes across all analyses, although the certainty of evidence was low or very low. A more recent ILCOR scoping review sought to identify new evidence to optimise DA-CPR. It included 31 studies examining innovations such as updated protocols, pre-recorded instructions, centralised dispatch systems, advanced dispatcher training, metronomes, and undressing guidance.[1,8,136] However, the available evidence was insufficient to draw conclusions about the effectiveness of these interventions. Among interventions with at least five supporting studies, some strategies showed promise for improving CPR quality—for example, simplifying instructions (e.g. 'Push as hard as you can') and incorporating video into emergency calls. However, language barriers may limit generalisability, and nearly half of the video-based studies were conducted in simulated settings.

In line with ILCOR, the ERC recommends that emergency medical dispatch centres implement systems allowing call handlers to deliver CPR instructions for adult cardiac arrest patients. Dispatchers should provide guidance when deemed necessary. However, current evidence is insufficient to support specific interventions aimed at improving the quality of dispatcher-assisted CPR.

Optimisation of dispatcher-assisted public-access AED retrieval and use

A recent ILCOR scoping review assessed DA instructions for public access AED retrieval and use among adult and paediatric OHCAs and identified 16 studies: 5 observational and 11 simulation studies (6 RCTs, 1 observational, and non-randomised comparisons). The review did not include AED use within volunteer first-responder systems. No studies assessed survival outcomes, ROSC, or quality of life. One observational study linked dispatcher-assisted AED retrieval instructions to improved bystander defibrillation, though its direct

impact was unclear. Observational studies showed low AED retrieval and application rates, with some reports of confusion and delays. Simulation studies found dispatcher assistance improved AED use competence but delayed the first shock. Video guidance had mixed results, and pre-recorded instructions were less effective than real-time dispatcher support.

ILCOR noted limited research and lack of data to support a systematic review. Given that most OHCAs occur in the home, public-access AEDs are likely to be in close proximity in only a minority of cases. A potential risk of delays in CPR and decreased CPR efficacy was identified, especially when a lone rescuer is present. Future studies should focus on optimising dispatcher instructions, AED retrieval integration, phrasing, video use, and technology-supported AED location assistance.[136] In line with ILCOR, the ERC encourages EMS agencies implementing DA public-access AED systems to monitor and evaluate their effectiveness. Once OHCA is recognised and CPR has begun, dispatchers are encouraged to ask if an AED is available. If no AED is accessible and multiple rescuers are present, dispatchers should provide instructions to locate and retrieve one, using up-to-date registries where available. Once an AED is retrieved, dispatchers should guide the caller in its use.[8]

Ambulance equipment

According to the European Standard EN 1789:2020 every road ambulance (type A1, A2, B and C) must be equipped with defibrillators that can record rhythm and patient data.[137] The ERC supports this recommendation as timely defibrillation with restoration of circulation is one of the strongest determinants of survival with favourable neurological outcome.[138] The chances of survival decrease rapidly with time, even when bystander CPR is provided, and defibrillation after 15 min is associated with dismal chances of survival with favourable neurological outcome. This is in line with the World Health Organization's Emergency Medical Teams 2030 Strategy which calls on countries and organisations to take a proactive approach, and to build and strengthen their EMT and rapid response capacities by implementing standardisation and quality assurance.[139]

AED accessibility (benefits and harms of locked AED cabinets)

A recent ILCOR scoping review evaluated the benefits and harms of locking AEDs in cabinets, identifying 10 studies (8 observational, 2 simulation) involving between 39 and 31,938 devices.[140] None reported patient outcomes. Most studies found low rates of theft and vandalism (<2.0 %), even when AEDs were accessible 24 h a day. A comparison between locked and unlocked cabinets showed similarly low theft rates (0.3 % vs 0.1 %). However, simulation studies demonstrated that locked cabinets delayed AED retrieval, and one study reported rescuer injuries caused by breaking glass to access cabinet keys.[140] In line with ILCOR, the ERC advises against locking AED cabinets or making them inaccessible in any other way. Novel anti-theft systems like geolocation tracking modules on the AEDs can be explored instead. However, if locks are unavoidable and still used, clear unlocking instructions must be provided to avoid delays. Systems deploying public-access defibrillators should also establish procedures for retrieving and redeploying used devices.

Prehospital critical care for out-of-hospital cardiac arrest

A recent ILCOR systematic review included 15 non-randomised studies assessing the impact of prehospital critical care teams on OHCA outcomes, involving 1,188,287 patients. Most teams included physicians, while some involved critical care paramedics, primarily in the UK and Australia.[135] Attendance of these teams at OHCAs was associated with increased rates of survival to hospital discharge and favourable neurological outcome. In line with ILCOR, the ERC recommends that prehospital critical care teams attend OHCAs if the EMS system has sufficient resource infrastructure.

EMS experience and exposure to OHCA

An ILCOR systematic review including seven non-randomised studies evaluated the impact of resuscitation exposure and career experience on out-of-hospital cardiac arrest (OHCA) outcomes.[141] The certainty of evidence was very low. Only one study[142] assessed EMS physician exposure but provided insufficient data to determine any effect on survival with favourable neurological outcome. Three studies[142–144] reported mixed findings on survival to hospital discharge: the largest study showed that higher team exposure over the previous three years was associated with increased survival, while two others found no association. However, both of these also reported lower survival among patients treated by teams with no resuscitation exposure in the preceding six months.[143] Two studies[142,145] found that higher paramedic exposure (defined as $\geq$15 cases over five years or $\geq$10 cases in one year) was associated with increased rate of ROSC, although no studies specifically assessed event survival. Four studies[143,146–148] found no consistent association between years of clinical experience and survival, except one, which reported higher survival rates among patients treated by more experienced EMS providers. Overall, the evidence suggests that greater exposure to resuscitation may improve survival and ROSC, but the findings are inconsistent and subject to bias.[1]

In line with ILCOR, the ERC suggests that EMS systems: (i) monitor clinical personnel's exposure to resuscitation; and (ii) implement strategies, where possible, to mitigate low exposure or ensure that teams include members with recent resuscitation experience.

EMS system performance improvements

An ILCOR systematic review evaluated system performance improvement initiatives for cardiac arrest management in both prehospital and in-hospital settings.[149] The review included one randomised controlled trial (RCT) and 41 non-randomised studies, focusing on interventions aimed at improving system structure, care pathways, clinical processes, and overall quality of care. One example is the use of real-time CPR feedback and post-event debriefing, which offer immediate guidance on compression quality and promote continuous team learning. The RCT[150] reported that system-level interventions improved resuscitation skills, including a lower compression rate (103 vs 108 per minute, $p < 0.001$), higher chest compression fraction (66 % vs 64 %, $p = 0.016$), deeper compressions (40 mm vs 38 mm, $p = 0.005$), and fewer incomplete releases (10 % vs 15 %, $p < 0.001$). However, there was no significant difference in survival. Among the 41 non-RCT studies, 17 showed significant improvements in neurologically favourable survival, 20 reported increased survival to hospital discharge, and 16 demonstrated enhanced skill performance. Additional studies reported improvements in system-level metrics such as response time and CPR quality. The overall certainty of evidence ranged from moderate to very low, with considerable heterogeneity across interventions. While system performance initiatives appear promising, their resource requirements and cost-effectiveness remain unclear and warrant further investigation. In line with ILCOR, the ERC recommends that EMS systems implement performance improvement strategies to enhance outcomes following OHCA.

OHCA Termination Of Resuscitation (TOR) rules

A recent ILCOR systematic review identified 10 new observational studies evaluating TOR rules for OHCA, focusing on prediction of no ROSC, in-hospital death, and survival with unfavourable neurological outcomes.[151] Due to high bias and heterogeneity, no meta-analysis was conducted.

Studies assessing ROSC prediction found variable sensitivity and high specificity, particularly in paediatric cases. For in-hospital death, adult TOR rules such as KoCARC and uTOR had moderate sensitivity (0.31–0.79) but high specificity (0.80–1.00), meaning they effectively identified non-survivors but had limited predictive accuracy. Studies evaluating death or unfavourable neurological outcomes reported low sensitivity but high specificity, limiting their clinical utility. Additionally, two cost-effectiveness studies found Korean and European TOR rules to be cost-effective, with potential savings in cases terminated in the field.[152,153]

One paediatric study developed a new TOR rule, achieving 99.1 % specificity, though with low sensitivity (30.4 %).[154] Overall, TOR rules accurately identify non-survivors but lack reliability in predicting individual survival, particularly in children.[1]

Consistent with ILCOR, the ERC conditionally recommends that EMS systems may implement TOR rules to assist clinicians in deciding whether to discontinue resuscitation efforts at the scene or to transport to hospital with ongoing CPR for adults. We suggest that TOR rules may only be implemented following local validation of the TOR rule with acceptable specificity considering local culture, values, and setting. For paediatric OHCA because of insufficient evidence we suggest against the use of TOR rules to decide whether to terminate resuscitation efforts (Fig. 11).

In-hospital cardiac arrest management

Rapid response systems (RRS)

An ILCOR systematic review identified 62 relevant papers.[155] There was high heterogeneity among studies, with overall evidence rated as very low to low due to serious risk of bias and imprecision. No studies reported on hospital discharge with favourable neurological outcomes. For survival to hospital discharge, low-certainty evidence from eight non-RCTs showed no significant improvement after implementation of a Rapid Response System (RRS). One study found that implementation of a RRS was associated with no difference in 30-



Fig. 11 – Optimising emergency dispatch for cardiac arrest response.

day survival after cardiac arrest, while another reported increased long-term survival in hip fracture patients ($p = 0.008$). Three RCTs found no significant reduction in the incidence of IHCA, while 56 non-RCTs provided mixed results: 39 showed significant improvement, and 17 did not. Adjusted analyses indicated that higher-intensity RRS implementations (e.g., frequent activation, senior medical staff) were more effective. Despite study heterogeneity, findings suggest a reduction in cardiac arrest incidence in hospitals implementing an RRS, with a dose–response effect favouring higher-intensity systems.[1] Consistent with ILCOR, the ERC suggests hospitals should introduce a RRS to reduce the incidence of IHCA.

In-hospital system performance improvements

To increase quality of IHCA detection and treatment on a system level, ILCOR proposes ten steps which include advice on plans, preparations and prevention of IHCA, as well as how to perform resuscitation and how to improve a culture of person-centered care.[156] A recent ILCOR systematic review assessed system performance improvement initiatives for cardiac arrest management in pre-hospital and in-hospital settings. The review included one RCT and 41 non-RCTs, examining interventions designed to enhance structure, care pathways, processes, and quality of care.[149] Among these 41 non-RCT studies, 17 showed a significant improvement in neurologically favourable survival, 20 reported increased survival to hospital discharge, and 16 found enhanced skill performance. Additional studies demonstrated improvements in system-level variables such as response time and CPR quality. The overall certainty of evidence ranged from moderate to very low, with significant heterogeneity across interventions. While system performance improvements showed promise, the resource requirements and cost-effectiveness remain uncertain, requiring further research.[1] Consistent with ILCOR, the ERC thus recommends that hospitals use system improvement strategies to improve patient outcomes after in-hospital cardiac arrest.

Family presence

An ILCOR systematic review examined the impact of family presence during adult resuscitation from cardiac arrest including 18 quantitative studies (including two RCTs), 12 qualitative studies, and one mixed methods study.[157] Providers experience was variable, and family members had mixed psychological outcome (e.g. depression, post-traumatic stress disorder). The evidence remains of low or very low certainty.

Additionally, a recent ILCOR systematic review focused on family presence during resuscitation in paediatric and neonatal cardiac arrest, which included 36 studies.[158] Papers addressing the experiences and opinions of parents and family found high agreement on the wish to be present during resuscitation. In contrast, the articles focusing on the healthcare providers´ experience and opinion showed mixed results. Healthcare providers who had experience in family presence during resuscitation had a higher agreement. There were seven studies on family presence during neonatal resuscitation, with different topics and approaches. As this is a highly emotional situation, there is a need for staff training for support and debriefing.

Consistent with ILCOR, the ERC suggests that family members be provided with the option to be present during in-hospital adult resuscitation from cardiac arrest. Hospitals should develop policies to guide family presence during resuscitation and provide healthcare providers with education to manage these situations effectively.[1]

Pre-arrest prediction of survival following in-hospital cardiac arrest

An ILCOR systematic review identified 23 studies evaluating 13 pre-arrest prediction rules for survival following IHCA.[159] The pre-arrest morbidity (PAM) score and prognosis after resuscitation (PAR) score were the most frequently studied, though clinical heterogeneity prevented *meta*-analysis.

For predicting survival to hospital discharge, seven historical cohort studies examined the PAM score, and four also assessed the PAR score. Sensitivity was generally high (close to 100 %), but specificity was low, meaning these scores often overestimated mortality risk. No single cut-off reliably predicted non-survival. Similarly, studies on the modified pre-arrest morbidity index (MPI) score, National Early Warning Score (NEWS), and Clinical Frailty Scale (CFS) showed inconsistent predictive value, with low certainty evidence due to bias, imprecision, and inconsistency. For predicting survival with favourable neurological outcomes, seven studies examined the Good Outcome Following Attempted Resuscitation (GO-FAR) score, which had high sensitivity but low specificity, meaning it identified most survivors but poorly distinguished non-survivors. Other models, including GO-FAR 2, prediction of outcome following in-hospital cardiac arrest (PIHCA), and classification and regression tree (CART), showed similar limitations.

Overall, no pre-arrest prediction rule reliably predicted survival or death following IHCA. The certainty of evidence was very low, limiting confidence in these models for clinical decision-making.[1]

In line with ILCOR, the ERC recommends against using any currently available pre-arrest prediction rule as a sole reason not to resuscitate an adult with in-hospital cardiac arrest.

Cardiac arrest centres (CAC)

Cardiac arrest centres are specialised hospitals that provide comprehensive post-resuscitation care through integrated, multidisciplinary teams, advanced technologies, and adherence to evidence-based guidelines.[160–162] Until recently, the definition of a cardiac arrest centre varied across healthcare systems, contributing to heterogeneity and limiting generalisability of findings.[163] In 2020, a European multi-society consensus document provided a standardised definition and outlined core characteristics of cardiac arrest centres.[161] The minimum requirements for cardiac arrest centres include:

- 24/7 on-site coronary angiography lab
- Emergency department
- ICU with temperature control capability
- Echocardiography, CT and MRI imaging
- Multimodal neuroprognostication
- Rehabilitation services
- Education and training facilities
- Data collection and quality assurance
- Clear protocols for transferring selected patients to OHCA hub hospitals with additional services

These hub hospitals offer expanded diagnostics and treatments during or after the acute phase, including extracorporeal CPR (ECPR), arrhythmia management and electrophysiological studies, device therapy (e.g., ICD implantation), survivor screening, genetic testing and counselling for families, research infrastructure, and fundraising capacity.

Local accreditation programmes have already been successfully implemented.[164,165] Accreditation should be based on defined interdisciplinary criteria, including:

- Structural quality: 24/7 percutaneous coronary intervention (PCI) availability and intensive care unit (ICU) capacity with temperature control (TC)
- Process quality: standard operating procedures (SOPs) for communication between EMS and emergency department staff, protocols for inter-hospital transfer following OHCA, and neuroprognostication guidelines
- Quality assessment: systematic recording of interventions, time intervals, and outcomes.
- Defined treatment pathways with clearly documented protocols
- Transparent communication of outcomes

Another important aim of designating cardiac arrest centres is to improve both survival and neurological outcomes in OHCA patients, while also fostering education and research in resuscitation care.

ILCOR conducted a systematic review in 2020 to assess the impact of cardiac arrest centres on OHCA survival. The review concluded that such centres might be beneficial, but all included studies were observational, limiting the strength of the evidence.[166] In response to emerging data, ILCOR performed a new systematic review in 2024, incorporating over 145,000 patients across 15 observational studies[162] and, for the first time, a randomised controlled trial (RCT)[167]: The observational studies consistently found that transporting OHCA patients to cardiac arrest centres was associated with improved survival and better neurological outcomes. However, the RCT found no significant differences in outcomes between cardiac arrest centres and non-designated hospitals (this study only assessed patients without post-ROSC ST elevations). This discrepancy highlights the limitations of observational studies, including potential confounding factors such as patient selection bias and variation in hospital resources.[168]

Despite these limitations, the overall body of evidence suggests that cardiac arrest centres may provide superior care, especially when advanced interventions such as PCI are available. Supporting this, a recent multi-centre European survey of 247 hospitals showed that cardiac arrest centres admit more patients annually, are better equipped, and more consistently follow guideline-based care.[169]

There is currently insufficient data to support subgroup-specific recommendations, such as for different ages, presenting rhythms, or primary versus secondary transfers. Additionally, cardiac arrest centres are likely to be feasible only in high-resource settings, and healthcare systems should ensure that resources are optimally distributed across the entire chain of survival.

In line with ILCOR, the ERC suggests that adult patients with non-traumatic OHCA should be treated in cardiac arrest centres whenever possible. Ongoing research and refinement of the criteria for such centres are essential to support further improvements.

System performance improvement

To improve survival outcomes, systems must continuously strive to enhance their performance. This principle is captured in the local implementation element of the Utstein formula of survival. System performance improvement refers to coordinated efforts aimed at strengthening the structure, care pathways, processes, and overall quality of care, either at the organisational or population level. These efforts may involve single or bundled interventions and can include one or multiple departments or organisations. This ERC recommendation is informed by the 2024 ILCOR CoSTR on system performance improvement.[170] The 2024 update included 15 additional studies, adding to the 27 identified in the 2020 review.[149] Reported interventions included:

- Implementation programmes
- Technology (e.g., dispatcher video connections, smartphone apps)
- Event-specific feedback (real-time coaching or post-event debriefing)
- Logistical and educational initiatives
- Public awareness campaigns (e.g., Kids Save Lives)
- System evaluations and audits

The updated ILCOR CoSTR found that four non-randomised studies reported improved survival with favourable neurological outcomes at discharge and six non-randomised studies reported increased survival to hospital discharge. These studies encompassed both OHCA and IHCA cases.

Based on the consistent positive impact across provider-, organisational-, and system-level outcomes, ILCOR issued a strong recommendation in support of performance improvement initiatives. However, implementing such strategies requires financial resources, personnel, and stakeholder support, which may vary across systems. Examples of impactful initiatives include the Resuscitation Academy programmes developed by the Global Resuscitation Alliance for OHCA, and the ILCOR consensus statement on Ten Steps Toward Improving In-Hospital Cardiac Arrest Quality of Care and Outcomes.[156,171] Based on this evidence, the ERC recommends that all organisations and communities involved in the treatment of cardiac arrest adopt system improvement strategies to enhance patient outcomes.

Survivorship and co-survivorship

Multidisciplinary care and long-term follow-up

Cardiac arrest survivors are individuals who have been successfully resuscitated from a cardiac arrest. Most will be discharged home with varying levels of neurological, psychological, and/or physical impairment.[168] Depending on local policies regarding the withdrawal of life-sustaining treatments, a smaller but varying proportion of patients may experience prolonged consciousness disorders, necessitating extended rehabilitation and institutionalization.[168]

Key supporters have been defined as individuals with a significant relationship with cardiac arrest survivors.[172] This group includes family members, spouses, partners, close friends, or others who share a close bond with the survivor. Key supporters play a crucial role in the survivor's recovery and well-being. Some within this group may identify as 'co-survivors,' recognising their shared experience and impact from the event'. The concept of survivorship and co-survivorship acknowledges the complex and often enduring emotional, physical, social, and economic challenges associated with life during and after critical illness such as cardiac arrest. It has been identified as one of the key challenges for the resuscitation community.[173]

Cardiac arrest survivors may exhibit an array of symptoms and challenges related to both the cause of the cardiac arrest and its aftermath.[168] Various physical, emotional, and cognitive limitations which can impact an individual's health-related quality of life and ability to re-engage with society can be present even in those discharged with 'favourable' neurological outcome; these limitations can persist

for years.[174–178] Family members and close friends, especially those who witnessed the arrest, may have substantial emotional problems and experience high levels of care-giver strain.[179] These issues require a comprehensive, multi-disciplinary approach involving medical, psychological, physical, occupational, and social support.[175–177] However, current follow-up programs may not fully address these needs.[180–182] Care pathways for survivors and co-survivors should be tailored to an individual's often fluctuating needs across the recovery journey, from both the early stages post-event to the longer-term follow-up. The focus should be on optimising psychological recovery, independence, societal reintegration, and improved health-related quality of life.[168]

Cardiac arrest survivor organisations

Recent evidence indicates that cardiac arrest survivors have a wide range of needs beyond just healthcare.[183] These needs encompass spirituality, social networks, practical assistance, legal issues, and economic support, highlighting the importance of community-based support systems. Cardiac arrest survivor organisations are community-based organisations supporting survivors and co-survivors. An international survey conducted by the ERC in 2024 aimed to identify active organisations and to examine their structure and activities.[184] The survey found eight active organisations worldwide, six based in Europe. These organisations offer resources and support during the recovery process, provide information, and raise awareness about cardiac arrest and its consequences. They also promote research in this field and create communities where individuals can share their experiences, benefitting from peer support. Although evidence of the impact of peer-support following cardiac arrest is limited, wide ranging benefits, including reduced anxiety and enhanced health-related quality of life, have been described in other conditions such as stroke and cancer.[184–188]

Cardiac arrest survivor organisations describe numerous barriers to the support that they can offer to survivors, including a lack of connection with healthcare systems and the local national resuscitation councils. It is also acknowledged that organisations focused on related diseases, such as cardiovascular diseases, could provide additional support for cardiac arrest survivors whose arrest is linked to their disease of interest. This underscores the importance of enhanced connectivity between national resuscitation councils, healthcare systems and survivor organisations with other major organisations to better address survivors' needs and the optimisation of resources (Fig. 12).

Patient and Public Involvement and Engagement (PPIE)

Although variously defined, Patient and Public Involvement and Engagement refers to the active involvement of people as partners in the planning and conduct of research, in developing the evidence-base for healthcare guidelines, and in contributing to policy decisions. This engagement is quite different to patients participating as passive research subjects; rather, activities are conducted 'with' or 'by' the public, rather than 'to' or 'for them.[189,190] Increasingly seen as a mainstay of healthcare research, PPIE is underpinned by ethical principles and an ambition to enhance both the quality of outcomes and the relevance, quality and integrity of decisions.[191] Whilst engagement with PPIE in resuscitation research is relatively new,[183,191–194] a growing body of research highlights its added value.[195]

Numerous funding bodies and organisations, such as the National Institute for Health Research in the UK, the Patient-Centered Outcomes Research Institute in the US, and the Canadian Health Institute, champion the importance of PPIE across all stages of the research cycle. Similarly, opportunities for PPIE exist throughout the chain of survival, but its potential in resuscitation research and healthcare policy remains largely untapped and unexplored.[196] Recognising the importance of PPIE to the future of resuscitation research, the ERC is committed to PPIE. As a starting point, initial steps have been taken to work collaboratively with community advi-

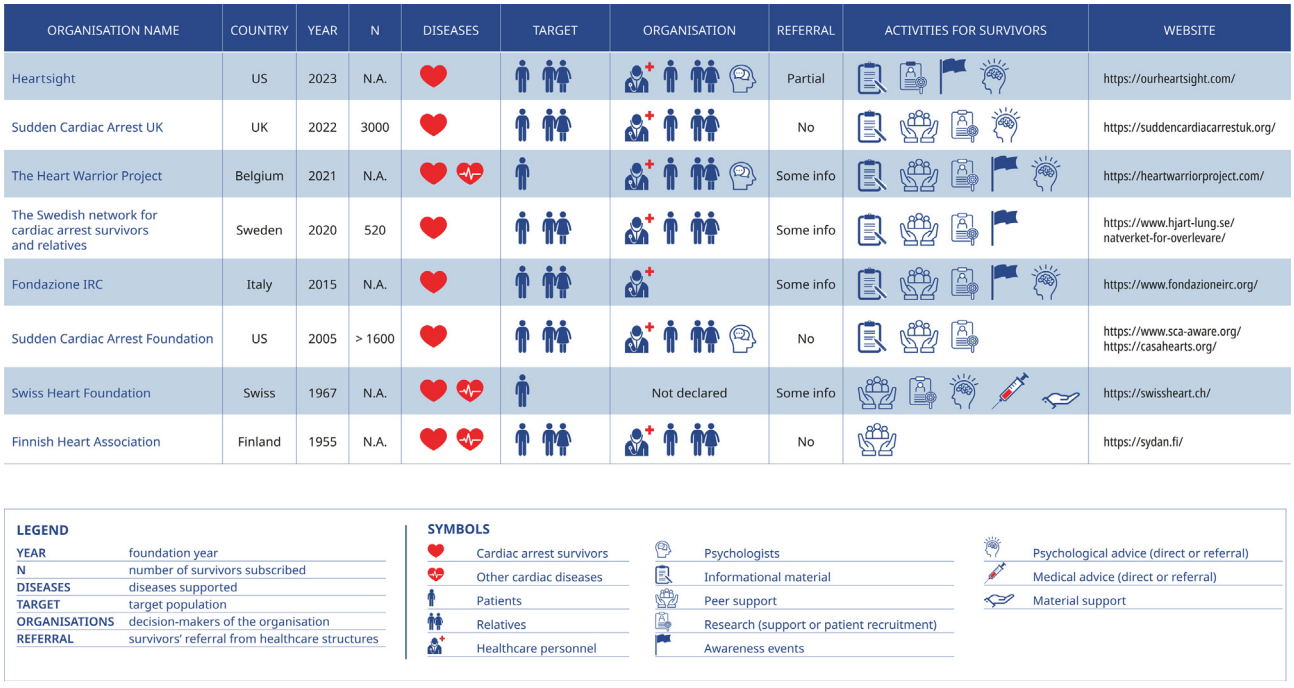


Fig. 12 – Survivorship and Co-Survivorship Communities.

sors (cardiac arrest survivors, co-survivors, etc.) in the development of this ERC Guidelines 2025. International standards for high-quality, evidence-based clinical guideline development include PPIE as a core principle[197] with the proposition that meaningful engagement enhances community relevance.[197] No standardised methodologies for active PPIE in the co-production of guidelines are available.[199]

New technologies and artificial intelligence

In recent years, digital health tools, artificial intelligence (AI), and advanced sensor-based monitoring systems have reshaped how cardiac arrest might be we identified and managed. While traditional resuscitation has typically relied on bystanders and EMS acting quickly, a significant change is underway.[200–207] AI-driven technologies, wearable devices, and automated systems are changing the response to these life-threatening emergencies.[208] Currently no ILCOR-graded evidence is available on this topic. The ERC System Saving Lives writing group explored new technologies in general narratively, while AI-related advancements are addressed through a scoping review.

The role of new technology in resuscitation

Wearable health devices including smartwatches and biometric patches are opening new doors for continuous, real-time cardiac monitoring.[209–213] According to recent studies, technologies like photoplethysmography and electrocardiogram sensors are highly effective in detecting arrhythmias, including atrial fibrillation, with both high sensitivity and specificity.[214–218] Projects such as Home Emergency Alerting and Response Technology – Survive A Fatal Event (HEART-SAFE) and BEating Cardiac Arrest (BECA) are developing AI-integrated smartwatches capable of detecting OHCA and the ability of autonomously alerting EMS, shaving off precious minutes from response times, especially in cases that would otherwise go unnoticed.[219,220]

Beyond wearables, contactless monitoring solutions use infrared and radar-based sensors broadening the ability to detect cardiac events from a distance.[220–226] Some smart speakers and home AI assistants are already being equipped with software capable of recognising agonal breathing, a tell-tale sign of cardiac arrest. These devices can automatically notify EMS, offering a possible lifeline in situations where no one is around to witness the collapse.[227,228]

Mobile apps and digital platforms are also playing a critical role in connecting bystanders with emergency resources. For example, smartphone apps that pinpoint the location of nearby AEDs, crowdsource first responder networks, and provide on-the-spot CPR guidance are helping bridge the gap between the moment a cardiac arrest occurs and when professional care arrives. AI-powered platforms capable of analysing real-time sensor data potentially allow life-saving interventions to be activated before a cardiac event fully develops.[229,230]

Education for resuscitation is also evolving. Smart technologies improve technique and performance. Wearable devices now offer live feedback on the depth and rate of chest compressions, and haptic feedback via smartwatches and similar tools is helping both trainees and professionals perform higher-quality resuscitations, which in turn is known to improve patient outcomes.[231–233]

Despite these advances, there are still tough challenges. The concerns about the accuracy of AI algorithms, hurdles in getting regulatory approval, and persistent questions about data privacy.[234,235] Not everyone has access to these technologies, particularly in lower-resource settings, raising important questions about health equity.[236,237]

Looking ahead, research should focus on fine-tuning AI detection systems, improving the ways different technologies work together, and testing these tools in clinical settings to show improved patient outcomes. As AI becomes more common in resuscitation protocols, building public trust and promoting awareness will be key. The intersection of AI, wearable technologies, and automated emergency responses represents a huge shift in resuscitation science. If implemented thoughtfully, these innovations could drastically reduce delays in cardiac arrest recognition and intervention, possibly leading to better survival rates and neurological outcomes. As the science moves forward, technology-driven solutions are likely to play a central role in reshaping how both healthcare professionals and the public respond to cardiac emergencies.

Artificial intelligence (AI)

Artificial intelligence (AI) is emerging as a powerful tool in cardiac arrest management, complementing traditional practices and advancing areas like early detection, risk assessment, treatment decision-making, and outcome forecasting.[238] But while AI holds promise, it's not without its complications. There are still big questions about data quality, algorithm bias, transparency, and patient privacy that need careful consideration.[239,240] We conducted a scoping review that mapped out the current state of AI applications in cardiac arrest management.[241] The review covered 197 studies, highlighting how AI is being used to improve risk assessment, CPR performance, and outcome prediction. AI-based models are consistently outperforming traditional methods in predicting ROSC and survival rates. Deep learning and machine learning systems are also helping identify shockable rhythms, guide CPR in real time, and optimise emergency dispatch protocols. Yet, most studies so far have been retrospective, with limited real-world validation. Prospective trials are urgently needed to confirm AI's impact on clinical outcomes.[241]

AI systems are showing impressive abilities when it comes to predicting cardiac arrests and life-threatening arrhythmias.[237] By continuously analysing ECG data, these models can pick up on subtle warning signs that may indicate an impending cardiac event. Studies even suggest AI can outperform conventional risk assessment tools, particularly in predicting in-hospital cardiac arrest—something traditional methods often struggle to do reliably.[204,241] This means clinicians could intervene earlier and potentially save lives. For example, by mining electronic health records, AI tools have identified patients at increased risk of cardiac death, often within a specified timeframe.[241,242] This insight allows healthcare providers to craft personalised prevention strategies. The ability of AI to detect subtle ECG changes that may be overlooked by human eyes is another advantage, offering early warnings and supporting timely clinical decisions.[241–245]

AI is also playing a growing role in diagnosing cardiac arrest. Systems powered by AI can quickly analyse patient data to identify shockable rhythms, allowing for prompt defibrillation.[245,246] And when it comes to CPR, AI-based systems can provide real-time feedback to healthcare providers, improving the quality of chest compressions and overall resuscitation efforts.[247] Beyond detection and diagnosis, AI is being explored for its ability to identify early risk factors and help refine CPR techniques.[246]

Another area where AI performs well is in interpreting ECGs. These algorithms can pick up on subtle irregularities that may indicate cardiac problems before they become apparent to even experienced cardiologists. This allows for earlier diagnosis and intervention.[247] AI is also being used to predict neurological outcomes following cardiac arrest. By analysing clinical factors and biomarkers, AI models offer guidance that can help clinicians make informed treatment decisions and provide families with more accurate prognostic information.[248] Artificial neural networks, in particular, have shown the potential for greater accuracy and personalization than traditional forecasting methods.[249,250] A recent review of 41 studies looking at 97 machine learning models and 16 deep learning models found strong predictive capabilities for key outcomes, including ROSC, survival, and neurological recovery. The pooled area under the curve for predicting favourable neurological outcomes (CPC 1–2) at hospital discharge was 0.871 (95 % CI: 0.813–0.928) for machine learning and 0.877 (95 % CI: 0.831–0.924) for deep learning models. Still, despite these encouraging numbers, challenges remain. Many studies have limitations because of missing data, inconsistent external validation, and varying methodologies, all of which can affect reliability and raise concerns about bias.[251]

The use of AI in healthcare is not without ethical implications. Patient privacy and data protection are major concerns, requiring strict data handling and security measures. Algorithmic bias is another serious issue. If AI models are trained on skewed datasets—say, overrepresenting one demographic group—they might perform poorly for patients outside that group.[252,253] That could mean misdiagnosis, delayed treatment, or even inappropriate care. To address these risks, it is important to train AI systems on diverse datasets, evaluate their performance across different populations, and build fairness into their development from the ground up. There is also the question of whether AI might depersonalise healthcare, reducing human interaction and making patients feel like they are being treated by machines rather than people. While AI can boost efficiency and accuracy, it is essential to keep empathy and patient engagement at the core of care.

AI's potential is enormous, but it is not without its limits. These systems require massive, diverse datasets to train on, and managing unstructured data—like imaging or free text in electronic records—is still a hurdle. Oversight by human experts remains essential to ensure AI's recommendations are reliable. Despite the expanding body of research in AI-driven cardiac arrest prediction, much of it still depends on traditional machine learning methods. Exploring advanced deep learning techniques could lead to even better results. However, concrete evidence that AI improves real-world outcomes in cardiac arrest remains limited for now. That is why future studies should focus on developing more robust, explainable AI models, testing them in varied clinical environments, and addressing the ethical challenges head-on. AI could also have a key role in global strategies for preventing cardiac death, which deserves more investigation.

AI offers exciting possibilities for improving how we manage cardiac arrest—helping clinicians detect problems earlier, make better treatment decisions, and predict outcomes more accurately. But to make the most of these technologies, we need to be mindful of their limitations and ethical issues. Healthcare providers should follow strict ethical guidelines, prioritise patient privacy, and work to minimise bias in AI tools. Continued research and collaboration are crucial for refining these systems and ensuring they are used responsibly in practice. Done right, AI could transform cardiac arrest care and significantly improve patient outcomes.[254–257]

AI integration in resuscitation medicine faces several key challenges. These include concerns about data privacy, algorithmic bias, the need for transparency, and earning the trust of clinicians and patients alike. Standardising evaluation metrics and conducting more collaborative research will be essential for promoting safe, equitable AI adoption in cardiac arrest care. By addressing these concerns thoughtfully and ethically, the medical community can unlock AI's full potential helping to optimise emergency response strategies, improve outcomes, and drive further innovations in resuscitation science.

Declaration of competing interest

Declarations of competing interests for all ERC Guidelines authors are displayed in a COI table which can be found online at https://doi.org/10.1016/j.resuscitation.2025.110821.

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Practice Guideline

European Resuscitation Council Guidelines 2025 Adult Basic Life Support

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Abstract

The European Resuscitation Council has produced these ERC Guidelines 2025 Basic Life Support for adults based on the ILCOR Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations published since 2021. The topics addressed include how to recognise cardiac arrest, alerting the emergency services, delivering chest compressions, performing rescue breaths, how to use an automated external defibrillator (AED) and safety considerations for rescuers. Quality of cardiopulmonary resuscitation (CPR) and the use of technology has been embedded into the relevant sections, rather than reported separately. The management of cardiac arrests in children, infants and neonates are described in the ERC guidelines 2025 Neonatal Life Support and Paediatric Life Support.

Keywords: Out-of-hospital cardiac arrest, Recognition of cardiac arrest, Cardiopulmonary resuscitation, Automated external defibrillator, Dispatcher-assisted CPR, Defibrillation

Introduction

These ERC Guidelines 2025 Basic Life Support (BLS) for adults have been written with reference to the International Liaison Committee on Resuscitation (ILCOR) Consensus on Science and Treatment Recommendations (CoSTR) for Basic Life Support.[1–4] If no recent ILCOR recommendation was available, the ERC used findings from recently published studies to inform guideline recommendations, and when required, the Guidelines was informed by expert consensus.

BLS Writing Group members and the Guidelines Steering Committee agreed to this version, which was posted for public comment between 5. and 30. May 2025. A total of 111 individuals submitted 114 comments, leading to20 changes in the final version. The guideline was presented to and approved by the ERC Board and the General Assembly in June 2025. The methodology used for guideline development is presented in the Executive summary.[5]

For the purpose of these Guidelines, the term CPR relates to the specific technical skills of cardiopulmonary resuscitation (i.e. performance metrics of chest compression and ventilation), whilst resuscitation is used as a generic term covering the broader range of skills and interventions. The term bystander is used to describe rescuers who happen to be at the scene to provide help, and the term first responder is used for those who have additional training and are

Abbreviations: ERC, European Resuscitation Council, CoSTR, Consensus on Science with Treatment Recommendations, ILCOR, International Liaison Committee on Resuscitation, HCPs, Healthcare professionals, AI, Artificial Intelligence, CPR, cardiopulmonary resuscitation, BLS, Basic Life Support, AED, Automated external defibrillator, ALS, Advanced Life Support, ILS, Immediate Life Support, PBLS, Paediatric Basic Life Support, NLS, Newborn Life Support, VR, virtual reality, AR, augmented reality, VLE, virtual learning environment, EMS, Emergency Medical Services, HBB, Helping Babies Breathe, PAD, Public Access Defibrillator, RCT, Randomised controlled trial

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alerted to attend the scene of a cardiac arrest. Healthcare Professionals (HCPs) are those who work in any healthcare sector (prehospital or in-hospital). Laypeople are persons not working in the healthcare sector. Basic Life Support (BLS) is defined as initiating the chain of survival, early high-quality chest compression, effective ventilation, and the early use of an automated external defibrillator (AED). Any form of resuscitation beyond BLS is described generically as advanced life support (neonatal, paediatric, and adult life support). Where the term 'ALS' is used, this refers specifically to the ERC adult Advanced Life Support course. The writing group of these ERC Guidelines 2025 Basic Life Support for adults considered the recently introduced ERC approach to diversity, equality, equity, and inclusion (DEI) while writing these Guidelines, and applied it whenever possible, recognising and realising that this is a field for improvement in the production of evidence-informed guidelines (Fig. 1, Table 1).

Concise resuscitation guidelines for all responders

If you encounter someone who appears to be unresponsive follow the 3 steps to save a life

1. Check
   - Is it safe to approach?
   - Is the person conscious?
2. **Call** EMS immediately if they are unresponsive
   - Assess breathing
   - If you are unsure the call-taker will assist you
3. **CPR**: Start CPR immediately if they are **unresponsive with abnormal breathing**.
   - As soon as an AED is available, attach it and follow the AED instructions
   - If you are unsure the call-taker will assist you

Recognising cardiac arrest

- Ensure it is safe to approach.
- Suspect cardiac arrest in any person who is unresponsive (Fig. 2).
- Call your local emergency number without delay.
- Assess their breathing while you wait for the call to be answered.
- Slow, laboured breathing, as well as other abnormal patterns such as agonal gasping or panting, must be recognised as signs of cardiac arrest.
- A short period of seizure-like activity may occur at the onset of cardiac arrest. Once the seizure stops, assess breathing.

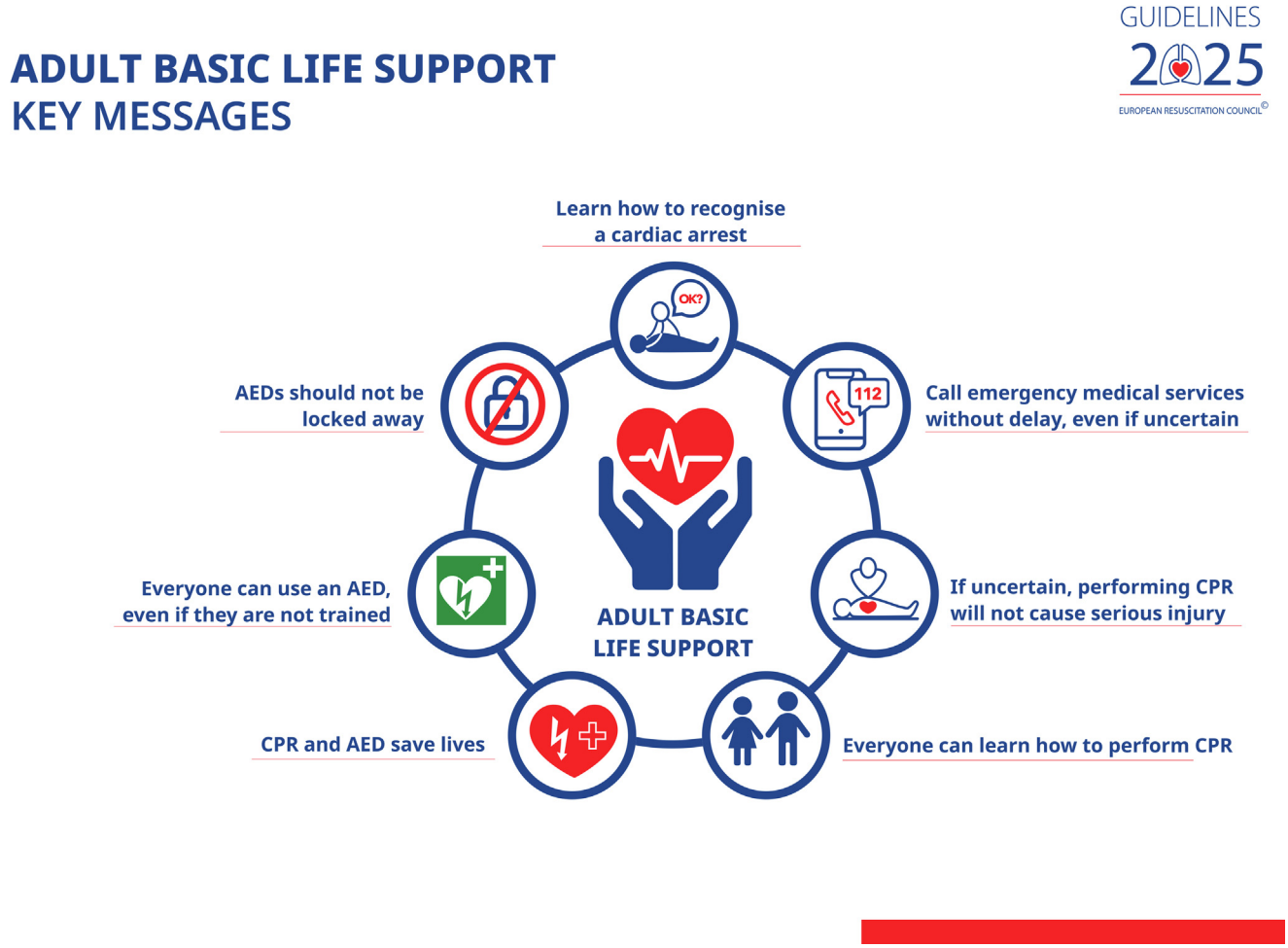


Fig. 1 – Adult Basic Life Support – key messages.

Table 1 – The major changes in the 2025 Guidelines for Adult Basic Life Support.

ERC Guidelines 2021	ERC Guidelines 2025
Changes to guidance	
The 2021 ERC BLS Guidelines emphasised recognising cardiac arrest in a person who is unresponsive and not breathing normally, before calling the local emergency services.	The 2025 ERC BLS Guidelines emphasises calling the local emergency services for any person who is unresponsive. Rescuers no longer need to confirm abnormal breathing before calling. Initiate the call first then assess breathing while waiting for the call to be answered. The dispatcher will be able assist you in identifying abnormal breathing, if needed.
The 2021 ERC BLS Guidelines emphasised descriptions of slow or laboured breathing as indicators of abnormal breathing.	Exercise is a common precipitant of cardiac arrest. Early after the onset of cardiac arrest, athletes may display a near normal or panting breathing pattern.
New topics added in the 2025 ERC BLS guidance	
The role of the dispatcher was previously addressed in the Systems Saves Lives chapter, which addresses the role of dispatchers with respect to system performance and the cardiac arrest population.	The 2025 ERC BLS Guidelines include some detail of the role of dispatcher. The role of the dispatcher is critical to early recognition of cardiac arrest and initiation of CPR.
There are a few studies to indicate that head-up CPR might help improve patient outcomes. There has been growing interest within the resuscitation community about the potential benefits of head-up CPR.	Existing studies of head-up CPR include a bundle of interventions and are not limited to just positioning the patient in a head-up position. Evidence addressing the impact of head-up CPR without the other elements of the CPR bundle is lacking.
Psychological wellbeing of rescuers was not previously addressed within BLS guidance.	There is increasing evidence that finding a person in cardiac arrest and attempting resuscitation is a potentially traumatic experience for many lay rescuers. The 2025 ERC BLS Guidelines now recognises that lay rescuers and bystanders may benefit from support.
CPR in obese patients was not previously addressed within BLS guidance.	There is a growing body of evidence exploring cardiac arrest management and outcomes in obese patients. The 2025 ERC BLS Guidelines advise that obese patients receive standard 30:2 CPR without modifications.
Topics removed from the ERC Guidelines 2025 BLS	
The 2021 ERC BLS Guidelines included guidance for modification of BLS in response to COVID-19.	BLS modifications for COVID-19 been removed from the BLS Guidelines. COVID-19 is now endemic in the community and this advice has been removed in line with national health policies. COVID-19 patients should be treated as any other patients. Modifications to CPR are no longer required.
The 2021 ERC BLS Guidelines included guidance for management of foreign body airway obstruction.	Management of foreign body airway obstruction has been relocated from BLS to the ERC Guidelines 2025 First Aid.[6]

- If any person is unresponsive with abnormal breathing, cardiac arrest should be assumed.
- If you are uncertain, the call-taker will be able to assist you.
- If there is any doubt, assume cardiac arrest and start CPR (Fig. 3).

Alerting the emergency services

- If you have a mobile phone, activate speaker mode, call the local emergency number without delay.
- Assess breathing while you wait for the call to be answered.
- If you are alone and do not have a mobile phone, or there is no mobile phone network/satellite connection, you can shout for help and then continue to assess breathing.
- If you think no-one will come to help, then you will have to leave the person to alert the local emergency service. Do this as quickly as possible.
- If they remain unresponsive and are not breathing normally when you return from summoning help, immediately commence CPR.

Role of the dispatcher

- Dispatchers should use standardised protocols to facilitate recognition of cardiac arrest.
- Once cardiac arrest is recognised, dispatchers should provide CPR instructions to all callers.
- Dispatchers should assume the caller does not know how to perform CPR and provide chest-compression-only instructions. If the caller subsequently states they know how to perform rescue breaths, then dispatchers should facilitate 30:2 CPR.
- Once CPR is underway, dispatchers should ask if there is an 'AED' or 'defibrillator' at the scene.

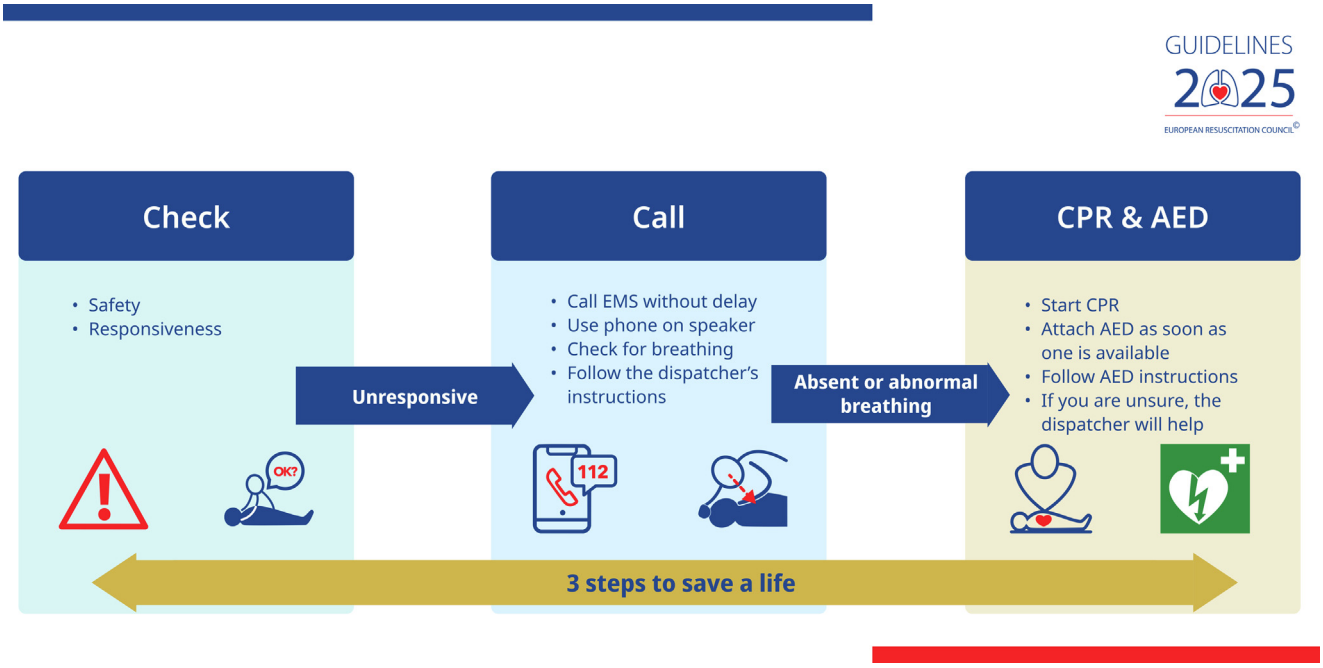


Fig. 2 – Three steps to save a life.

- If no AED is available at the scene, and more than one bystander is present, dispatchers should guide bystanders to the nearest AED.
- As soon as an AED is available at the patient, dispatchers should instruct the bystander to activate the AED and to follow the AED instructions.
- Where first responder systems have been implemented, dispatchers should activate registered community volunteer responders to the incident and to retrieve a nearby AED (Fig. 4).

High quality chest compressions

- Commence chest compressions as soon as possible.
- Place the heel of one hand on the lower half of the sternum ('in the centre of the chest').
- If you are unable to adequately visualise the sternum due to clothing, it is reasonable to displace or remove such garments so you can identify the correct anatomic landmark.
- Place the heel of your other hand on top of the first hand.
- Interlock your fingers of the hands to ensure that pressure is not applied over the ribs.
- Keep your arms straight.
- Position your shoulders vertically above the persons chest.
- Compress to a depth of at least 5 cm, but not more than 6 cm.
- Compress the chest at a rate of 100–120 min^{-1} with as few interruptions as possible.
- Allow the chest to recoil completely after each compression; avoid leaning on the chest.
- CPR is most effective when performed on a firm surface. However, rescuers should not move a person from a 'soft' surface e.g. bed, to the floor. Start CPR on the bed and, if needed, compress the chest deeper to compensate for the soft mattress.

Rescue breaths

- If you have been trained to provide rescue breaths, alternate 30 chest compressions with 2 rescue breaths.
- When providing rescue breaths, deliver just enough air to make the chest start to rise; avoid excessive ventilation.
- If you are unable ventilate the chest after 2 attempts, consider foreign body airway obstruction (see ERC Guidelines 2025 First Aid).[6]
- If you are not trained to provide rescue breaths, perform continuous chest compressions, without interruptions.

Using an automated external defibrillator (AED)

- Anyone can use an Automated External Defibrillator (AED).

How to find an AED

- Ensure that AED locations are indicated by clear signage (see Fig. 5).
- Signage should state that AEDs can be used by anyone and that no training is needed.
- AED locations may also be identified using electronic mapping systems available on some mobile phone and computer applications.
- The local emergency service should be able to direct callers to the nearest available AED.

When and how to use an AED

- Use an AED as soon as it is available.
- Open the AED case (if present). Some AEDs automatically turn on when opened. If not, identify the power button and turn it on.
- Follow the audio/visual prompts from the AED.
- Attach the electrode pads to the person's bare chest according to the position shown on the AED (or AED pads) and in Fig. 6.

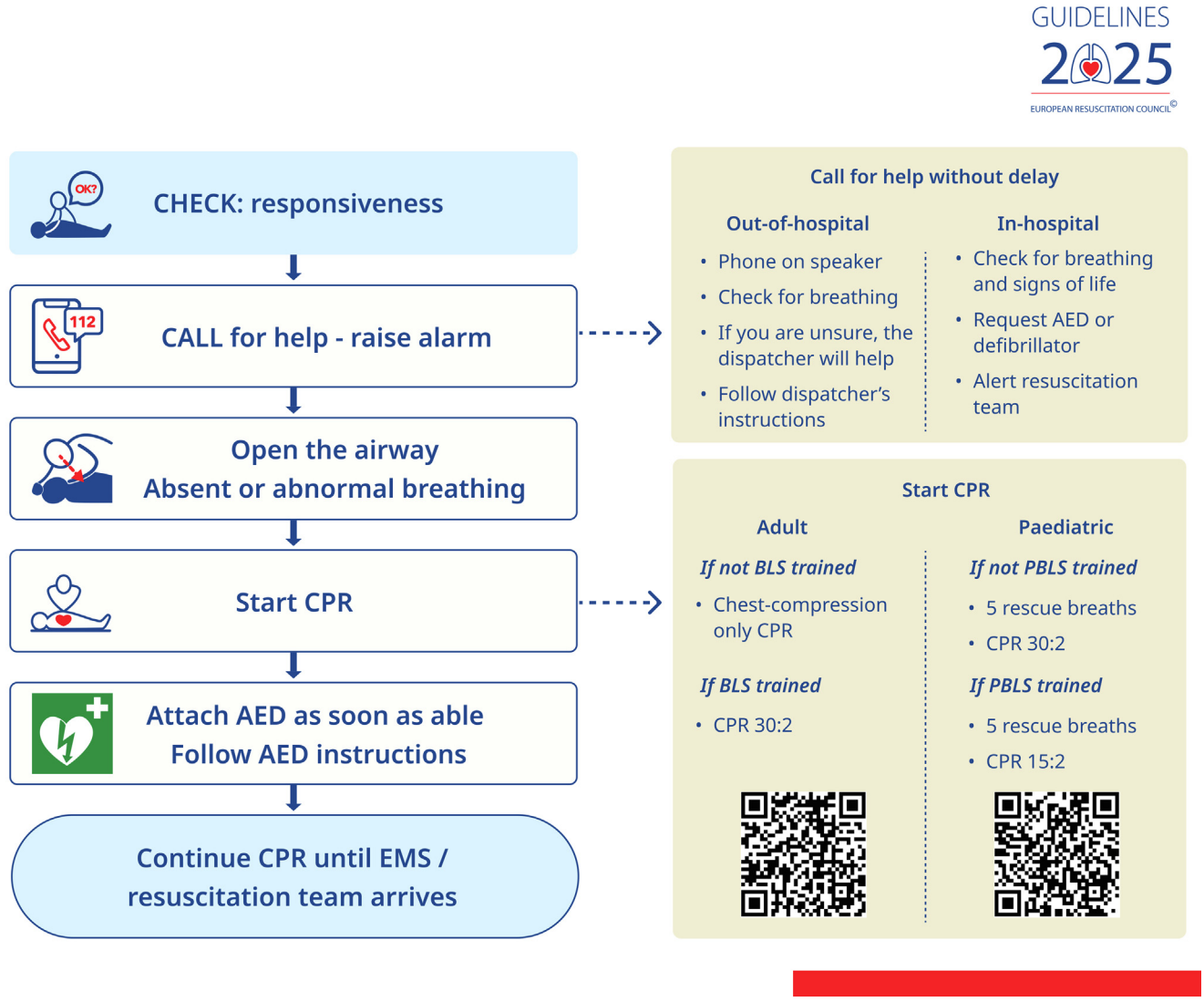


Fig. 3 – Universal BLS algorithm.

- If more than one rescuer is present, continue CPR while the defibrillation pads are being attached.
- Ensure that nobody touches the person whilst the AED is analysing the heart rhythm.
- If a shock is indicated, ensure that nobody is touching the person.
- Some AEDs (fully automatic AEDs) will deliver a shock automatically, while others (semi-automatic AEDs) will require the rescuer to press the shock button to deliver the shock.
- After the shock has been delivered, immediately restart chest compressions.
- If no shock is indicated, immediately restart CPR chest compressions.
- Continue to follow the AED instructions.
- Usually, the AED will instruct the rescuer to perform CPR, then, after a set time interval the AED will instruct the rescuer to pause CPR to undertake rhythm analysis.

Where to place AEDs

- AEDs should be placed in clear sight.
- AED cabinets should be unlocked and readily available 24 h a day, 7 days a week, 365 days per year.
- Locations with a high population flow, such as airports, shopping centres and train stations should have on-site AEDs that are readily available for public use.
- Communities are encouraged to deploy AEDs in public spaces, particularly those with a higher incidence of cardiac arrest.
- AEDs should be registered with the local emergency service, especially if they are linked to AED registries and first responder programmes.

Safety

- Ensure the safety of yourself, the person in cardiac arrest, and any bystanders (Fig. 7).

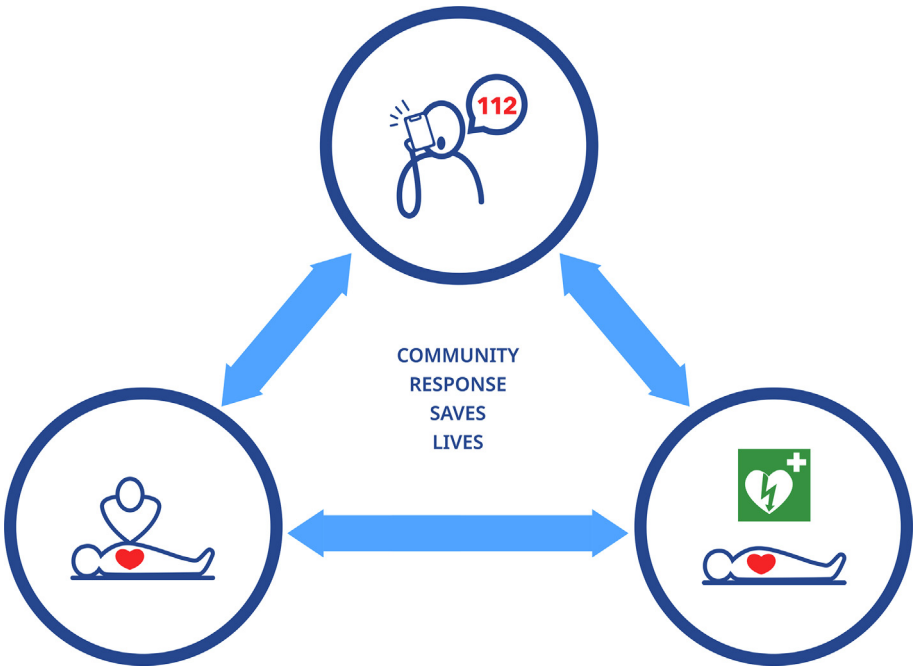


Fig. 4 – Community response.

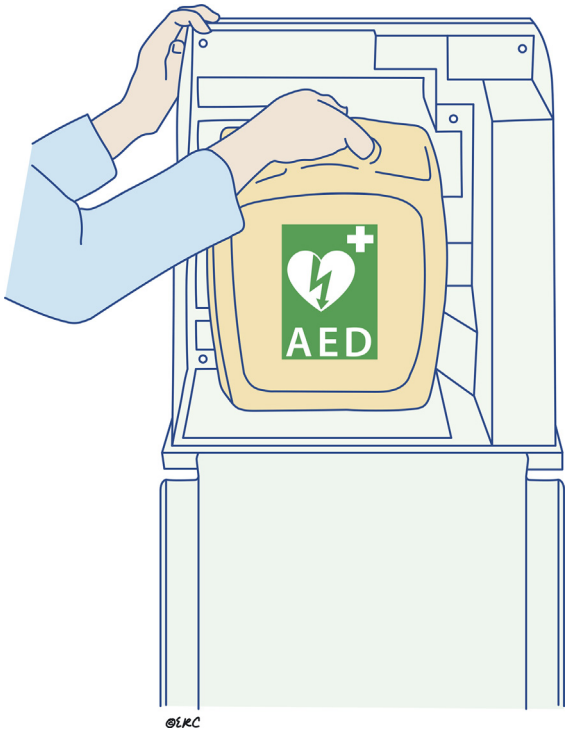


Fig. 5 – AED signage.

- Lay people should commence CPR for presumed cardiac arrest without concerns of harm to patients not in cardiac arrest.
- The risk of infection to rescuers performing CPR is low.
- The risk of harm to rescuers, from accidental shock during AED use, is low.
- The risk of physical injury to the rescuer, from performing CPR, is low.
- Consider the wellbeing of lay person and bystanders – offer them support).

Evidence informing the guidelines

Recognising cardiac arrest

The practical, operational definition of cardiac arrest is when a person is unresponsive and not breathing normally.[7] Although unresponsiveness and abnormal breathing are present in other potentially life-threatening medical emergencies, they have very high sensitivity as diagnostic criteria for cardiac arrest.[8,9] Using these criteria will over triage for cardiac arrest,[10] however the small risk of commencing CPR in an unresponsive individual, who is not breathing normally but is not in cardiac arrest, is far outweighed by the increased mortality associated with delayed CPR for those in cardiac arrest.[11] The ERC acknowledges that confirming unconsciousness with abnormal breathing remains the primary barrier to recognition of cardiac arrest (Fig. 8a and Fig. 8b).[12,13]

Abnormal breathing

The ERC Guidelines 2025 BLS continue to highlight the importance of recognising agonal breathing as a sign of cardiac arrest.[12] Agonal breathing is an abnormal breathing pattern. It is observed in 30–60 % of cardiac arrests,[13] most commonly at the onset of cardiac arrest.[14] It indicates the presence of residual brain stem function and is associated with improved outcomes.[15]

Agonal breathing is frequently misinterpreted as a sign of life.[8] This presents a challenge to lay people, first responders, emergency medical dispatchers and HCPs. Common terms used by lay people

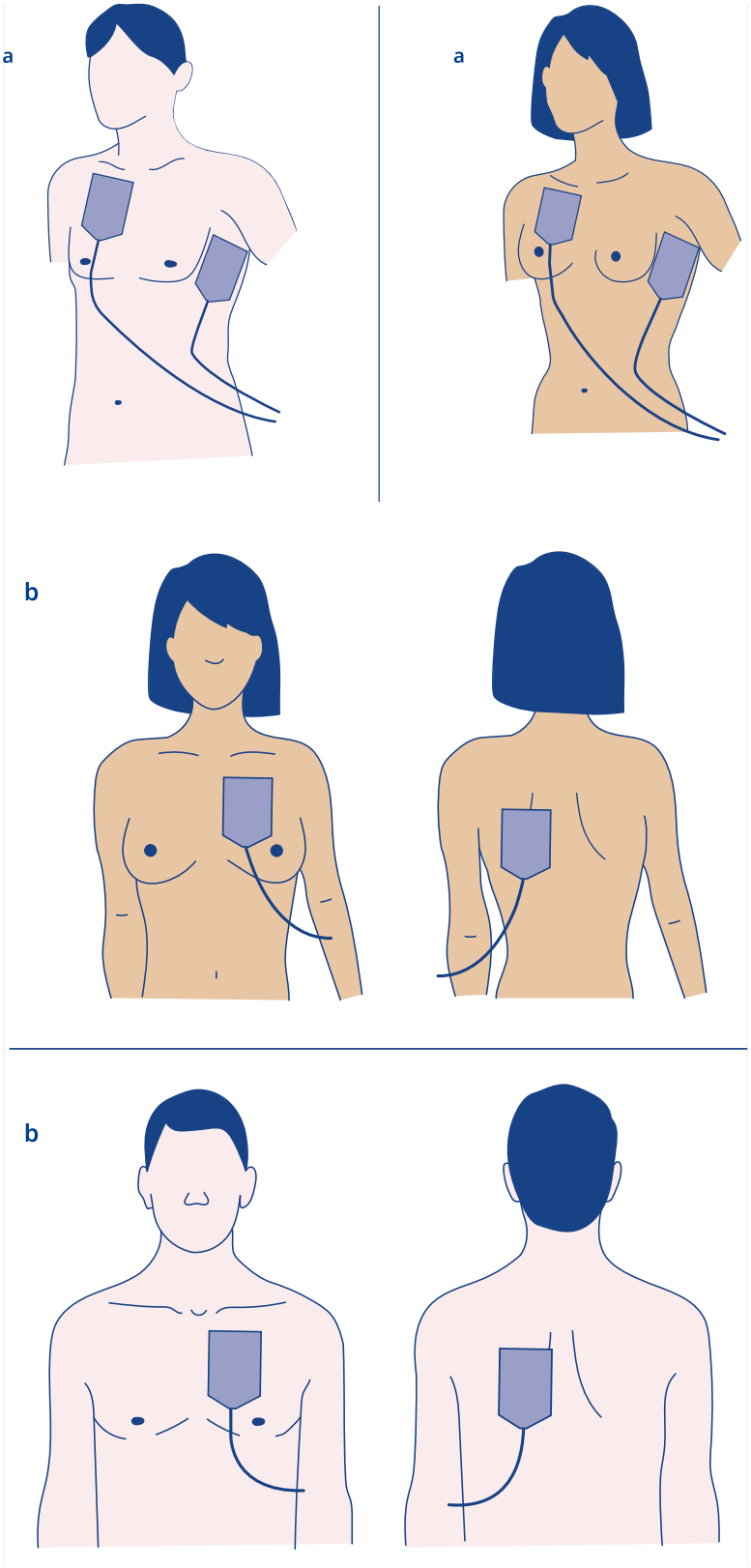


Fig. 6 – Anterior-lateral pad position (a) or anterior-posterior pad position (b).

GUIDELINES 2025
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SEQUENCE / ACTION	TECHNICAL DESCRIPTION
SAFETY 	• Make sure that you, the victim and bystanders are safe
RESPONSE Check for a response 	• Shake the victim gently by the shoulders and ask loudly: ***"Are you all right?"***
ALERT EMERGENCY SERVICES 	• If victim is unresponsive, ask a helper to call the emergency medical services or call them yourself • Stay with the victim if possible • Activate the speaker function or hands-free option on the telephone so that you can start CPR whilst talking to the dispatcher
AIRWAY Open the airway 	• If there is no response, position the victim on their back • With your hand on the forehead and your fingertips under the point of the chin, gently tilt the victim's head backwards, lifting the chin to open the airway
BREATHING Look, listen and feel for breathing 	• Look, listen and feel for breathing for no more than 10 seconds • A victim who is barely breathing, or taking infrequent, slow and noisy gasps, is not breathing normally
SEND FOR AED Send someone to get an AED 	• Send someone to find and bring back an AED, if available • If you are on your own, fetch an AED only if you can get and apply it within one minute; otherwise, start CPR immediately
CIRCULATION Start chest compressions 	• Kneel by the side of the victim • Place the heel of one hand in the centre of the victim's chest - this is the lower half of the victim's breastbone (sternum) • Place the heel of your other hand on top of the first hand and interlock your fingers • Keep your arms straight • Position yourself vertically above the victim's chest and press down on the sternum at least 5 cm (but not more than 6 cm) • After each compression, release all the pressure on the chest without losing contact between your hand and the chest • Repeat at a rate of 100-120 min^{-1}
COMPRESSION-ONLY CPR 	• **If you are untrained, or unable to give rescue breaths,** give chest-compression-only CPR (continuous compressions at a rate of 100-120 min^{-1})

Fig. 7 – BLS step by step.

COMBINE RESCUE BREATHING WITH CHEST COMPRESSIONS 	• **If you are trained to do so**, after 30 compressions, open the airway again, using head tilt and chin lift • Pinch the soft part of the nose closed, using your index finger and thumb of your hand on the forehead • Allow the victim's mouth to open, but maintain chin lift • Take a normal breath and place your lips around the victim's mouth, making sure that you have an airtight seal • Blow steadily into the mouth whilst watching for the chest to rise, taking about 1 second as in normal breathing. This is an effective rescue breath • Maintaining head tilt and chin lift, take your mouth away from the victim and watch for the chest to fall as air comes out • Take another normal breath and blow into the victim's mouth once more to achieve a total of two rescue breaths • Do not interrupt compressions by more than 10 seconds to deliver the two breaths, even if one or both are not effective • Then return your hands without delay to the correct position on the sternum and give a further 30 chest compressions • Continue with chest compressions and rescue breaths in a 30:2 ratio
WHEN AED ARRIVES Switch on the AED and attach the electrode pads 	• As soon as the AED arrives, switch it on and attach the electrode pads to the victim's bare chest • If more than one rescuer is present, CPR should be continued whilst the electrode pads are being attached to the chest
FOLLOW THE SPOKEN/ VISUAL DIRECTIONS	• Follow the spoken and visual directions given by the AED • **If a shock is advised**, ensure that neither you nor anyone else is touching the victim • Push the shock button as directed • Then **immediately** resume CPR as directed by the AED
IF NO SHOCK IS ADVISED Continue CPR 	• **If no shock is advised,** immediately resume CPR and continue as directed by the AED

IF NO AED IS AVAILABLE Continue CPR 	• If no AED is available, **or** whilst waiting for one to arrive, continue CPR
	• Do not interrupt resuscitation until:
	  • A healthcare professional tells you to stop OR
	  • The victim is definitely waking up, moving, opening eyes, and breathing normally OR
	  • You become exhausted
	• It is rare for CPR alone to restart the heart. Unless you are certain that the victim has recovered, continue CPR
	• Signs that the victim has recovered
	  • Waking-up
	  • Moving
	  • Opening eyes
	  • Breathing normally

Fig 7. (continued)

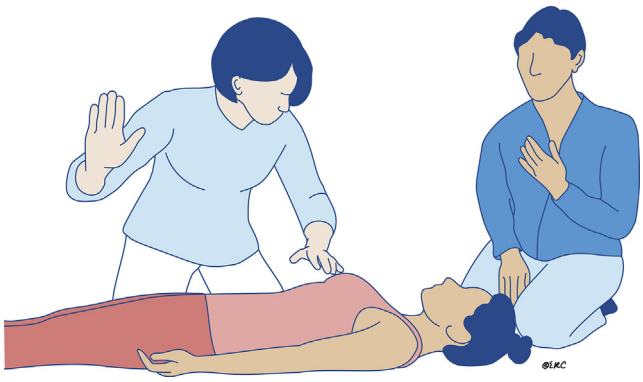


Fig. 8a – Safety.

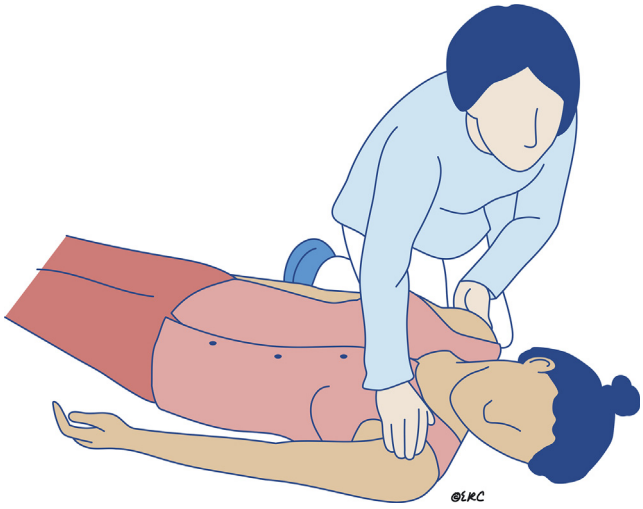


Fig. 8b – Check.



Fig. 8c – Unconscious – Call.



Fig. 8d – Check for breathing – open the airway.

to describe agonal breathing include gasping, barely or occasionally breathing, moaning, sighing, gurgling, noisy, groaning, snorting, heavy or laboured breathing.[13,16]

Misinterpretation of abnormal breathing remains the biggest barrier to recognition of cardiac arrest.[9,13,17] Recognition of abnormal breathing as a sign of cardiac arrest will enable CPR to be started without delay. Failure to recognise cardiac arrest by dispatchers during emergency calls is also associated with decreased survival.[18,19]

In addition to agonal breathing patterns, other abnormal breathing patterns have been described, particularly when cardiac arrest is associated with collapse whilst playing sport.[20] Athletes who sustain a cardiac arrest may continue breathing more regularly[21–23] and/or have their eyes open following collapse.[24] This has prompted the ERC to include the descriptor of panting within the recognition of cardiac arrest section (Fig. 8c and Fig. 8d).

Seizures

Seizure-like movements of short duration among patients in cardiac arrest pose another important barrier to recognition of cardiac arrests. Seizures are common medical emergencies and are reported to constitute approximately 3–4 % of all emergency medical calls.[25,26] However, only 0.6–2.1 % of these calls will be cardiac arrests.[27–29] An observational study including 3502 OHCAs identified 149 (4.3 %) individuals with seizure-like activity.[29] Patients in cardiac arrest who presented with seizure-like activity were younger (54 vs. 66 years; $p < 0.05$), were more likely to have a witnessed arrest (88 % vs 45 %; $p < 0.05$), more likely to present with an initial shockable rhythm (52 % vs. 24 %; $p < 0.05$), and more likely to survive to hospital discharge (44 % vs. 16 %; $p < 0.05$). A more recent study identified seizure activity in 59/465 non-traumatic OHCA (12.7 %) and also observed an association with improved outcomes.[30] Similar to agonal respiration, seizures complicate the recognition of cardiac arrest for lay people, first responders and HCPs (median time to dispatcher identification of the cardiac arrest; 130 s vs 62 s; $p < 0.05$).[29]

Recognising cardiac arrest after a seizure episode when the person remains unresponsive with abnormal breathing is important to prevent delayed CPR. The risk of delaying CPR in cardiac arrest far outweighs any risk from performing CPR on a person who is not in cardiac arrest.

Alerting the emergency services

Whenever a person is found unresponsive, bystanders who have a mobile phone should call the local emergency number and activate speaker mode.[31] While waiting for the call to be answered, the caller should continue to assess for the presence of abnormal breathing.

If the person is unresponsive and not breathing normally, commence CPR (30:2) immediately.[12] If there is any doubt about breathing status, the dispatcher will assist the caller to identify abnormal breathing.[13] Callers should not delay contacting the emergency services to confirm the presence of abnormal breathing.

This recommendation is based on a recent ILCOR scoping review demonstrating that most cardiac arrests are initially recognised by the dispatcher during the call, rather than by bystanders at the scene.[13] Prioritising calling local emergency services for all unresponsive patients will increase the number of calls made for patients not in cardiac arrest, however the majority of such unresponsive patients are likely to require assistance from the emergency services, even though they might not be in cardiac arrest. This approach is unlikely to adversely impact emergency service performance.[32] Despite widespread availability of mobile phones, there will inevitably be circumstances where no mobile phone is available, or the mobile phone is not able to connect to any form of network. In these circumstances, a lone rescuer has two options – shout for help or leave the person in cardiac arrest to alert local emergency services.

If a lone rescuer believes there are people nearby, who will come to their assistance, it is reasonable to shout for help and commence CPR. However, if no-one responds to the call for help, then the lone rescuer will have to stop CPR and leave the person in cardiac arrest, to summon the local emergency services. There is currently no evidence addressing how long to continue CPR before leaving the person to alert the local emergency services. If the lone rescuer does need to leave the person in cardiac arrest to summon help, the ERC advises that this is done as quickly as possible (Fig. 8e).



Fig. 8e – Not breathing normally.

Role of the dispatcher

Dispatcher recognition of cardiac arrest

Prompt and accurate recognition of cardiac arrest is essential to initiating timely bystander CPR, including dispatch-assisted CPR and the appropriate emergency medical service (EMS) response.[33] Most cardiac arrests are not recognised by bystanders and are first recognised by the dispatcher during the call to the dispatch centre, emphasising dispatchers' critical role in facilitating recognition as quickly as possible.[13] A diagnostic systematic review by ILCOR published in 2021 included 47 studies and reported wide variability in dispatchers' ability to recognise OHCA (sensitivities and specificities for OHCA recognition varied from 0.46 to 0.98 and 0.32 to 1.00, respectively). It was not possible to identify any differences in diagnostic accuracy between criteria or algorithms.[10]

A more recent ILCOR scoping review assessed 62 studies and found the most pertinent challenge to dispatcher-assisted recognition of OHCA is establishing whether or not the patient is breathing normally.[13] Several strategies were studied, but no strategy performed better than the commonly used 'two-questions' strategies (i.e., "Is the person conscious?" and "Are they breathing normally?"). Although several strategies were tested, there were no randomised controlled trials (RCT) comparing different strategies. One of the included RCTs tested the addition of an artificial intelligence (AI) model but did not find this intervention improved dispatcher-assisted recognition of OHCA.[76]

In accordance with ILCOR, the ERC continues to recommend dispatchers follow a standardised algorithm and/or standardised criteria to quickly identify if a patient is in cardiac arrest at the time of emergency call.[12] Further detail addressing how dispatch processes can improve outcomes from cardiac arrest can be found in the ERC Guidelines 2025 Systems Save Lives.[34]

Dispatcher CPR instructions

Dispatch-assisted CPR is recommended for a person in cardiac arrest[33] and is widely implemented.[35,38] Compared with no CPR instructions, dispatch-assisted CPR is associated with improvements in survival to hospital discharge (OR 1.67, 95% CI 1.39 to 2.0) and survival to hospital discharge with favourable neurological outcome (OR 2.21, 95% 1.44 to 3.40).[39]

A 2024 ILCOR scoping review was unable to identify sufficient high-certainty evidence to recommend specific interventions to optimise dispatch-assisted CPR.[33] However, dispatch-assisted CPR studies addressing the impact of simple language to deliver CPR instructions suggest a reduction in time to first compression[40–42] and an increase in CPR quality.[43,44] Modifying the statement "Do you want to do CPR" to "We need to do CPR" increased the number of cases where CPR was actually peformed,[45] however instructions to "Put the phone down" found no difference in the quality of CPR.[46]

Although there is currently insufficient evidence to support any specific approach to dispatcher-assisted CPR instructions, the ERC continues to recommend that dispatchers provide CPR instructions for all patients in cardiac arrest.

The use of video for dispatcher CPR instructions

Traditionally, dispatchers provide audio-only CPR instructions. Newly developed technology enables dispatchers to provide video CPR instructions through the caller's mobile phone. A recent scoping review and *meta*-analysis identified nine studies evaluating video instructions for simulated OHCA.[33] Compression fraction was

greater with video instructions,[47–49] compression rates were higher with video-instructions,[48–51] and there was a trend towards better hand-placement.[48] No difference was observed in compression depth or time to first ventilation, and there was a slight increase in the time it took to start CPR with video instructions. In a more recent retrospective study of adult OHCA, 1720 eligible OHCA patients (1489 and 231 in the audio and video groups, respectively) were evaluated. The median instruction time interval was similar (136 s in the audio group and 122 s in the video group); however, survival to discharge rates were 8.9 % in the audio group and 14.3 % in the video groups ($p < 0.001$). Good neurological outcome occurred in 5.8 % and 10.4 % in the audio and video groups, respectively ($p < 0.001$).[52] RCTs testing the effect of live video streaming on outcomes are lacking[1,3a].

There is currently insufficient evidence to support the widespread implementation of video for dispatcher CPR instructions. The ERC recommends that where such technology is implemented that it should be in a highly controlled manner, and preferably as part of a formal research programme.

Dispatcher AED instructions

High survival rates have been observed following on-site AED use by bystanders, such as in casinos, airports, sports facilities and train stations.[53–64] There is less evidence about dispatch instructions for AED retrieval and use, even though they are in widespread use.[11,38] In a 2024 ILCOR scoping review there were no studies that addressed clinical outcomes attributable to dispatcher instructions for AED retrieval and use[64a]. This review did not include studies of AED use by dispatched responders.[4] In 2024, a before-and-after study reported that successful AED retrieval and pad placement following dispatcher instruction were associated with increased survival to hospital discharge and survival with favourable neurological outcome. AED shock delivery itself was not associated with any improvement in these clinical outcomes, either as a product of the few patients receiving a shock or because of unrecognised confounders.[65]

There is limited evidence that volunteer responders—whether laypeople, first responders, or HCPs—who are alerted via mobile app or text message to bring an AED to the scene, improve survival. One RCT randomised 5989 lay volunteer responders dispatched through a text-message system and found bystander-initiated CPR was higher in the intervention group compared with the control group (62 % vs 48 %, $p < 0.001$).[66] One cluster-randomised stepped-wedge trial dispatched 5,735 volunteer responders to OHCAs in private residences and found survival increased from 26 % to 39 % with improved neurologically favourable survival.[67] Several observational studies have found that activation of volunteer responders is associated with increased bystander CPR, bystander defibrillation, decreased time to defibrillation and improved survival.[68–70] However, substantial heterogeneity in systems' structure and reporting, limits comparison between systems and transferability of results[70a]. Furthermore, there is increasing interest in the use of drones to deliver AEDs to cardiac arrests. As these systems develop, it is reasonable for dispatchers to inform bystanders that additional help and/or an AED may be arriving on scene[1]. In accordance with ILCOR, the ERC recommends that, after recognising cardiac arrest and starting CPR, dispatchers should ask if there is an AED on-scene. If there is not, and if there is more than one bystander on scene, dispatchers should offer instructions to locate and retrieve an AED, if one is available nearby.[12] The location and availability of AEDs should be recorded in AED registries, and these registries should be integrated into dispatch systems to facilitate this.[71]

Use of technology to support dispatchers

The use of technology to support dispatchers is more completely addressed in the ERC Guidelines 2025 Systems Save Lives.[34] The overview below is included in the ERC Guidelines 2025 BLS to demonstrate how dispatchers might interact with technology during calls for cardiac arrest.

Closed-circuit television (CCTV)

A 2024 ILCOR scoping review identified two studies that explored how CCTV footage impacted dispatchers' understanding of the OHCA scene.[13] One study suggested that a lack of situational awareness was a barrier to recognition and that live-stream video from the scene would improve the situational awareness.[72] The second suggested that visual information from the scene would improve dispatcher understanding of the OHCA scene, which might, in turn, enhance communication, and improve dispatcher ability to coach bystanders and improve the quality of CPR.[73]

Machine learning

A 2024 ILCOR scoping review identified six studies that explored how machine learning might improve recognition of cardiac arrest.[13] Two of these studies assessed whether a machine-learning model could recognise OHCA using historical audio recordings of calls made to EMS.[74,75] The first assessed how the machine learning model performed compared with dispatchers.[74] The machine learning model had higher sensitivity (72.5 % vs. 84.1 %, $p < 0.001$) but lower specificity (98.8 % versus 97.3 %, $p < 0.001$) and lower positive predictive value than dispatchers (20.9 % versus 33.0 %, $p < 0.001$). Time-to-recognition was shorter for the machine learning model compared with the dispatchers (median 44 s versus 54 s, $p < 0.001$).

The second study assessed the ability of a deep neural network model to detect OHCA through speech recognition.[75] The machine learning model recognised 36 % ($n = 305$) of the OHCAs within 60 s with median time to recognition of 72 s (IQR, 40–132 s), whereas the dispatchers recognised 25 % ($n = 213$), median time to recognition was 94 s (IQR, 51–174 s). The machine learning model and dispatchers were equally effective at recognising OHCA at any time during the call. The machine learning model recognised 6 % ($n = 52$) of OHCAs not identified by dispatchers, whereas dispatchers recognised 4 % ($n = 38$) of OHCAs, not recognised by the machine learning model.

An RCT evaluated the impact of a machine learning cardiac arrest alert on dispatcher recognition of OHCA.[76]Dispatchers in one group were alerted when the machine learning model suspected an OHCA, while those in the other group followed normal protocols without a machine learning model alert. Dispatchers recognised 93.1 % of confirmed cardiac arrests in the alert group and 90.5 % of cardiac arrests in the no-alert group ($P = 0.15$). Cases with a machine-learning alert had a significantly higher sensitivity than cases without alerts for confirmed cardiac arrest (85.0 % vs. 77.5 %; $P < 0.001$) but lower specificity (97.4 % vs 99.6 %; $P < 0.001$) and lower positive predictive value (17.8 % vs. 55.8 %; $P < 0.001$). The study did not find a significant increase in dispatchers' ability to recognise cardiac arrest when using the machine learning algorithm. There is currently insufficient evidence that machine learning technologies improve patient outcomes. However, the

ERC recognises that this is a rapidly evolving area of research, and it may play a significant role in the future, as technology improves. The ERC recommends that where machine learning is embedded into dispatcher algorithms that it should be implemented in a highly controlled manner, and preferably as part of a formal research programme.

Smart devices to detect agonal breathing

ILCOR found only one proof-of-concept study using existing technology to detect agonal breathing.[13] The study sought to determine if a smart speaker and mobile phone could be trained to recognise agonal breathing using calls recorded in the dispatch centre, compared with normal sleep sounds recorded in a sleep laboratory. The authors reported a sensitivity of 97.17 % (95 % CI: 96.79–97.55 %) specificity of 99.38 % (95 % CI: 99.20–99.56 %) and false positive rate of 0.22 %.[77] To date, there is no evidence that these technologies improve patient outcomes.[13] There is currently insufficient evidence that using smart devices to detect agonal breathing improves patient outcomes. However, this technology may have a role to play if technology improves. The ERC recommends that use of smart devices to detect agonal breathing should only be implemented within a formal research programme.

Wearable devices

Wearable devices capable of detecting and monitoring a person's heart rhythm have been developed.[78] Some devices are able to detect abnormal and life-threatening heart arrhythmias or absence of a pulse, and automatically alert EMS. These technologies are currently being evaluated in experimental settings[79] Recently, a commercially available smartwatch able to automatically detect pulselessness became available, bringing automated cardiac arrest detection outside the hospital for the first time.[80] Such devices can potentially reduce the interval from collapse to recognition of cardiac arrest and initiation of CPR and thus improve both care and outcomes in cardiac arrest, particularly among patients with unwitnessed cardiac arrest.[81] However, there are currently no clinical studies showing the benefit of wearing these devices on clinical outcomes. Thus, there is currently no evidence to support the use of wearable devices to improve outcomes after cardiac arrest. The ERC recommends that use of wearable devices to detect life-threatening arrythmias should only be implemented within a formal research programme.

High quality chest compressions

Chest compressions are a critical component of effective CPR, serving as the most accessible means of maintaining cerebral and organ perfusion during cardiac arrest. Their effectiveness depends on correct hand position and chest compression depth, rate, and degree of chest wall recoil. Pauses in chest compressions interrupt perfusion and must be avoided to minimise the risk of ischaemic injury.

Mechanical CPR falls outside the scope of BLS and is addressed in the ERC Guidelines 2025 Advanced Life Support.[82]

Initiating CPR

The sequence for commencing CPR (compressions first versus breathing first) was updated by ILCOR in 2025.[4] Five studies were included.[83–87] All of the studies were manikin studies, one of which employed a paediatric manikin.[87]

Three adult manikin studies addressed time to first compression.[83,85,86] A compression first approach resulted in shorter time to first compression. One adult manikin study addressed time to first ventilation.[85] A compression first approach resulted in a longer time to first ventilation. One adult manikin study addressed time to completion of first CPR cycle (30 chest compressions and 2 rescue breaths).[85] A compression first approach resulted in a shorter time to completion of first CPR cycle. One adult manikin study addressed the impact of compression first versus ventilation first approach on compression rate, compression depth and chest compression fraction.[83] This study found that choice of approach had no impact on chest compression rate, depth or chest compression fraction.

Following the ILCOR treatment recommendation, the ERC recommends a compression first approach.

Surface on which chest compression is performed

ILCOR updated the CoSTR for performing chest compressions on a firm surface in 2024.[88] When chest compression is performed on a soft surface (e.g. a mattress), both the chest wall and the underlying mattress are compressed.[89] This has the potential to reduce chest compression depth. However, effective compression depths can be achieved on a soft surface, providing the CPR provider increases overall compression depth to compensate for mattress compression.[90–96] ILCOR identified 17 studies addressing the importance of a firm surface during CPR. The studies were analysed by categories – floor versus firm hospital mattress, backboard versus hospital mattress, floor versus home mattress and other surface types. No studies reporting clinical outcomes were identified.[88]

Two manikin RCTs[97,98] compared chest compressions delivered on a hospital bed versus on the floor. Seven manikin RCTs[90,99–104] compared chest compressions with and without a backboard on a hospital mattress. Two manikin RCTs compared chest compressions delivered on a normal bed versus on the floor.[105,106] There was no difference in chest compression depth on a hospital bed or normal bed versus on the floor.[88] There was a small improvement in chest compression depth when using a backboard.[88] Two further manikin RCTs compared chest compressions delivered on a sports mattress, with and without a backboard,[107] and in a dental chair.[108] Chest compressions were shallower on both sports matting and in the dental chair.[107,108]

Consistent with ILCOR, the ERC suggests performing chest compressions on a firm surface. For the in-hospital setting, if a mattress has a 'CPR mode' to increase mattress stiffness, it should be activated when performing CPR. Moving a patient from the bed to the floor is not recommended as it delays time to first compressions and increases the risk of inury to the rescuer. The ERC does not advocate using a backboard.

Hand position during chest compressions

The evidence for optimal hand position was reviewed by ILCOR in 2025.[4] Only three studies were identified, none of which included the critical outcomes of favourable neurological outcome, survival, or ROSC. All the identified studies reported physiological endpoints only.[109–111] Imaging studies were excluded from the ILCOR

systematic review as they do not report clinical outcomes for patients in cardiac arrest. However, such studies may provide supporting evidence addressing optimal hand position for chest compressions. This evidence indicates that, in most adults and children, the maximal ventricular cross-sectional area underlies the lower third of the sternum/xiphisternal junction, while the ascending aorta and left ventricular outflow tract underlie the centre of the chest.[110,112–117] However, there will be variation in anatomy between individuals dependent upon age, body mass index, congenital cardiac disease and pregnancy. Consequently, one specific hand placement strategy might not provide optimal compressions for all persons.[113,116,118]

The 2025 ILCOR systematic review identified one crossover study in 17 adults with prolonged resuscitation from non-traumatic cardiac arrest that observed improved peak arterial pressure during compressions and higher end-tidal carbon dioxide when compressions were performed on the lower third of the sternum compared with the centre of the chest. Arterial pressure during compression recoil, peak right atrial pressure, and coronary perfusion pressure did not differ.[109] A second crossover study in 30 adults observed no association between end-tidal carbon dioxide values and hand placement.[111] The remaining crossover study in 10 children observed higher peak systolic pressure and higher mean arterial blood pressure when compressions were performed over the lower third of the sternum compared with the middle of the sternum.[119]

Consistent with the ILCOR recommendation,[4] the ERC continues to recommend performing and teaching that chest compressions be delivered 'in the centre of the chest', whilst at the same time demonstrating this position is on the lower half of the sternum (Figs. 8f–8h).

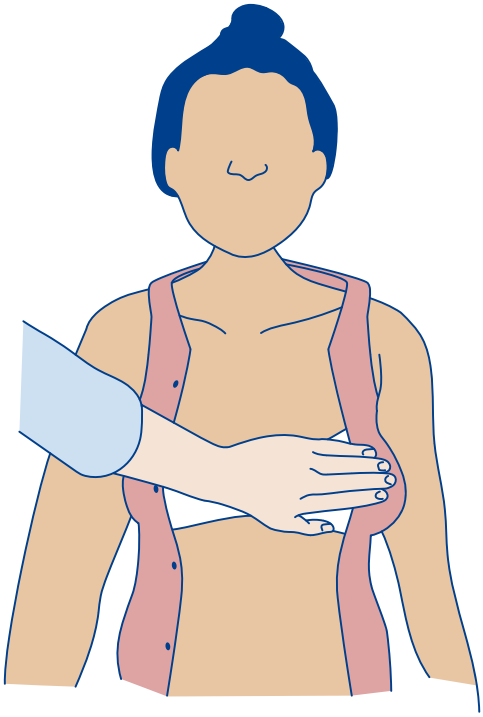


Fig. 8f – Hand in the centre of the chest.

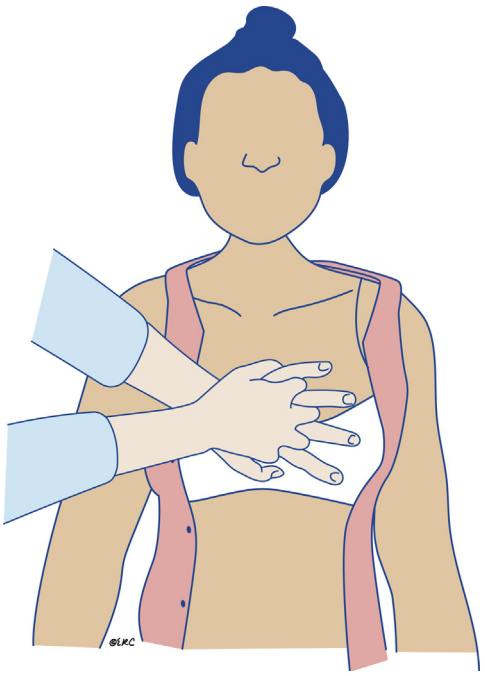


Fig. 8g – Both hands perform chest compressions.

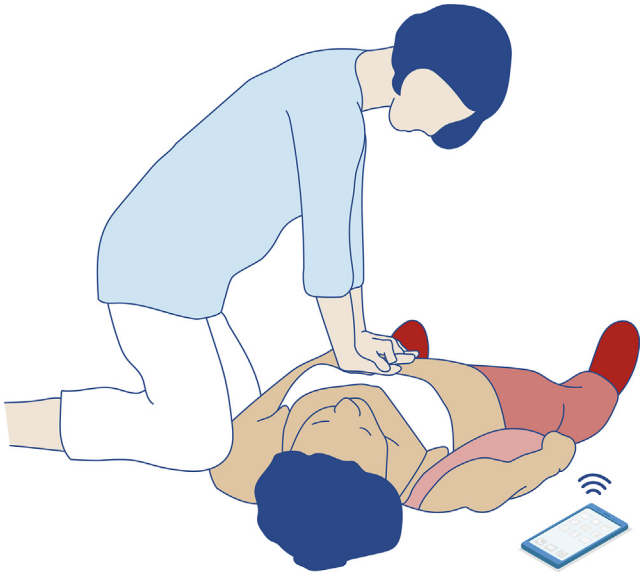


Fig. 8h – Arms straight, vertical above the victim.

Chest compression depth, rate and recoil

The ERC Guidelines 2025 BLS maintain the previous recommendations from 2021[12] and the previously published ILCOR scoping review.[120] This review included five observational studies that examined both chest compression rate and chest compression depth.[121–125] One RCT,[126] one crossover trial,[127] and six observational studies[123,128–132] examined chest compression rate only. One RCT[133] and six observational studies examined chest compression depth only, [134–139] while two observational studies examined chest wall recoil.[140,141] No studies were identified that examined different measures of leaning.

Consistent with ILCOR, the ERC continues to recommend a chest compression rate of 100 to 120min^{-1} and a compression depth of 5–6cm (avoiding excessive chest compression depths greater than 6cm), while avoiding leaning on the chest between compressions to allow full chest wall recoil.[12]

Consistent with ILCOR, the ERC continues to recommend a chest compression rate of 100 to 120 min^{-1} and a compression depth of 5–6 cm (avoiding excessive chest compression depths greater than 6 cm), while avoiding leaning on the chest between compressions to allow full chest wall recoil.[12]

Minimising interruptions to chest compressions

Interruptions comprise pauses for rhythm analysis, charging the defibrillator, defibrillation, airway management, ventilation, pulse checks and any other unspecified interruption to chest compressions. The interval where chest compressions are not being performed is described as hands-off time. The chest compression fraction (CCF) is defined as the proportion of the CPR cycle devoted to compressions. Increasing hands-off time reduces the CCF. The evidence assessing the impact of interruptions to CPR was updated by ILCOR in 2025. One systematic review[142] and six non-randomised studies[143–148] were identified.[4]

A systematic review included eight studies indicating that feedback, both real-time and post-event, may be associated with a marginal improvement in CCF but was not associated with improved clinical outcomes.[142] One RCT[149] and four observational studies[150–153] suggested that real-time feedback did not improve CCF. Three observational studies suggested post-event feedback did lead to improved CCF (MD 7.11; 95 % CI, 5.85, 8.36) (I^2 = 0 %).[142]

Six more recent observational studies suggested that interruptions had no impact on CCF,[143,145,146] ROSC[143,145,146] or survival to discharge.[146] Pre-charging the defibrillator while chest compressions were ongoing increased the CCF and may be associated with ROSC (adjusted OR 2.91; 95 %CI 1.09–7.8),[144] while placement of an advanced airway (tracheal tube or supraglottic airway) resulted in increased CCF (89.9 % vs 84.5 %) and ROSC (31.8 % vs 12.2 %).[108]

ILCOR continues to recommend that pre- and post-shock pauses should be as short as possible. Furthermore, the CCF should be as high as possible, and at least 60 %.[4] Consistent with the ILCOR recommendation, the ERC continues to recommend teaching that hands-off time should be minimised, and chest compression fraction should be maximised.

Compression-only CPR

The role of ventilation and oxygenation in the initial management of cardiac arrest remains debated. ILCOR last published a systematic review of continuous chest compressions (CCC) versus standard CPR in 2017.[154] ILCOR has since undertaken three different reviews addressing CCC by lay responders, EMS personnel and in-hospital clinicians.

A 2024 systematic review[4] failed to identify any new studies addressing CCC by lay responders. The previous systematic review[154] included four relevant observational studies[155–158] comparing CCC with CPR at a ratio of 15 compressions to two ventilations(15:2)[155,156,158] or 30 compressions to two ventilations (30:2).[157] One of the identified studies reported an improvement in favourable neurological with CCC compared to 15:2.[158] In one adult only study, survival to hospital discharge was higher for CCC than for 30:2.[157] However, in two all-age studies, one found there was no difference in ROSC or survival to discharge,[155] while the other reported no difference in survival to hospital admission or survival to 30 days,[156] when comparing CCC and 15:2.[156]

A 2024 systematic review identified one RCT[159] and three cohort studies[147,160,161] addressing CCC by EMS personnel.[4] Two of the cohort studies[147,161] were post-hoc/secondary analyses of previously published trials.[159,162,163] The RCT failed to identify any difference in favourable neurological outcome, survival to hospital discharge or ROSC when comparing CCC and 30:2.[159]

Secondary analysis of pooled trial data[159,162,163] initially suggested CCC by EMS personnel may be associated with improved survival to hospital discharge.[147] However, when analysed by adherence to the intended treatment strategy, CCC were associated with a lower survival rate than 30:2.[147] The remaining observational study[160] failed to report favourable neurological outcome but concluded that minimally interrupted cardiac resuscitation was associated with improved survival to hospital discharge but found no difference in ROSC.

Similarly, a 2024 systematic review[4] failed to identify any new studies addressing CCC in hospital. The previous systematic review[154] included a single observational study comparing continuous mechanical chest compressions (with asynchronous ventilation via a secure airway) and interrupted mechanical chest compressions (5 compressions to 1 ventilation via a secure airway), among patients admitted to the emergency department following OHCA.[164] Patients who received continuous mechanical CPR with asynchronous ventilation were more likely to achieve ROSC and more likely to survive to hospital discharge than patients who received interrupted mechanical chest compressions.[164]

Finally, an ILCOR scoping review addressing continuous chest compressions and fatigue[3] identified four manikin studies.[165–168] One study[165] involved 84 lay persons comparing standard 30:2 CPR with CCC and reported no difference in the proportion of correct (rate and depth) compressions and no difference in the time to commencing chest compressions. They further reported a higher number of compressions with CCC and longer periods off the chest with 30:2. They also found no difference in the time to exhaustion or the level of exhaustion.[165] A larger study randomised 517 lay persons to different CPR protocols; 30 compressions:2 s pause (30c:2s), 50 compressions:5 s pause (50c:5s), 100 compressions:10 s pause (100c:10 s) and CCC. They reported a significant difference in the percentage of compressions with correct depth among the groups (30c2s, 96 %; 50c5s, 96 %; 100c10s, 92 %; CCC, 79 %; p = 0.006). They also reported a higher CCF in the CCC group and a greater frequency of pauses longer than 10 s in the 100c10s group.[167]

A different study involving 124 HCPs randomised participants to perform CCC in one of two CPR positions – from the conventional position at the manikin's side or straddling the manikin.[166] They found no difference in compression rate, compression depth or fatigue (measured using participant blood pressure, heart rate and respiratory rate). However, the intervention period was only 4-min long.[166]

Finally, one study recruited three male participants to perform CPR at altitude (3776 m) to assess the impact of performing CPR



Fig. 8i – If untrained or unable to do rescue breath, apply only chest compression.

in a low oxygen environment.[168] Physical exertion was measured using percutaneous arterial oxygen saturation and reported using the Borg scale, a subjective score of fatigue. Percutaneous oxygen saturations were reduced when performing CCC but not when performing 30:2 CPR. Self-reported fatigue was noted to be 'somewhat hard' or 'hard'.[168]

The ERC supports the ILCOR recommendations that chest compressions are performed for all adults in cardiac arrest[4]. Where bystanders are trained, able, and willing to provide rescue breaths they should perform CPR with a ratio of 30 compressions to 2 ventilations. If they are not trained, able or willing they should deliver CCC. HCPs may perform either CPR with a ratio of 30 compressions to 2 ventilations, or CCC with asynchronous positive-pressure ventilations, until such time as the airway has been secured with a tracheal tube or supraglottic airway device. Once the airway has been secured, they should provide CCC with asynchronous ventilations (Fig. 8i).

CPR in patients living with obesity

The increasing prevalence of obesity worldwide and the challenges in providing CPR to this population prompted ILCOR to complete a scoping review in 2024.[169]

Fifteen studies reported favourable neurological outcome data related to adults. Eight studies suggested obese patients had worse outcomes when compared with non-obese patients,[170–177] six studies suggested there was no difference in favourable neurological outcome[178–183] while one study suggested obese patients were more likely to have a favourable neurological outcome.[184]

Twenty-two studies reported survival to hospital discharge data related to adults. Nine studies suggested obese patients had worse survival to discharge outcomes than non-obese patients,[170–172,175,185–189] nine suggested there was no difference in survival to hospital discharge,[178–181,190–194] while four studies suggested obese patients were more likely to survive to hospital discharge.[195–198]

Six studies reported long-term survival data (months to years) related to adults. One study suggested obese patients had worse outcomes than non-obese patients,[179] four suggested there was no difference in long-term survival[170,182,183,199] while one study suggested obese patients were more likely to survive long-term.[195]

Six studies reported ROSC data related to adults. Two studies suggested obese patients had lower rates of ROSC than non-obese patients,[186,188] two suggested there was no difference in ROSC rates[190,191] while one study suggested obese patients were more likely to achieve ROSC.[198] One study further reported a difference in outcomes dependent upon the underlying aetiology of cardiac arrest.[200] In patients sustaining cardiac arrest of cardiac origin, ROSC was less likely in obese patients, whereas in cardiac arrest of non-cardiac aetiology, there was no difference in ROSC rates.[200]

The association between obesity and neurological outcomes, survival to hospital discharge, longer-term survival (months to years), and ROSC displayed considerable variation. Few studies reported resuscitation quality indicators, and no studies reported on adjustments to CPR techniques or provider outcomes. ILCOR and the ERC advise that standard CPR protocols should be used in obese patients.[3a]

Head-up CPR

The updated ILCOR CoSTR for head-up CPR[1] found two new studies[201,202] to supplement the single study[203] identified in the former 2021 review. All three studies were undertaken by the same research group. The first study, a before-after study[203] comprising 2322 adult OHCAs, compared two CPR bundles. The first, an extended care bundle, comprising a pit-crew approach with rapid deployment of a mechanical CPR device, placing the patient in a head-up position (≈ 20°), use of an impedance threshold device and deferring positive pressure ventilation for several minutes. The second bundle comprised mechanical CPR with an impedance threshold device alone. Following introduction of the extended care bundle, poorly described resuscitation rates increased and survival with favourable neurology was higher (17.9 % vs 34.2 %), however there was no difference in survival with favourable neurological outcome (actual numbers were not reported).[203] The second study[201] compared outcomes for 227 patients resuscitated using the head-up CPR bundle with a propensity matched cohort of 860 supine patients drawn from three previous trials. Survival with favourable neurological outcome was higher in the head-up CPR group 5.9 % (13/222) versus 4.1 % (35/860); OR, 1.47 (95 %CI, 0.76–2.82).[201]

The third study[202] compared outcomes for 353 non-shockable cardiac arrests resuscitated using the head-up CPR bundle with a propensity matched cohort of supine patients drawn from two previous trials. Survival with favourable neurological outcome was higher in the head-up CPR group 4.2 % (15/353) versus 1.1 % (4/353); OR, 3.87 (95 %CI, 1.27–11.78).[202]

Despite an apparent improvement in favourable neurological outcome associated with a head-up CPR bundle, there is currently insufficient evidence to indicate that routine use of head-up CPR, without the other elements of the described CPR bundle (mechanical CPR, impedance threshold device), is associated with improved outcomes. The head-up CPR bundle includes use of an automated head/thorax-up positioning device, a mechanical CPR device, an impedance threshold device and considerable investment in additional training. Consistent with ILCOR[3a], the ERC suggest against

routine use of head-up CPR in isolation, as we were unable to identify any evidence indicating head-up CPR, without a CPR bundle, leads to improved outcomes.

Use of CPR feedback devices

To improve CPR quality, key CPR metrics should be measured. CPR quality data can be presented to the rescuer in real-time and/or provided in a summary report at the end of a resuscitation. Three different types of feedback device were described, all for guiding chest compression: 1) digital audio-visual feedback including corrective audio prompts; 2) analogue audio and tactile 'clicker' feedback for chest compression depth and release; and 3) metronome guidance for chest compression rate.

The recent ILCOR CoSTR for feedback for CPR quality in real resuscitation[3] comprised 60 manuscripts, 24 of which were published since 2020.[204] Five themes were identified – system change/quality improvement, impact on patient outcomes, improved CPR quality without improved patient outcomes, CPR feedback as a generator of other CPR metrics and CPR feedback as a potential harm.[204] Use of CPR feedback to improve system performance is addressed in the ERC Guidelines 2025 Systems Save Lives.[34] This section will address the impact of real-time CPR feedback devices on patient outcomes and CPR metrics.

Forty studies examined impact of real-time feedback on both chest compression quality and/or patient outcomes.[125,127,133,139,142,145,149,153,205–236] Real-time feedback did not lead to improved ROSC,[133,142,149,153,205,208,209,211,214–216,218–220,224,228,229,231,233,235] improved survival[125,142,149,205,208,209,211,214–216,218,220,228,229,231,235] or survival with favourable neurological outcome.[142,208,214,218,220,229]

Real-time feedback did improve chest compression quality. Six studies reported improved compliance with life support guideline recommendations,[133,207,230,233,234,236]. Two studies reported improved cardiac output.[215,228] Multiple studies reported improved chest compression rate,[125,139,142,145,153,205,208,213,214,216,219,223–227,231] chest compression depth,[125,139,142,145,149,205,208,213,214,216,217,219,223–225,227] chest compression fraction,[125,142,145,153,205,208,214,223–225] reduced hands-off time,[139,209,225,227] reduced leaning,[139,142,145,210,213,219,222,225] more appropriate ventilation rates,[142,205,223,236] and increased $EtCO_2$.[127,206,230,235,236] A single manuscript described cases where patients had died with visible damage to the chest wall caused by a feedback device.[237]

The ERC endorses the ILCOR recommendation against routine implementation of audiovisual feedback and prompt devices in isolation during chest compression, i.e. feedback devices are unlikely to improve clinical outcome for the patient directly in front of you.[3a] Rather, feedback devices are best implemented as part of a comprehensive quality improvement programme after action, designed to elevate CPR quality across resuscitation systems (see ERC Guidelines 2025 Systems Saving Lives[34]).

Rescue breaths

Ventilation during cardiac arrest is a critical aspect of cardiopulmonary resuscitation that influences outcomes.[238,239] In the BLS context, ventilation may be provided by mouth-to-mouth, mouth-to-nose, mouth-to-stoma, mouth-to-mask or bag-valve-mask techniques. The ERC recommends that rescue breaths should have sufficient volume to cause the chest to rise visibly.[240] Rescuers should aim for an inflation duration of about 1 s, with sufficient volume to make the chest begin to rise, but avoid rapid or forceful breaths. If the rescuer is unable to make the chest rise, airway obstruction should be considered (see ERC Guidelines 2025 First Aid[6]). The maximum interruption in chest compression to deliver two breaths should not exceed 10 s.[241] These recommendations apply to all forms of ventilation during CPR when the airway is unsecured, including mouth-to-mouth and bag-valve-mask ventilation, with and without supplementary oxygen (Fig. 8j).

Ventilation feedback devices

There is a growing body of evidence to indicate that ventilation during resuscitation may not adhere to resuscitation guideline recommendations.[242,243] Several real-time feedback devices have been developed to improve quality of ventilation during cardiac arrest. ILCOR undertook a scoping review to determine if there was sufficient evidence to recommend their implementation.[244] Nineteen studies were identified, of which six were human studies[218,245–248] and 13 were simulation studies.[249–261]

Only two studies,[218,245]one RCT[218] and two prospective observational studies,[245] examined clinical outcomes with and without real-time feedback. The RCT reported improved higher rates of ROSC (55.5% versus 36.2%, p=0.004) with real-time feedback, but found no difference in survival with favourable neurological outcome (11.1% versus 10.3%, p=0.77).[218] The observational studies found no difference in either ROSC or survival to discharge; however, both reported improved ventilation parameters with real-time feedback.[245] Most simulation studies suggested improved ventilation quality when real-time feedback devices were used. ILCOR have not made a recommendation or good practice statement. Based upon the ILCOR scoping review, it is the view of ERC that there is currently insufficient evidence to recommend routine use of ventilation feedback devices during CPR. The ERC also recognises that this is an evolving area of research, and it may play a role in the future, as technology improves. The ERC recommends that where ventilation feedback devices are implemented, it should only occur in a highly controlled manner, and preferably as part of a formal research programme.

Compression to ventilation ratios

ILCOR updated the CoSTR for chest compressions-to-ventilation ratios in 2025,[4] and identified seven retrospective cohort studies,[262–268] and one prospective study,[269] examining the impact of the changes in 2005, from 15 compressions to 2 ventilations (15:2) to 30 compressions to 2 ventilations (30:2).[270] Two cohort studies reported favourable neurological outcomes following the switch from

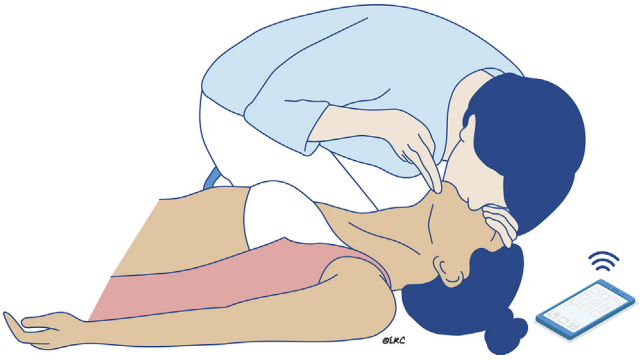


Fig. 8j – If trained and able provide rescue breaths with a compression-ventilation ratio of 30:2.

15:2 to 30:2.[262,269] One study comprising 3960 non-shockable cases reported improved neurologically favourable survival at hospital discharge with 30:2 compared to 15:2.[262] However, a different cohort study comprising 522 shockable cases reported no difference in neurologically favourable survival (CPC score 1–2).[269]

Six cohort studies reported on survival to hospital discharge or 30-day survival.[263–266] Three studies [262,265,266] reported that 30:2 improved survival, whereas two studies found no difference in the odds of survival.[264,268] An analysis of 200 bystander witnessed cardiac arrests with shockable rhythms reported an improvement in survival to hospital discharge with a compressions-to-ventilation ratio of 50:2 compared to 5:1.[263] Consistent with ILCOR[3a], the ERC recommends a compression–ventilation ratio of 30:2 in adult patients in cardiac arrest.

Passive ventilation

Passive ventilation describes gas exchange secondary to recoil of the chest and lungs occurring during chest compressions. It has been suggested that passive ventilation may produce tidal volumes sufficient to provide adequate gas exchange during cardiac arrest.[271] ILCOR updated their 2022 systematic review in 2025 and did not identify any new studies.[4]

Three RCTs,[272–274] one of which was a very small pilot study,[274] and one observational study[275] were identified. Meta-analysis of two of the RCT's[272,273] suggested passive ventilation did not improve ROSC or survival to ICU discharge.[2] Based on the ILCOR review, [3a] the ERC advises against the routine use of passive ventilation techniques during conventional CPR.

Using an automated external defibrillator (AED)

An automated external defibrillator (AED) is a portable, battery-powered device that includes adhesive defibrillation pads to attach to a patient's chest to detect the heart rhythm following suspected cardiac arrest. AEDs are accurate in their interpretation of the heart rhythm and are safe and effective when used by laypeople.[276] If the rhythm is a shockable rhythm (ventricular fibrillation or pulseless ventricular tachycardia), an audible (and sometimes visual) prompt is given to the operator to deliver a direct current electric shock (defibrillation) to re-establish a coordinated heart rhythm.[277]

Among patients in a shockable rhythm, each minute delay to defibrillation is associated with 6 % higher probability of failure to terminate VF, and 3–6 % lower probability of survival to discharge.[278–280] For other heart rhythms (including asystole and a normal rhythm), no shock is advised.

The probability of survival after OHCA can be markedly increased if patients receive immediate CPR and an AED is used.[281] AEDs make it possible for laypeople to attempt defibrillation following cardiac arrest many minutes before professional help arrives.[281] The highest survival rates following lay rescuer resuscitation have been reported after use of on-site AEDs such as at airports, casinos, sports facilities or train stations.[55,282–285] A recent update of the 2020 systematic review by ILCOR identified one ILCOR scientific statement,[286] one systematic review[287] and four observational studies.[288–290] The systematic review included 30 studies and reported that bystander CPR with use of an AED increased survival.[287] One observational study reported improvement in favourable neurological outcome[291] while another suggested no difference in favourable neurologic outcome.[288] Similarly, one observational study reported improvement in ROSC[289] while another suggested no difference in favourable neurological outcome.[288] The fourth study reported that annual rates of cardiac death reduced following implementation of a public access defibrillation (PAD) programme for patients under 65 years of age, but not for patients aged 65 or over.[290] Based on the ILCOR CoSTR,[3] the ERC recommends the implementation of public access defibrillation programmes, and recommends that public-access AEDs should be available for use 24 h a day, 7 days a week, be stored in locations easily accessible to the general public and in unlocked cabinets.

This section addresses defibrillation in the BLS context. More advanced concepts including synchronised cardioversion, vector change and dual sequence defibrillation can be found in the ERC Guidelines 2025 Adult Advanced Life Support.[82] Wider systems considerations for the placement and deployment of Automated External Defibrillators are addressed in the ERC Guidelines 2025 Systems Save Lives.[34]

Ultra-portable AEDs

Several manufacturers have developed ultraportable or pocket AEDs for personal use or equipping community volunteer responders. This presents an opportunity to increase AED availability and consequently patient outcomes. However, these devices may be limited in the number and the energy of shocks they can deliver (e.g. restricted to up to 20 shocks and a maximum of 85 J). Although these devices may have been approved as safe to use, this does not provide evidence of device performance in real-world settings. Consequently ILCOR has reviewed the evidence of efficacy to inform implementation decisions.[292] The review identified three studies.[293–295] One was an economic modelling suggesting ultraportable AEDs would reduce the annual risk of cardiac death and improve quality of life measures.[293] One was a study protocol for a cluster RCT,[294] while the third was an abstract publication describing preliminary data from the cluster RCT.[295] There is currently insufficient clinical evidence to indicate ultraportable AEDs improve patient outcomes.[3] The ERC is currently unable to recommend their adoption until high-certainty clinical data demonstrate improved patient outcomes with their use.

How to find an AED

All public access AEDs should be registered with the local emergency service. Such registries enable the dispatcher to identify the nearest available AED at the time of the emergency call.[296–301] If more than one bystander is present at a cardiac arrest, the dispatcher is able to guide a bystander to locate and retrieve an AED. Prompting the bystander making the emergency call specifically about public-access AEDs on-site (i.e. immediately visible from the location at which the patient has collapsed) is another way in which an available AED can be retrieved and used for a patient. If the public-access AED is immediately adjacent to the patient, and time away from the patient can be minimised, it may be appropriate even for a lone rescuer to retrieve the device. The ERC recommends that local emergency services should maintain an accurate registry of AED locations.

Geolocation applications

Global positioning systems (GPS) in smartphones have enabled numerous apps to locate the user and display the location and availability of nearby AEDs.[300–303] They often allow the user to add details about new AEDs and to provide data about missing or mal-

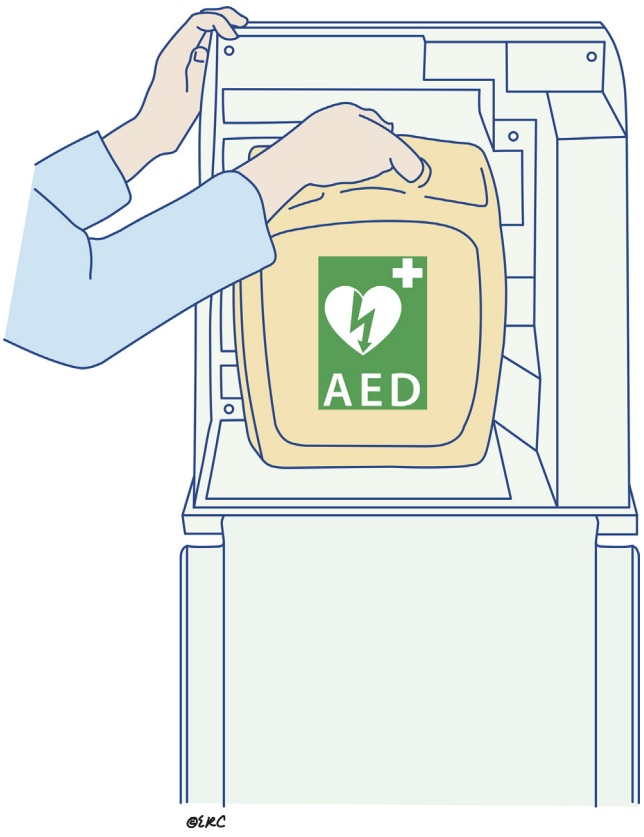


Fig. 8k – Send for AED.

functioning AEDs. These apps can complement existing registries.[300,301] The apps may be capable of providing walking directions to the AED and can be integrated with dispatch systems so that dispatchers can send a push notification to a mobile phone (or other smart device e.g. smartwatch) during an emergency to help guide a bystander to the nearest AED.[300,303] The role of mobile phone technology as a tool to locate AEDs is described in more detail in the ERC Guidelines 2025 Systems Saving Lives.[34]

AED signage *(Fig. 8k)*

Although several different AED signs are available, understanding of these signs' meaning is often lacking.[304–306] Newer signs have been developed following public consultation,[306,307] but evidence addressing how signs increase AED deployment is lacking. Furthermore, many AEDs have no signage at their location, or signs in the vicinity that could guide bystanders to its location.[308] The ERC and ILCOR recommend that AED locations should be highly visible and easy to locate.[3a] This includes clear signage at its location that is visible from a distance as well as signs in the vicinity of the AED that clearly direct bystanders toward its location. Signs should indicate what the AED is for, and that anyone can use the AED, even if they have not had previous training.

AED cabinets

Concerns about theft or vandalism have led to security measures, such as using locked cabinets, to house AEDs in public locations. Since each minute of delay in attempting defibrillation critically decreases the chance of survival, the additional time needed to access an AED in a locked cabinet may negatively impact patient survival.[309] A 2025 ILCOR scoping review assessed the benefits and harms of placing AEDs in locked cabinets versus unlocked cabinets[309a]. There was limited evidence because only 10 studies were identified, some of which were simulation studies or conference abstracts.[310–318] Taken together, a low risk of theft, missing AEDs or vandalism was reported (<2%). Furthermore, two simulation studies identified significantly slower AED retrieval when additional security measures, such as locked cabinets, were used.[310] A survey of first responders further reported that half of all injuries sustained while accessing an AED were incurred when attempting to break glass to access the AED.[319] Consistent with ILCOR, the ERC recommends that AED cabinets are not locked. If locks are necessary, unlocking instructions must be clear to prevent delays. Responsible systems should establish strategies for retrieving used public-access defibrillators.

Use of drones to deliver AEDs

Drones or unmanned aerial vehicles have the potential to speed up the delivery of an AED, especially for areas with longer response times. Evidence underpinning drone deployment of AEDs is currently lacking but real-world studies demonstrate feasibility of drone AED delivery, with a time advantage of 1–3min over ambulances observed in approximately 60% of cases. Mathematical modelling can be used to optimise the location of drones to improve the emergency response in OHCA. ILCOR performed a scoping review in 2023[3] and an evidence update in 2024[4] to investigate the feasibility and impact of drone delivered AEDs for OHCA response[319a]. A total of 39 studies were included. Most of the studies were simulation studies or computer/prediction models. Only three studies reported drone AED delivery to real OHCAs.[320–322] There were no RCTs investigating drone AED delivery. The ERC recommends that where drone delivery of AEDs is possible, dispatchers should advise bystanders that a drone has been tasked to deliver an AED and provide basic instructions on retrieving the AED from the drone.

How and when to use an AED

An AED should only be attached to a person who is unresponsive with abnormal breathing. CPR should not be delayed whilst locating and retrieving an AED, but as soon as an AED has been brought to the patient's side, it should be attached to the patient.[3] If more than one bystander is present, one should continue CPR whilst the other attaches the defibrillation pads. Some devices will power on auto-



Fig. 8l – When AED arrives, continue chest compressions, while placing defibrillation pads.

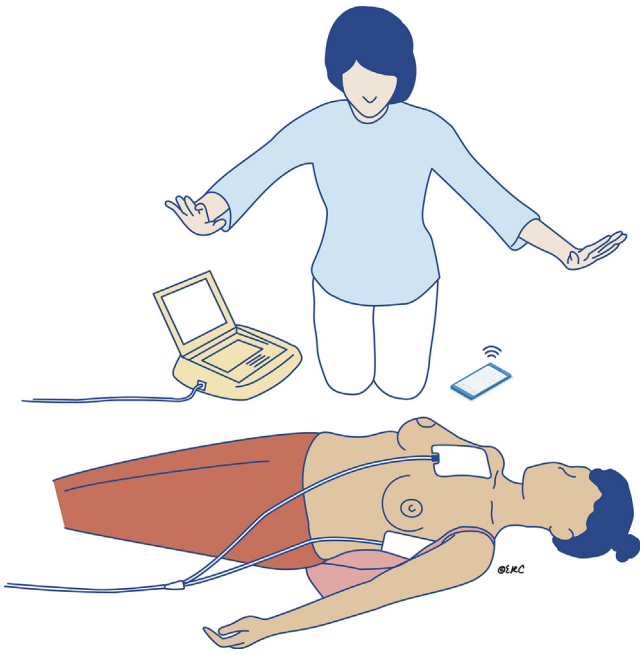


Fig. 8m – Follow the directions of the AED.

matically once their carrier/ case has been opened, whereas others may require the user to press a power on button. Most AEDs have voice ± visual prompts about where to locate the adhesive pads. Once the defibrillation pads are connected, no-one should touch the patient whilst the AED performs rhythm analysis. If the AED advises a shock, it will either give that shock itself (fully automatic AEDs) or prompt the user to press a shock button (semi-automatic AEDs). Some AEDs also provide guidance and feedback on quality chest compressions (Figs. 8l–8o).

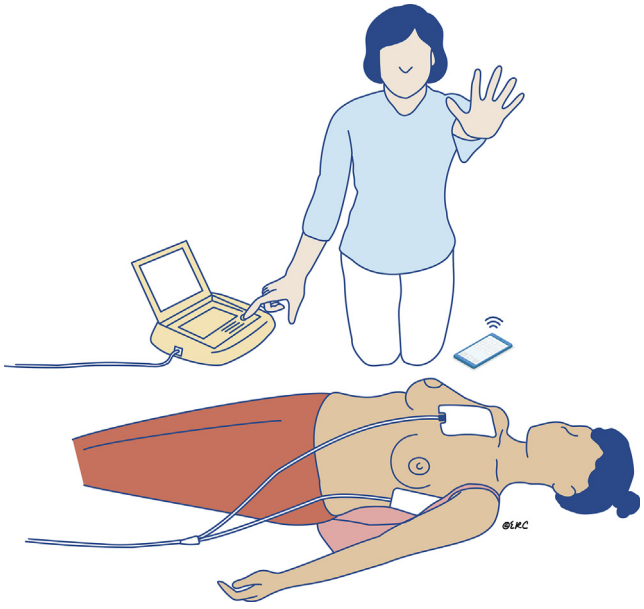


Fig. 8n – If shock is indicated, deliver shock and continue chest compressions.



Fig. 8o – If a shock is not indicated, continue chest compressions.

Should chest compressions be performed before defibrillation?

ILCOR has updated the 2020 CoSTR[11] addressing when to perform defibrillation twice since the last guidelines however no new studies have been identified.[2,3] A 2020 systematic review by ILCOR[1] identified five RCTs[323–327] comparing a shorter with a longer interval of chest compressions before defibrillation.[1] No clear benefit from additional CPR before defibrillation was found. Four studies reported no significant difference in favourable neurological outcome in patients who received a shorter period of CPR before defibrillation compared with a longer period of CPR.[323,324,326,327] Five studies reported no significant difference in survival to hospital discharge in patients who received a shorter period of CPR before defibrillation compared with a longer period of CPR.[324–327] Consistent with ILCOR, the ERC recommends CPR be provided until an AED arrives on site, is switched on and defibrillation pads are attached to the patient. Once the defibrillation pads are attached, the AED will analyse and, if indicated, a shock should be delivered without delay. Defibrillation should not be delayed to provide additional CPR.

Positioning of defibrillation pads

ILCOR undertook a systematic review addressing AED pad size and placement in 2024.[4] Two observational studies[328,329] and one RCT[330] were identified. No studies addressed the impact of different pad sizes on ROSC, survival or favourable neurological outcome. One observational study reported no difference in defibrillation success when using large defibrillation pads.[328]

One prospective study[329] found no significant difference in favourable neurological outcome, survival to hospital discharge or defibrillation success with initial anterior-posterior pad placement compared with initial anterior-lateral placement. However, anterior-posterior pad placement was associated with higher ROSC rates after adjusting for known predictors. The RCT[330] addressed pad placement for refractory ventricular fibrillation, which is beyond BLS, and further information can be found in the ERC Guidelines 2025 Adult Advanced Life Support.[82]

There is currently insufficient evidence to recommend a specific pad size or position for optimal external defibrillation in adults. ILCOR has issued a good practice statement that recommends following the manufacturer's AED guidance and instructions for adult pad placement[4]. The ERC endorses this recommendation.

For most manufacturers this will mean placing defibrillation pads on the front of the persons chest and their left side (the anterior-lateral position). One defibrillation pad should be positioned below the patient's right clavicle, just to the right of the upper sternal border. The other defibrillation pad should be centred on the patient's left mid-axillary line, below the armpit. Pad placement should avoid breast tissue if possible. This approach requires less manual handling so lowers the risk of manual handling injury to the rescuer, minimises the time needed to place defibrillation pads and therefore minimises interruptions to chest compressions.

For most manufacturers this will mean placing defibrillation pads on the front of the persons chest and their left side (the anterior-lateral position). One defibrillation pad should be positioned below the patient's right clavicle, just to the right of the upper sternal border. The other defibrillation pad should be centred on the patient's left mid-axillary line, below the armpit. Pad placement should avoid breast tissue if possible. This approach requires less manual handling so lowers the risk of manual handling injury to the rescuer, minimises the time needed to place defibrillation pads and therefore minimises interruptions to chest compressions.

The other possible position entails placing the defibrillation pads on the persons chest and back (the anterior-posterior position). Place the anterior defibrillation pad on the left side of the chest, between the midline and the nipple. For female patients, try to avoid as much breast tissue as much as possible. The posterior defibrillation pad should be placed on the left side of the patient's spine, just below the scapula. This approach requires more manual handling than the anterior-lateral position. If the anterior-lateral pad position is not feasible, then the rescuer can consider using the anterior-posterior pad position if trained (Fig. 6).

Removing a bra prior to defibrillation

Evidence indicates females in cardiac arrest are less likely to receive cardiopulmonary resuscitation and defibrillation from bystanders.[331–333] This may stem from apprehension about exposing and touching a woman's chest and fears of being accused of sexual assault.[334] To assess the impact of wearing a bra on defibrillation, ILCOR undertook a systematic review that identified two manikin studies[335,336] and one animal study.[337,338] The animal study suggested that a metal wire inside a bra did not adversely impact the defibrillation attempt nor cause any injury to the patient or rescuer.[337] The manikin studies suggested female manikins were less likely to be exposed or disrobed,[335] and time to defibrillation was longer with female manikins.[336] No studies addressing ROSC, survival or favourable neurologic outcome were identified.[338a]

AED adhesive pads should be placed onto bare skin. In people wearing bras, there is little evidence addressing whether the bra needs to be unfastened or cut-off, and no evidence that an underwire in a bra causes harm. ILCOR advises that there is insufficient evidence to guide the routine unfastening or cutting of a bra. Defibrillation pads must be placed on bare skin in the correct position, which may be possible by adjusting the position of the bra, rather than by unfastening or cutting it.

The ERC recommends that rescuers prioritise placing defibrillation pads in the correct location, and in contact with bare skin. If this can be quickly accomplished without unfastening or cutting the bra then, it is acceptable to leave the bra in place. However, if the bra interferes with correctly locating the defibrillation pads, then the bra should be displaced to facilitate correct defibrillation pad application. Rescuers should not be concerned about exposing the persons chest to apply defibrillation pads. They should prioritise life-saving interventions over concerns for modesty.

The ERC further recommends that manufacturers of manikins should develop realistic manikins that reflect different body sizes and shapes. CPR training should incorporate pad placement in people wearing bras.

Where to place an AED in public

Evidence pertaining to geographical placement of AEDs can be found in the ERC Guidelines 2025 Systems Save Lives. The ERC recommends data informed AED placement considering historical OHCA rate, EMS response times and location of current AEDs.

Safety

Personal protective equipment (PPE)

The use of personal protective equipment during resuscitation plays an important role in protecting rescuers from potential exposure to infectious agents ILCOR completed a systematic review in 2023 including 17 simulation studies and 1 clinical study, concluding PPE was not associated with lower quality CPR or reduced survival.[338a] A *meta*-analysis of six simulation-based randomised studies found no meaningful impact of personal protective equipment on the depth or rate of chest compressions in adult CPR. This was also the case in studies carried out during the COVID-19 pandemic, when personal protective equipment was widely used. However, rescuers wearing personal protective equipment reported feeling more fatigued. While personal protective equipment should be used when available—especially in settings with known or suspected infection risk—its use should not lead to unnecessary delays in starting chest compressions. The ERC recommends that regular training to facilitate timely donning and doffing of personal protective equipment is required, so that protection and prompt action can go hand in hand.[339]

Harm to people providing CPR

ILCOR performed a scoping review related to harm to people providing CPR and very few reports of harm from performing CPR and defibrillation were identified. Five experimental studies and one case report published since 2008 were reviewed. The five experimental studies reported perceptions in experimental settings during shock administration for elective cardioversion. The authors measured current flow and the average leakage current in different experiments to assess rescuer safety. Despite limited evidence evaluating safety ILCOR and ERC support the interpretation that the use of an AED is generally safe.[11,270] The ERC consistent with ILCOR, recommend that rescuers perform chest compressions and use an AED as the risk of damage from accidental shock during AED use is low.

Unintentional injury from CPR to patients not in cardiac arrest

Lay people may be reluctant to perform CPR on an unresponsive person who is not breathing normally due to concern that performing chest compressions on a person who is not in cardiac arrest could cause serious harm. However, there is little evidence that CPR performed on a person not in cardiac arrest causes significant harm.

There is however significant concern that delays to CPR results in worse patient outcomes.[309] The potential survival benefits of CPR initiated by lay persons for patients in cardiac arrest far outweigh the low risk of injury in patients not in cardiac arrest.

ILCOR recommends that lay persons, trained bystanders and first responders initiate CPR for presumed cardiac arrest without concerns of harm to patients not in cardiac arrest (good practice statement). The ERC guideline recommendations are consistent with the ILCOR treatment recommendations.

Safety of AEDs

Errors in AED use most commonly occur because of problems with how the operator interacts with the AED, rather than faults in or malfunction of the device itself, and include continuing CPR during rhythm analysis, not delivering a shock when instructed and premature removal of the AED.[340]

Simulation studies suggest that fully automatic AEDs increase safety, reduce error and shorten time to defibrillation compared to semi-automatic AEDs.[341,342] The ERC recommends the use of AEDs as they are safe to use and present a low risk of injury to rescuers.

Declaration of competing interest

Declarations of competing interests for all ERC Guidelines authors are displayed in a COI table which can be found online at https://doi.org/10.1016/j.resuscitation.2025.110771.

Collaborators

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Practice Guideline

European Resuscitation Council Guidelines 2025 Adult Advanced Life Support

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Abstract

These European Resuscitation Council (ERC) Guidelines 2025 Adult Advanced Life Support (ALS) are based on the International Liaison Committee on Resuscitation (ILCOR) Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations (CoSTR). The evidence informing the ALS Guidelines is also included. When ILCOR has not addressed a specific topic, the ERC ALS Writing Group has provided its own guidance and the evidence supporting it. This section provides recommendations for ALS for adults with in- or out-of-hospital cardiac arrest. The ERC Guidelines 2025 ALS emphasise providing *early* and *effective* ALS interventions to improve survival from cardiac arrest in adults.

Keywords: Cardiac arrest, cardiopulmonary resuscitation, advanced life support

Introduction

These European Resuscitation Council (ERC) Guidelines 2025 Adult Advanced Life Support (ALS) include the advanced interventions that can be used in addition to basic life support (BLS) and automated external defibrillator (AED) by health care professionals. These ALS treatments are helpful when started quickly and early during cardiac arrest. ALS includes the prevention and treatment of both in-hospital cardiac arrest (IHCA) and out-of-hospital cardiac arrest (OHCA), the ALS algorithm, manual defibrillation, airway management during cardiopulmonary resuscitation (CPR), medication and their delivery, and the treatment of peri-arrest arrhythmias. These ERC Guidelines 2025 are based on the International Liaison Committee on Resuscitation (ILCOR) Consensus on Science and Treatment Recommendations (CoSTR) for ALS.[1] For these ERC Guidelines, the ILCOR recommendations were supplemented by focused literature reviews undertaken by the ERC ALS Writing Group for those topics not reviewed by ILCOR. When required, the guidelines were informed by the expert consensus of the writing group membership. For the first time we have had a patient public representative (GC) on the ALS Writing Group.

Abbreviations: AED, automated external defibrillator, AF, atrial fibrillation, ALS, advanced life support, BLS, basic life support, BP, blood pressure, CHD, coronary heart disease, CoSTR, Consensus on Science and Treatment Recommendation, CPR, cardiopulmonary resuscitation, DC, direct current, DNACPR, do not attempt cardiopulmonary resuscitation, DSD, dual (double) sequential defibrillation, ECG, electrocardiogram, ECPR, extra-corporeal cardiopulmonary resuscitation, EMS, emergency medical service, ERC, European Resuscitation Council, $ETCO_2$, End-tidal carbon dioxide, EWS, early warning score, ICD, implantable cardioverter defibrillator, IHCA, in-hospital cardiac arrest, ILCOR, International Liaison Committee on Resuscitation, IO, intraosseous, IV, intravenous, OHCA, out-of-hospital cardiac arrest, PEA, pulseless electrical activity, POCUS, point of care ultrasound, ROSC, return of spontaneous circulation, SBAR, situation, background, assessment, recommendation., SCD, sudden cardiac death, SGA, supraglottic airway, STEMI, ST-elevation myocardial Infarction, TOR, termination of resuscitation, VT, ventricular tachycardia, VF, ventricular fibrillation, VF/pVT, ventricular fibrillation/pulseless VT

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The scope of the 2025 ALS Guidelines was posted for feedback from National Resuscitation Councils (NRCs) and public comment and several new topics were added based on the scoping process that included a survey of NRCs.[2] The ALS Guidelines were drafted and agreed by the ALS Writing Group members and the ERC Guidelines 2025 Steering Committee. These Guidelines were posted for public comment between 5 and 30 May 2025. A total of 203 individuals or organisations submitted 325 comments, which resulted in 66 significant changes in the final version. The Guidelines were presented to and approved by the ERC Board and the General Assembly in June 2025. The methodology used for guideline development is presented in the Executive summary.[3]

The key messages are presented in Fig. 1. Table 1 summarises the major changes that have been made. Fig. 2 shows the 2025 ALS Algorithm.

Concise guidelines for clinical practice

Prevention of in-hospital cardiac arrest

The ERC recommends that:

- Shared decision making and advance care planning which integrates resuscitation decisions with emergency care treatment plans is used to increase clarity of treatment goals and also prevent inadvertent deprivation of other indicated treatments, besides CPR. These plans should be recorded in a consistent manner (See ERC Guidelines 2025 Ethics in Resuscitation).[4]
- Hospitals use a track and trigger early warning score system for the early identification of patients who are critically ill or at risk of clinical deterioration.
- Hospitals train staff in the recognition, monitoring and immediate care of the acutely ill patient.
- Hospitals empower all staff to call for help when they identify a patient at risk of physiological deterioration. This includes calls based on clinical concern, rather than solely on vital signs.
- Hospitals have a clear policy for the clinical response to abnormal vital signs and critical illness. This may include a critical care outreach service and, or emergency team (e.g. medical emergency team, rapid response team).
- Hospital staff use structured communication tools to ensure effective handover of information.
- Patients receive care in a clinical area that has the appropriate staffing, skills, and facilities for their severity of illness.
- Hospitals should review cardiac arrest events to identify opportunities for system improvement and share key learning points with hospital staff.
- Participation in national cardiac arrest audit as a benchmark for local performance.

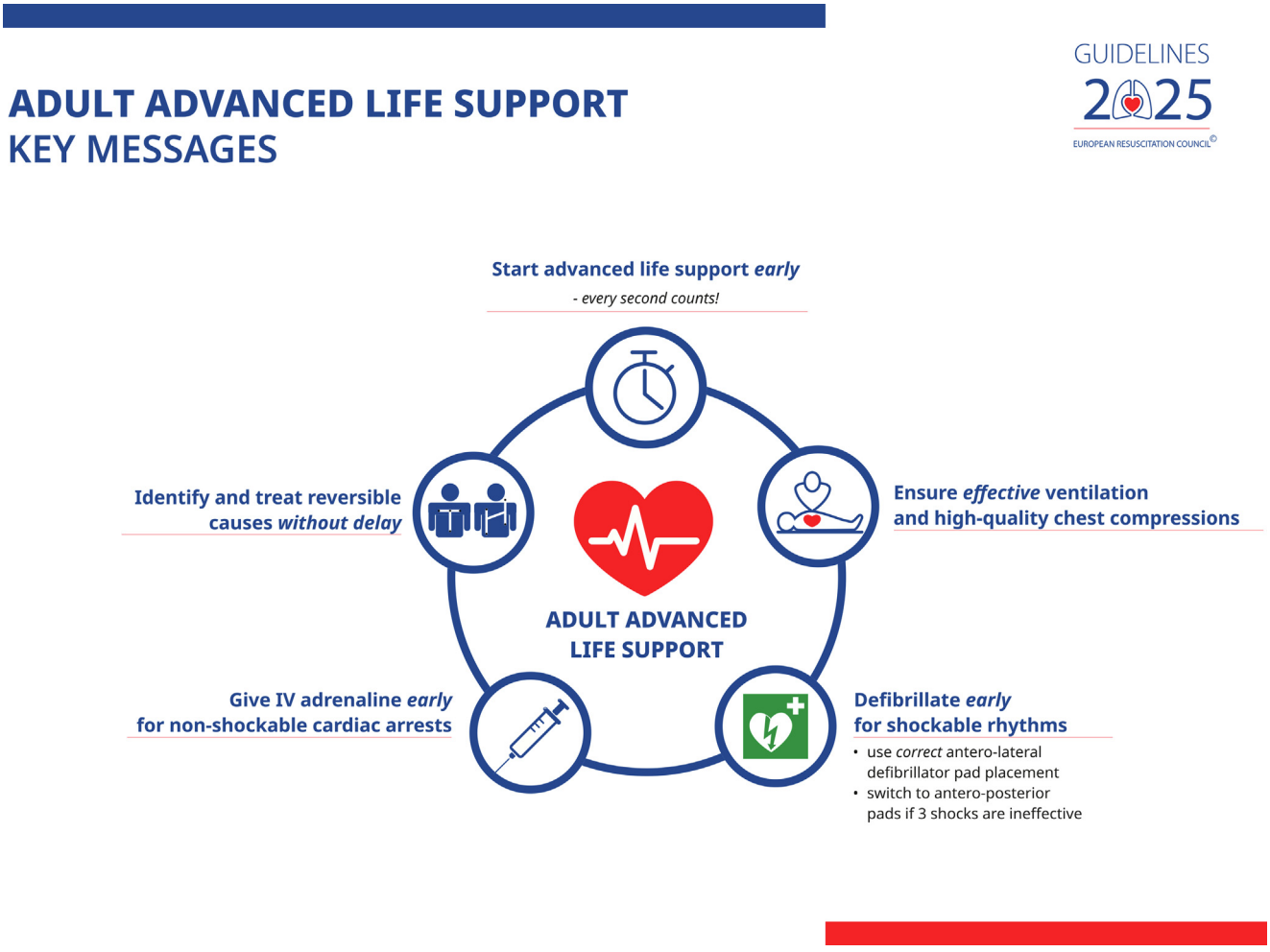


Fig. 1 – Advanced life support – Key messages.

Table 1 – What's new in the ERC Guidelines 2025 adult Advanced Life Support?

	Guidelines 2021	Guidelines 2025
Headlines	• Emphasis on: ○ High-quality chest compression ○ Premonitory signs to prevent cardiac arrest ○ Using basic and advanced airway techniques in a step wise fashion – only rescuers with a high success rate should use tracheal intubation ○ Early adrenaline for non-shockable rhythms	• Greater emphasis on: ○ Starting ALS as early as possible to help save more lives. ○ Effective oxygenation and ventilation breaths with high-quality chest compressions. ○ Correct apical (lateral) pad position for defibrillation. ○ Use of waveform capnography to confirm correct tracheal tube placement • What's out? o Calcium and sodium bicarbonate have no role during CPR except for very specific indications. o Precordial thump is no longer included in these Guidelines.
ALS in low resource settings	• Not mentioned in guidelines 2021	• ALS guidelines may have to be adapted according to resources and there may need to be a greater focus on prevention, early first aid, and basic life support measures. • Rescuers should be aware that even in high-income settings, ALS may be constrained by limited resources. • A two-tiered approach incorporating basic and advanced interventions may be the safest and most effective.
CPR-induced consciousness	• Not mentioned in guidelines 2021	• Rescuers may consider using sedative or analgesic drugs (or both) in small doses to prevent pain and distress to patients who are conscious during CPR (without ROSC). • Neuromuscular blocking drugs alone should not be given to conscious patients. • Drug regimens may be based on those used in critically ill patients and according to local protocols such as small doses of opioids, ketamine and/or midazolam.
Defibrillation: AED versus manual defibrillation during ALS	• Not clarified in 2021	• Manual defibrillators should only be used by rescuers who can quickly and accurately identify a cardiac arrest rhythm (within 5 s) and, if needed, deliver a safe shock with minimal interruption (aim for less than 5 s) to chest compressions. • ALS providers must be proficient in using both an AED and a manual defibrillator. • If an AED is already in use when ALS providers arrive, they should follow its shock prompts. When possible, they should transition to a manual defibrillator during a 2-minute CPR cycle.
Manual defibrillation strategy	• Mentioned in the supporting text: The 2015 ERC ALS Guideline stated that if there is doubt about whether the rhythm is asystole or extremely fine VF, do not attempt defibrillation; instead, continue chest compressions and ventilation. We wish to clarify that when the rhythm is clearly judged to be VF a shock should be given.	• Immediate defibrillation of (ventricular fibrillation) VF of any amplitude (even fine VF) should be attempted.
Refractory ventricular fibrillation	• For refractory VF, consider using an alternative defibrillation pad position (e.g. antero-posterior) • Do not use dual (double) sequential defibrillation for refractory VF outside of a research setting.	• For refractory VF, defined as continuous VF after three consecutive shocks, and having ensured correct antero-lateral pad positioning, consider using a defibrillation vector change by using an alternative defibrillation pad position (e.g. antero-posterior). • Dual (double) sequential defibrillation (DSD), involves using a combination of antero-lateral and antero-posterior pad positioning, discharged in close succession.

(*continued on next page*)

Table 1 (continued)

	Guidelines 2021	Guidelines 2025
		Given the practical challenges of using two defibrillators to deliver DSD and the limited evidence for its efficacy the ERC does not recommend its routine use.
Bag-mask ventilation	• Not emphasised in 2021	• Deliver effective bag-mask ventilation breaths by optimising mask seal and airway patency and if necessary use a two-person technique for bag-mask ventilation.
Choice of supraglottic airway	• This was not specified in 2021	• When using a supraglottic airway (SGA), an i-gel is preferred to a laryngeal tube.
Confirmation of correct tracheal tube placement	• Use waveform capnography to confirm tracheal tube position.	• A sustained $ETCO_2$ trace on waveform capnography must be used to exclude oesophageal placement of the tracheal tube.
Mechanical ventilator settings during chest compressions	• This was not specified in 2021	• If a mechanical ventilator is used during CPR, use a volume-controlled or pressure regulated mode during chest compressions set the ventilator to a tidal volume of 6–8 mL kg^{-1} (predicted body weight), or to achieve a visible chest movements, the maximum fraction of inspired oxygen, a respiratory rate of 10 min^{-1}, an inspiratory time of 1–1.5 s, a positive end expiratory pressure (PEEP) 0–5 cm H_2O, the peak pressure alarm at 60–70 cm H_2O, and turn off the inspiratory trigger. Ensure mechanical ventilation is effective and if not, use manual ventilation.
Vascular access	• Attempt intravenous (IV) access first to enable drug delivery in adults in cardiac arrest. • Consider intraosseous (IO) access if attempts at IV access are unsuccessful or IV access is not feasible	• Attempt intravenous (IV) rather than intraosseous (IO) access first, to enable drug delivery in adults in cardiac arrest. • If IV access cannot be rapidly achieved within two attempts, it is reasonable to consider IO access as an alternative route for vascular access during adult cardiac arrest.
Use of calcium, sodium bicarbonate and corticosteroids	• This was not made explicit in 2021	• Do not routinely give calcium, sodium bicarbonate or corticosteroids during cardiac arrest.
ALS in highly-monitored cardiac arrest, and physiology-guided CPR	• Not mentioned in Guidelines 2021	• A sudden decrease in $ETCO_2$ may indicate a cardiac arrest or very low cardiac output state. • Consider starting chest compressions if the systolic blood pressure decreases and remains < 50 mmHg despite interventions. • In adults with continuous intra-arterial blood pressure monitoring, we suggest that adrenaline is initially given in small increments (e.g., 50–100 μg IV) rather than a 1 mg bolus. • A pragmatic approach during physiology-guided CPR is to aim for a diastolic blood pressure of ≥30 mmHg (when using intra-arterial blood pressure monitoring) and an $ETCO_2 \geq 25$ mmHg (3.3 kPa).
Peri-arrest arrhythmias		• The 2025 has a greater emphasis on those arrhythmias that require immediate treatment before or after cardiac arrest. • The tachycardias section has been renamed tachyarrhythmias. • There is greater emphasis on use of electrical cardioversion with a synchronised shock for patients immediately after ROSC, or who are unstable.

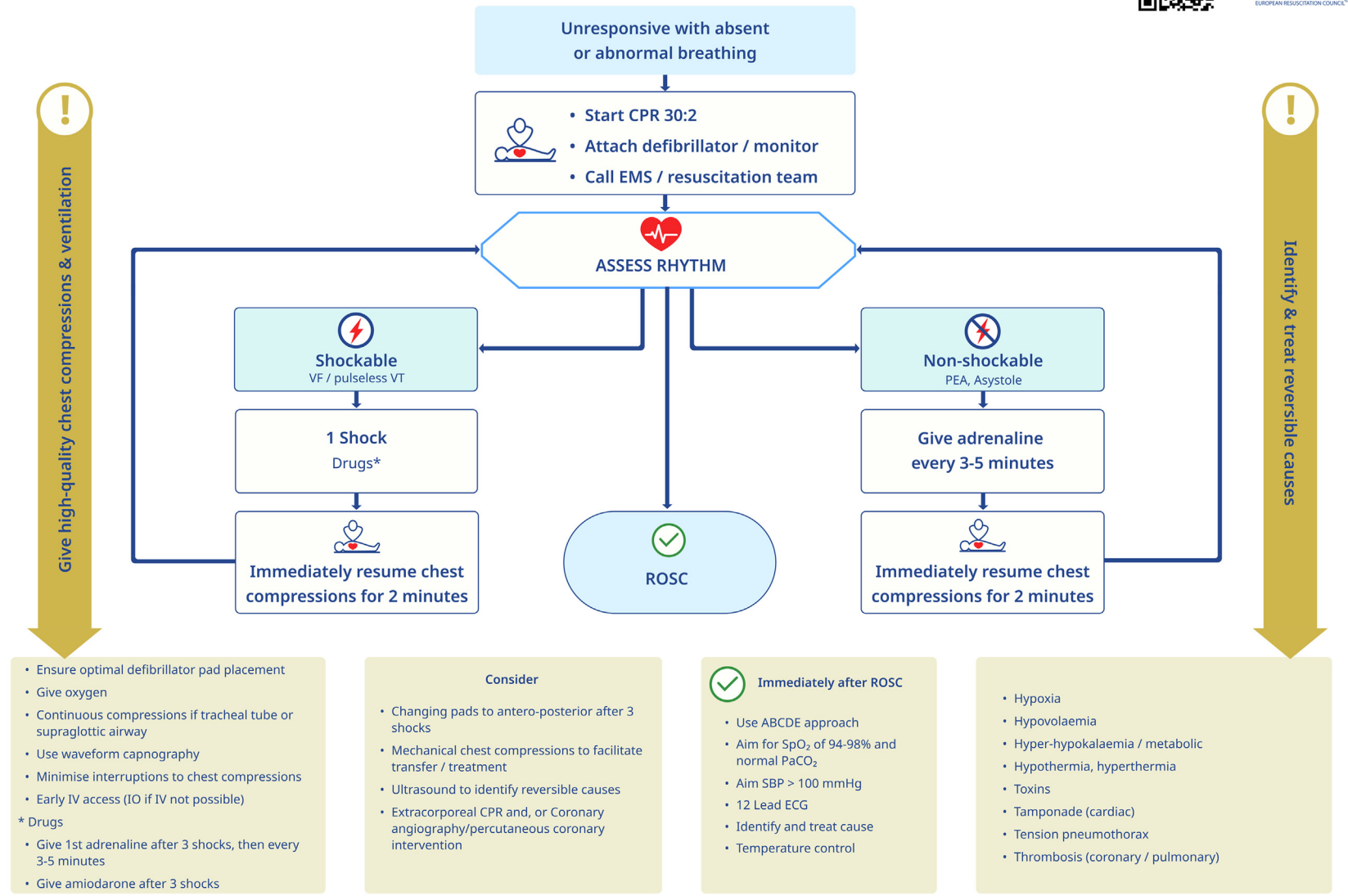


Fig. 2 – Advanced Life Support algorithm

ABCDE airway, breathing, circulation, disability, exposure; CPR cardiopulmonary resuscitation; ECG electrocardiogram; EMS emergency medical system; IO intraosseous; IV intravenous; PEA pulseless electrical activity; $PaCO_2$ arterial partial pressure of carbon dioxide; ROSC return of spontaneous circulation; SpO_2 oxygen saturation measured with pulse oximetry; VF ventricular fibrillation; VT ventricular tachycardia.

Prevention of out-of-hospital cardiac arrest

- Coronary heart disease (CHD) is the leading cause of sudden cardiac death (SCD), responsible for 80 % of cases, particularly in older patients. Non-ischaemic cardiomyopathies contribute to 10–15 % of SCD cases. In younger individuals, the main causes of SCD include inherited heart diseases, congenital heart defects, myocarditis, and substance misuse. In these patient groups, risk stratification is possible, and preventive treatments may be effective.
- Predicting SCD is challenging because most cases happen in individuals with undiagnosed heart disease. As a result, detecting early warning signs, implementing an efficient emergency medical services (EMS) system, and focusing on the prevention of cardiovascular disease (CVD) risk factors are crucial in the general population.
- Symptoms such as chest pain, syncope (especially during exercise, while sitting or supine), palpitations, dizziness or sudden shortness of breath that are consistent with cardiac ischaemia or an arrhythmia should be investigated.
- Overtly healthy young adults who have SCD can also have preceding signs and symptoms (e.g. syncope/pre-syncope, chest pain and palpitations) that should alert healthcare professionals to seek expert help to prevent cardiac arrest.
- Young adults presenting with characteristic symptoms of arrhythmic syncope should have a specialist cardiology assessment, which should include an electrocardiogram (ECG) and in most cases echocardiography, 24-hour ECG monitoring and an exercise test.
- Systematic evaluation in a clinic specialising in the care of those at risk for SCD is recommended in family members of young victims of SCD or those with a known cardiac disorder resulting in an increased risk of SCD.
- Identification of individuals with inherited conditions and screening of family members can help prevent deaths in young people with inherited heart disorders.
- Follow current European Society of Cardiology (ESC) guidelines for the diagnosis and management of syncope and arrhythmias.

Treatment of in-hospital cardiac arrest

- Start ALS as early as possible.
- Hospital systems should aim to recognise cardiac arrest, start CPR immediately, defibrillate rapidly (<3 min) for shockable rhythms, give adrenaline rapidly for non-shockable rhythms, and identify and treat reversible causes.
- All hospital staff should be able to recognise cardiac arrest rapidly, call for help, start CPR and defibrillate (attach an AED and follow the AED prompts, or use a manual defibrillator).
- Hospitals should adopt a standard 'Cardiac Arrest Call' telephone number (2222).
- Hospitals should have a resuscitation team that immediately responds to IHCAs.
- The hospital resuscitation team should include team members who have completed an accredited adult ALS course that incorporates teamwork and leadership training.
- Resuscitation team members should have the key skills and knowledge to manage a cardiac arrest including manual defibrillation, advanced airway management, intravenous access, intra-osseous access, and identification and treatment of reversible causes.
- The resuscitation team should meet at the beginning of each shift for introductions and allocation of team roles.
- Hospitals should standardise resuscitation equipment.
- Termination of resuscitation rules (TOR) should not be used as a sole strategy for terminating an in-hospital resuscitation attempt (See Ethics in Resuscitation[4]).

Treatment of out-of-hospital cardiac arrest

- Start ALS as early as possible – EMS systems should be organised to provide a rapid ALS response with sufficient qualified personnel. This may include a prehospital critical care team.
- Adults with non-traumatic OHCA should be considered for transport to a cardiac arrest centre according to local protocols and take into account which interventions can be provided on scene.
- Emergency medical systems should consider implementing validated criteria for the withholding and termination of resuscitation (TOR) taking into consideration specific local legal, organisational and cultural context (See Ethics in Resuscitation[4]).
- Emergency medical systems should monitor staff exposure to resuscitation and low exposure should be addressed to increase EMS team experience in resuscitation.

Debriefing

Use data-driven, performance-focused debriefing of rescuers to improve CPR quality and patient outcomes (See Education ERC Guidelines 2025 Education for Resuscitation[5]).

ALS in low-resource settings

- Advanced Life Support guidelines may have to be adapted according to resources and there may need to be a greater focus on prevention, early first aid, and basic life support measures (See the ERC Guidelines 2025 System Saving Lives[6] and First Aid[7]).
- Rescuers should be aware that even in high-income settings, ALS may be constrained by limited resources.
- A two-tiered approach incorporating basic and advanced interventions may be the safest and most effective.

CPR-induced consciousness

- Cardiopulmonary resuscitation induced consciousness (without ROSC) is uncommon but increasingly reported. Rescuers may consider using sedative or analgesic drugs (or both) in small doses to prevent pain and distress to patients who are conscious during CPR.
- Neuromuscular blocking drugs alone should not be given to conscious patients.
- The optimal drug regimen for sedation and analgesia during CPR is uncertain. Regimens may be based on those used in critically ill patients and according to local protocols such as small doses of fentanyl, ketamine and/or midazolam.

Defibrillation

Automated external defibrillation (AED) versus manual defibrillation during ALS

- Manual defibrillators should only be used by rescuers who can quickly and accurately identify a cardiac arrest rhythm (within 5 s) and, if needed, deliver a safe shock with minimal interruption (aim for less than 5 s) to chest compressions.
- Advanced Life Support providers must be proficient in using both an AED and a manual defibrillator.

- If an AED is already in use when ALS providers arrive, they should follow its shock prompts. When possible, they should transition to a manual defibrillator during a 2-minute CPR cycle.

Defibrillation strategy

- Continue CPR while a defibrillator is retrieved and defibrillation pads applied. High-quality CPR improves the chances of successful defibrillation.
- Give a shock as early as possible when appropriate.
- Deliver shocks with minimal interruption to chest compressions and minimise the pre-shock and post-shock pause. This is achieved by continuing chest compressions during defibrillator charging, delivering defibrillation aiming for an interruption in chest compressions of less than 5 s and then immediately resuming chest compressions.
- Immediate defibrillation of (ventricular fibrillation) VF of any amplitude (even fine VF) should be attempted.
- Immediately resume chest compressions after shock delivery. If there is a combination of clinical and physiological signs of return of spontaneous circulation (ROSC) such as return of consciousness, purposeful movement, arterial waveform or a sharp rise in $ETCO_2$, consider stopping chest compressions for rhythm analysis, and if appropriate, a pulse check.
- When using a defibrillator that displays the ECG with the motion artefact caused by chest compressions removed, the underlying cardiac arrest rhythm may guide the decision to perform a rhythm and pulse check every two minutes. If asystole is displayed there would be no need to pause chest compressions for a rhythm check.

Safe and effective defibrillation

- Minimise the risk of fire by taking off any oxygen mask, nasal cannulae or bag mask and by placing them at least 1 m away from the patient's chest. When using a mechanical ventilator, oxygen exhaust from ventilation circuits should be directed away from the chest. A self-inflating bag or the ventilator circuit should remain attached to a supraglottic airway or tracheal tube.
- Charging the defibrillator in anticipation of each rhythm check may minimise hands-off time prior to shock delivery and is an acceptable alternative strategy if delivered without prolonging the peri-shock pause.
- A shock with a manual defibrillator can be safely delivered without interrupting mechanical chest compression.
- Do not defibrillate during manual chest compressions (even when wearing clinical gloves), as that practice is not safe to the rescuer.

Defibrillation pads and paddles

- There is insufficient evidence to recommend a specific pad or paddle size for optimal external defibrillation in adults.
- When available, defibrillation pads are preferable to paddles as they offer practical benefits for routine monitoring and defibrillation. Pads enable the operator to stand clear during defibrillation and minimise pre- and post-shock pauses to chest compressions by enabling hands-free operation. Better contact with the chest wall may also reduce the risk of arcing and subsequent fires.
- When using defibrillation paddles, apply firm force to both defibrillation paddles to optimise skin contact, minimise transthoracic impedance and reduce the risk of electrical arcing.
- Antero-lateral pad position is the position of choice for initial pad/-paddle placement. In particular, ensure that the apical (lateral) pad is positioned correctly (i.e. below the armpit in the mid-axillary line).
- Consider and antero-posterior pad position for vector change defibrillation following three failed shocks in cases of refractory shockable rhythms. The anterior pad is placed to the left of the sternum, avoiding as much breast tissue as possible. The posterior pad is placed at the same height, centred just medial to the left scapula.
- In patients with an implantable pacemaker/defibrillator (ICD), place the pad more than 8 cm away from the device, or use an alternative pad position.
- Consider an alternative pad position when the patient is in the prone position (bi-axillary), or in a refractory shockable rhythm.

Energy levels and number of shocks

- Use single shocks followed by a 2-minute cycle of chest compressions.
- The use of up to three stacked shocks may be considered only if initial ventricular fibrillation/pulseless ventricular tachycardia (VF/pVT) occurs during a witnessed, monitored cardiac arrest with a defibrillator immediately available, e.g. during cardiac catheterisation or in a high dependency area. (For the purposes of adrenaline and amiodarone administration after three failed shocks, the initial three stacked shocks should be counted as the initial shock).
- Energy levels:
  - For biphasic waveforms (rectilinear biphasic or truncated exponential biphasic, but not pulsed biphasic), defibrillation shock energy levels for the first shock is at least 150 J.
  - For pulsed biphasic waveforms, deliver the first shock at 130–150 J.
- If the first shock is not successful and the defibrillator is capable of delivering shocks of higher energy, it is reasonable to increase the energy for subsequent shocks.
- If the rescuer is unaware of the recommended energy settings of the defibrillator, for an adult use the highest energy setting for all shocks.
- Use standard energy levels in obese patients.

Refractory ventricular fibrillation

- Consider escalating the shock energy, after a failed shock.
- For refractory VF, defined as continuous VF after three consecutive shocks, and having ensured correct antero-lateral pad positioning, consider using a defibrillation vector change by using an alternative defibrillation pad position (e.g. antero-posterior). After a failed third shock, prepare to place a fresh set of defibrillation pads, at the time of the following rhythm check. Optimise transthoracic impedance by shaving the anticipated areas of pad placement (if necessary).

Dual (double) sequential defibrillation (DSD), involves using a combination of antero-lateral and antero-posterior pad positioning, discharged in close succession and has been advocated for use in refractory shockable rhythms. Given the practical challenges of using two defibrillators to deliver DSD and the limited evidence for its efficacy the ERC does not recommend its routine use.

Ventricular fibrillation waveform analysis for optimising shock success

- Rescuers should give defibrillation shocks according to AED prompts or use a manual defibrillator for ventricular fibrillation/ pulseless ventricular tachycardia (VF/pVT) according to the ALS algorithm – there is currently no role for VF waveform analysis (e.g., based on amplitude) for identifying the optimal time for defibrillation.

Patients with actively discharging implantable cardioverter defibrillators

- Rescuers may sense a significant shock across their arms if a shock is delivered by an ICD while they are performing external chest compressions, even when wearing clinical gloves.
- If an ICD fails to terminate a shockable rhythm, conventional external shocks should be delivered, placing any defibrillation pad/paddle more than 8 cm from the defibrillator box (as above).
- If the ICD is incorrectly detecting arrhythmias and shocking inappropriately, a magnet placed over the ICD can temporarily stop shocks but will not disable pacing (if programmed).

Airway and ventilation

- During CPR, start with basic airway techniques and progress stepwise according to the skills of the rescuer until effective ventilation is achieved.
- Give the highest feasible inspired oxygen during CPR.
- Start effective ventilation breaths as soon as possible ensuring the rate and tidal volume are appropriate to prevent both inadequate ventilation (hypoventilation) and excessive ventilation (hyperventilation).
- Deliver effective bag-mask ventilation breaths by optimising mask seal and airway patency and if necessary, use a two-person technique for bag-mask ventilation.
- Give each inspiratory breath over 1 s to achieve a visible chest movement.
- When using a supraglottic airway (SGA), an i-gel is preferred to a laryngeal tube.
- Tracheal intubation should only be attempted by rescuers with a high success rate and with the use of continuous waveform capnography. The expert consensus is that a high tracheal intubation success rate is over 95 % within two attempts at intubation.
- Aim for less than a 5-second interruption in chest compression for tracheal intubation.
- Use direct or video laryngoscopy for tracheal intubation according to local protocols and rescuer experience. In settings where video laryngoscopy is immediately available, it is preferable to use video laryngoscopy instead of direct laryngoscopy.
- A sustained $ETCO_2$ trace on waveform capnography must be used to exclude oesophageal placement of the tracheal tube.
- Once a tracheal tube or a SGA has been inserted, ventilate the lungs at a rate of 10 min^{-1} and continue chest compressions without pausing during ventilations. With a SGA, if gas leakage results in inadequate ventilation, pause compressions for ventilation using a compression-ventilation ratio of 30:2.
- If using mechanical ventilation, use a volume-controlled mode during chest compressions set the ventilator to a tidal volume of 6–8 mL kg^{-1} (predicted body weight), or to achieve a visible chest movement, the maximum inspired oxygen, a respiratory rate of 10 min^{-1}, an inspiratory time of 1–2 s, a positive end expiratory pressure (PEEP) 0–5 cm H_2O, the peak pressure alarm at 60–70 cm H_2O, and the flow trigger off. Ensure mechanical ventilation is effective and if not, use manual ventilation.
- If standard airway management strategies (oropharyngeal airway and bag-mask/supraglottic airway/ tracheal tube) fail during cardiac arrest, appropriately trained rescuers should attempt surgical cricothyroidotomy to enable oxygenation and ventilation.

Medication and fluids

Vascular access

- Attempt intravenous (IV) rather than intraosseous (IO) access first, to enable drug delivery in adults in cardiac arrest.
- If IV access cannot be rapidly achieved within two attempts, it is reasonable to consider IO access as an alternative route for vascular access during adult cardiac arrest.

Vasopressor drugs

- Give adrenaline 1 mg as soon as possible for adult patients in cardiac arrest with a non-shockable rhythm.
- Give adrenaline 1 mg after the third shock for adult patients in cardiac arrest with a shockable rhythm.
- Repeat adrenaline 1 mg every 3–5 min whilst ALS continues.

Antiarrhythmic drugs

- Give amiodarone 300 mg IV for adult patients in cardiac arrest who are in VF/pVT after three shocks have been administered.
- Give a further dose of amiodarone 150 mg IV for adult patients in cardiac arrest who are in VF/pVT after five shocks have been administered.
- Give the first dose of amiodarone after three shocks, and the second dose after five shocks, irrespective of whether the shockable rhythms are sequential (refractory) or intermittent (recurrent).
- Lidocaine 100 mg IV may be used as an alternative if amiodarone is not available or a local decision has been made to use lidocaine instead of amiodarone. An additional bolus of lidocaine 50 mg can also be given after five defibrillation attempts.

Thrombolytic drugs

- Consider immediate thrombolytic drug therapy when pulmonary embolism is the suspected or confirmed cause of cardiac arrest.
- In select patients with suspected pulmonary embolism, consider CPR for 60–90 min after administration of thrombolytic drugs.

Fluids

- Give fluids during CPR only if cardiac arrest is caused by hypovolaemia.
- Use either isotonic saline or balanced crystalloids for fluid infusion during CPR.

Other medication

- Do not routinely give calcium, sodium bicarbonate or corticosteroids during cardiac arrest.

ALS in highly-monitored cardiac arrest, and physiology-guided CPR

- A sudden decrease in $ETCO_2$ may indicate a cardiac arrest or very low cardiac output state.
- Consider starting chest compressions if the systolic blood pressure decreases and remains <50 mmHg despite interventions.

- In adults undergoing continuous intra-arterial blood pressure monitoring, we suggest that adrenaline is initially given in small increments (e.g., 50–100 μg IV) rather than a 1 mg bolus. If a total of 1 mg has been given with no response, ensure that there is no extravasation and consider giving further IV adrenaline doses of 1 mg every 3–5 min.
- A pragmatic approach during physiology-guided CPR is to aim for a diastolic blood pressure of ≥30 mmHg (when using intra-arterial blood pressure monitoring) and an $ETCO_2$ - ≥ 25 mmHg (3.3 kPa).

Waveform capnography during advanced life support

- Use waveform capnography to confirm correct tracheal tube placement during CPR.
- Use waveform capnography to monitor the quality of CPR.
- An increase in $ETCO_2$ during CPR may indicate that ROSC has occurred. However, chest compression should not be interrupted based on this sign alone. Use a combination of clinical and physiological signs of ROSC (e.g., consciousness, purposeful movement, arterial waveform, rise in $ETCO_2$) before stopping chest compressions for rhythm analysis, and if appropriate, a pulse check.
- Do not use a low $ETCO_2$ value alone to decide if a resuscitation attempt should be stopped.

Use of ultrasound imaging during advanced life support

- Only skilled operators should use intra-arrest point-of-care ultrasound (POCUS).
- POCUS must not cause additional or prolonged interruptions in chest compressions.
- POCUS may help identify treatable causes of cardiac arrest such as cardiac tamponade and tension pneumothorax.
- Right ventricular dilation in isolation during cardiac arrest should not be used to diagnose pulmonary embolism.
- Do not use POCUS for assessing contractility of the myocardium as a sole indicator for terminating CPR.

Devices

Mechanical chest compression devices

- Consider mechanical chest compressions only if high-quality manual chest compression is not practical or compromises provider safety.
- When a mechanical chest compression device is used, minimise interruptions to chest compression during device application by using only trained teams familiar with the device.

Resuscitative endovascular balloon occlusion of the aorta (REBOA)

- The ERC does not recommend the routine use of REBOA for cardiac arrest unless being evaluated in a clinical trial.

Intra-arrest cooling

- We do not recommend intra-arrest cooling during advanced life support (unless there is severe hyperthermia).

Extracorporeal CPR

- ECPR may be considered as a rescue therapy for selected adults with IHCA and OHCA when conventional CPR is failing to restore spontaneous circulation, in settings in which this can be implemented.

Peri-arrest arrhythmias

- The ERC Guidelines 2025 ALS and the algorithms focus on those arrhythmias that require immediate treatment before or after cardiac arrest.
- Rescuers should seek expert advice if the arrhythmia and/or life-threatening features persist.
- The assessment and treatment of all arrhythmias address the condition of the patient (stable versus unstable) and the nature of the arrhythmia. Persistent arrhythmias require careful evaluation, as they are often linked to underlying structural heart disease and may indicate unresolved issues such as myocardial ischaemia. In addition to an arrhythmia occurring immediately after ROSC, life-threatening features in an unstable patient include:
  - Shock – recognised by hypotension (e.g., systolic blood pressure <90 mmHg) along with signs of compensatory mechanisms, such as increased sympathetic activity, and evidence of inadequate organ perfusion
  - Syncope – as a consequence of reduced cerebral blood flow.
  - Heart failure – manifested by pulmonary oedema (failure of the left ventricle) and/or raised jugular venous pressure (failure of the right ventricle).
  - Myocardial ischaemia – may present with chest pain (angina) or may occur without pain as an isolated finding on the 12-lead ECG (silent ischaemia).

Tachyarrhythmias

- Electrical cardioversion is the preferred treatment for tachyarrhythmia in the unstable patient displaying potentially life-threatening adverse signs or immediately after ROSC.
- Electrical cardioversion is recommended for stable patients with monomorphic VT who have structural heart disease or when it is unclear whether there is underlying heart muscle damage.
- Conscious patients require careful anaesthesia or sedation before attempting synchronised cardioversion – be aware of the risk of haemodynamic deterioration with anaesthesia/sedation.
- When cardioverting atrial or ventricular tachyarrhythmias, the shock must be synchronised to occur with the R wave of the ECG.
- For atrial fibrillation:
  - An initial synchronised shock at maximum defibrillator output, rather than an escalating approach, is a reasonable strategy based on current data.
- For atrial flutter and paroxysmal supraventricular tachycardia:
  - Give an initial shock of 70–120 J.
  - Give subsequent shocks using stepwise increases in energy.
- For ventricular tachycardia with a pulse:
  - Use energy levels of 120–150 J for the initial shock.
  - Consider stepwise increases in energy if the first shock fails to achieve sinus rhythm.
- If cardioversion fails to restore sinus rhythm and the patient remains unstable, give amiodarone 300 mg intravenously over 10–20 min (or procainamide 10–15 mg/kg over 20 min) and re-attempt electrical cardioversion. The loading dose of amiodarone can be followed by an infusion of 900 mg over 24 h.
- Pharmacological treatment may be considered in haemodynamically stable patients with monomorphic ventricular tachycardia if there is an increased risk with sedation or anaesthesia.

- Consider amiodarone for acute heart rate control in patients with AF and haemodynamic instability and severely reduced left ventricular ejection fraction (LVEF). For stable patients with LVEF < 40 % consider the smallest dose of beta-blocker to achieve a heart rate less than 110 min^{-1}. Add digoxin if necessary.

Bradycardia

- If bradycardia is accompanied by adverse signs, give atropine 500 μg IV (IO) and, if necessary, repeat every 3–5 min to a total of 3 mg.
- If treatment with atropine is ineffective, consider second-line drugs. These include isoprenaline (5 μg min^{-1} starting dose), and adrenaline (2–10 μg min^{-1}).
- For bradycardia in patients with cardiac transplant or spinal cord injury, consider giving aminophylline (100–200 mg slow intravenous injection). Do not give atropine to patients with cardiac transplants – it can cause a high-degree atrioventricular block or even sinus arrest – use aminophylline.
- Consider giving glucagon if beta-blockers or calcium channel blockers are a potential cause of the bradycardia.
- Do not give atropine to patients with high-degree atrioventricular block and wide QRS. It is ineffective and may worsen the block.
- Consider pacing in patients who are unstable, with symptomatic bradycardia refractory to drug therapies.
  - Establish early transvenous pacing in unstable patients with symptomatic bradycardia.
  - Consider transthoracic (transcutaneous) pacing as a bridge to transvenous pacing or when transvenous pacing is not readily available.
- Whenever a diagnosis of asystole is made, check the ECG carefully for the presence of P waves because, unlike true asystole, this is more likely to respond to cardiac pacing.
- If atropine is ineffective and transvenous/transcutaneous pacing is not immediately available, fist pacing can be attempted while waiting for pacing equipment.

Uncontrolled organ donation after circulatory death

- When there is no ROSC, consider uncontrolled organ donation after circulatory death in settings where there is an established programme, and in accordance with local protocols and legislation.

Evidence informing the guidelines

Prevention of in-hospital cardiac arrest

IHCA occurs in about 1.5 patients per 1000 admitted to hospital.[8–12] There are two main strategies to prevent cardiac arrest and the need for attempted CPR:

- Patient-focused decision-making to determine if CPR is appropriate.
- Identifying and treating physiological deterioration early to prevent cardiac arrest.

Emergency care treatment and CPR decisions

Most patients who die in hospital do not have a resuscitation attempt.[13–16] The ERC Guidelines 2025 on Ethics in Resuscitation promote shared decision-making and advanced care planning which integrates resuscitation decisions with emergency care treatment plans to increase clarity of treatment goals and also prevent inadvertent deprivation of other indicated treatments, besides CPR. Further information is provided in the ERC Guidelines 2025 Ethics in Resuscitation.[4]

Physiological deterioration

In-hospital cardiac arrest is often preceded by physiological deterioration.[17,18] This provides an opportunity to recognise deterioration and prevent cardiac arrest. The 5 key steps have been conceptualised as the in-hospital chain of survival: 'staff education', 'monitoring', 'recognition', the 'call for help' and the 'response'.[19] This ERC guidance is based on an ILCOR COSTR and systematic review of adult rapid response systems, and UK guidance for early warning scores and recognising and responding to deterioration of acutely ill adults in hospital, the ILCOR´s 'Ten Steps Toward Improving In-Hospital Cardiac Arrest Quality of Care and Outcomes' and the Society of Critical Care Medicine´s guidelines on "Recognizing and Responding to Clinical Deterioration Outside the ICU".[10,20–23]

Staff education. Education should include knowing the importance of timely and serial measurement of vital signs for the early prediction of patient deterioration, a structured ABCDE-type approach that includes assessment and initial treatment interventions, use of structured communication tools such as Situation-Background-Assessment-Recommendation (SBAR), and how to call for help and escalate care.[21] Staff should also be aware of treatment escalation plans, protocols for critical care admission, implementation of local policies regarding do-not-attempt CPR (DNACPR) decisions and the management of end-of-life care. Timely treatment escalation and DNACPR decisions will avoid ineffective treatments or treatments patients may not wish to have(see Ethics in Resuscitation).[4]

Monitoring. Most patients with IHCA have an initial non-shockable rhythm, and preceding signs of respiratory depression or shock are common.[8,9,24] Although the supporting evidence is low to very low certainty, there is consensus that to help detect deterioration and critical illness early, all patients should have a documented plan for vital sign monitoring that includes which physiological measurements should be recorded and how frequently.[25,26] This can be addressed by using a standardised early warning score (EWS) system for all patients.[27] The choice of system depends on local circumstances and should align with national guidelines. For example in the UK, the National Early Warning Score (NEWS) is endorsed by the National Institute for Health and Care Excellence (NICE) guidelines.[20,21] Higher trained and nurse staffing levels are associated with lower rates of failure to respond to abnormal vital signs, and improved patient outcomes.[28,29] There is a lack of randomised controlled trials (RCTs) or consensus on which patients should undergo continuous ECG or other continuous vital sign monitoring.[12] In a registry-based study, settings where patients are closely monitored were associated with improved survival irrespective of initial rhythm.[30] The use of artificial intelligence to predict patient deterioration has gained interest during recent years but currently the evidence does not support its wider adoption without further studies on effectiveness and impact on clinical management.[31] Implementation of an automated predictive model to identify high-risk patients in 19 United States hospitals was associated with decreased mortality.[32]

Recognition. In non-ICU patients, strategies to simplify and standardise tracking of a patient's condition, and recognising acute illness or deterioration, and triggering a response include early warning score (EWS) systems. These scoring systems have a predefined graded and escalating response according to the patient's EWS. The EWS is used to identify ward patients needing escalation of care, increasing vital sign monitoring, and may improve identification of deterioration, and reduce time to emergency team activation.[33] Clinical concern from nurses and other members of the multidisciplinary team can also indicate patient deterioration.[34,35]

The call for help. All staff should be empowered to call for help and also trained to use structured communication tools such as SBAR to ensure effective communication.[36–38] The response to patients who are critically ill or who are at risk of becoming critically ill is often provided by a rapid response system (which includes medical emergency team (MET), rapid response team (RRT), or critical care outreach team (CCOT)). Any member of the healthcare team can initiate a call to such a team according to explicit activation criteria. In some hospitals, the patient, and their family and friends, are also encouraged to activate the team.[39–41] Such a patient safety initiative is being implemented throughout English hospitals.[42]

Response. The response to patients who are or at risk of being critically ill is often provided by a MET/RRT/CCOT. These teams usually comprise critical care medical and nursing staff who respond to specific calling criteria. They replace or coexist with traditional cardiac arrest teams, which typically only respond to patients already in cardiac arrest. These teams regardless of composition should function 24/7. Systematic reviews, meta-analyses and multicentre studies suggest that RRT/MET/CCOT systems reduce the rate of IHCA and hospital mortality.[43,44] These data led ILCOR to suggest that hospitals consider the introduction of rapid response systems to reduce the incidence of IHCA and in-hospital mortality (weak recommendation, low-certainty evidence).[22] Team interventions often involve simple tasks such as starting oxygen therapy and IV fluids, as well as more complex decision-making such as transferring the patient to the intensive care unit (ICU) or initiating discussions regarding DNACPR, treatment escalation or end-of-life care plans (See ERC Guidelines 2025 Ethics in Resuscitation[4]). An important part of the response is to place a patient at risk of deterioration, or an already deteriorating patient, in an appropriate setting. Patients should be treated in a clinical area that is equipped and staffed to meet the patient's needs. A quality improvement process should be implemented for RRT/MET/CCOT systems.[10]

Prevention of out-of-hospital cardiac arrest

In high-income settings, sudden cardiac death (SCD) is the third leading cause of death. Survival following OHCA is generally no more than 10 % or less,[45–47] and a positive survival trend has been observed in only half of the countries studied recently which underscores the importance of OHCA prevention.[48,49]

Even seemingly healthy young adults who experience SCD may present with prodromal signs and symptoms—such as syncope, presyncope, chest pain, or palpitations—that should prompt healthcare professionals to seek expert evaluation to prevent cardiac arrest.[50–59]

There is no ILCOR systematic review on this topic and existing guidelines of the European Society of Cardiology (ESC), the American Heart Association (AHA) and ERC[60] were also considered.

Epidemiology and pathophysiology of sudden cardiac death

Coronary heart disease (CHD) is the underlying cause of SCD in 80 % of cases, especially in older patients, and non-ischaemic cardiomyopathies account for another 10–15 %.[61] In the young, inherited diseases, congenital heart disease, myocarditis and substance misuse are predominant causes. Knowledge of the causes of SCD assists in early treatment and the prevention of OHCA (Table 2).

Coronary heart disease (CHD)

Arrhythmias triggered by acute myocardial infarction (AMI) or subsequent myocardial scarring can result in SCD.[63] About two-thirds of SCDs occur as the first CHD event or in individuals considered to be at low risk.[61] During the last 50 years primary prevention and secondary revascularisation have reduced CHD age-adjusted mortality.[61] The percentage of SCDs associated with CHD remains unchanged, suggesting that there are interactions between CHD and triggering events such as autonomic nervous system dysfunction, electrolyte disturbances, drug toxicity and individual genetic profiles.[61] Cardiac electrophysiology studies can identify patients with CHD at high versus low risk of SCD.[64] Additional factors such as heart failure (HF) and left ventricular hypertrophy (LVH) predispose to ventricular arrhythmias (polymorphic VT and VF). How to effec-

Table 2 – Causes of sudden cardiac arrest (SCD).

Coronary heart disease
ST-segment elevation myocardial infarction
Other myocardial infarction
Unstable angina
Silent ischaemia
Electrical heart disease, often associated with SCD in the young
Long QT-syndrome (LQTS)
Short QT syndrome
Brugada syndrome
Catecholaminergic Polymorphic Ventricular Tachycardia (CPVT)
Triadin knock-out syndrome (TKOS)
Arrhythmogenic bi-leaflet mitral valve prolapse
Drug or medication induced
Non-atherosclerotic coronary artery anomalies
Congenital heart disease
Hypertrophic cardiomyopathy (HCM)
Dilated cardiomyopathy (DCM)
Valvular heart disease

Adapted from Kandala[61] and Winkel.[69]

tively identify patients at high risk of SCD with HF and LVH is uncertain.[65] Changes in left ventricular geometry affect the likelihood of developing VT and VF. The only indicator that has been identified to be consistently associated with an increased risk of SCD in the setting of CHD and left ventricular (LV) dysfunction is LV ejection fraction (LVEF).[63] LVEF is used to indicate the need for an ICD for the primary and secondary prevention of SCD.[66]

Cardiac MRI has been proposed as a tool for detecting scar burden and assessing risk of SCD. Recently, artificial intelligence (AI) and deep learning analysis of the scars have been used to assess patient-specific prognosis.[67] Despite considerable progress, the ability to recognise the risk of SCD before the event remains very limited.[63]

SCD in the young

SCD in the young (SCDY, 5–35 years of age) accounts for 7 % of all SCDs[62]; with an incidence of 1–8/100 000 fatalities per year.[68] In adolescent SCD, 50 % of patients had misinterpreted symptoms before death.[58] CHD is the most frequent cause of explained SCDY, but 25–31 % of the cases remain unexplained after post mortem examination (Sudden Arrhythmic Death Syndrome- SADS).[69] The majority of inherited cardiac diseases can be treated if diagnosed, yet most young SCD victims are not diagnosed.[56] Premonitory signs of SCDY were present in only 29 % in one study, and thus less common than in older patients.[70] QT-prolonging and psychotropic drugs, alone or in combination, increase the risk of SCD.[62] Investigation of cardiac arrest survivors or post mortem examination is crucial to identify inherited cardiac disease in unexplained cases of SCD; this should result in a cardiac investigation of first-degree relatives. In one study, this screening resulted in a diagnosis of an inherited cardiac disease in over half of the families.[71] In a large retrospective SCDY study, a cause was identified in 113/180 patients (62.8 %), the rest were classified as idiopathic VF.[72] With improvements in diagnosis (e.g. provocation drug testing for cardiac channelopathies and coronary vasospasm, genetic testing), the number of unexplained SCDs should decrease.[72] (See ERC Guidelines 2025 Epidemiology in Resuscitation).[48]

Non-atherosclerotic coronary artery anomalies

Coronary artery embolism, coronary arteritis (e.g. Kawasaki disease, polyarteritis nodosa), spasm and myocardial bridging have all been described with SCD.

Congenital heart disease

Congenital coronary anomalies are present in 1 % of all patients. SCD because of congenital coronary anomalies is exercise-related and accounts for 17 % of SCD in young athletes.[61,70]

Hypertrophic cardiomyopathy (HCM)

Hypertrophic cardiomyopathy is the most common genetic disorder of the heart, and the most common cause of SCDY.[73] It often remains clinically silent until SCD presents as the first cardiac event. The incidence of SCD in families with HCM is 2–4 % a year and 4–6 % in children and adolescents.[61]

The 2022 ESC guideline on the management of ventricular arrhythmias and prevention of SCD death proposed 10 new key aspects that may improve the management of SCD.[74] (Table 3).

The prediction of SCD presents an epidemiological paradox: although high-risk patients have a greater individual risk, the absolute number of OHCA is higher in the much larger low-risk general population. Preventing and predicting SCD is challenging, as most events occur in individuals from the general population without known heart disease. In response, *The Lancet Commission on SCD* recently issued a call for multidisciplinary action to reduce the burden of SCD, addressing all aspects of prevention and treatment.[75] The development of high-quality, population-based registries of OHCA is important for improving our understanding and prediction of SCD.

Table 3 – Key points from the European Society of Cardiology guidelines for the treatment of ventricular arrhythmias and sudden cardiac death.

1 Development of public BLS and access to automatic defibrillators
2 Focus on the management of electrical storm
3 Increased relevance of cardiac MRI
4 Increased relevance of catheter ablation
5 Implementation of SCD risk scores and calculators
6 New algorithms for diagnostic evaluation
7 Upgrade of genetic counselling and testing
8 Algorithm for antiarrhythmic drug therapy
9 Individualized risk stratification
10 Change regarding primary electrical diseases

(Adapted from Könemann, 2023[74]).

However, there are currently no established strategies or guidelines for preventing OHCA in the general population.

SCD may be associated with a range of factors—some related to cardiovascular disease, others linked to the broader socioeconomic environment (e.g., obesity, climate, pollution, lifestyle).

Many drugs prescribed commonly (antibiotics, antidepressants) impacting cardiac electrophysiology mainly by prolonging the QT interval, may also increase the risk of OHCA.[76] Recently, proton pump inhibitors, were also identified to be associated with this risk even in patients without cardiovascular disease.[77]

AI and machine learning models offer new possibilities by linking cardiac arrest patient's files and the health records of the general population. It may identify new factors driving risk of SCD and lead to improved targeted screening at the patient level.[78] AI may also help to predict SCD with pulseless electrical activity (PEA) and the understanding of mechanisms and warning symptoms, in this population with a poorer prognosis of survival.[79]

Premonitory signs

Approximately 50 % of cardiac arrests occur in individuals with undiagnosed CHD.[63,80] Many SCD victims have a history of cardiac disease and warning signs before cardiac arrest, most commonly chest or upper abdominal pain or dyspnoea that has not been acted on by the patient or health care professionals.[81,82] Approximately one third of elderly patients will have symptoms in the days or hours before cardiac arrest; primarily chest pain, dyspnoea, syncope, and/or cold sweats.[82,83] In 1960 OHCA patients, 9.4 % had been assessed by an ambulance crew within the preceding 48 h.[84] Emergency care in patients with symptoms is associated with improved survival.[81] Early recognition of acute coronary syndrome (ACS) by EMS teams with 12-lead ECG capabilities and reduction of time to reperfusion may prevent SCD.[85]

Table 4 – High risk features suggesting a serious condition in patients with syncope at initial evaluation in the emergency department.

Syncopal event features
Major
New onset of chest discomfort, breathlessness, abdominal pain or headache[98–100]
Syncope during exertion or when supine[101]
Sudden onset palpitation immediately followed by syncope[101]
Minor
No warning symptoms or short (<10 s) prodrome [101–104]
Family history of SCD at young age[105]
Syncope in the sitting position[106]
Past medical history
Major
Severe structural or coronary artery disease (heart failure, low LVEF or previous myocardial infarction)[98,100]
Physical examination
Major
Unexplained systolic blood pressure <90 mmHg[98,100]
Persistent bradycardia (<40 min^{-1}) in an awake state, in absence of physical training
Undiagnosed systolic murmur
ECG
Major
ECG changes consistent with acute ischaemia
Mobitz II second- and third-degree atrioventricular (AV) block
Slow atrial fibrillation (AF) (<40 min^{-1})
Persistent sinus bradycardia (<40 min^{-1}) or repetitive sinoatrial block or sinus pauses >3 s in an awake state, in absence of physical training
Bundle branch block, intraventricular conduction disturbance, ventricular hypertrophy or Q waves consistent with ischaemic heart disease or cardiomyopathy[99,104]
Sustained and non-sustained VT
Dysfunction of an implantable cardiac device (pacemaker or ICD)
ST-segment elevation with type 1 morphology in leads V1-V3 (Brugada pattern)
QTc >460 ms in repeated 12-lead ECGs indicating long QT syndrome (LQTS)[85]
Minor (high-risk only if history consistent with arrhythmic syncope)
Mobitz I second-degree AV block and 1st degree AV block with markedly prolonged PR interval
Asymptomatic inappropriate mild sinus bradycardia (40–50 bpm.)[104]
Paroxysmal supraventricular (SVT) or atrial fibrillation[107]
Pre-excited QRS complex
Short QTc interval ($\leq$340 ms)[85]
Atypical Brugada patterns[86]
Negative T waves in right precordial leads, epsilon waves suggestive of arrhythmogenic right ventricular cardiomyopathy (ARVC)[86]

Adapted from Brignole 2018.[66] ECG electrocardiogram, ICD implantable cardioverter defibrillator, LVEF left ventricular ejection fraction, SCD sudden cardiac death, VT ventricular tachycardia.

The most effective approach to prevent SCD in the general population remains the quantification of the individual risk of developing CHD, followed by control of risk factors.[86] Syncope can be an important premonitory sign of SCD.

Syncope

Syncope occurring during strenuous exercise, while sitting or in the supine position should always raise the suspicion of a cardiac cause; in other situations it is more likely to be vasovagal syncope or postural hypotension.[85] In patients with known cardiac disease, syncope (with or without prodrome, particularly recent or recurrent) is an independent risk factor for increased risk of death.[66,73,87–97] High-risk (suggesting a serious condition) and low-risk features (suggesting a benign condition) of patients with syncope at initial evaluation in the emergency department have been published by the ESC (Table 4).[66] Early EMS acquisition of a 12 lead-ECG may be helpful.

Screening programs for athletes may be helpful but vary between countries.[108–110] In one study from the United Kingdom between 1996 and 2016, 11,168 athletes received cardiovascular screening and diseases associated with SCD were identified in 0.38 % (n = 42).[111] The incidence of SCD in competitive athletes is higher than in non-athletes.[111] Subpopulations that have been identified as at increased risk include male, black ethnicity, basketball or football players.[112] Screening commonly includes physical examination and ECG. The ECG has a false positive risk because of some ECG features that are particular to athletes. Despite more specialised screening, the risk decreases globally but SCD may still occur. Consequently awareness, CPR training, and availability of AEDs during sport remain important for the protection of athletes.[113,114]

Preventive measures against SCD

Prevention of SCD focuses on identifying and managing medical conditions that may contribute to or exacerbate arrhythmias, assess-

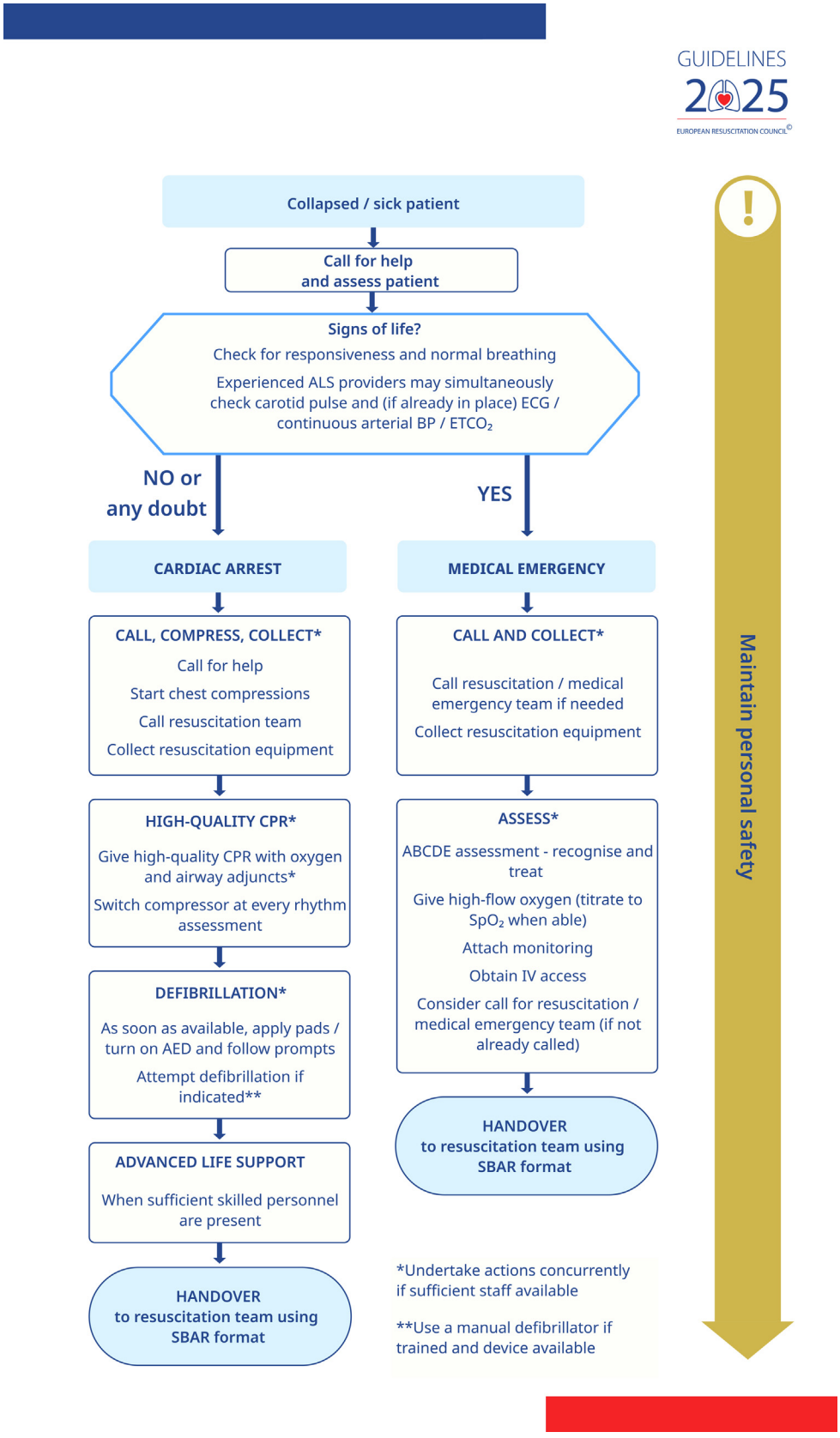


Fig. 3 – In-hospital resuscitation algorithm

ABCDE airway breathing circulation disability exposure; AED automated external defibrillator; ALS advanced life support; BP blood pressure; CPR cardiopulmonary resuscitation; $ETCO_2$ end-tidal carbon dioxide; IV intravenous; SBAR situation, background, assessment, recommendation; SpO_2 oxygen saturation measured with pulse oximetry.

ing the risk posed by the arrhythmia itself, and evaluating the risk–benefit ratio of potential therapies. Interventions may include anti-arrhythmic medications, ICDs, and catheter ablation or surgery.[66,115] The effective management of non-cardiovascular diseases associated with an increased risk of cardiac arrest has also been proposed as a strategy for preventing SCD.[116] For instance, a large registry study found that treatment of sleep apnoea with continuous positive airway pressure (CPAP) was associated with a lower risk of OHCA compared with patients who did not receive treatment.[117]

Non-invasive telemetry or implantable devices transmitting the ECG are currently used in selected groups of patients to detect high risk arrhythmias and prevent SCD. More recently, connected devices with arrhythmia detection capabilities (smartwatch, smartphone applications) have been introduced and may be helpful in detecting asymptomatic AF, however their potential role in the general population to detect SCD arrhythmias is unknown.[118,119] A recent review on smartwatches identified 57 publications including 24 cohort studies mostly focused on AF, and often detected by Apple Watch™.[120] Automated cardiac arrest diagnosis, using smart devices such as wearables and phones, remains an innovative field of research. It promotes the possibility of transforming unwitnessed SCD to witnessed events. However, most of the studies published have been aimed at feasibility and concern a small population.[121] They need to be validated in diverse populations and then integrated into EMS protocols. They carry the risk of false positive alarms which may be responsible for patient anxiety and stress and inappropriate activation of the EMS response, overwhelming the available resources.[122]

Educating the public to report on symptoms before SCD and to help a person in cardiac arrest is important.[81] An awareness campaign on chest pain was associated with an increase in EMS calls and a reduction in OHCA incidence and may serve in part, as an effective primary prevention strategy for OHCA. The campaign period was associated with an 8.8 % (Incident rate ratio [IRR] 1.09, 95 % CI: 1.07, 1.11) increase in the incidence of EMS attendances for chest pain and a 5.6 % (IRR 0.94, 95 % CI: 0.92, 0.97) reduction in OHCA attendances.[123]

Treatment of in-hospital cardiac arrest

Cardiac arrest treatment principles, such as early defibrillation, early delivery of adrenaline and delivery of high-quality CPR, are consistent across both the IHCA and OHCA settings. In the hospital setting, the immediate availability of trained clinical staff and equipment provides an opportunity for the rapid identification of cardiac arrest and initiation of treatment. An IHCA can be defined as any cardiac arrest that occurs on the hospital premises. This may include a cardiac arrest in patients, hospital visitors or staff, in a variety of hospital settings. For IHCA, BLS and ALS interventions can often start and take place at the same time (Fig. 3).

Initial responders

The clinical skill of the initial responder may range from a non-clinical member of staff trained in BLS to an ALS provider. Irrespective of skill level, the initial action of the initial responder is to recognise cardiac arrest, immediately start CPR, call for help and facilitate rapid defibrillation. Delays in starting treatment reduce the likelihood of a successful outcome.[124,125]

The process for calling for help may differ between hospitals or locations within a hospital. If the responder is alone, they may need to leave the patient to call for help. Where a telephone system is used to activate the emergency team, the standard European number (2222) should be used.[126] European Board of Anaesthesiology has also included the 'Cardiac Arrest Call 'telephone number 2222 as a Principal Requirement in the 2025 update of the Helsinki Declaration on Patient Safety in Anaesthesiology 2.0 launched in May 2025. To date, hospital uptake of the standard number across European countries has been variable.[127–129] This is despite changing the number being relatively easy and completely safe if 2222 and the old number are both operated in parallel for a transition period.

Following the completion of initial actions and provided sufficient staff are available, staff should collect ALS equipment and prepare to hand over to the resuscitation team using a standardised communication system, such as SBAR (Situation, Background, Assessment, Recommendation) or RSVP (Reason, Story, Vital Signs, Plan).[36,130,131] Each clinical area in a hospital should consider patient acuity, risk of cardiac arrest, and geographical location (e.g. distance for the resuscitation team to travel) in determining the specific training needs of staff.

Resuscitation team

The resuscitation team may take the form of a traditional cardiac arrest team that responds only to cardiac arrest events or a medical emergency team/ rapid response team (MET/RRT) that responds to both cardiac arrests and critically unwell patients. ILCOR recommends accredited ALS-level training for healthcare staff (strong recommendation based on very low certainty evidence) as this type of training is associated with improved patient outcomes.[22,132] ILCOR also recommends that ALS training incorporates team and leadership training (weak recommendation based on very low certainty evidence) because it is associated with improved patient and process outcomes.[22]

Resuscitation teams often form on an ad hoc basis depending on hospital work rosters and may include individuals from a range of specialities (e.g. emergency medicine, acute medicine, cardiology, critical care, anaesthesia). Lack of knowledge of team member roles, including who is acting as team leader can lead to errors during ALS for IHCA.[133,134] A team meeting at the beginning of each shift for introductions and allocation of roles is straightforward to implement and may support effective team-working during resuscitation, although its effect on patient outcomes is uncertain.[135]

Equipment

Hospitals should ensure that clinical areas have immediate access to resuscitation equipment and medication to facilitate rapid resuscitation of the patient in cardiac arrest. Missing or malfunctioning equipment contributes to treatment delays.[133,136] Equipment should be standardised throughout the hospital and regularly checked to ensure proper functioning. In contrast to OHCA, most patients who have an IHCA will have vascular access at the time of cardiac arrest, facilitating rapid administration of time-critical drugs, such as adrenaline.[137–139]

Termination of CPR rules for in-hospital cardiac arrest

Research on termination of resuscitation (TOR) rules for IHCA remains limited. An ILCOR systematic review published in 2021 identified only very low-certainty evidence for a single clinical decision rule, the UN10 rule, which included three variables: unwitnessed, initial non-shockable rhythm, and resuscitation duration of more than 10 min.[140–142] While the rule had a false-positive rate of 0 % in the derivation cohort, later validation revealed a false-positive rate above the 1 % threshold deemed acceptable for clinical use.[4] Consequently, ILCOR concluded that no identified tool was reliable in predicting death after IHCA and specifically recommended against using the UN10 as a sole strategy for termination of resuscitation in IHCA (strong recommendation, very low–certainty evidence).[143]

Following the 2021 ILCOR systematic review, a Scandinavian study enrolling IHCA patients from Denmark, Sweden, and Norway developed and validated five TOR rules for IHCA.[144] The best-performing rule included four variables (unwitnessed, unmonitored, initial rhythm of asystole, and resuscitation duration of 10 min or more). This rule incorrectly predicted 30-day mortality in 6 per 1000 cases, and proposed termination in 110 per 1000 cardiac arrests, potentially reducing futile resuscitation attempts. Notably, a large observational study demonstrated that survival to hospital discharge is possible even after prolonged IHCA (>1 h), although survival rates were less than 1 % after 40 min of resuscitation.[145] An Austrian study found that machine learning models effectively predicted failure to achieve ROSC and poor functional outcomes while CPR was ongoing; however, the positive predictive value was insufficient to justify early termination of resuscitation efforts.[146]

In alignment with ILCOR, the ERC does not recommend using TOR rules as the sole basis for TOR in IHCA. While the results of the Scandinavian study are promising, further external validation is needed before the rule can be considered for use in clinical practice.[144] TOR rules should be validated in local, regional, or national cohorts before implementation and revisited as survival rates change. Decisions to terminate resuscitation should also consider the local legal, organisational, and cultural context. The ERC Guidelines 2025 on Ethics in Resuscitation provide additional guidance on the use of termination of resuscitation rules.[4]

Treatment of out-of-hospital cardiac arrest

This section provides an overview of specific ALS issues related to resuscitation for OHCA. Further information is available in the ERC Guidelines 2025 Basic Life Support, Cardiac Arrest in Special Circumstances, Systems Saving Lives, Epidemiology, Post Resuscitation Care, and Ethics in Resuscitation.[4,6,114,129,147,148]

Transfer of patients with OHCA

The aim of ALS for OHCA is to provide the same interventions as available in hospital as early as possible, and to rapidly transfer the patient to hospital for those interventions that are not feasible out-of-hospital. A recent systematic review addressed the benefit of rapid transport from the scene to definitive in-hospital care versus extended on-scene resuscitation in OHCA.[149] Nine studies (8 cohort studies, one RCT) were included. In pooled analysis, expedited (or earlier) transfer was not predictive of survival to discharge (odds ratio [OR] 1.16, 95 % confidence interval [CI] 0.53 to 2.53, $I^2 = 99$ %, $p = 0.65$) or favourable neurological outcome (OR 1.06, 95 % CI 0.48 to 2.37, $I^2 = 99$ %, $p = 0.85$). The certainty of evidence was assessed as very low with a moderate risk of bias. Significant heterogeneity was observed mostly related to the region of the EMS studied. In a large North American registry a propensity-matched cohort, which included 27,705 patients, survival to hospital discharge occurred in 4.0 % of patients who underwent intra-arrest transport compared with 8.5 % who received on-scene resuscitation (risk difference, 4.6 % [95 % CI, 4.0–5.1 %]).[150] The decision regarding at which stage conveyance to hospital should be undertaken will depend on EMS system factors that include the clinical skills of rescuers, the ALS interventions available on scene, and the use of termination of resuscitation protocols.[149]

Care at cardiac arrest centres

An ILCOR systematic review assessed the benefits of care at a dedicated cardiac arrest centre. The resulting ILCOR treatment recommendations include[151]:

- Adult patients with non-traumatic OHCA should be considered for transport to a cardiac arrest centre, according to local protocols.
- Adult patients with non-traumatic OHCA should be cared for at a cardiac arrest centre whenever possible.
- Health care networks should establish local protocols to develop and maintain a cardiac arrest network.

The ERC has adopted these recommendations on cardiac arrest centres and further details can be found in ERC Guidelines 2025 Systems Saving Lives and Post Resuscitation Care.

Initial treatment of OHCA

Several patient and CPR factors affect outcome from OHCA (Table 5). Community programmes of lay bystander CPR and AED use improve outcome from OHCA.[152] Chest compressions and early defibrillation are the cornerstones of CPR in OHCA. The only definitive treatment for VF remains prompt defibrillation.[153]

EMS personnel and interventions

ILCOR conducted a systematic review examining how EMS exposure to and experience with OHCA impacts outcomes.[154] The largest study in this review studied the association between the number of times a paramedic had attended an OHCA with patient survival to hospital discharge.[155] Increasing paramedic exposure to OHCA in the preceding three years was associated with increased survival to discharge: ≤6 exposure (control group), >6–11 exposures (adjusted odds ratio [aOR] 1.26, 95 % CI 1.04–1.54), 11–17 exposures (aOR 1.29, 95 %CI 1.04–1.59), >17 exposures (aOR 1.50, 95 %CI 1.22–1.86).[155] Another large observational study reported that increased exposure of the treating paramedic was associated with increased ROSC (<15 exposures [control group] vs. ≥ 15 exposures, aOR 1.22, 95 %CI 1.11–1.36).[156] The ILCOR CoSTR concluded that EMS should monitor exposure of their clinical personnel to resuscitation and implement strategies to address low exposure or ensure that treating teams have members with recent exposure (weak recommendation, very-low certainty of evidence).[23]

There is no recommendation on the optimal number of members in prehospital ALS teams. A recent review of 22 articles published between 2005 and 2023 assessed the effectiveness of ALS CPR performed by two-member teams and found insufficient evidence to support adapting ALS protocols to such settings. [157] A recent review in 2023 identified four non-RCT studies and concluded that

Table 5 – Patient and resuscitation factors affecting outcome from OHCA.

Patient
Age
Sex
Comorbidities (cardiac, pulmonary, renal, trauma)
Special circumstances
Cardiopulmonary resuscitation
Location (private vs. public)
Witnessed vs. unwitnessed cardiac arrest
Bystander CPR
Type of bystander CPR (compression only vs. standard)
First cardiac arrest rhythm
Use of AED by bystander
Time to return of spontaneous circulation

Adapted from Kandala 2017.[61] AED denotes automated external defibrillator, CPR cardiopulmonary resuscitation.

prehospital ALS care with a ratio of on-scene ALS-trained personnel >50 % could improve survival-to-discharge with a certainty of evidence rated as very low.[158] A large national cohort analysis conducted in a system with prehospital ALS and the initial dispatch of more than one EMS crew found both a higher number of EMS crew members (three or more) and a higher proportion of ALS providers in the first-contact EMS crew. This was associated with improved neurological recovery in adults with non-traumatic OHCA. Specifically, good neurological recovery was associated with an adjusted odds ratio (95 % confidence interval) of 1.23 (1.06–1.43) for three-member crews, and 1.28 (1.17–1.40) for crews with a higher proportion of ALS-trained providers.[159]

A 2024 ILCOR review compared prehospital critical care for OHCA with standard prehospital ALS.[23,160] Prehospital critical care was defined as care involving enhanced clinical competencies beyond standard ALS, delivered by dedicated EMS teams dispatched to critically ill patients. These teams were staffed by physicians (specialised in emergency medicine, anaesthesia, critical care, or intensive care) or specially trained critical care paramedics. This was compared with standard prehospital ALS. The review included 15 articles. Prehospital critical care was associated with improved outcomes for several measures: survival to hospital admission, ROSC (OR 1.95, 95 % CI 1.35–2.82), survival to hospital discharge (OR 1.34, 95 % CI 1.10–1.63), 30-day survival (OR 1.56, 95 % CI 1.38–1.75), and favourable neurological outcome at 30 days (OR 1.56, 95 % CI 1.38–1.75). ILCOR recommends that adults with non-traumatic OHCA receive care from prehospital critical care teams in EMS systems with sufficient resource infrastructure (weak recommendation, low certainty of evidence). However, the included studies did not report on resource costs, cost-effectiveness, impact on health equity, or implementation feasibility; therefore, these aspects were not analysed.

Prehospital critical care teams also provide the opportunity to complement ALS with more advanced and invasive resuscitation techniques, such as ECPR, balloon occlusion, and emergency thoracotomy.[161] These techniques, their targets populations, and their potential impacts on outcome are discussed in other parts of the guidelines.

Termination of resuscitation rules for out-of-hospital cardiac arrest

Termination of resuscitation (TOR) rules guide EMS in deciding whether to continue resuscitation or transport a patient with ongoing CPR. An ILCOR review found that current TOR rules may result in some missed survivors but do also prevent premature termination of resuscitation.[1,23,162] ILCOR makes a conditional recommendation based on very low certainty evidence that EMS systems may use TOR rules to guide decisions on stopping resuscitation or transporting with ongoing CPR – the rules should only be implemented after local validation, ensuring acceptable specificity and alignment with local culture, values, and context. Further ethical guidance is available in the ERC Guidelines 2025 Ethics in Resuscitation.[4]

Debriefing

In 2020, ILCOR conducted a systematic review of debriefing following cardiac arrest[22], including four observational studies.[163–166] At that time, debriefing was associated with improved hospital survival, ROSC, and CPR quality. In 2024, ILCOR conducted a new systematic review, incorporating ten non-randomised studies—six involving adult patients[135,163,165–168] one paediatric,[164] and two neonatal cardiac arrest.[169,170] This updated review revealed that, despite the very low certainty of evidence because of significant risks of bias and inconsistency, post-event debriefing was either associated with no effect or with improvements in ROSC, survival to hospital discharge, favourable neurological outcomes, and enhanced CPR quality. The ILCOR review did not identify any negative consequences, such as emotional trauma to the debriefed team or significant resource demands (including costs), associated with debriefing after cardiac arrest in the studies examined. Based on these findings, ILCOR suggests, and the ERC recommends, implementing post-event debriefing following adult cardiac arrest (weak recommendation, very low certainty of evidence). This recommendation stems from the review's conclusion that debriefing has a neutral to positive impact on critical and important outcomes, which likely outweighs any potential undesirable effects. The ERC Guidelines 2025 Education for Resuscitation include further details on these issues.[5]

ALS in low-resource settings

This review was informed by a narrative ILCOR review.[171] Low-resource settings in CPR are most often associated with low-income countries. High-income countries may also have scenarios where the resources are low (e.g., mass-casualty incidents, at night, or during bad weather, natural disasters, pandemics or war) or due to location (e.g., difficult access – mountains and sea, remote locations – aircraft, oil platforms, ships). Implementation of resuscitation guidelines from well-resourced settings may not be applicable in low-resource settings because of lack of logistics, personnel and infrastructure. Several organisations from the global south and the World Health Organization (WHO) have developed and are further developing resuscitation guidelines tailored to low-resource settings.[171–191] These guidelines often focus on emergency prevention, first aid and basic life support. The ERC Guidelines 2025 Special Circumstances have addressed some settings which can also have low resources, such as cardiac arrest inflight, on cruise ships and mass casualty incidents.[114,186] An adapted approach towards the chain of survival has been proposed to address the different needs and opportunities in low-resource settings[171] and is described in more detail in the ERC Guidelines for Systems Saving Lives.[6]

CPR-induced recovery of consciousness

CPR induced consciousness (CPRIC) occurs when the patient is conscious during CPR but has not achieved ROSC. This guidance is based on an ILCOR summary statement 2024,[192] which is an update of the previous 2021 summary statement[193] and a scoping review from 2022, which included eight observational studies, 26 case studies, and three reviews.[194] A 2025 scoping review identified two additional observational studies,[195,196] a case series,[197] and one review on prehospital guidelines to treat CPR-induced consciousness.[198] ILCOR has made the following good practice statements:

- In settings in which it is feasible, rescuers may consider using sedative or analgesic drugs (or both) in very small doses to prevent pain and distress to patients who are conscious during CPR.
- Neuromuscular-blocking drugs alone should not be given to conscious patients.
- The optimal drug regimen for sedation and analgesia during CPR is uncertain. Regimens can be based on those used in critically ill patients and according to local protocols.

CPR-induced consciousness can be defined as 'a demonstration of consciousness whilst undergoing CPR with no measurable spontaneous cardiac output displayed'.[194] The incidence of CPR-induced conscious-

ness is 0.23–0.90 % in observational studies of patients[199] and 48–57 % of experienced healthcare professionals have reported observing patients with CPR-induced consciousness.[200] CPR-induced consciousness is associated with witnessed and shockable cardiac arrests, younger age, and better outcomes.[197] Longer CPR attempts in patients with CPR-induced consciousness may be reasonable.[197]

Patients with CPR-induced consciousness may interfere with and prevent effective CPR[194,197] and sedation may be required. Consider using sedatives or analgesics (or both) in very small doses to prevent pain and distress in patients who are conscious or where consciousness cannot be ruled out during CPR. The optimal drug regimen for sedation and analgesia during CPR is uncertain, and local and national protocols exist.[198] Use drug regimens based on those used in critically ill patients such as small doses of fentanyl, ketamine and/or midazolam. Do not give neuromuscular blocking drugs alone to conscious patients. Consciousness during CPR or awareness without visible consciousness may lead to post-traumatic stress disorder for clinicians, bystanders, and cardiac arrest survivors.[196,201]

ALS treatment algorithm

Cardiac arrest is associated with either shockable rhythms (VF/pVT) or non-shockable rhythms (asystole and PEA). The main difference in the treatment of shockable rhythms is the need for attempted defibrillation. Other interventions, including high-quality chest compressions with minimal interruption, airway management and effective ventilation, venous access, administration of adrenaline and the identification and treatment of reversible causes, are common for all arrests. The ALS algorithm (Fig. 2) provides an overview of these key interventions. These are based on the expert consensus of the ERC ALS Writing Group. The ALS cardiac arrest algorithm is applicable to all adult cardiac arrests. Additional interventions may be indicated for cardiac arrest caused by special circumstances.[114,202] To improve understanding of timing of shocks and drugs we have provided some example flow charts – these examples do not cover every possible scenario or transition between cardiac arrest rhythms or ROSC (QR code 1). Although asystole and PEA are both treated as non-shockable rhythms, the treatment of PEA can be more nuanced in highly monitored settings (e.g., with continuous invasive blood pressure monitoring) and this is addressed in the sections below on ALS in highly monitored settings, and physiologically guided CPR.

QR code 1 – Four examples on advanced life support for timing of shocks and drugs (not every possible scenario is included).

Defibrillation

Automated external defibrillation versus manual defibrillation during ALS

This guidance is based on an ILCOR Evidence update from 2020[203] and a scoping review from January 2020 to January 2025 which identified three systematic reviews,[204–206] and two observational studies.[207,208]

ALS providers require frequent training and advanced ECG recognition skills for manual defibrillation.[203] They should preferentially use manual defibrillation but also be skilled in AED use. Despite the faster time to first shock with AEDs, studies suggest that this does not translate into improved survival when used instead of manual defibrillators. For instance, a study in paramedics reported that while AEDs improved the time to first shock within 2 min (aOR 1.72; 95 % CI 1.32–2.26; $P < 0.001$), they were associated with a reduction in survival to hospital discharge (aOR 0.71; 95 % CI 0.55–0.92; $P = 0.009$), event survival (aOR 0.74; 95 % CI 0.62–0.88; $P = 0.001$), and prehospital ROSC (aOR 0.81; 95 % CI, 0.68–0.96; $P = 0.01$) compared with manual defibrillation.[209] Manual defibrillation has been associated with shorter pauses in chest compressions, which is critical for maintaining coronary and cerebral perfusion during resuscitation.[210] Software that filters chest compression artefacts and enables rhythm analysis during CPR and performing chest compressions while charging for defibrillation also provides an advantage for manual defibrillation over use of AEDs.

In two-tier systems, ALS providers may arrive after an AED has already been attached to the patient and is in use. If an AED is already in use when ALS providers arrive, they should follow its shock prompts. When possible, they should transition to a manual defibrillator during a 2-minute CPR cycle. There is insufficient evidence to recommend the placement of an additional manual defibrillator in a vector-changing position when an AED is already in place.[211]

Compared with following AED prompts, manual defibrillation may result in more inappropriate defibrillation shocks (because a shock would not have been advised by an AED), and more missed shocks (because a shock would have been advised by an AED).[212] A shock should be given if the ALS provider is in doubt whether fine VF or asystole are displayed on the monitor. In recommending this the ERC balanced the risks of not shocking VF versus shocking a patient in asystole, and variability between rescuers in deciding if a rhythm is VF or fine VF. If rescuers are not confident in making shockable versus non-shockable rhythm decisions rapidly (within 5 s) during a resuscitation attempt they should use the defibrillator in an AED mode.

Manual defibrillation

Attempted defibrillation is a vital component of CPR as it has the potential to terminate VF/pVT and achieve ROSC. Although defibrillation is indicated in approximately 20 % of cardiac arrests, more than 80 % of those who survive present in a shockable rhythm.[213] As defibrillation effectiveness decreases with both time and VF duration, defibrillation attempts must be timely, whilst remaining efficient and safe.[214] Knowledge of how to use a defibrillator (manual or AED) is key for rescuers performing ALS. Rescuers who use a manual defibrillator should aim to take less than 5 s to recognise a shockable cardiac arrest rhythm and make the decision to give a shock to minimise interruption to chest compressions. If the delay exceeds 5 s, consider resuming chest compressions, switch the device to AED mode and then allow the device to analyse immediately.

Since 2015, ERC defibrillation guidelines have referred solely to biphasic energy waveforms and defibrillation pads. In this ERC Guidelines 2025 ALS, we reintroduce recommendations on the use of defibrillation paddles which in some countries, remain in clinical use.[215] The evidence for this section is based on ILCOR 2020 CoSTRs, the ERC 2015 ALS Guidelines, and expert consensus.[152,203,215]

Strategies for minimising the peri-shock pause. The delay between stopping chest compressions and shock delivery (the pre-shock pause) must be kept to an absolute minimum; even a 5–10 s delay will reduce the chances of the shock being success-

ful.[216–221] The pre-shock pause can be reduced to less than 5 s by continuing compressions during charging of the defibrillator and by having an efficient team coordinated by a leader who communicates effectively.[222,223] The safety check to avoid rescuer contact with the patient at the moment of defibrillation should be undertaken rapidly but efficiently. The delay between shock delivery and recommencing chest compressions (the post-shock pause) is minimised by immediately resuming chest compressions after shock delivery.[224] If there are both clinical and physiological signs of ROSC (e.g., return of consciousness, movement, arterial waveform, increase in $ETCO_2$), chest compressions can be paused briefly for rhythm analysis. The entire process of manual defibrillation should be achievable with less than a 5 s interruption to chest compressions.

CPR versus defibrillation as the initial treatment. A 2020 ILCOR systematic review addressed whether a specified period (typically 1.5–3 min) of chest compressions before shock delivery compared with a short period of chest compressions (to enable defibrillator start-up) before shock delivery affected resuscitation outcomes. Outcomes were no different when CPR was provided for up to 180 s before attempted defibrillation, compared with rhythm analysis and attempted defibrillation first.[152] Therefore, the routine delivery of a pre-specified period of CPR (e.g., 2–3 min) before rhythm analysis and shock delivery is not recommended. ILCOR made a weak recommend based on low certainty evidence for rescuers providing a short period of CPR until the defibrillator is ready for rhythm analysis in unmonitored cardiac arrest. Defibrillation should then be delivered as indicated, without delay. Immediate defibrillation of VF of any amplitude should be attempted at the end of each 2-minute cycle.

Anticipatory defibrillator charging. Using this method, the defibrillator is charged as the end of a compression cycle is approached, but before the rhythm is checked – this method is also called 'pre-charging'. When compressions are paused briefly to check the rhythm, a shock can be delivered immediately (if indicated) from a defibrillator that is already charged, thereby avoiding a period of further chest compressions while the defibrillator is being charged. This method was reviewed by ILCOR in 2020 as the technique is already in use in some countries as an alternative to the conventional sequence.[225] Manikin studies show anticipatory charging is feasible, and can reduce the overall number of interruptions to chest compression, but can increase pre-, post, and peri-shock pause duration. A Danish study showed an association between pre-charging and the total hands-off fraction, a longer pre-shock pause, and increased ROSC.[226] This technique may be a reasonable alternative for use by well-drilled teams that can minimise pre- post, and peri-shock pause duration. Further clinical studies are required to determine the best technique for manual defibrillation.

Safe use of oxygen during defibrillation

In an oxygen-enriched atmosphere, sparking from poorly applied defibrillator paddles can cause a fire and significant burns to the patient.[227–232] Although defibrillation pads may be safer than paddles with regards to arcing and spark generation, recommendations for the safe use of oxygen during defibrillation remain unchanged in this ERC Guidelines 2025 ALS. The use of non-invasive ventilation and high flow nasal oxygen increases the risk of an oxygen enriched environment. The risk of fire during attempted defibrillation can be minimised by taking the following precautions:

- Take off any oxygen mask (including bag mask) or nasal cannulae and place them at least 1 m away from the patient's chest.
- Leave the ventilation bag or ventilation circuit connected to the tracheal tube or supraglottic airway, and ensure any oxygen exhaust is directed away from the chest.
- If the patient is connected to a ventilator, for example in the operating room or critical care unit, leave the ventilator tubing (breathing circuit) connected to the tracheal tube. Oxygen exhaust from ventilators should be directed away from the chest.

Pad contact with the chest and anatomical position

A 2024 ILCOR systematic review found no RCTs since the 2021 guidelines regarding optimal defibrillation pad position and evidence from two observational studies in OHCA patients was rated as very low certainty.[192]

The techniques described below aim to place external defibrillation pads (self-adhesive pads) in an optimal position to maximise transmyocardial current density and minimise transthoracic impedance. No human studies have evaluated the pad position as a determinant of ROSC or survival from VF/pVT.[152] Transmyocardial current during defibrillation is likely to be maximal when defibrillation pads are placed so that the area of the heart that is fibrillating lies directly between them (i.e. ventricles in VF/pVT, atria in AF). Therefore, the optimal pad position may not be the same for ventricular and atrial arrhythmias. The antero-lateral pad position is preferred as the initial pad position for VF/VT because it is easier to place and avoids interruptions to CPR while the posterior pad is positioned.

Pad placement for ventricular arrhythmias and cardiac arrest. In adults, place defibrillator pads or paddles in the antero-lateral position to optimise placement speed and minimise interruptions to chest compressions. One pad/paddle should be positioned below the patient's right clavicle, just to the right of the upper sternal border. The other pad/paddle should be placed on the patient's left mid-axillary line, below the armpit (Fig. 4).

In adults, if the initial antero-lateral position is not feasible, consider using the antero-posterior pad position if trained (Fig. 5). Place the anterior pad on the left side of the chest, between the midline and the nipple. For female patients, place the anterior pad to the left of the lower sternum, ensuring it avoids breast tissue as much as possible.[233] The posterior pad should be placed on the left side of the patient's spine, just below the scapula.

A study of initial antero-posterior (AP) versus antero-lateral (AL) pad positioning on outcomes in patients with shockable OHCA due to VF or pVT found that initial AP pad placement was significantly associated with higher odds of achieving ROSC at any time compared to AL placement (aOR 2.64; 95 % CI, 1.50–4.65). Approximately 74.1 % of patients with AP placement achieved ROSC versus 50.5 % with AL placement. Given the limitations of a non-randomised study and the potential delays in applying AP rather than AL pads, we continue to recommend AL pads as the preferred initial pad position.[234]

Other acceptable pad positions include:

- Placement of each pad on the lateral chest walls, one on the right and the other on the left side (bi-axillary).
- One pad in the standard axillary position and the other on the right upper back.

Either pad can be placed in either position (apex or sternal). An observational study in patients undergoing elective cardioversion with external defibrillator paddles showed that transthoracic impe-

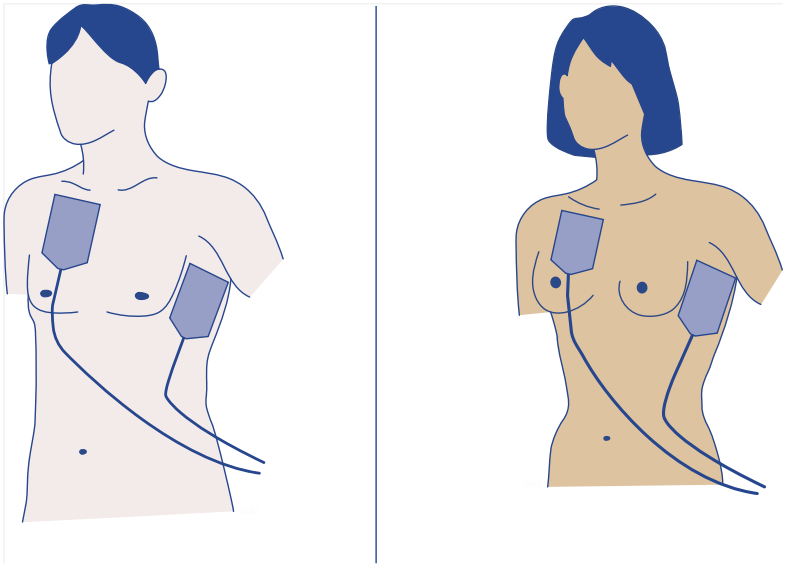


Fig. 4 – Correct antero-lateral pad placement for defibrillation.

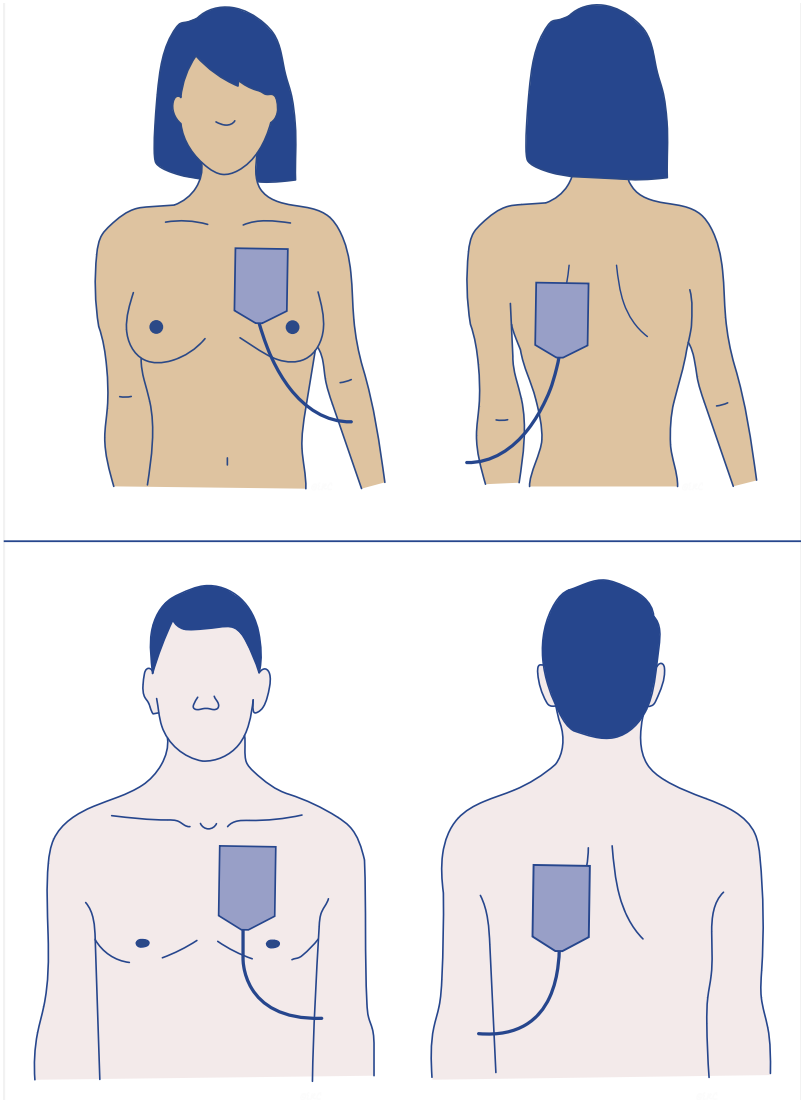


Fig. 5 – Antero-posterior pad placement.

dance was lower when the paddle was oriented in a cranio-caudal direction.[235] Consider shaving the chest if it is very hairy and the electrodes will not stick firmly. Do not delay shock delivery, and consider alternative pad positions if necessary.

Pad placement for atrial arrhythmias. Atrial fibrillation is usually maintained by functional re-entry circuits in the left atrium. As the left atrium is located posteriorly in the thorax, pad positions that result in a more posterior current pathway may theoretically be more effective for atrial arrhythmias. Although some studies have shown that antero-posterior pad placement is more effective than the traditional antero-apical position in elective cardioversion of atrial fibrillation,[236,237] the majority have failed to show any clear advantage of any specific pad position.[238–241] Efficacy of cardioversion may be less dependent on pad position when using biphasic impedance-compensated waveforms.[240–242] The following pad positions are safe and effective for cardioversion of atrial arrhythmias:

- Traditional sternal-apical position.
- Antero-posterior position (one pad anteriorly, over the left precordium, and the other pad posteriorly to the heart, just below the left scapula).

Pad placement to avoid implantable medical devices. More patients are presenting with implantable medical devices (e.g. permanent pacemaker, implantable cardioverter defibrillator (ICD)). Medic Alert bracelets are recommended for these patients. Implantable medical devices may be damaged during defibrillation if current is discharged through defibrillation pads placed directly over the device.[243,244] Place the pad away from the device (at least 8 cm) or use an alternative pad position (antero-lateral, antero-posterior).[243,245,246]

Hands-on defibrillation

By allowing continuous chest compressions during the delivery of the defibrillation shock, hands-on defibrillation would minimise peri-shock pause and enable continuation of chest compressions during defibrillation. However, the benefits of this approach are unproven, and further studies are required to assess the safety and efficacy of this technique. A post-hoc analysis of a multi-centre trial did not observe any benefit when shocks were delivered without pausing manual or mechanical chest compressions.[246] Only Class 1 electrical safety gloves, but not standard clinical gloves (or bare hands), provide a safe level of electrical insulation for hands-on defibrillation.[247] There have been no new studies since the 2021 guidelines and the ERC recommendation 2025 therefore remains unchanged.[60,215]

Respiratory phase

High levels of positive end expiratory pressure (PEEP) increase transthoracic impedance and should be minimised where possible during defibrillation. Auto-PEEP (gas trapping) may be particularly high in patients with asthma and may necessitate higher than usual energy values for defibrillation.[248]

One shock versus three stacked shock sequence

In 2010, it was recommended that when defibrillation was required, a single shock should be provided with immediate resumption of chest compressions after the shock.[249] This recommendation was made for two reasons. Firstly, to minimise peri-shock interruptions to chest compressions and secondly, given the greater efficacy of biphasic shocks, if a biphasic shock failed to defibrillate, a further period of chest compressions could be beneficial. Studies have not shown that any specific shock strategy is of benefit for any survival endpoint.[250,251] There is no conclusive evidence that a single-shock strategy is of benefit for ROSC or recurrence of VF compared with three stacked shocks, but given the evidence suggesting that outcome is improved by minimising interruptions to chest compressions, the ERC continued in 2020 to recommend single shocks for most situations.

When defibrillation is warranted, give a single shock and resume chest compressions immediately following the shock.[152] Do not delay CPR for rhythm reanalysis or a pulse check immediately after a shock. Continue CPR for 2 min until rhythm reanalysis is undertaken and another shock given (if indicated). Even if the defibrillation attempt is successful, it takes time until the post shock circulation is established and it is very rare for a pulse to be palpable immediately after defibrillation.[252,253] Patients can remain pulseless for over 2 min and the duration of asystole before ROSC can be longer than 2 min in as many as 25 % of successful shocks.[254] In patients where defibrillation achieves a perfusing rhythm, the effect of chest compressions on re-inducing VF is not clear.[255]

Monitored and witnessed shockable cardiac arrest. If a patient has a monitored and witnessed cardiac arrest (e.g. in the catheter laboratory, coronary care unit, or other monitored critical care setting in or out-of-hospital) and a manual defibrillator is rapidly available:

- Confirm cardiac arrest and shout for help.
- If the initial rhythm is VF/pVT, give up to three quick successive (stacked) shocks.
- Rapidly check for a rhythm change and, if appropriate, ROSC after each defibrillation attempt.
- Start chest compressions and continue CPR for 2 min if the third shock is unsuccessful.

This three-shock strategy may also be considered for an initial, witnessed VF/pVT cardiac arrest if the patient is already connected to a manual defibrillator. Although there are no data supporting a three-shock strategy in any of these circumstances, it is unlikely that chest compressions will improve the already very high chance of ROSC when defibrillation occurs early in the electrical phase,[256] immediately after onset of VF/pVT. For giving drugs after three stacked shocks:

- Give the first dose of amiodarone (or lidocaine) after the third shock if VF/pVT persists.
- Consider the stacked shocks as the first shock in the ALS algorithm for the purposes of adrenaline and amiodarone dosing.

Waveforms

Biphasic waveforms are now well established as a safe and effective waveform for defibrillation. Biphasic defibrillators compensate for the wide variations in transthoracic impedance by electronically adjusting the waveform magnitude and duration to ensure optimal current delivery to the myocardium, irrespective of the patient's size (impedance compensation). There are two main types of biphasic waveform: the biphasic truncated exponential (BTE) and rectilinear biphasic (RLB). A pulsed biphasic waveform is also in clinical use, in which the current rapidly oscillates between baseline and a positive value before inverting in a negative pattern.[33]

Energy levels

Defibrillation requires the delivery of sufficient electrical energy to defibrillate a critical mass of myocardium, abolish the wavefronts of VF and enable restoration of spontaneous synchronised electrical activity in the form of an organised rhythm. The optimal energy for defibrillation is that which achieves defibrillation whilst causing the minimum of myocardial damage.[257] Selection of an appropriate energy level also reduces the number of repetitive shocks, which in turn limits myocardial damage.[258]

Optimal energy levels for defibrillation are unknown. The recommendations for energy levels are based on a consensus following careful review of the current literature. Although delivered energy levels are selected for defibrillation, it is the transmyocardial current that achieves defibrillation; the electrical current correlates well with successful defibrillation and cardioversion.[259] A recent large database study revealed no significant association between initial energy level and outcomes, such as ROSC or survival to hospital discharge.[260] Defibrillation shock energy levels for the common BTE and RLB waveforms are unchanged from the 2021 guidelines, with pulsed biphasic energy levels increased to a minimum to 130 J to reflect the clinical evidence.[60,261] Studies of defibrillation energy levels in obese patients have generally found that defibrillation efficacy for any given energy level is unchanged.[262]

First shock. Few studies have been published with which to refine the current defibrillation energy levels set in the 2010 guidelines.[263] There is no evidence that one biphasic waveform or device is more effective than another. First shock efficacy of the BTE waveform using 150–200 J has been reported as 86–100 %.[264–269] First shock efficacy of the RLB waveform using 120 J has been reported as 85 %.[270] Four studies have suggested equivalence with lower and higher starting energy biphasic defibrillation (BTE waveform)[271–274] although one has suggested that initial low energy (150 J) defibrillation is associated with better survival.[275] Although human studies have not shown harm (raised biomarkers, ECG changes, ejection fraction) from any biphasic waveform up to 360 J[271,276], several animal studies have suggested the potential for harm with higher energy levels.[277–280]

The initial biphasic shock should be no lower than 150 J for RLB and BTE waveforms. For pulsed biphasic waveforms, begin at 130–150 J. Ideally, the initial biphasic shock energy should be at least 150 J for all biphasic waveforms to simplify energy levels across all defibrillators, particularly because the type of waveform delivered by a defibrillator is not marked. Manufacturers should display the effective waveform dose range on the face of the biphasic defibrillator. If the rescuer is unaware of the recommended energy settings of the defibrillator, for an adult, use the highest energy setting for all shocks.

Second and subsequent shocks. The 2010 guidelines recommended either a fixed or escalating energy strategy for defibrillation. Several studies of BTE waveform show that although an escalating strategy reduces the number of shocks required to restore an organised rhythm compared with low fixed-dose biphasic defibrillation, and may be needed for successful defibrillation,[281,282] rates of ROSC or survival to hospital discharge are not significantly different between strategies.[271–273] Additionally, a rectilinear biphasic protocol using a fixed low energy level showed high cardioversion rates (>90 %) but a significantly lower ROSC rate for recurrent VF could not be excluded.[283] Several in-hospital studies using an escalating shock energy strategy have shown improvement in cardioversion rates (compared with fixed dose protocols) in non-arrest rhythms.[284–289]

In 2025, there remains no evidence to support either a fixed or escalating energy protocol. Both strategies are acceptable; however, if the first shock is not successful and the defibrillator is capable of delivering shocks of higher energy, it is reasonable to increase the energy for subsequent shocks.

Recurrent ventricular fibrillation (refibrillation)

Recurrence of fibrillation is usually defined as 'recurrence of VF during a documented cardiac arrest episode, occurring after initial termination of VF while the patient remains under the care of the same providers (usually out-of-hospital).' Refibrillation is common and occurs in >50 % of patients following initial first-shock termination of VF.[281] Two studies showed termination rates of subsequent refibrillation were unchanged when using fixed 120 J or 150 J shock protocols respectively,[283,290] but a larger study showed termination rates of refibrillation declined when using repeated 200 J shocks, unless an increased energy level (360 J) was selected.[281] In a retrospective analysis, conversion of VF to an organised rhythm was higher if the VF had first appeared after a perfusing rhythm, than after PEA or asystole.[223]

In view of the larger study suggesting benefit from higher subsequent energy levels for refibrillation,[281] the ERC recommends that if a shockable rhythm recurs after successful defibrillation, and the defibrillator can deliver shocks of a higher energy, it is reasonable to increase the energy for subsequent shocks.

Refractory ventricular fibrillation

Refractory VF is defined as fibrillation that persists after three or more shocks. It was initially reported as occurring in approximately 20 % of patients who present in VF,[281] but more recent studies have suggested that the true incidence may be a low as 5 %. The majority of patients cardiovert successfully, but refibrillate during the two-minute period of chest compression following the shock.[291] These cases of refibrillation may therefore make up a large proportion of cases of refractory VF. Duration of VF correlates negatively with good outcome. Actively search for and correct any reversible causes (Fig. 2. ALS algorithm). Ensure that the defibrillation energy output is on the maximum setting. Check that the defibrillation pads are placed correctly (particularly the apical [lateral] pad, when using the antero-lateral pad position). Consider using an alternative defibrillation pad position (e.g., antero-posterior) – this is unchanged from previous guidance but has been given increased prominence.

Dual/double sequential defibrillation (DSD). Patients in refractory VF have significantly lower rates of survival than patients who respond to standard resuscitation treatments. Double sequential defibrillation (DSD) is the use of two defibrillators to deliver two overlapping shocks or two rapid sequential shocks, one with standard pad placement and the other with either antero-posterior or additional antero-lateral pad placement. The technique has been suggested as a possible means of increasing VF termination rates. With numerous case reports and some observational studies,[292–299] in 2020 ILCOR reviewed the efficacy of this technique

and based on very low certainty evidence made a weak recommendation against the routine use of a DSD strategy in comparison with standard defibrillation strategy for cardiac arrest with a refractory shockable rhythm.[84,224] More recently, ILCOR again reviewed the evidence[1] following the publication of a RCT (DOSE VF) of OHCA incorporating DSD.[211] The updated ILCOR recommendation suggested that a DSD (weak recommendation, low certainty of evidence) or a vector change defibrillation strategy (weak recommendation, very low certainty of evidence) may be considered for adults with cardiac arrest who remain in VF/pVT after three or more consecutive shocks. However, in view of the practical challenges of delivering DSD using two defibrillators and the limited evidence for its efficacy, the ERC guidelines do not recommend its introduction into routine practice. Following the public comment period in May 2025, the writing group further considered DSD. The group had already considered the evidence for DSD and in particular the DOSE VF RCT in detail. Following the public feedback, we did not identify any new evidence to change the recommendations. Our considerations included that the DOSE VF study was stopped early due to the COVID pandemic, recruited fewer than half the planned number of patients, and the final results included data from the initial feasibility study. We noted the lack of support from manufacturers and the potential for defibrillator damage.[300,301] We also considered the need for additional resources (equipment and training) required to implement DSD for routine use. Equipoise still exists regarding DSD and there are two European trials (STRAT-DEFI [NCT06781892], The Dual Defib Trial [NCT06672159]) of DSD that will help inform guideline updates. These guidelines are reviewed annually, and if necessary the guidance on DSD will be updated. Finally, considering vector change for refractory VF cardiac arrest has been part of previous ERC ALS guidelines and is unchanged.

Manual pressure augmentation. The application of manual pressure on defibrillation pads to reduce impedance and thereby increase defibrillation shock success has been studied. There is evidence that this technique may be helpful for treating resistant cardioversion of atrial fibrillation.[302] However, the safety and efficacy of manual pressure augmentation has not been studied in the context of shockable OHCA.

Percutaneous stellate ganglion block in refractory electrical storm. Percutaneous stellate ganglion block (PSGB) is an emerging, minimally invasive strategy for electrical storm treatment.[303] A large, prospective, multicentre study provides some evidence in favour of the effectiveness and safety of PSGB for treating refractory electrical storm.[304] A secondary analysis of this study, including 14 patients who were treated with PSGB during IHCA due to refractory or recurrent VF, found no major complications; 11 (78 %) patients survived for at least 24 h, and 7 (50 %) were discharged with favourable neurological outcome.[305] However, data on the use of PSGB in patients experiencing refractory cardiac arrest is very limited, and larger studies are needed before its introduction into routine practice.

Analysis of rhythm during chest compression

New software technology in some defibrillators enables the removal of ECG motion artefact generated during chest compressions to show the real-time underlying waveform during CPR. An ILCOR systematic review found no studies in humans evaluating this technology, leading to a weak recommendation based on very low certainty evidence to suggest against the routine use of artefact-filtering algorithms for analysis of electrocardiographic rhythm during CPR.[152] In making its recommendation ILCOR placed a priority on avoiding the costs of a new technology where effectiveness remains to be determined. The ILCOR task force acknowledged that some EMS already use artefact-filtering algorithms for rhythm analysis during chest compressions, and strongly encouraged EMS to report their experience to build the evidence base regarding these technologies in clinical practice.

Implantable cardioverter defibrillators. Implantable cardioverter defibrillators (ICDs) are becoming increasingly common as they are implanted more frequently in an aging population. They are implanted because a patient is at risk from, or has had, a life-threatening shockable arrhythmia. They are usually embedded under the pectoral muscle below the left clavicle (in a similar position to pacemakers, from which they cannot be immediately distinguished). More recently, extravascular devices can be implanted subcutaneously in the left chest wall, with a lead running parallel to the left of the sternum.[306] In a recent RCT, the subcutaneous ICD (S-ICD) was non-inferior to the transvenous ICD with respect to device-related complications and inappropriate shocks.[307]

On sensing a shockable rhythm, an ICD will discharge approximately 40 J (approximately 80 J for subcutaneous devices) through an internal pacing wire embedded in the right ventricle. On detecting VF/pVT, ICD devices will discharge no more than eight times but may reset if they detect a new period of VF/pVT. Patients with fractured ICD leads may suffer repeated internal defibrillation as the electrical noise is mistaken for a shockable rhythm. In these circumstances, the patient is likely to be conscious, with the ECG showing a relatively normal rate. A magnet placed over the ICD will turn off the defibrillation function.[245]

Discharge of an ICD may cause pectoral muscle contraction in the patient, and shocks to the rescuer have been documented.[308] Given the low energy values discharged by conventional ICDs, it is unlikely that any harm will come to the rescuer, but minimising contact with the patient whilst the device is discharging is prudent. Surface current from subcutaneous ICDs is significant and may cause a perceptible shock to the rescuer.[309,310] Cardioverter and pacing function should always be re-evaluated following external defibrillation, both to check the device itself and to check pacing/defibrillation thresholds of the device leads.

Pacemaker spikes generated by devices programmed to unipolar pacing may confuse AED software and emergency personnel and may prevent the detection of VF.[311] The diagnostic algorithms of modern AEDs can be insensitive to such spikes.

Ultraportable automated external defibrillators. A recent ILCOR scoping review found no evidence of ultraportable AED device performance, clinical or safety outcomes, particularly in relation to their novel low-energy waveforms.[312] ILCOR recommends that the safety and efficacy of these devices are established prior to clinical introduction and this recommendation is supported by the ERC.

Patients with actively discharging implantable cardioverter defibrillators (ICD)

Patients considered at risk of cardiovascular collapse from malignant arrhythmias may have a pre-emptive ICD placed. There are two main types:

a) Transvenous (standard) ICD: Conventional placement beneath the left pectoral muscle, with a lead inserted into the right ventricle (Fig. 6). Typically delivers 40 J on discharge.

b) Subcutaneous ICD: Placed beneath the skin in the left lateral chest wall with a lead placed subcutaneously along the left sternal border (Fig. 7). Typically delivers 80 J on discharge.

If either device senses a shockable rhythm, the ICD will deliver a defibrillation shock between the ICD and the distal section of the wire. Externally, this is often not apparent with a standard ICD, but a S-ICD depolarises more chest muscle to make the shock visible externally.

Most ICDs deliver up to 6–8 shocks per episode before stopping. During this time, the shock intervals are approximately 5–20 s (depending on the internal programming). A lead fracture may cause intermittent erroneous sensing, resulting in resetting of the discharge programme and near-continuous internal defibrillation. Because the S-ICD does not have intracardiac leads, it requires a higher energy output to ensure effective defibrillation. Rescuers may sense a significant shock across their arms while performing external chest compressions, even when wearing clinical gloves. If an ICD/S-ICD fails to terminate a shockable rhythm, conventional external shocks should be delivered, placing any defibrillation pad/paddle >8 cm from the defibrillator box (as above).

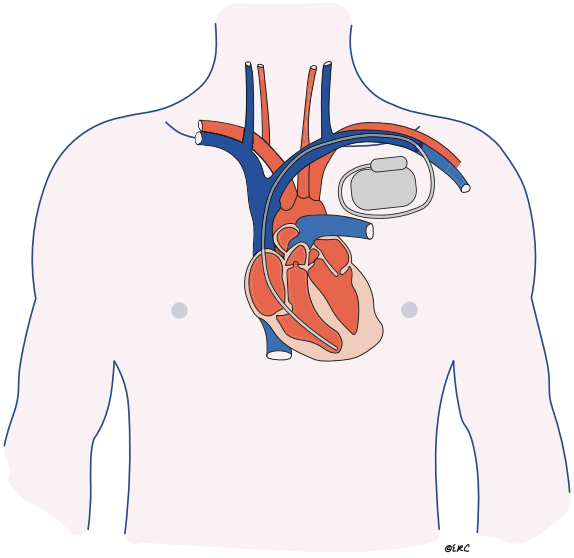


Fig. 6 – Position of a transvenous (standard) Implantable Cardioverter Defibrillator.

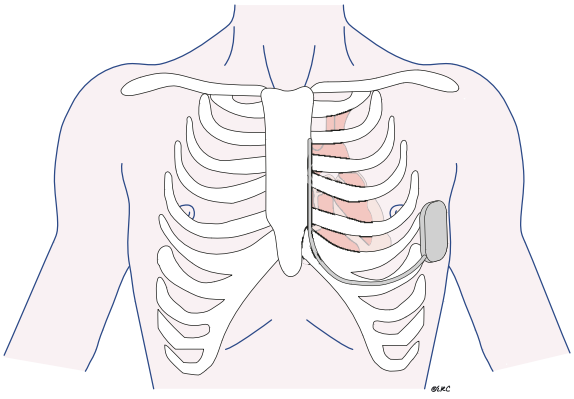


Fig. 7 – Position of a subcutaneous Implantable Cardioverter Defibrillator.

Waveform analysis during CPR

It is possible to predict, with varying reliability, the success of defibrillation from the fibrillation waveform.[220,313–334] If optimal defibrillation waveforms and the optimal timing of shock delivery can be determined in prospective studies, it should be possible to prevent the delivery of unsuccessful high energy shocks and minimise myocardial injury. Since the 2021 guidelines,[60] one small RCT, 10 observational studies, one systematic review and one narrative review were identified.[205,335–346] Most of the studies identified were retrospective and observational, assessing the ability of VF waveform analysis to predict defibrillation success or ROSC. The only RCT showed the prospective real-time use of VF waveform analysis using Amplitude Spectrum Area (AMSA) analysis during CPR.[335] Amplitude Spectrum Area is the most studied parameter (9/10 studies) and showed the highest accuracy to predict defibrillation success[304,336–338,341,342], although its predictivity was inferior to a machine learning algorithm during chest compression.[342] The small RCT that compared AMSA-guided CPR with standard CPR showed no evidence of improvement in termination of VF (primary outcome), ROSC or in long-term survival.[335] Recent developments include the use of convolutional neural networks to calculate AMSA during continuous CPR.[344] Additionally, information other than the outcome of an immediate defibrillation can be obtained from the waveform analysis. For instance, two retrospective observational studies assessed the ability of AMSA to detect coronary occlusion, showing lower AMSA values in case of acute myocardial infarction.[345] A recent ILCOR systematic review update[347] found two observational studies focusing on software-based cardiac rhythm analysis during CPR in OHCA patients.[348,349] Both studies were observational and used historical controls, showing improved CPR quality metrics with rhythm analysis during compressions. None of the studies evaluated survival rates or neurological outcomes, leaving it uncertain whether these technologies enhance patient outcomes. ILCOR found insufficient evidence to make a treatment recommendation, given the absence of RCTs or well-controlled observational studies. Consistent with previous recommendations, there remains insufficient evidence to support routine use of VF waveform analysis to guide the optimal timing for a shock attempt.

Airway and ventilation

Since 2015 the ERC has recommended a stepwise approach to airway management during CPR.[215] Three large RCTs of airway management for OHCA have been published since 2015 that have supported this guidance.[350–352] An ILCOR systematic review addressed whether a specific advanced airway management strategy (use of supraglottic airway devices (SGA) or tracheal intubation) improved outcome from cardiac arrest in comparison with an alternative airway management strategy.[353,354] Seventy-eight observational studies were included; nine of these addressed the timing of advanced airway management. Eleven controlled trials were included but only three of these were RCTs.[354] The first of these RCTs compared early tracheal intubation with bag-mask ventilation (tracheal intubation delayed until after ROSC) in a physician-

staffed EMS system.[351] The result of this non-inferiority trial that recruited over 2,000 patients was inconclusive –4.3 % versus 4.2 % for 28-day survival with favourable functional outcome (Cerebral Performance Category [CPC] 1–2), no significant difference. Notably, the tracheal intubation success rate was 98 % and 146 patients in the bag-mask ventilation group underwent 'rescue intubation' (i.e., crossed over); 100 of these were because of regurgitation. In a comparison of initial laryngeal tube (although technically an infraglottic airway, it is usually included within the SGA group of devices) insertion with tracheal intubation in 3,000 OHCAs by paramedics in the United States, 72-h survival (primary outcome) was higher in the laryngeal tube group (18.2 % versus 15.3 %; $p = 0.04$).[352] However, the overall tracheal intubation success rate was just 51 % making it possible that the lower survival rate in the tracheal intubation group was a reflection of the poor tracheal intubation success rate. The third of these RCTs was a comparison of the initial insertion of an i-gel supraglottic airway (SGA) with tracheal intubation in OHCA treated by paramedics in the United Kingdom (UK).[350] Among the more than 9,000 patients enrolled, there was no difference in the primary outcome of favourable functional survival (modified Rankin Scale [mRS] ≤ 3; 6.4 % versus 6.8 %; $P = 0.33$).

A cluster RCT in Taiwan compared insertion of i-gel with tracheal intubation in 936 OHCA patients and found no difference in the rate of sustained ROSC, the primary outcome.[355] Three observational studies have compared the use of the laryngeal tube with i-gel in OHCA. Rates of successful airway placement and survival to hospital discharge were higher with the i-gel than the laryngeal tube.[356–358]

In a cluster-randomised trial in patients with OHCA in Singapore, use of the laryngeal tube by paramedics was associated with more complications and fewer successful placements compared with a laryngeal mask airway (Ambu Aura-i LMA).[359] There are many different SGAs currently available, but only a few have been studied in recent RCTs. Ultimately it will be a local system decision on which SGA to use.

A large observational cohort study of IHCA from the American Heart Association (AHA) Get with the Guidelines-Resuscitation (GWTG-R) registry, compared outcomes in patients intubated at any given minute within the first 15 min after cardiac arrest onset against matched patients still receiving CPR at risk of being intubated within the same minute.[360] The matching was based on time-dependent propensity scores, pairing 43,314 intubated patients and non-intubated patients with similar propensity for intubation. Compared with not intubating, tracheal intubation was associated with a lower rate of ROSC (risk ratio [RR] 0.97; 95 % CI 0.96–0.99; $p < 0.001$), lower survival to hospital discharge (RR 0.84; 95 % CI 0.81–0.87; $p < 0.001$), and worse neurological outcome (RR 0.78; 95 % CI 0.75–0.81; $p < 0.001$). Two ongoing RCTs are comparing insertion of an i-gel with tracheal intubation in IHCA.[361,362]

After reviewing the evidence for airway management during cardiac arrest, the ILCOR ALS Task Force made the following treatment recommendations,[354] which the ERC has adopted, and these remain unchanged following an evidence update in 2025[1]:

- We suggest using bag-mask ventilation or an advanced airway strategy during CPR for adult cardiac arrest in any setting (weak recommendation, low to moderate certainty of evidence).
- If an advanced airway is used, we suggest a SGA for adults with OHCA in settings with a low tracheal intubation success rate (weak recommendation, low certainty of evidence).
- If an advanced airway is used, we suggest an SGA or tracheal intubation for adults with OHCA in settings with a high tracheal intubation success rate (weak recommendation, very low certainty of evidence).
- If an advanced airway is used, we suggest an SGA or tracheal intubation for adults with IHCA (weak recommendation, very low certainty of evidence).

Patients often have more than one type of airway intervention, typically starting with basic and advancing to more complex techniques that are inevitably applied later during cardiac arrest – the stepwise approach.[350,363] The best airway, or combination of airway techniques will vary according to patient factors, the phase of the resuscitation attempt (during CPR, after ROSC), and the skills of rescuers. If basic airway techniques enable effective ventilation, there may be no need to progress to advanced techniques until after ROSC. One potential advantage of inserting an advanced airway is that it enables chest compressions to be delivered continuously without pausing during ventilation. The quality of the seal between the glottis and an SGA is variable – in some cases the oropharyngeal leak pressure is very low and excessive gas leakage will occur, rendering effective ventilation impossible and resulting in imperceptible chest movement.[364] If this occurs, revert to bag-mask ventilation or, if the appropriately skilled personnel are available, intubate the trachea. Most patients with ROSC remain comatose and will need tracheal intubation and mechanical ventilation (See Post-resuscitation Care).[147]

Airway obstruction

Patients requiring CPR often have an obstructed airway, usually secondary to loss of consciousness, but occasionally it may be the primary cause of cardiorespiratory arrest.

Basic airway management and adjuncts. Three manoeuvres may improve the patency of an airway obstructed by the tongue or other upper airway structures: head tilt, chin lift, and jaw thrust. Despite a total lack of published data on the use of nasopharyngeal and oropharyngeal airways during CPR, they are often helpful, and sometimes essential, to maintain an open airway, particularly when CPR is prolonged.

Oxygen during CPR

During cardiac arrest, the blood flow and oxygen reaching the brain are low, even with effective CPR. Based on the physiological rationale and expert opinion, ILCOR and ERC recommends giving the highest feasible inspired oxygen concentration during cardiac arrest to maximise oxygen delivery to the brain thereby minimising hypoxic-ischaemic injury.[203] Observational studies have shown that a higher PaO_2 during CPR is associated with a higher likelihood of ROSC and patient survival.[365,366] After ROSC, as soon as SpO_2 can be measured reliably or arterial blood gas values are obtained, titrate the inspired oxygen to achieve an arterial oxygen saturation of 94–98 % or arterial partial pressure of oxygen (PaO_2) of 10–13 kPa (75–100 mmHg). Rescuers should be aware that pulse oximetry

can overestimate the true oxygen saturation in people with darker skin tones.[367,368]

Choking

The initial management of foreign body airway obstruction (choking) is addressed in the ERC Guidelines 2025 First Aid.[7] This topic has been recently assessed by an ILCOR evidence update[369] and a previous systematic review.[370] In an unconscious patient with suspected foreign body airway obstruction if initial basic measures are unsuccessful use laryngoscopy and forceps to remove the foreign body under direct vision. To do this effectively requires training. Some patients with foreign body airway obstruction may require emergency front of neck access and this is addressed further below.

Ventilation

Ventilation breath volume. Recent studies suggest that effective ventilation and oxygenation is often done poorly during ALS and this is associated with poorer outcomes.[371] This is increasingly important given that patients have often received a period of chest compression only CPR before ALS trained providers arrive. Advanced life support providers should give artificial ventilation as soon as possible for any patient in whom spontaneous ventilation is inadequate or absent. This is usually achieved with a self-inflating bag attached to a facemask or an advanced airway. Deliver each breath over approximately 1 s, giving a volume that corresponds to normal chest movement. The chest should visibly rise; this represents a compromise between giving an adequate volume, minimizing the risk of gastric inflation, and allowing adequate time for chest compressions. The choice of self-inflating bag may also effect outcome – in a recent observational study of adult OHCA patients the use of a smaller self-inflating bag was associated with poorer survival.[372]

30:2 versus asynchronous ventilation. Although the delivery of continuous chest compressions during face-mask ventilation was previously thought to increase the risk of regurgitation, a trial of continuous versus interrupted chest compressions during CPR (CCC Trial) that enrolled more than 23,000 patients showed no statistically significant difference in survival to discharge.[373] ILCOR has subsequently recommended that when using bag mask, EMS providers perform CPR either using a 30:2 compression-ventilation ratio (pausing chest compressions for ventilation) or continuous chest compressions without pausing while delivering positive pressure ventilation (strong recommendation, high-quality evidence).[374] In Europe, the most common approach during CPR with an unprotected airway is to give two ventilations after each sequence of 30 chest compressions. A secondary analysis of the CCC trial examined the frequency of effective ventilations delivered with bag-mask and measured via thoracic bioimpedance during pauses in chest compressions among 1976 OHCA patients of the 30:2 arm of the trial.[371] The study revealed that the quality of ventilation was notably poor: in 60 % of the patients, lung inflation was observed in less than half of the chest compression pauses, with a median time to the first ventilation greater than 4 min. Patients who experienced lung inflations in at least 50 % of pauses showed higher rates of ROSC (RR 1.3 [95 % CIs 1.2–1.5]; $p < 0.0001$), survival at hospital discharge (RR 2.2 [95 % CIs 1.6–3.0]; $p < 0.0001$) and survival with favourable neurological outcomes (RR 2.8 [95 % CIs 1.8–4.3]; $p < 0.0001$) (1). The ERC recommends, that advanced life support providers should ensure effective ventilation when using a bag-mask. If ventilation is inadequate, efforts should be made to optimise bag-mask ventilation by improving the mask seal, maintaining airway patency, and, using a two-person technique – rescuers who do not regularly and frequently use a bag-mask should use a two-person technique to ensure effective ventilation.[375,376]

Once a tracheal tube or an SGA has been inserted, ventilate the lungs at a rate of 10 min^{-1} and continue chest compressions without pausing during ventilations.[377] The laryngeal seal achieved with an SGA may not be good enough to prevent at least some gas leaking when inspiration coincides with chest compressions. Moderate gas leakage is acceptable (unless there is a significant risk of infection),[378,379] particularly as most of this gas will pass up through the patient's mouth. If excessive gas leakage results in inadequate ventilation of the patient's lungs, chest compressions will have to be interrupted to enable ventilation, using a compression – ventilation ratio of 30:2. One observational study of OHCA patients who had received prolonged CPR with a mechanical device has documented worse blood gases among those whose airway was managed with an SGA compared with tracheal intubation.[380]

Ventilation rate. Since the 2021 guidelines review, one small RCT, a secondary analysis of an RCT, and three observational studies assessing ventilation rate during CPR have been identified through a systematic search strategy.[372,381–384] A small RCT randomised 46 patients after tracheal intubation to receive either 10 or 20 breaths/min delivered with mechanical ventilation in volume-controlled mode with a tidal volume of 6 mL kg^{-1}.[381] The study was terminated early, failing to achieve the planned sample size, and showed a higher minute ventilation in the group randomised to 20 breaths min^{-1} (primary outcome) with no evidence of improvement in hypercapnia, hypoxia, and ROSC rates. A secondary analysis of the Pragmatic Airway Resuscitation Trial (PART) compared laryngeal tubes with tracheal intubation evaluated the association between ventilation rates and outcomes.[382] A median ventilation rate of 8 min^{-1} was observed in both groups, and the duration of hypoventilation (defined as <6 min^{-1}) was associated with decreased rates of ROSC and hospital survival. The duration of mild hyperventilation (>12 to 16 min^{-1}) was associated with improved ROSC, survival to hospital discharge and survival with favourable neurological outcome. Two retrospective observational studies failed to demonstrate an association between ventilation rates and patient outcomes.[372,384] Although there is increasing evidence in ALS settings showing that respiratory rate is frequently below 10 min^{-1} during CPR and that the duration of hypoventilation is associated with worse outcomes, there remains insufficient evidence to establish an optimal ventilation rate during CPR.

Mechanical ventilation during CPR. Two RCTs and two observational studies comparing mechanical ventilation and bag ventilation during CPR were identified.[385–388] The RCTs were feasibility studies comparing mechanical ventilation delivered in volume-controlled mode (tidal volume 6–7 mL kg^{-1}, RR 10 min^{-1}, FiO_2 1.0) with bag ventilation after advanced airway placement. Each study included 60 patients and no sample size calculations were performed. They showed that the use of mechanical ventilation during both mechanical[385] and manual[386] chest compressions was feasible. Neither of these trials found differences in oxygenation, ROSC, or survival. A prospective observational study indicated that mechanical ventilation is associated with reduced $PaCO_2$ values; however, it did not affect the rates of ROSC, survival, or survival with favourable neurological outcomes.[387] The retrospective study compared

mechanical ventilation delivered in cardiopulmonary ventilation mode (298 patients) with bag ventilation (2268 patients), showing that mechanical ventilation may increase the rate of ROSC with no effect on survival with favourable neurological outcomes.[388]

Although studies show that the use of mechanical ventilation during chest compressions is feasible, there is insufficient evidence to support the use of mechanical ventilation over manual bag ventilation or to recommend a specific ventilation mode. We suggest that if using mechanical ventilation (volume controlled or pressure regulated modes) during CPR, the following initial settings are used: tidal volume of 6–8 mL kg^{-1} (predicted body weight) or sufficient to cause a visible chest movements, the maximum fraction inspired oxygen, a respiratory rate of 10 min^{-1}, an inspiratory time of 1–1.5 s, PEEP 0–5 cmH_2O, alarm for peak pressure set at 60–70 cm H_2O, and the inspiratory trigger turned off. If mechanical ventilation is not effective, switch to manual ventilation.

Ventilation during mechanical chest compressions. Ventilation during mechanical chest compressions may be particularly challenging because of the mechanical forces applied to the chest, causing lung volume to decrease below functional residual capacity (FRC).[389,390] One RCT and one retrospective observational study evaluated ventilation during mechanical chest compressions.[391,392] The pilot RCT randomised 30 OHCA patients undergoing mechanical chest compressions after tracheal intubation into one of the following three ventilation strategies: 1) biphasic positive airway pressure (BIPAP) with assisted spontaneous breathing; 2) continuous positive airway pressure (CPAP) and 3) volume-controlled ventilation. This study showed a higher tidal volume delivered in BIPAP mode than in CPAP mode, while no differences in the rate of ROSC were detected. The retrospective observational study evaluated the frequency of bag-ventilation during pauses in mechanical chest compressions delivered at a 30:2 ratio and showed inadequate ventilation during 3-second pauses in mechanical chest compressions – two inflations were successfully provided in 45 % of compression pauses, and no ventilation was delivered in 19 % of compression pauses.[392] A particularly low likelihood of delivering two successful insufflations was detected in the first four minutes after mechanical chest compression device placement. The best method for ventilation during mechanical chest compression is uncertain.

Passive oxygen delivery. In the presence of a patent airway, chest compressions alone may result in some ventilation of the lungs.[393] Oxygen can be delivered passively, either via an adapted tracheal tube (Boussignac tube),[394,395] or with the combination of an oropharyngeal airway and standard oxygen mask with a non-rebreather reservoir.[396] In theory, a SGA can also be used to deliver oxygen passively but this has yet to be studied. One study has shown higher neurologically favourable survival with passive oxygen delivery (oral airway and oxygen mask) compared with bag-mask ventilation after shockable OHCA, but this was a retrospective analysis and is subject to numerous confounders.[396] A trial of continuous or interrupted chest compressions during CPR (CCC Trial) included a subgroup of patients who were treated with passive oxygenation but until further data are available, passive oxygen delivery without ventilation is not recommended for routine use during CPR.[373]

Choice of airway devices

Disadvantages of tracheal intubation over bag-mask ventilation include:

- The risk of an unrecognised misplaced tracheal tube – in patients with OHCA the reliably documented incidence ranges from 0.5 % to 17 %: emergency physicians – 0.5 %[397]; paramedics – 2.4 %[398], 6 %[399,400], 9 %,[401] and 17 %[402]
- A prolonged period without chest compressions while tracheal intubation is attempted. In a study of prehospital tracheal intubation by paramedics during 100 cardiac arrests the median duration of the interruptions in CPR associated with tracheal intubation attempts was 110 s (interquartile range 54–198 s; range 13–446 s).[403] Tracheal intubation attempts accounted for almost 25 % of all CPR interruptions.
- A comparatively high failure rate. Intubation success rates correlate with the tracheal intubation experience attained by individual paramedics.[404] The high failure rate of 51 % documented in the PART trial[352] is similar to those documented in some prehospital systems more than 20 years ago.[405,406]
- Tracheal intubation is a difficult skill to acquire and maintain. In one study, anaesthesia residents required about 125 intubations with direct laryngoscopy in the operating room setting before they were able to achieve a tracheal intubation success rate of 95 % under such optimal conditions.[407]

Healthcare personnel who undertake prehospital tracheal intubation should do so only within a structured, monitored program, which should include comprehensive competency-based training and regular opportunities to refresh skills.

The ILCOR recommendation is that only systems that achieve high tracheal intubation success rates should use this technique.[354] ILCOR did not recommend a particular success rate but suggested it should be similar to that achieved in the RCT comparing early tracheal intubation with bag-mask ventilation (tracheal intubation delayed until after ROSC) in a physician-staffed EMS system.[351] The tracheal intubation success rate in this study was 98 %. The expert consensus of the ERC 2021 ALS Guidelines writing group was that a high success rate is greater than 95 % with up to two intubation attempts.[60]

Rescuers must weigh the risks and benefits of tracheal intubation against the need to provide effective chest compressions. To avoid any interruptions in chest compressions, unless alternative airway management techniques are ineffective, it is reasonable to defer tracheal intubation until after ROSC. In settings with personnel skilled in advanced airway management, laryngoscopy should be undertaken without stopping chest compressions; a brief pause in chest compressions will be required only as the tube is passed through the vocal cords. The tracheal intubation attempt should interrupt chest compressions for less than 5 s; if intubation is not achievable within these constraints, recommence bag-mask ventilation. After tracheal intubation, tube placement must be confirmed immediately (see below) and the tube must be secured adequately.

Video laryngoscopy. Video laryngoscopy (VL) is being used increasingly in anaesthetic and critical care practice.[408,409] Preliminary studies indicate that compared with direct laryngoscopy (DL), VL during CPR improves laryngeal view and tracheal intubation success rates,[410,411] reduces the risk of oesophageal intubation[412] and reduces interruptions to chest compressions.[413] One systematic review concluded that in the prehospital setting, VL decreased the first-attempt tracheal intubation success rate (RR, 0.57; $P < 0.01$; high-quality evidence) and overall success rate (RR, 0.58; 95 % CI, 0.48–0.69; moderate-quality evidence) by experienced operators.[414] A later meta-analysis of OHCAs and IHCAs

that included six observational studies and one RCT documented higher first pass success rate and better grade of view with VL compared with DL.[415] A secondary analysis of an RCT also documented a higher rate of successful tracheal intubation on the first attempt with VL compared with DL.[416] Several different VL systems are available and they do not all perform in the same way. The expert consensus of the writing group and recommendation of the ERC is that the rescuer's choice of direct laryngoscopy or video laryngoscopy should be guided by local protocols and rescuer experience. However, in settings where VL is immediately available, it is preferable to use VL instead of DL.

Confirmation of correct placement of the tracheal tube

Unrecognised oesophageal intubation is the most serious complication of attempted tracheal intubation in patients with and without cardiac arrest. One large RCT comparing bag-mask ventilation and tracheal intubation during CPR by skilled prehospital physicians reported accidental but recognised oesophageal intubation in 10 % of attempts.[351] Another study found the rate of unrecognised oesophageal intubation in OHCA by paramedics was 5 %.[400] Therefore, accurate means to verify correct tracheal tube placement in CPR are of greatest importance. The previous evidence supporting these guidelines is summarised in longstanding ILCOR recommendations.[33,224,417] The 2022 PUMA Guidelines for the prevention of unrecognised oesophageal intubation state clearly that the only accurate method to confirm tracheal placement of the tracheal tube is the presence of a sustained $ETCO_2$ trace for at least seven breaths on waveform capnography in patients with and without cardiac arrest.[418] Clinical assessment such as chest and abdominal auscultation, observation of chest expansion, and fogging of the tube cannot be used to confirm tracheal placement if waveform capnography suggests otherwise. The 'No Trace = Wrong Place' campaign by the UK Royal College of Anaesthetists emphasised that immediately after tracheal intubation (even during cardiac arrest) the absence of exhaled CO_2 strongly suggested oesophageal intubation.[419] It is accepted that this is not sufficient and that in some cases of unrecognised oesophageal intubation there has been some CO_2 detected – this has led to the need for sustained exhaled CO_2 trace to exclude oesophageal intubation.[420] If waveform capnography does not confirm correct placement of the tracheal tube in patients without cardiac arrest the PUMA Guidelines suggest using repeat laryngoscopy to view the passage of the tube, use of a flexible bronchoscope or ultrasound of the neck. Portable monitors make capnographic initial confirmation and continuous monitoring of tracheal tube position feasible in both in- and out-of-hospital settings where tracheal intubation is performed. Although a sustained $ETCO_2$ trace confirms that the tube is not in the oesophagus, it could still be misplaced in a bronchus which can cause severe hypoxaemia. Check the tube length at the teeth to ensure that it is not inserted too far. Auscultation of the lungs may also help to exclude endobronchial intubation, but this is challenging during cardiac arrest and must not delay chest compressions.

Ultrasonography of the neck or visualisation with a flexible fibreoptic scope by skilled operators can also be used to confirm the presence of a tracheal tube in the trachea.[421]

Cricoid pressure

The use of cricoid pressure in cardiac arrest is not recommended (expert consensus). Cricoid pressure can impair ventilation, laryngoscopy, tracheal tube and SGA insertion, and may even cause complete airway obstruction.[422]

Securing the tracheal tube and supraglottic airway

Accidental dislodgement of a tracheal tube can occur at any time but may be more likely during CPR and during transport. An SGA is more prone to being dislodged than a tracheal tube.[350] The most effective method for securing the tracheal tube or SGA has yet to be determined. Use either conventional tapes or ties, or purpose-made holders.

Emergency front of neck access (eFONA)

In rare cases, it may be impossible to oxygenate a patient in cardiac arrest using bag-mask ventilation, or to insert a tracheal tube or supraglottic airway. This may occur in patients with extensive facial trauma or laryngeal obstruction caused by oedema, tumour or a foreign body. In 2023, ILCOR undertook a scoping review which summarised evidence from 69 studies across four domains: incidence of eFONA; success rates of eFONA attempts; clinical outcomes in patients with an eFONA attempt; and complications associated with eFONA attempts.[423] The review found that none of the identified studies focused specifically on cardiac arrest, and noted that the available evidence was highly heterogeneous. Consistent with a systematic review on pre-hospital eFONA success rates, the scoping review observed that, when attempted, eFONA success rates were typically high.[424] Based on the available evidence, ILCOR identified that it was not possible to undertake a systematic review, but made a good practice statement supporting the use of cricothyroidotomy in patients where standard airway management and ventilation strategies have been unsuccessful.[1] An Australian observational study, published in 2024, reported on 80 cricothyroidotomy attempts of which 56 occurred in OHCA patients.[425] The reported incidence was 1.1 cricothyroidotomies per 1000 attempted resuscitations with a success rate in cardiac arrest of 58.9 %. The use of a surgical approach was associated with a higher success rate than a needle approach (88.2 % v. 54.6 %, $p = 0.003$). Consistent with Difficult Airway Society recommendations, the ERC recommends, where feasible, the use of a scalpel-bougie cricothyroidotomy.[426]

Medication and fluids

Vascular access

The effectiveness of medication in cardiac arrest is time-dependent.[427–429] The IO route has been proposed as an alternative strategy for initial vascular access in adult cardiac arrest, based on the perceived ease of insertion and an RCT showing that the time to drug administration was fastest with a tibial IO strategy, compared to both a peripheral IV or humeral IO strategy.[430,431] Observational studies show that the use of the IO route in clinical practice has increased over recent years.[432,433]

In 2024, three large RCTs compared an IO-first with an IV-first strategy in adult cardiac arrest.[434–436] In contrast to earlier research, none of these trials found that the IO route facilitated more rapid drug administration. These three trials, which comprised 9,332 patients, formed the basis of a systematic review and meta-analysis led by the ILCOR ALS Task Force.[437] The meta-analysis showed that an IO-first strategy, compared with an IV-first strategy, did not improve the rate of survival to 30-days or discharge with favourable neurological outcome (OR 1.07; 95 % CI 0.88–1.30; low-certainty evidence) and 30-day survival (OR 0.99: 95 % CI 0.84–1.17; moderate-certainty evidence), but may reduce the rate of sustained ROSC

(OR 0.89, 95 % CI 0.80–0.99; moderate-certainty evidence). There was no evidence that the treatment effect was influenced by baseline patient characteristics or the anatomical site of the IO cannula. In formulating its treatment recommendation, ILCOR noted the routine availability of the peripheral IV route across international systems, the high cost of IO cannulae, the additional training requirement associated with intraosseous use, and the evidence from the meta-analysis suggesting that an IO-first strategy reduces the odds of achieving ROSC.[1] ILCOR noted that no RCTs had been undertaken in an IHCA but observed that the IO route is infrequently required in such cases.

Consistent with ILCOR, the ERC recommends that the IV route should be used as the primary route for vascular access in adult cardiac arrest. We recognise that the IO route may be a reasonable vascular access strategy where IV access cannot be rapidly achieved. Consistent with the two European RCTs, we recommend that two IV vascular access attempts are made before considering attempting IO access.[435,436]

There has been recent interest in the use of intramuscular (IM) adrenaline for cardiac arrest based on animal studies and observational data.[438–441] In a single-centre before-and-after observational study, a single dose of 5 mg IM adrenaline in 420 patients with OHCA was associated with improved survival to hospital admission, survival to hospital discharge, and functional survival compared with standard adrenaline dosing.[441] The role of the IM route for adrenaline in cardiac arrest needs to be studied with RCTs before considering its inclusion in guidelines.

Vasopressors

ILCOR recently updated their review of vasopressors in cardiac arrest.[1] The systematic reviews and *meta*-analyses evaluated standard dose adrenaline (1 mg) versus placebo, high dose (5–10 mg) versus standard dose (1 mg) adrenaline, adrenaline versus vasopressin, and adrenaline and vasopressin versus adrenaline alone.[192,442–444] The evidence showed that adrenaline (1 mg) improved ROSC, survival to hospital admission, survival to hospital discharge, and long-term survival (up to 12 months), although the effect on favourable neurological outcome remains uncertain. By contrast, the use of high-dose adrenaline or vasopressin (with or without adrenaline) did not improve long-term survival or favourable neurological outcome.

Based on this evidence, ILCOR makes a strong recommendation in favour of adrenaline during CPR (strong recommendation, low certainty of evidence).[192] The justification and evidence to decision framework highlights that the Task Force placed a very high value on the apparent life-preserving benefit of adrenaline, even if the absolute effect size is likely to be small and the effect on survival with favourable neurological outcome is uncertain.

The evidence supporting adrenaline use comes primarily from two placebo-controlled trials.[445,446] The PARAMEDIC2 trial followed the ERC ALS 2015 Guidelines, which recommended adrenaline administration as soon as vascular access was obtained for non-shockable rhythms, and after three unsuccessful defibrillation attempts for shockable rhythms.[215,446] Analysis of this trial continues to provide new evidence, with long-term follow-up data showing sustained survival benefits at 12 months.[447] Meta-analyses with the earlier PACA trial found greater effects of adrenaline on ROSC and survival to hospital discharge in initial non-shockable rhythms compared to shockable rhythms, although this difference was less pronounced for longer-term survival and favourable neurological outcomes.[213] A secondary analysis of time to drug administration found that while relative treatment effects of adrenaline remained constant, survival and favourable neurological outcome rates decreased over time, suggesting potential benefit from early intervention.[427]

Consequently, ILCOR recommends that adrenaline is administered as soon as feasible for non-shockable rhythms (PEA/asystole) (strong recommendation, very low certainty of evidence). For shockable rhythms (VF/pVT), ILCOR suggests administration of adrenaline after initial defibrillation attempts are unsuccessful during CPR (weak recommendation, very low certainty of evidence).

Consistent with the ILCOR Treatment Recommendations, the ERC recommends that adrenaline 1 mg is administered as soon as possible for adult patients in cardiac arrest with a non-shockable rhythm. For patients with a shockable rhythm persisting after three initial shocks, administer adrenaline 1 mg. Repeat adrenaline 1 mg every 3–5 min whilst ALS continues. While practical challenges may affect the timing of adrenaline in the prehospital setting, early administration remains a priority, particularly for non-shockable rhythms where alternative interventions are limited.

The optimal dose of adrenaline remains unclear. Pharmacokinetic and observational data suggest further investigation is needed regarding dosing strategies.[448,449] This includes the standard 1 mg dose, the cumulative effects of repeated doses, and potential alternative approaches such as titrated dosing in closely monitored settings. Alternative routes such as intracoronary administration, have been studied in cardiac catheterisation laboratories, but evidence is insufficient to support these approaches.[450,451]

If three stacked shocks have been given for a witnessed and monitored shockable cardiac arrest where immediate defibrillation is possible, these initial three stacked shocks should be considered as the first shock with regards to timing of the first dose of adrenaline and amiodarone. After these stacked shocks, providers should continue resuscitation attempts and adrenaline and amiodarone dosing according to the standard ALS algorithm.

A recent cost-effectiveness analysis of PARAMEDIC2 incorporating both direct survival benefits and increased organ donation rates supports the use of adrenaline during cardiac arrest, although costs may vary between healthcare systems.[452]

Consistent with the ILCOR treatment recommendation, the ERC does not support the use of vasopressin during cardiac arrest.

Antiarrhythmic drugs

ILCOR updated the CoSTR for antiarrhythmic drugs in 2018.[453] This was followed by ILCOR evidence updates in July 2023 and October 2024.[1,192] The 2018 CoSTR made the following recommendations:

- We suggest the use of amiodarone or lidocaine in adults with shock refractory VF/pVT (weak recommendation, low-quality evidence).
- We suggest against the routine use of magnesium in adults with shock-refractory VF/pVT (weak recommendation, very low-quality evidence).
- The confidence in effect estimates is currently too low to support an ALS Task Force recommendation about the use of bretylium, nifekalant, or sotalol in the treatment of adults in cardiac arrest with shock-refractory VF/pVT.
- The confidence in effect estimates is currently too low to support an ALS Task Force recommendation about the use of prophylactic antiarrhythmic drugs immediately after ROSC in adults with VF/pVT cardiac arrest.

Despite many studies, the ILCOR evidence updates in 2023 did not identify any compelling new data that would justify a further systematic review or changes to the treatment recommendations.[192] The 2024 evidence update [1] identified one additional small pilot RCT of the beta-blocker landiolol including 36 patients.[454] Given the interest in beta-blockers for cardiac arrest and in particular esmolol and landiolol, and the fact that sotalol is not considered a primary beta-blocker, the ILCOR ALS Task Force clarified the third bullet point of its 2018 treatment recommendation to state:

- The confidence in effect estimates is currently too low to support an ALS Task Force recommendation about the use of beta-blocker drugs, bretylium, or nifekalant, or sotalol in the treatment of adults in cardiac arrest with shock-refractory VF/pVT.

This 2025 guidance is therefore primarily based on the 2018 ILCOR systematic review that identified evidence from 14 RCTs and 17 observational studies that included lidocaine, amiodarone, magnesium, bretylium, nifekalant, procainamide, sotalol and beta-blockers.[455] Meta-analysis of randomised trials in adults, found that none of the antiarrhythmic drugs improved survival or favourable neurological outcome compared to placebo.

The largest randomised trial compared amiodarone, lidocaine or placebo in patients with VF/pVT refractory after at least one defibrillation attempt. Compared with placebo, amiodarone and lidocaine increased survival to hospital admission. However, there was no difference in survival to discharge or favourable neurological survival at discharge between groups.[456] In the pre-defined sub-group of bystander-witnessed cardiac arrests, amiodarone and lidocaine increased survival to hospital discharge compared with placebo. Survival was also higher with amiodarone than with placebo after EMS-witnessed arrest.

These data led ILCOR to suggest that amiodarone or lidocaine could be used in adults with shock refractory VF/pVT (weak recommendation, low quality evidence).[453] The values and preferences analysis indicates that the Task Force prioritised the pre-defined and reported sub-group analysis from the ALPS study, which showed greater survival with amiodarone and lidocaine in patients with a witnessed cardiac arrest. ILCOR did not support the use of magnesium, bretylium, nifekalant or procainamide.

The ERC updated its guidelines in 2018 to recommend that amiodarone should be given after three unsuccessful defibrillation attempts, irrespective of whether they are consecutive shocks, or interrupted by CPR, or for recurrent VF/pVT during cardiac arrest.[457] The initial recommended dose is amiodarone 300 mg; a further dose of 150 mg may be given after five defibrillation attempts. The recommendation in favour of amiodarone was based on 21 of 24 National Resuscitation Councils of Europe reporting that amiodarone was the main drug used during CPR.[457] Lidocaine 100 mg may be used as an alternative if amiodarone is not available, or a local decision has been made to use lidocaine instead of amiodarone. An additional bolus of lidocaine 50 mg can also be given after five defibrillation attempts.[457]

Thrombolytic therapy

ILCOR evidence updates in 2022 and 2024 for the treatment of pulmonary embolism did not identify sufficient new evidence to justify an update of the previous 2020 ILCOR systematic review.[192,193] We also considered a recent systematic review that identified 13 studies with 804 patients.[458] The 2020 ILCOR CoSTR pooled evidence from a sub-group analysis of the TROICA trial[459] and four observational studies which examined the use of thrombolytic drugs in cardiac arrest caused by suspected or confirmed pulmonary embolism (PE).[460–463] The studies did not find evidence that thrombolytic drugs improved neurological outcome.[459,462] By contrast, in one study, 30-day survival was higher in the intervention group (16 % vs 6 %; $P = 0.005$)[463] but not in three other studies which examined survival to discharge.[460–462] ROSC also improved in one study [461]but not in two others. [460,462] In making a weak recommendation for the use of thrombolytic drugs for suspected or confirmed PE and cardiac arrest based on very low certainty evidence, the ILCOR Task Force considered that the potential benefits outweighed the potential harm from bleeding.[224]

The ERC endorses the recommendation from ILCOR, which aligns with the ERC guidelines in 2015 and 2021.[60,215] The ERC does not support the routine use of thrombolytic drugs in cardiac arrest, unless the cause is suspected or confirmed PE. When thrombolytic drugs have been administered, based on evidence from case series consider continuing CPR attempts for at least 60–90 min before termination of resuscitation attempts.[464–466] As for all cardiac arrests the duration of the CPR attempt should take into account the possibility of reversing the underlying cause, and other factors such as patient comorbidity and frailty.

Fluids and blood components

ILCOR has not recently addressed the use of fluids during cardiac arrest. The ERC ALS Writing Group performed its own search up to February 2025. No RCTs have evaluated the routine administration of fluids versus no fluids as a treatment strategy for cardiac arrest. Two large RCTs provide indirect evidence from treatment strategies designed to induce hypothermia, which included the administration of up to 2 L of ice-cold IV fluids during OHCA[467] or immediately after ROSC.[468] The studies found no improvement in short[467,468] or long-term outcomes.[469] The studies reported evidence of reduced ROSC in patients with VF,[467] increased rate of re-arrest,[468] and higher rates of pulmonary oedema.[467,468] It is not possible to determine from these studies whether the harmful effects were related to fluid volume, the rate of infusion, or the temperature of the infused fluids.[470] The routine rapid infusion of large-volume fluids should be avoided unless there is evidence or suspicion of a hypovolaemic cause of the cardiac arrest. A clinical assessment, the history of events before cardiac arrest, and when the skills are available, POCUS can help identify hypovolaemia during resuscitation.

A recent systematic review on fluid therapy during and after CPR for non-traumatic CA confirmed the limited evidence for the use of either isotonic saline or balanced crystalloids, and the potential benefit of hypertonic fluids, and mentioned the potential role of optimised fluid resuscitation with accurate clinical assessment of volumes status during CPR, including considering medical history, exam findings and POCUS.[471]

Either isotonic saline or balanced crystalloids can be considered during CPR. A multicentre RCT ($n = 432$) compared the infusion of two units each of packed red blood cells (PRBC) and fresh frozen plasma versus 1 L of isotonic saline in patients with traumatic haem-

orrhagic shock.[472] The study was stopped earlier than the planned sample size of 490 patients due to the COVID-19 pandemic. No difference was observed in the primary outcome parameter (composite of mortality and lactate clearance failure) and secondary outcomes: i) mortality and ii) lactate clearance failure); serious adverse events were comparable. The role of intra- and peri-arrest administration of hypertonic fluids,[473] blood, and blood products for non-traumatic cardiac arrest remains uncertain,[472] and these products should only be used in clinical trials. Small bolus doses (e.g., 20 mL) of fluid, or a slow fluid infusion should be used to flush drugs given during CPR.

Other drugs

Calcium. ILCOR updated the CoSTR for calcium administration during cardiac arrest based on a systematic review that included three randomized trials and eight observational studies in adult cardiac arrest.[474] The largest and most recent trial of 391 patients comparing calcium chloride with placebo during OHCA was terminated early because an interim analysis suggested potential harm.[475,476] While no statistically significant differences were observed in ROSC, neurological outcomes at 30 days, or survival up to 1 year, patients receiving calcium had lower rates of favourable neurological outcome at 90 days and 1 year, with a signal of harm across multiple outcomes. Two older, smaller trials of cardiac arrest patients with refractory asystole or pulseless electrical activity, along with most observational studies, also failed to show any survival benefit.[474,477,478] These data led ILCOR to recommend against routine calcium administration in both OHCA (strong recommendation, moderate certainty evidence) and IHCA (weak recommendation, low certainty evidence).[1] Consistent with ILCOR, the ERC recommends not routinely giving calcium during cardiac arrest. As noted in the ERC Guidelines 2025 Special Circumstances, for cardiac arrest caused by suspected hyperkalaemia, ILCOR found insufficient evidence to recommend for or against calcium administration.[114]

Sodium bicarbonate. ILCOR updated the CoSTR for sodium bicarbonate administration during cardiac arrest based on a systematic review including three RCTs and three observational studies in OHCA.[1] Meta-analyses found no benefit of sodium bicarbonate administration compared to standard care for short-term survival, survival to hospital discharge, and survival with favourable neurological outcome at one month.[479–481] Supporting observational data showed similar results.[482–487] Although the evidence is inconclusive, sodium bicarbonate is commonly given during cardiac arrest.[487–489] ILCOR suggests against routine sodium bicarbonate administration in both OHCA (weak recommendation, low certainty evidence) and IHCA (weak recommendation, very low certainty evidence).[1] The ERC does not support the routine administration of sodium bicarbonate during cardiac arrest, unless there is a specific indication.

Corticosteroids. The guidance for administering corticosteroids during cardiac arrest, whether given alone or in combination with vasopressin, is based on an ILCOR evidence update and systematic review of individual participants data.[1,490,491] In adult IHCA, three RCTs comparing vasopressin and methylprednisolone to placebo found higher rates of ROSC and favourable neurological outcome at hospital discharge, but no significant improvement in survival, longer-term neurological outcome, or health-related quality of life up to 90 days.[137,492,493] Secondary analyses of the largest trial also found no difference in haemodynamic or long-term outcomes for vasopressin and methylprednisolone.[494,495] The two earlier smaller trials that administered corticosteroids both during and after ROSC reported improved outcomes overall.[492,493] Given that no consistent survival benefit was identified in meta-analyses, ILCOR suggests against using vasopressin and corticosteroids in addition to usual care for adult cardiac arrest.[1] For corticosteroids as a standalone intervention during cardiac arrest, early small trials have found no meaningful benefit, including three trials in OHCA and one in IHCA.[496,497] Based on these data, and considering the practical challenges of incorporating additional medication into resuscitation protocols, the ERC recommends against the routine use of corticosteroids either alone or in combination with vasopressin during cardiac arrest except when this is done as part of a clinical trial.

ALS for cardiac arrest in highly-monitored settings

Patients in highly monitored settings such as critical care areas, operating or recovery rooms, and cardiac catheterisation laboratories are closely and continuously monitored, and causes of unexpected cardiac arrest may be promptly reversible, particularly when detected immediately (e.g., a sudden arrhythmia in the ICU or a relative overdose of induction drug in the operating room). If blood pressure is monitored continuously using an indwelling arterial cannula, sudden changes in blood pressure can be detected almost immediately and a pulsatile arterial waveform may be seen even if peripheral and central pulses are no longer palpable. A sudden decrease in cardiac output, including cardiac arrest, may be detected very quickly by a sudden decrease in $ETCO_2$ if this is being monitored continuously. These are just some of the features of cardiac arrest in a highly monitored setting that may warrant adjustment of the doses of resuscitation drugs, changes in defibrillation strategy, and different indications for starting chest compressions.

A recent Royal College of Anaesthetists National Audit in the United Kingdom (National Audit Project 7) estimated the incidence of intra-operative cardiac arrest to be 3 in 10,000.[498] Of the 548 patients with intraoperative cardiac arrest during the one-year period of study, half had invasive blood pressure monitoring. Sustained ROSC was achieved in 78 % of patients and 62 % were alive at the time of reporting. Only 70 patients (13 %) had a shockable rhythm. Among the patients with an initial rhythm of PEA or bradycardia, the three most reported triggers for starting CPR were an impalpable pulse (57 %), severe hypotension (47 %), and a reduction in $ETCO_2$ (25 %).

In adults during general anaesthesia, it has been suggested that chest compressions should be started if the systolic blood pressure decreases and remains <50 mmHg despite interventions.[499,500] This approach is likely also applicable to any patient undergoing invasive arterial monitoring (e.g., in an critical care setting). A systolic blood pressure <50 mmHg is likely to be associated with impalpable pulses[501] and the benefit from the additional cerebral and coronary blood flow produced by chest compressions will likely outweigh the risk of harm from chest compressions.[499]

Although the ERC Guidelines 2025 ALS recommend a dose of 1 mg adrenaline, the optimal dose of adrenaline to treat cardiac arrest is unknown.[502] Smaller doses are likely appropriate when adrenaline is first given IV for profound hypotension, when there is a high probability of a low-flow state during PEA or severe bradycardia, or when there is a very short time between the onset of cardiac arrest and injection of adrenaline. With continuous monitoring, car-

diac arrest can be diagnosed immediately and treated rapidly with the likelihood of restoring spontaneous circulation very quickly. Under these circumstances, giving a 1 mg bolus of adrenaline may lead to severe hypertension and tachyarrhythmias. Thus, we suggest that adrenaline is given initially in increments (e.g., 50–100 μg IV) rather than a 1 mg bolus, but if 1 mg in total has been given with no response, further IV adrenaline doses of 1 mg are given at the usual 3–5 min intervals. Australasian guidelines for resuscitation after cardiac surgery include similar recommendations.[503] When continuously monitoring arterial blood pressure it is reasonable to aim to achieve a diastolic blood pressure higher than 30 mmHg by combining high-quality chest compressions and titrated adrenaline (by giving 50–100 μg boluses or an infusion) (see physiology-guided CPR).[504,505]

The International Liaison Committee on Resuscitation does not recommend the precordial thump for established cardiac arrest, citing its low success rate documented in a systematic review – although already de-emphasised in previous ERC guidelines, we have removed it completely from these Guidelines.[506] In two studies of patients undergoing electrophysiological testing, it terminated malignant ventricular arrhythmias (VT or VF) in only 1 of 80 and 2 of 155 cases, respectively—all cases were VT, and none of the 49 VF cases responded.[507,508] In an OHCA study, a precordial thump restored circulation in 5 of 103 patients (3 VF, 2 pVT) but worsened rhythms in 10 cases.[509] Another Italian OHCA study found it effective in only 3 of 144 patients, all initially in asystole.[510]

Physiology-guided CPR

The quality of CPR is associated with survival and the ability to monitor the quality of CPR is fundamental to its improvement.[511] The quality of CPR can be measured by monitoring the performance of the rescuer to ensure adherence to guidelines; this might include compression rate, depth and recoil, chest compression fraction and ventilation rate and volume. Many of the current defibrillator-monitors are capable of monitoring and providing these metrics in real time. Another way of monitoring CPR performance is to assess its effect on the patient's physiology using intra-arterial blood pressure, capnography or cerebral oximetry.

During low flow conditions, $ETCO_2$ values are more strongly associated with cardiac output and pulmonary blood flow than with ventilation.[512] The use of $ETCO_2$ to guide the quality of chest compressions was first described almost 40 years ago.[513] Two observational studies have subsequently shown that chest compression depth but not rate is associated with $ETCO_2$ values,[514,515] although a third observational study did show a small association between compression rate and $ETCO_2$.[516] In a pig model of neonatal asphyxial cardiac arrest, chest compressions aimed at maximising $ETCO_2$ increased the rate of ROSC compared with a control group of standard CPR.[517]

A systematic review of haemodynamic-directed feedback during CPR identified six animal studies.[518] Four of these studies examined the effect of haemodynamic-directed CPR on survival in swine. The hemodynamic-directed CPR groups had chest compression depth titrated to a systolic blood pressure (SBP) of 100 mmHg and vasopressors titrated to maintain a coronary perfusion pressure (CPP) >20 mmHg. Pooled results showed that 35/37 (94.6 %) of the animals survived in the haemodynamic-directed CPR groups and 12/35 (34.3 %) survived in the control groups ($p < 0.001$).

Most of the clinical studies of physiology-directed CPR have involved children. In a stepped-wedge cluster randomised trial in 18 paediatric intensive care units, a bundled intervention comprising physiologically focused CPR training at the point of care and structured clinical event debriefings did not improve survival to hospital discharge with favourable functional outcome.[519] In this study, when an arterial line or $ETCO_2$ was in place, clinicians were educated to aim for a systolic blood pressure above 100 mmHg in older children (i.e. not neonates or infants) and an $ETCO_2$ above 25 mmHg. Observational data from this study demonstrate that achieving a mean diastolic BP (DBP) during CPR greater than 30 mmHg for older children is associated with higher rates of survival to hospital discharge.[504]

In one of the first clinical studies in adults on this topic, invasive blood pressure was measured during CPR in 104 patients.[520] A chest compression rate of 100–120 min^{-1} and compression depth $\geq$6 cm was associated with a DBP $\geq$ 30 mmHg in both femoral and radial recordings. However, although there was a weak upward trend in blood pressure as compression depth increased in individual subjects, deeper compression depth did not result in a higher blood pressure in all patients. In a more recent study, 80 OHCA adults had invasive blood pressure monitoring during CPR delivered by helicopter emergency medicine service (HEMS) clinicians.[505] The maximum, average and delta-DBP (difference between the initial and maximum values); and maximum and average mean arterial pressure (MAP) were positively associated with ROSC. Maximum DBP had an optimal threshold value of 35 mmHg (sensitivity 94.1 %; specificity 58.7 %) for predicting ROSC. The odds ratio for ROSC was 1.05 (95 % CI 1.03–1.08) for every 1 mmHg increase in maximum DBP.

A consensus statement from the American Heart Association suggested several physiological targets during CPR, all of which were based on expert consensus:[511]

- If both an arterial line and a central venous catheter are in situ during cardiac arrest, aim to achieve a coronary perfusion pressure (CPP) >20 mmHg.
- If only an arterial line is in situ during cardiac arrest, aim to maintain a DBP > 25 mmHg.
- If only capnography is available during cardiac arrest, aim to achieve an $ETCO_2$ > 20 mmHg (2.67 KPa).

Given the recent observational data,[504,505,520] the ERC suggests aiming for a diastolic blood pressure of $\geq$30 mmHg when using intra-arterial blood pressure monitoring for physiology-guided CPR. This is only feasible in very specialist settings with expert resuscitators – assessing diastolic BP in real time may be challenging in some patients. Further studies are still needed to increase our understanding of the optimum blood pressure target during CPR and how to measure it in real time.

Other potential physiological targets during CPR include cerebral oximetry and EEG. Higher cerebral oxygenation saturation during CPR is associated with ROSC,[521] but although theoretically cerebral oxygenation could be used as a physiological target during CPR, this has yet to be investigated (see below).

Waveform capnography during advanced life support

End-tidal CO_2 ($ETCO_2$) is the partial pressure of carbon dioxide (PCO_2) measured at the end of expiration. It reflects cardiac output, tissue perfusion, pulmonary blood flow, and minute ventilation. Carbon dioxide is produced in perfused tissues by aerobic metabolism, transported by the venous system to the right side of the heart and

pumped to the lungs by the right ventricle, where it is removed by alveolar ventilation.

Waveform capnography enables a continuous, non-invasive measurement of PCO_2 in the exhaled air during CPR. In the typical capnogram, the $ETCO_2$ recorded at the end of the expiratory plateau best reflects the alveolar PCO2.[522] $ETCO_2$ is most reliable when the patient's trachea is intubated, but it can also be detected with a supraglottic airway device or bag mask.[523]

The aims of monitoring waveform capnography during CPR include:

- **Confirming tracheal tube placement** (this has been addressed above).
- **Monitoring the quality of CPR**. $ETCO_2$ monitoring during CPR enables the measurement of the ventilation rate helping rescuers avoid hypo- or hyperventilation.[384,523] Observational studies on adults with in-hospital or OHCA have shown that $ETCO_2$ values are proportional to the chest compression depth measured using transthoracic impedance. In contrast, variations in the chest compression rate do not affect $ETCO_2$.[514,515]
- **Detecting ROSC during CPR**. When ROSC occurs, $ETCO_2$ may rise three times above the values during CPR. Capnography during CPR might, therefore, help avoid unnecessary chest compression or potentially harmful administration of adrenaline in a patient with ROSC. However, no consistent amount of $ETCO_2$ rise has been identified as a criterion for diagnosing that ROSC has occurred. In addition, the rise in $ETCO_2$ associated with ROSC is not immediate and can start 10 min or more before a palpable pulse is detected.[524–526]
- **Prognostication during CPR**. Lower $ETCO_2$ values during CPR indicate a lower likelihood of ROSC. Previous evidence suggested that failure to achieve an $ETCO_2$ value >10 mmHg (1.33 kPa) was associated with a poor outcome.[527,528] This threshold has also been suggested as a criterion for withholding e-CPR in refractory cardiac arrest.[529] However, recent evidence has shown that patients may survive with ETCO2 values below 10 mmHg during CPR. In a study on 617 adults with refractory OHCA from non-shockable rhythm, of whom 615 (99.3 %) died before hospital discharge, $ETCO_2$ at 30 min was still above 10 mmHg in 88 % of non-survivors. In one of the two survivors, 30-min $ETCO_2$ was below 10 mmHg.[530] In a study on 14,122 adult non-traumatic OHCA from all rhythms, 4.2 % of the 9,226 patients who subsequently achieved ROSC and 3.3 % of those who survived to hospital discharge had $ETCO_2 < 10$ mmHg at 20 min.[531] In that study, the adjusted odds of mortality in patients with maximum prehospital $ETCO_2$ values above 50 mmHg (6.67 Kpa) were 50 % higher than in patients with $ETCO_2$ values of 30–40 mmHg (4.0–5.33 KPa), probably reflecting hypoventilation. Other factors affecting $ETCO_2$ during cardiac arrest include the presence of airway closure,[532] and the cause of arrest.[533–535]

Besides single values of $ETCO_2$, the changes in $ETCO_2$ during CPR have also been investigated to predict ROSC.[536,537] In a recent secondary analysis of 1113 patients enrolled in the multicentre cluster randomised PART trial, in which patients were ventilated with supraglottic airways or tracheal tube, the median $ETCO_2$ increased from 30.5 at 10 min to 43.0 mmHg (p for trend <0.001) five minutes before the end of resuscitation in ROSC patients, while it declined from 30.8 to 22.5 mmHg (p for trend <0.001) in non-ROSC patients, respectively.[538] After adjusting for major confounders, the slope of the $ETCO_2$ during CPR remained associated with both ROSC and 72-h survival (OR 1.45 [1.31–1.61] and 1.33 [1.20–1.45] respectively). $ETCO_2$ trends are probably more appropriate than point values for predicting ROSC during CPR.[528] In the study on refractory non-shockable OHCA mentioned above, while only one of the two survivors to discharge had an $ETCO_2$ above 10 mmHg at 30 min, both had an $ETCO_2$ increase from the initial value to 30 min (specificity 13 % vs 33 %).[530] In a multicentre study on 668 OHCA patients of any aetiology and rhythm, both an $ETCO_2$ value at intubation greater than 20 mmHg (2.67 KPa) and its increase 10 min later were independent predictors of survival to hospital admission and survival at hospital discharge. However, after adjustment for bystander and CPR status, presenting rhythm and EMS arrival time, only the $ETCO_2$ change at 10 min remained an independent predictor of outcome.[539]

Evidence regarding the prognostic value of $ETCO_2$ is based on observational, unblinded studies, which may have caused a self-fulfilling prophecy. Although $ETCO_2$ values below 10 mmHg after prolonged CPR are strongly associated with unfavourable outcome (no ROSC or death before hospital discharge), the ERC recommends that they should not be used alone as a mortality predictor or for deciding to stop a resuscitation attempt.

Near infra-red spectroscopy (NIRS), and EEG monitoring during CPR

Although NIRS and EEG monitoring during CPR were within the scope of the ERC Guidelines 2025 ALS update, the ERC has not made any recommendations for their use and the rea sons are set out below. Near infrared spectroscopy is a non-invasive method to monitor the oxygenation of the combination of arterial and venous blood in the brain. NIRS monitoring can be conducted with external electrodes placed on the forehead of the patient. With the emission of infrared light, the monitor can provide the regional oxygen saturation proportion in tissue and blood. When applied to the forehead of a patient this will provide an estimation of the amount of oxygen saturation in brain tissue. Given the risk of hypoxic-ischaemic brain injury in patients undergoing CPR this has raised much interest. According to a systematic review conducted in 2021, NIRS monitoring may provide information on the likelihood of ROSC.[540] The systematic review including 17 studies showed that higher initial cerebral regional oxygen saturation (rSO_2) values were associated with the likelihood of ROSC. Thus far only one study has compared $ETCO_2$ and NIRS and this study suggested superiority for NIRS compared with $ETCO_2$.[541] This finding should however be confirmed in future studies. On the other hand, studies have failed to show any association of NIRS values with the quality of chest compressions, the amount of oxygen in the blood or the administration of adrenaline.[366,542] Thus, it is unclear if NIRS can be used to modify the delivery of resuscitation measures in any way. No study to date has assessed the cost effectiveness of NIRS monitoring. Therefore, there is not enough evidence to recommend NIRS as a monitoring tool for patients undergoing CPR.

EEG monitors the electric activity of the brain noninvasively. Changes in EEG correlate with changes in cerebral blood flow. Some studies have assessed the feasibility of using EEG during resuscitation to monitor the efficacy and outcome of CPR.[543] The EEG methods used include traditional multichannel EEG as well as the raw EEG signal from monitors of the depth of anaesthesia, including the bispectral index (BIS®). The existing evidence is inconclusive and comes mainly from smaller observational studies and case-reports. At present, the use of EEG is not recommended by the

ERC either for monitoring the performance of CPR or estimating the outcome.

Use of ultrasound imaging during advanced life support

Point-of-care ultrasound (POCUS) imaging is already commonly used in emergency care settings. Its use during CPR is also increasing. Previous and current guidance emphasises the need for skilled POCUS operators and minimising interruption in chest compression to acquire images.[60,215]

An ILCOR systematic review assessed the role of POCUS during cardiac arrest as a prognostic tool in which assessment of cardiac motion informs the likelihood of achieving ROSC and clinical decisions to terminate resuscitation.[544] The review identified several limitations such as inconsistent definitions and terminology around sonographic evidence of cardiac motion, low inter-rater reliability of findings, low sensitivity and specificity for outcomes, confounding from self-fulfilling prophecy when terminating resuscitation in unblinded settings as well as unspecified timing of POCUS. The review concluded that no sonographic finding had sufficiently diagnostic accuracy to support its use as a sole criterion to terminate resuscitation. A 2025 ILCOR Evidence Update[1] identified additional studies with small sample sizes, and heterogeneous POCUS findings and clinical outcomes.[545–548] All studies were potentially biased by lack of blinding of the resuscitating team to POCUS findings. There was a lack of agreement in the interpretation of acquired views in most of studies, which highlighted the inherent real-time clinical challenge of time-limited image acquisition and the need for skilled POCUS operators.

A further ILCOR systematic review assessed the role of POCUS to diagnose treatable causes of cardiac arrest such as cardiac tamponade, pneumothorax, pulmonary embolism, myocardial infarction, aortic dissection, and hypovolaemia.[549] There was a high degree of clinical heterogeneity and a critical risk of bias, which precluded a meta-analysis. The certainty of evidence was very low, and individual studies were difficult to interpret. However, the review stressed the issue of misinterpreting POCUS findings as the cause of cardiac arrest as opposed to an incidental finding. For example, unilaterally absent lung sliding could indicate a small pneumothorax or mainstem bronchial intubation, rather than a tension pneumothorax. Likewise, visualised peritoneal fluid could be ascites, rather than an acute haemorrhage; a pericardial effusion could be present without cardiac tamponade; and right heart dilation can occur during CPR without a massive pulmonary embolism. Right ventricular dilation a few minutes after the onset of cardiac arrest as blood moves from the systemic circulation to the right heart along its pressure gradient [550] was consistently observed in a porcine model of cardiac arrest caused by hypovolaemia, hyperkalaemia, and primary arrhythmia.[551] This is a common trans-oesophageal echocardiography (TOE) observation in patients with OHCA regardless of the cause.[552]

Since 2015, the ERC ALS guidelines recommend a transthoracic sub-xiphoid view with the probe placed just before chest compressions are paused for a planned rhythm assessment,[215] minimising additional interruptions in chest compressions, which may delay or impede other therapies.[553,554] A strategy to deal with this is to record brief sonographic video clips during pulse/rhythm checks (less than 10 s) and then view/interpret them after the resumption of chest compressions. In addition, sonographers may pre-localise the approximate acoustic window during chest compressions with subsequent fine-tuning during pauses in CPR.[555] Finally, to avoid prolonged pauses in chest compressions, when feasible the sonographer should not be simultaneously leading the team and, or doing rhythm checks.[554]

Another possibility for reducing hands-off time during cardiac arrest is the use of TOE. In 2021, a systematic review of TOE in cardiac arrest concluded that because of the heterogeneity of studies, small sample size and inconsistent reference standard, the evidence for TOE in cardiac arrest resuscitation is of low certainty and is affected by a high risk of bias.[556] Further studies are needed to better understand the true diagnostic accuracy of TOE in identifying reversible causes of arrest and cardiac contractility. Since then, additional case series and observational studies have been published, which showed that in experienced hands, TOE provides useful diagnostic and therapeutic information and that the rate of adequate cardiac visualisation can be excellent with a low complication rate.[557] During CPR, TOE may help to improve hand positioning for chest compression and improve left ventricular compression.[558,559] In an observational study, improving left ventricular compression was associated with increased ROSC.[548] The use of TOE during cardiac arrest requires additional equipment and expertise.

Devices

Mechanical chest compression devices

Since the 2021 guidelines,[60] ILCOR has published updated recommendations for the use of mechanical chest compression. The ILCOR 2024 systematic review identified 14 reports of 11 RCTs conducted post-2000.[1] Trials before this date were not included because of the significant changes to CPR and cardiac arrest treatment that have occurred since 2000. Three new RCTs were identified since the 2021 ERC guidelines, each providing very low certainty evidence.[560–562] One study, enrolling 1191 patients, assessed the use of the LUCAS device following OHCA. No difference in ROSC (RR 0.90 [95 % CI 0.62 to 1.32]) or survival to 30 days (RR 0.89 [95 % CI 0.41 to 1.92]) was found when comparing LUCAS with manual CPR.[560] Two studies compared LUCAS with manual CPR following IHCA.[561,562] One study enrolled patients with IHCA (but not in the emergency department) with non-shockable rhythms (n = 127).[561] No benefit in survival with favourable neurological outcome was found with LUCAS compared with manual CPR (RR 1.13 [95 % CI 0.13 to 9.72]). A trial enrolling patients sustaining witnessed cardiac arrest in the emergency department found no difference in ROSC when using a LUCAS device compared with manual CPR (RR 0.80 [95 % CI 0.55 to 1.173]).[562] No new RCTs reporting safety outcomes were identified in the ILCOR systematic review. Consistent with the ILCOR treatment recommendations, the ERC recommends considering mechanical chest compression only if high-quality manual chest compressions are not practical (e.g., during percutaneous coronary intervention or ECMO cannulation) or compromise provider safety (e.g. during transport). When a mechanical device is used, delays in the initial defibrillation attempt should be avoided and pauses to chest compression during device deployment minimised. Mechanical chest compression should only be used by trained teams familiar with the device.

Resuscitative endovascular balloon occlusion of the aorta (REBOA)

Resuscitative endovascular balloon occlusion of the aorta (REBOA) is a technique in which blood flow through the aorta is

occluded by inflating an intra-aortic balloon. The use of REBOA has not yet been addressed by ILCOR but was included in the scope of the ERC guidelines. REBOA has been used in the management of haemorrhagic shock and traumatic cardiac arrest.[563,564] However, in a recent RCT the in-hospital use of REBOA in patients with exsanguinating traumatic haemorrhage did not improve 90-day survival and may even have increased mortality compared with standard care alone.[565] It has recently been proposed as an adjunctive treatment for patients with non-traumatic cardiac arrest because of its potential to redistribute blood flow to organs proximal to the occlusion, thereby increasing cerebral and coronary perfusion.[566]

In animal models of non-traumatic cardiac arrest, inflation of REBOA increases central diastolic arterial pressure, which is a surrogate marker of coronary artery pressure and cerebral perfusion.[567,568] However, human evidence is currently limited to case reports[569–573] and small case series with a total of 78 patients.[574–582] These studies aimed to assess the feasibility of positioning REBOA during resuscitation. REBOA positioning was successful in 72 cases (92 %) and ROSC was achieved in 35 cases (45 %) but only 16 (20.5 %) had sustained ROSC. Approximately 80 % of patients with sustained ROSC died (13/16); of these, nearly half died from brain injury[570,571,577,582] and less frequently from withdrawal of life-sustaining treatment or re-arrest after balloon deflation.[576]

Currently, there are no data to support the use of REBOA in non-traumatic OHCA. There are two (one pre-hospital; one emergency department) ongoing efficacy RCTs which aim to evaluate the ability of REBOA to increase ROSC in adult, witnessed, non-traumatic cardiac arrest and its potential effects on survival and neurological outcome.[583,584]

Intra-arrest cooling

Cooling of patients during CPR may potentially alleviate reperfusion injury and prevent or reduce hypoxic-ischaemic brain injury. The most recent ILCOR systematic review on temperature control in cardiac arrest patients found no evidence of improved outcome in patients treated with pre-hospital cooling in patients with OHCA.[585–587] These reviews did not separate cooling conducted during or after ROSC. This may be important with respect of both the effects and side effects of the intervention. A systematic review focusing on cooling during CPR was published in 2021.[588] This review identified four RCTs (two of high certainty and two of moderate certainty of evidence) including 2305 patients that compared intra-arrest cooling with cooling started in the hospital.[467,589–591] Two studies used evaporative intranasal cooling: one used cooling with cold IV fluids (up to 2000 mL) and one used a combination of cold fluids (up 2000 mL) and external cooling with gel pads. In comparison with the control patients, the use of cooling during CPR was not associated with improved favourable neurological outcome (OR 0.96 [95 % CIs 0.68–1.37]; $p = 0.84$), any change in ROSC (OR 1.11 [95 % CIs 0.83–1.49]; $p = 0.46$) or survival to hospital discharge (OR 0.91 [95 % CIs 0.73–1.14]; $p = 0.43$). A further analysis of the method of intra-arrest cooling did not appear to influence the results. Therefore, the use of intra arrest cooling is not currently recommended by the ERC (unless there is severe hyperthermia). The ongoing PRINCESS 2 trial will assess the effect of intranasal evaporative cooling in patients resuscitated from a shockable initial rhythm.[592]

Extracorporeal CPR

Extracorporeal CPR (ECPR) is the rapid deployment of veno-arterial extracorporeal membrane oxygenation (VA-ECMO) during ongoing CPR to restore and maintain organ perfusion in patients in whom conventional CPR is unsuccessful in achieving a sustained ROSC.[593] The use of ECPR has continued to increase for both IHCA and OHCA in recent years[594] despite uncertainty in evidence.[595,596]

Since 2020, three RCTs of ECPR have been published. The Advanced Reperfusion Strategies for Patients with OHCA and Refractory Ventricular Fibrillation Trial (ARREST) demonstrated higher survival to hospital discharge with ECPR compared to conventional CPR in OHCA patients with an initial shockable rhythm.[597] The Prague OHCA study found improved survival with a favourable neurological outcome at 30 days but not at six months (primary outcome) among 264 patients with all-rhythms refractory OHCA.[598] Of note, these were both single-centre trials performed in well-established ECPR systems. A third, multi-centre trial conducted in 10 cardiosurgical centres, Early Initiation of Extracorporeal Life Support in Refractory OHCA Trial (INCEPTION) showed no difference between ECPR and conventional CPR in OHCA patients with an initial shockable rhythm.[599] Additionally, a small pilot RCT, the Extracorporeal Cardiopulmonary Resuscitation for Refractory Out-of-Hospital Cardiac Arrest (EROCA) trial, failed to meet the feasibility goal of transporting patients to an ECPR-capable emergency department within 30 min from OHCA.[600] A meta-analysis of these four trials demonstrated higher survival with favourable neurological outcome with ECPR compared to conventional CPR.[601] A Bayesian meta-analysis found a posterior probability of a clinically relevant ECPR-based treatment effect on 6-month neurologically favourable survival of 71 % in patients with all rhythms and 76 % in shockable rhythms.[602] For IHCA, RCTs have not been conducted, and a meta-analysis of observational data found that ECPR was effective in improving survival and favourable neurological outcomes.[603]

The use of ECPR during cardiac arrest was addressed by an ILCOR systematic review in 2022, which was updated in 2024.[192,596] The ILCOR ALS Task suggested, and the ERC recommends that ECPR may be considered as a rescue therapy for selected adults with IHCA and OHCA when conventional CPR is failing to restore spontaneous circulation in settings where this can be implemented (weak recommendation). The overall certainty of evidence was rated as low for OHCA and as very low for IHCA (downgraded further because all evidence was in OHCA).[1]

ECPR is not intended for the entire population of cardiac arrest patients, with only approximately 10 % of OHCA cases being eligible candidates.[598] However, there are no universally agreed selection criteria for ECPR, and practices vary widely among centres, particularly regarding the inclusion of older patients, those with initial non-shockable rhythms (pulseless electrical activity or asystole), and those with longer low-flow times. A recent systematic review and meta-analysis found that younger age, initial shockable rhythm, witnessed arrest, immediate CPR, pre-cannulation ROSC at any time, and shorter low-flow times are associated with increased likelihood of survival with favourable neurological outcome.[604] Adopting more liberal selection criteria impacts survival and survival with favourable neurological outcome[605–607] but also influences organ donation rates.[608] Conversely, more restrictive criteria may exclude potential survivors and organ donors.

The ERC, European Extracorporeal Life Support Organization (EuroELSO), European Society of Intensive Care Medicine (ESICM),

European Society of Emergency Medicine (EuSEM), European Society of Anaesthesia and Intensive Care (ESAIC), and the European Board of Cardiovascular Perfusion (EBCP) have produced consensus guidelines for ECPR in adults and the brief guidance below is based on these guidelines. Given the time-sensitive nature of ECPR, in systems where ECPR is available, it is crucial for clinicians to promptly recognise when a patient with ongoing ALS is in refractory cardiac arrest (i.e., three consecutive unsuccessful defibrillation attempts or 10 min of resuscitation in case of non-shockable rhythms) and might be a suitable candidate, enabling rapid activation of the ECPR team.

Currently used selection criteria for initiating ECPR include:

- Younger patients (upper age limit of 50–75 years), no perceived frailty, and absence of major comorbidities.
- Witnessed cardiac arrest with immediate CPR (i.e., a no-flow duration of $\leq$ 5 min)

In addition to the previous criteria, the following criteria are commonly applied:

- Initial shockable or PEA rhythms.
- Estimated time to establish ECPR from starting CPR (i.e., low-flow time) is ideally within 45 to 60 min.
- Known or suspected treatable underlying cause of cardiac arrest.
- ROSC at any time prior to cannulation.
- Presence of signs of life during CPR.
- $ETCO_2$ > 10 mmHg (1.3 kPa).
- Mechanical CPR during transport.

Whether initiating ECPR for OHCA in the pre-hospital setting is superior to in-hospital setting remains uncertain,[609–611] and ongoing clinical trials aim to address this question (ON-SCENE [ClinicalTrials.gov NCT04620070], RACE [NCT06789978], PACER [NCT06177730]).

Peri-arrest arrhythmias

Prompt identification and treatment of life-threatening arrhythmias may prevent cardiac arrest or its recurrence. This section offers guidance and treatment algorithms for the non-specialist ALS provider. The scope is to focus on arrhythmias occurring pre-arrest or immediately post-ROSC and causing life-threatening instability. In case of persistent arrhythmia, the first goal should be to ascertain the patient's stability and seek advice from a specialist or more experienced physician. Electrical cardioversion is required in the peri-arrest patient with a clinically unstable tachyarrhythmia, while pacing is used in refractory, clinically important bradycardia. The key interventions are summarised in Fig. 8. and Fig. 9.

These ERC Guidelines 2025 ALS follow recommendations published by international cardiology societies, including the European Society of Cardiology (ESC), the European Heart Rhythm Association (EHRA), the European Society of Cardiothoracic Surgeons, the American Heart Association (AHA), the American College of Cardiology (ACC) and the Heart Rhythm Society (HRS).[86,115,612–615] Table 6 summarises the supporting evidence for vagal manoeuvres and some of the more commonly used drugs for the treatment of arrhythmias.

Ventricular arrhythmias occurring peri-arrest usually originate from a complex interplay between underlying structural or electrical heart disease, external triggering factors and dominance of the sympathetic limb of the autonomic nervous system.[616] Reversible triggering factors include acute myocardial ischaemia, electrolyte imbalance, fever or hypothermia, hormonal factors, sepsis, starvation and decompensated heart failure.[617,618] For patients with wide QRS arrhythmias peri-arrest, expert help should be pursued whenever possible to either help with the termination of the arrhythmia or to prevent recurrences.

Treatment of ventricular arrhythmias depends on the haemodynamic consequences of the arrhythmia, its morphology on ECG and the underlying myocardial substrate.[617] For patients with monomorphic VT and structural heart disease or uncertain myocardial substrate, current European Society of Cardiology (ESC) guidelines (which are supported by the ERC) recommend synchronised external cardioversion, even when the patient is haemodynamically stable, as haemodynamic deterioration may occur if monomorphic VT is not treated. Pharmacological treatment may be an alternative if the risk of sedation/anaesthesia is high.[612]

For patients with polymorphic VT, precipitating factors should be sought and removed.[619] In case there is a prolongation of the QTc interval at baseline, IV Mg^{2+} and K^+ infusion might help. Also increasing heart rate with isoproterenol or temporary pacing should be considered.[620]

In the case of recurrent ventricular arrhythmias, uncontrolled with non-invasive measures, consider reprogramming the ICD (if one is already in place), suppressing sympathetic activity (beta-blockers, sedation, autonomic modulation), starting mechanical circulatory support and referring the patient for catheter ablation.[616,620]

The ESC has published recent guidelines for the acute management of regular tachycardias without an established diagnosis. The guidelines for treating regular narrow QRS ($\leq$ 120 ms) and life-threatening wide QRS (> 120 ms) tachycardias have been incorporated into the tachycardia algorithm. The ESC Guidelines provide more detailed recommendations and evidence for treating rhythms once a specific diagnosis of the rhythm has been made.[115]

In a randomised trial involving haemodynamically stable patients with wide QRS-complex tachycardia of unknown aetiology, procainamide was associated with fewer major adverse cardiac events and a higher proportion of tachycardia termination within 40 min, compared with amiodarone.[621] However, in many countries, procainamide is either unavailable or unlicensed.

In critical low-perfusion conditions like hypovolaemic, cardiogenic, or distributive shock, sinus tachycardia is a compensatory response to enhance blood flow to ischaemic tissues. In patients with sinus tachycardia, the primary focus of treatment should be to address the underlying cause of sinus tachycardia, such as through fluid administration. Rescuers should avoid trying to normalise the heart rate through rate-control strategies, such as beta-blocker administration, as this may result in patient deterioration or even haemodynamic collapse.

In acute settings, rescuers should evaluate and manage underlying causes or triggering factors that initiate AF such as sepsis, fluid overload or cardiogenic shock.[622] The selection of rate versus rhythm control strategy and the appropriate drug will depend on the patient's characteristics, the presence of heart failure and the haemodynamic profile.[623] In patients with AF and acute or worsening haemodynamic instability, electrical cardioversion is recommended.[624,625]

The rate of pharmacological cardioversion to sinus rhythm in patients with recent onset AF may be high, ranging from 50 to 95 % in 10 min to 6 h with the use of fast-acting drugs such as flecainide (200–300 mg orally once), propafenone (450–600 mg orally once), ibutilide (if patient <60 kg, 0.6 mg kg^{-1}; if patient >60 Kg, 1 mg IV. The dose may be repeated after 10 min if the initial dose is ineffective) and vernakalant (3 mg kg^{-1} IV over a 10-min period.

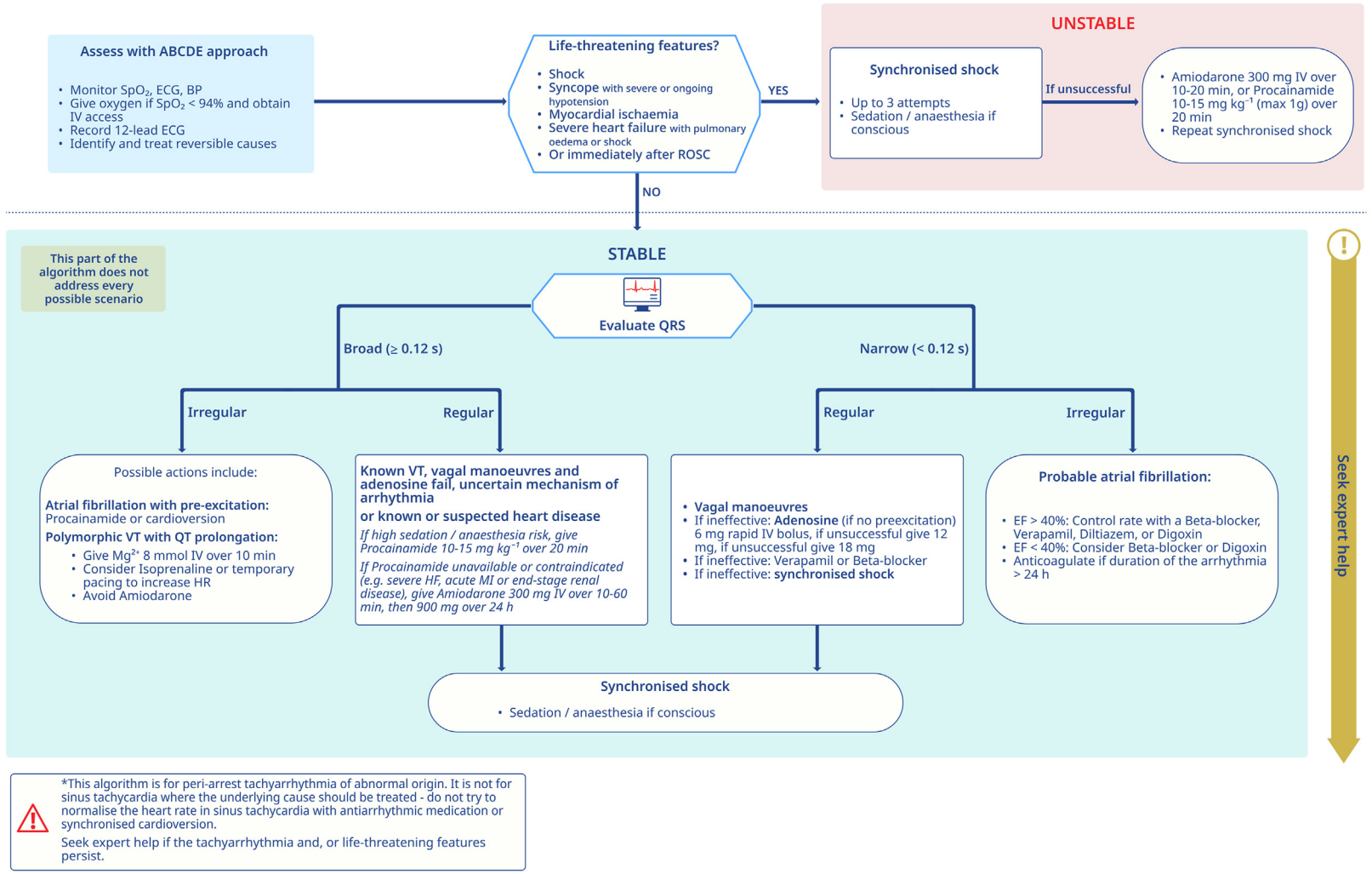


Fig. 8 – Peri-arrest Tachyarrhythmia Algorithm

ABCDE airway, breathing, circulation, disability, exposure; BP blood pressure; DC direct current; ECG electrocardiogram; EF ejection fraction; IV intravenous; ROSC return of spontaneous circulation; SpO_2 oxygen saturation measured with pulse oximetry; VT ventricular tachycardia.

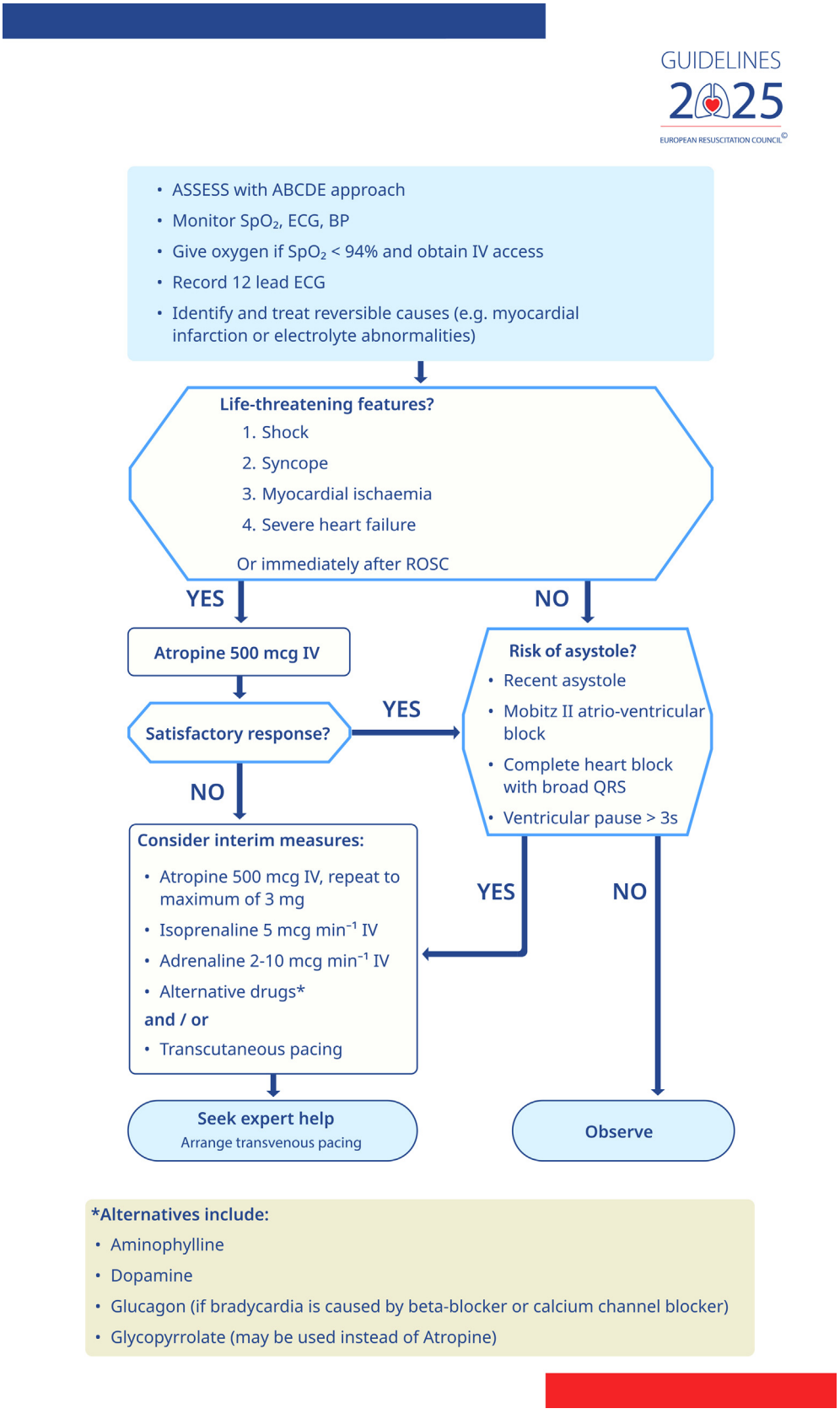


Fig. 9 – Bradycardia Algorithm

ABCDE airway, breathing, circulation, disability, exposure; BP blood pressure; ECG electrocardiogram; IV intravenous; SpO_2 oxygen saturation measured with pulse oximetry.

Table 6 – Recommendations for the acute management of narrow and wide QRS tachycardia. Drugs may be administered via peripheral IV in an emergency.

Drug/ procedure	Indication	Timing	Dose/delivery	Notes
Vagal Manoeuvres	Regular narrow QRS tachycardia Wide QRS tachycardia[612]		Blow into a 10 mL syringe with sufficient force to move the plunger	Preferably in the supine position with leg elevation[661,662]
Adenosine	Regular narrow QRS tachycardia Wide QRS tachycardia[612]	Recommended if vagal manoeuvres fail	Incremental, starting at 6 mg, followed by 12 mg IV. An 18 mg dose should then be considered	If no evidence of pre-excitation on resting ECG[115,663] When using an 18 mg dose, consider the tolerability/side effects in the individual patient.
Verapamil or diltiazem	Regular narrow QRS tachycardia	Consider if vagal manoeuvres and adenosine fail	Verapamil (0.075 – 0.15 mg/kg IV [average 5–10 mg] over 2 min) Diltiazem [0.25 mg/kg IV (average 20 mg) over 2 min].	Should be avoided in patients with haemodynamic instability, HF with reduced LV ejection fraction (<40)%[663]
Esmolol	Narrow QRS tachycardia Wide QRS	Heart rate control in SVT including AF and Atrial Flutter, and perioperative tachycardias Electrical storm	500 μg/kg IV optional bolus over 1 min followed by 50–300 μg/kg/min infusion	Short acting (elimination half-life 9 min), beta-1 selective, may be considered in patients with haemodynamic instability[625 616]
Landiolol	Narrow QRS tachycardia Wide QRS	Heart rate control in SVT including AF and Atrial Flutter, and perioperative tachycardias Electrical storm	Optional loading dose of 100 μg/kg IV over 1 min followed by 10–40 μg/kg/min infusion, or 1–10 μg/kg/min if impaired LV function	Ultra short half-life (about 4 min), beta-1 selective, may be considered in patients with haemodynamic instability[625 616]
Metoprolol	Narrow QRS tachycardia	Consider if vagal manoeuvres andadenosine fail	Metoprolol (2.5–15 mg given IV in 2.5 mg boluses),	For settings where Esmolol and Landiolol are not available
Procainamide	Wide QRS tachycardia	Consider if vagal manoeuvres and adenosine fail[612]	10–15 mg/kg IV over 20 min	[115,621]
Amiodarone	Narrow and wide QRS tachycardia	For acute management of VT or wide QRS tachycardia in the absence of an established diagnosis if vagal manoeuvres and adenosine fail[612]	300 mg IV over 10–60 min according to circumstances – followed by infusion of 900 mg in 24 h	Contraindicated in pre-excited AF-can – recognised by the fast, broad, irregular 'FBI' ECG pattern[115,612,664]
Lidocaine	Wide QRS tachycardia		50–200 mg bolus, then 2–4 mg/min	Reduce dose in shock states.
Magnesium	Polymorphic wide QRS tachycardia (torsades de pointes –TdP)		8 mmol[665] IV over 10 min. Can be repeated once if necessary.	Magnesium can suppress episodes of TdP without necessarily shortening QT, even when serum magnesium concentration is normal[612,616,666]

HF heart failure; LV left ventricular.

If AF persists 15 min after the completion of the initial infusion, a second dose of 2 mg kg^{-1} may be administered over 10 min).[626] However, only amiodarone is indicated in patients with severe left ventricular hypertrophy, heart failure with reduced ejection fraction and coronary artery disease, which are common in patients presenting with cardiac arrest.[627,628] The rate of successful restoration of sinus rhythm with amiodarone is 44 % at 8–12 h to several days after IV administration.[627] In selected patients, rate control may be preferred. For this purpose, beta-blockers and diltiazem/verapamil are preferred over digoxin because of their rapid onset of action and effectiveness in patients with high sympathetic tone. For patients with left ventricular ejection fraction less than 40 %, consider the smallest dose of beta-blocker to achieve a heart rate of less than 110 min^{-1} and add digoxin if necessary.[625]

Evidence for the treatment of patients with bradycardia was included in the American College of Cardiology (ACC)/American Heart Association (AHA)/Heart Rhythm Society (HRS) guidelines published in 2019, and these form the basis of the ERC bradycardia algorithm (Fig. 9. Bradycardia algorithm).[613] If bradycardia is accompanied by adverse haemodynamic signs, atropine remains the first-choice drug.[215] Conversely, atropine is ineffective and may worsen the block in patients with high-degree atrioventricular block and wide QRS complexes.[613] When atropine is ineffective, second-line drugs include isoprenaline (5 mcg.min^{-1} starting dose) and adrenaline (2 to 10 μg.min^{-1}). For bradycardia in cases of sympathetic denervation, such as heart transplant or spinal cord injury, consider giving aminophylline (100–200 mg, slowly IV).[613] Atropine can cause a high-degree AV block or even sinus arrest in heart transplant patients.[629]

Consider giving IV glucagon (one or more initial IV 3 to 10 mg push doses over 1–2 min. If effective, start a continuous infusion at 2–5 mg.h^{-1}) if beta-blockers or calcium channel blockers are themselves a potential cause of the bradycardia.[630] Consider pacing in unstable patients, with symptomatic bradycardia refractory to drug therapy (see below).

Cardioversion

Electrical cardioversion is the preferred treatment for tachycardia in the unstable patient displaying potentially life-threatening adverse haemodynamic signs (Fig. 8. ERC Peri-arrest Tachyarrhythmia algorithm).[612,614,616] The shock must be synchronised to occur with the R wave of the ECG: VF can be induced if a shock is delivered during the T wave which is a relative refractory portion of the cardiac cycle.[631] Synchronisation can be difficult in VT because of the wide-complex and variable forms of ventricular arrhythmia. Inspect the synchronisation marker carefully for consistent recognition of the R wave. If needed, choose another lead and/or adjust the amplitude. If synchronisation fails, give unsynchronised shocks to the unstable patient in VT to avoid prolonged delay in restoring sinus rhythm. Ventricular fibrillation (VF) or pulseless VT (pVT) require unsynchronised shocks. Conscious patients require anaesthesia or sedation before attempting synchronised cardioversion.

Cardioversion for atrial fibrillation. There is no single optimal position for external defibrillation electrodes. A meta-analysis of 10 RCTs comparing antero-posterior with antero-lateral electrode positioning in AF showed no difference in sinus rhythm restoration.[632] Applying active compression to the anterior defibrillation pad with antero-posterior pads is associated with lower defibrillation thresholds, lower total energy delivery, fewer shocks for successful electric cardioversion, and higher success rates.[302] More data are needed before specific recommendations can be made for optimal biphasic energy levels and different biphasic waveforms. Biphasic rectilinear and biphasic truncated exponential (BTE) waveforms show similar high efficacy in the elective cardioversion of atrial fibrillation.[633] An RCT showed that maximum fixed energy electrical cardioversion (360 J BTE) was more effective in achieving sinus rhythm one minute after cardioversion than an energy-escalating strategy.[634] There was no increase in adverse events. Starting synchronised shocks using the maximum defibrillator energy rather than an escalating approach is a reasonable strategy based on current data. In stable patients, follow appropriate guidelines on the need for anticoagulation before cardioversion to minimise stroke risk.[625]

Cardioversion for atrial flutter and paroxysmal supraventricular tachycardia. Atrial flutter and paroxysmal supraventricular tachycardia (SVT) generally require less energy than atrial fibrillation for cardioversion.[635] The ERC recommends giving an initial shock of 70–120 J. Give subsequent shocks using stepwise increases in energy, as required.

Cardioversion for ventricular tachycardia with a pulse. The energy required for cardioversion of VT with pulse depends on the morphological characteristics and rate of the arrhythmia. Ventricular tachycardia with a pulse responds well to initial shocks with energy levels of 120–150 J. Consider stepwise increases if the first shock fails to achieve sinus rhythm.[257]

Bradycardias and pacing. The treatment of bradycardia is summarised in Fig. 9. Consider pacing in unstable patients with symptomatic bradycardia refractory to drug therapy. Immediate pacing is indicated especially when the block is at or below the His-Purkinje level. Transvenous pacing should be established as soon as possible.[613,615] Consider transthoracic (transcutaneous) pacing as a bridge to transvenous pacing or when transvenous pacing is not readily available. Whenever a diagnosis of asystole is made start CPR, and when chest compressions are paused for a rhythm check look at the ECG carefully for the presence of P waves because this may respond to cardiac pacing. If there is no immediate electrical and mechanical capture with pacing restart CPR. The use of epicardial wires to pace the myocardium following cardiac surgery is effective. Do not attempt pacing for asystole unless P waves are present; it does not increase short or long-term survival in-hospital or out-of-hospital.[636,637] Transcutaneous pacing is a short term bridging measure and may not always be successful.[638] Monitor patients closely, and seek expert help early and arrange transvenous pacing for those patients who do not respond to medication, require transcutaneous pacing, or have an ongoing risk of asystole (Fig. 9).

For haemodynamically unstable, conscious patients with bradyarrhythmia, for whom transthoracic pacing is not readily available, percussion pacing may be attempted as a bridge to electrical pacing, although its effectiveness has not been established.[94,152,639] Give serial rhythmic blows with the closed fist over the left lower edge of the sternum to pace the heart at a physiological rate of 50–70 min^{-1}. Transthoracic and percussion pacing can cause discomfort, so consider giving analgesic or sedative drugs to conscious patients.

Uncontrolled organ donation after circulatory death

Less than half of patients achieve ROSC after resuscitation from cardiac arrest.[47,640] When standard ALS fails to achieve ROSC, there are three broad treatment strategies:[641]

- Stop resuscitation and declare death.
- In selected patients, consider ECPR.
- In settings with an uncontrolled organ donation after circulatory death (uDCD) programme, continue CPR to preserve organ perfusion and transport the patient to a hospital with a designated uDCD pathway, following local protocols and legal requirements.

This ERC Guidelines 2025 ALS focuses on uDCDs. These are defined as donors after unsuccessful resuscitation from unwitnessed (Maastricht category I) or witnessed (Maastricht category II) cardiac arrest, either in-hospital or out-of-hospital.[642] The ERC Guidelines 2025 on Post Resuscitation Care include guidance for organ donation pathways following brain death (donation after brain death: DBD) or controlled donation after circulatory death (cDCD, Maastricht category III donors) in patients who achieve ROSC or are treated with ECPR.[147,643] We acknowledge the ethical, cultural, and legislative issues that lead to variations in the use of uDCD.

There is a mismatch between the availability of organs and demand across the world. Uncontrolled donation after circulatory death (uDCD) provides an opportunity for cardiac arrest victims in whom ROSC cannot be achieved to become organ donors. In Europe, uDCD is currently undertaken in Austria, Belgium, Israel, Italy, Lithuania, Portugal, Russia, and Spain.[642,644] Organs that can be recovered include kidneys, liver, pancreas and lungs. In 2025, an ILCOR systematic review showed that the rates of early dysfunction (primary non-function or delayed graft function) of kidneys and long-term function of livers recovered from uDCD were higher than in DBD or cDCD.[1,645] However, in most studies, long-term graft function was comparable.[644,646–649] This difference may be partly due to the longer warm ischaemia time of uDCD compared with other organ recovery approaches.

There is no universal consensus on selection criteria for uDCD, and identifying a potential donor currently follows regional/national protocols. Criteria generally include age above those of consent (variable by nation, but usually above18 years) and not over 55–65 years, a no-flow time (the interval from emergency call or witnessed arrest to CPR start) within 15 min, and a total warm ischaemia time (the interval between cardiac arrest and the start of organ preservation) not longer than 150 min. Exclusion criteria generally include trauma, homicide, or suicide as a cause of arrest and comorbidities such as cancer, sepsis, and, according to local programmes and the targeted organ to transplant, kidney and liver disease.[650] In a 2024 study conducted on the Parisian registry, of 19,976 adult patients who were resuscitated from 2011 to 2020, 12,890 (65 %) had no ROSC, 9461 (47 %) met termination of resuscitation (TOR) criteria, and 6720 (52 %) could be considered for uDCD kidney donors.[640]

Uncontrolled donation after circulatory death is a time-critical, resource-intensive, complex and ethically challenging process.[651] Following the termination of resuscitation efforts, a 'no-touch' period is observed to rule out the possibility of autoresuscitation, i.e., ROSC after CPR has been stopped or life-sustaining measures have been withdrawn in the intensive care unit. In most countries where uDCD is practised, the prescribed duration of the no-touch period is five minutes,[652] but some require 20 min.[653] An updated systematic review on autoresuscitation identified seven observational studies, of which one investigated OHCA.[654] Among 840 patients whose resuscitation measures were terminated on site, the study reported five cases of ROSC occurring 3 to 8 min after cessation of CPR. Three of these five patients died on scene, while two died in hospital, one within 1.5 h and the other within 26 h.

After the no-touch period, organ preservation procedures are started and continued until consent for organ recovery is ascertained.[655–657] Obtaining consent from a surrogate decision maker (e.g., a family member) is particularly challenging for uDCD, given the unexpected nature of the arrest, the considerable time pressure, and the difficult environment of an emergency department. Establishing clear local protocols and legislative and societal acceptance is crucial for this process.[658] Previous consent registered on a donor card or a public registry is invaluable and must be rapidly retrieved. Adopting an opt-out system with implied consent to donation is an effective strategy to improve the rates of organ donation if the legal and cultural context allows.[659] The ERC Guidelines 2025 Ethics in Resuscitation includes further details on these issues.[4]

For abdominal organs, organ preservation typically uses extracorporeal circulation with membrane oxygenation via a femoro-femoral bypass.[658] Catheters with balloons are used to limit circulation to the abdominal cavity.[660]

Disclosures

Declarations of competing interests for all ERC Guidelines authors are displayed in a COI table which can be found online at https://doi.org/10.1016/j.resuscitation.2025.110769.

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Practice Guideline

European Resuscitation Council Guidelines 2025 Paediatric Life Support

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Abstract

These European Resuscitation Council Guidelines 2025 Paediatric Life Support (PLS) are based on the Consensus on Science with Treatment Recommendations (CoSTR) of the International Liaison Committee on Resuscitation (ILCOR) and rapid reviews performed by the ERC Writing Group Paediatric Life Support of topics not covered by ILCOR. These Guidelines provide recommendations on the prevention of cardiac arrest, basic life support, advanced life support, resuscitation in special circumstances, post-resuscitation care, prognostication, and post-discharge care in infants, children and adolescents add brackets (aged 0–18 years), but does not cover resuscitation of the neonate at birth. The recommendations have been formulated for healthcare providers who take care of children and for the general public and includes recommendations on how to implement the Guidelines and system factors. Stakeholders from a range of health care settings were involved in the Guidelines development process and the views of the community advisors representing families of paediatric cardiac arrest survivors and non-survivors were also considered.

Keywords: Paediatric cardiac arrest, paediatric basic life support, paediatric advanced life support, post-resuscitation care, prognostication, post-discharge care, critically ill child, critically injured child

Abbreviations: ABCDE, Airway, Breathing, Circulation, Disability, Exposure, ABG, Arterial-blood-gas (analysis), AED, Automated external defibrillator, AVPU, Alert-Verbal-Pain-Unresponsive, BBB, Behaviour, Breathing, Body colour, BLS, Basic Life Support, BMI, Body mass index, BP, Blood pressure, CoSTR, Consensus on Science with Treatment Recommendations, CPR, Cardiopulmonary resuscitation, ECG, Electrocardiogram, ECMO, Extracorporeal membrane oxygenation, ECPR, Extracorporeal cardiopulmonary resuscitation, EEG, Electroencephalography, EMS, Emergency medical service, ERC, European Resuscitation Council, $ETCO_2$, End-tidal carbon dioxide, FiO_2, Fraction of inspired oxygen, GCS, Glasgow Coma Scale, HOPE, Hypothermia Outcome Prediction after Extracorporeal life support, HOTT, Hypotension, Oxygenation (hypoxia), Tension pneumothorax and cardiac Tamponade, HR, Heart rate min^{-1}, ICU, Intensive care unit, IHCA, In-hospital cardiac arrest, ILCOR, International Liaison Committee on Resuscitation, IM, Intramuscular, IO, Intraosseous, IV, Intravenous, MAP, Mean arterial pressure, NIBP, Non-invasive blood pressure, NLS, Newborn Life Support, OHCA, Out-of-hospital cardiac arrest, $PaCO_2$, Partial pressure of carbon dioxide in arterial blood, PALS, Paediatric advanced life-support, PaO_2, Partial pressure of oxygen in arterial blood, PBLS, Paediatric basic life support, PCR, Polymerase chain reaction, PEA, Pulseless electrical activity, PEEP, Positive end expiratory pressure, PLS, Paediatric Life Support, PLS WG, Paediatric Life Support Writing Group, POCUS, Point-of-care ultrasound, pVT, Pulseless ventricular tachycardia, ROSC, Return of spontaneous circulation, RR, Respiratory rate min^{-1}, SBAR, Situation, Background, Assessment, Recommendation, SGA, Supraglottic airway device, SpO_2, Arterial oxygen saturation as measured by pulse oximetry, SvO_2, Mixed venous oxygen saturation, SVT, Supraventricular tachycardia, VF, Ventricular fibrillation, VT, Ventricular tachycardia

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Introduction

These European Resuscitation Council (ERC) Resuscitation Guidelines 2025 on Paediatric Life Support (PLS) is based on evidence from the International Liaison Committee on Resuscitation (ILCOR) and from rapid reviews performed by the ERC Paediatric Life Support Writing Group (PLS WG). These PLS WG rapid reviews addressed topics formulated as questions in PICOST (Population, Intervention, Comparison, Outcomes, Study design, Timeframe) format using a stepwise methodology of identifying and analysing relevant literature similar to that used in the Cochrane rapid reviews.[1] The full methodology of our reviews is available from the authors on request.

Where there was insufficient evidence on a topic either from ILCOR or from our rapid reviews, we reached consensus by iterated discussions within the PLS WG. Where no new evidence was available, we kept our recommendations consistent with previous guidelines. We also considered comments from representatives of the community mentioned in the list of collaborators for these Guidelines. In our evidence to decision process, we considered the formula for survival (science, education and implementation). We included information on how our recommendations can be implemented in different systems, including access-limited, resource-limited and context-limited healthcare settings.[2] The Guidelines describe general principles and recommendations but cannot fully describe the detailed care for individual children, especially those with rare or complex chronic conditions or special medical needs. In general, the recommendations described in these Guidelines are presented as the standard of care when there is no reason to further individualise the approach.

Paediatric patients are defined as persons aged 0–18 years of age. In these Guidelines, we use the term 'children' to encompass all age categories. When distinguishing between age groups, e.g. for specific skills or techniques, we use the word 'infant' for neonates and children up to 1 year, the words 'child' for children aged 1–12 years and the word 'adolescents' for teenagers aged 13–18 years.

The ERC Guidelines 2025 Newborn Life Support (NLS) are primarily intended for newborns at birth (shortly after delivery). The transition phase from fetus to neonate at birth involves major physiological changes. The duration of this phase is variable and there is a lack of scientific data to define when it ends. This makes it difficult to recommend a specific time point at which an infant should be resuscitated according to the ERC Guidelines 2025 NLS or PLS, and this is particularly true for preterm neonates. The PLS and NLS WGs agree that all neonates discharged from a maternity or neonatal unit to home should be resuscitated using the PLS Guidelines. We also recommend that hospitals, maternity and neonatal units, and health care teams establish clear protocols specifying which algorithm should be applied to which paediatric population. These protocols should be incorporated into local resuscitation educational programs.[3] Further details about this topic can be found in the ERC Guidelines 2025 Newborn Life Support of transition of infants at birth.[4]

The ERC also acknowledges that distinguishing adolescents from adults can sometimes be challenging. If the rescuer considers a person to be an adult, they should use the adult algorithm, otherwise, they should use the paediatric algorithm. The differences in adult and paediatric resuscitation algorithms are primarily based on the distinct causes of cardiac arrest. However, if an adult person is mistakenly resuscitated using a paediatric algorithm, little or no harm will occur as studies of aetiology have shown that the paediatric causes of arrest continue into young adulthood.[5–7]

Paediatric cardiac arrest is a rare event that can have devastating consequences for patients, their families and society. Despite the fact that cardiac arrest in children comprises a mere fraction of all cardiac arrests, their overall impact on society may be far reaching given the long-term consequences.[8] These consequences may include increased lifelong health care costs and impaired ability to deal with daily life, which can limit participation in society during adulthood, including work force participation. Despite some improvements in overall survival worldwide, the rate of survival with good neurological outcome after paediatric out-of-hospital cardiac arrest (OHCA) remains poor with major differences across Europe.[9,10] This highlights the need for novel approaches to science, prevention, resuscitation and training.[11–13] A European registry of all paediatric cardiac arrests would provide insights, which would be of help in this process. Children from lower socioeconomic environments and racial or ethnic minorities seem to be disproportionately impacted by cardiac arrest and specific interventions targeting these populations are needed.[14] Half of all paediatric OHCAs have a distinguishable reversible cause with hypoxia being the most prevalent of these.[15,16] In adolescents, trauma, intoxications and suicide attempts are among the leading causes of OHCA.[17] Therefore, preventing traffic accidents, violence, drug abuse, and improving mental health seem to be reasonable society-level strategies to prevent cardiac arrest in this age group. Exercise-related paediatric OHCAs are rare but are associated with higher survival rates.[18] Paediatric in-hospital cardiac arrest (IHCA) has better outcomes compared with paediatric OHCA, particularly in institutions adhering to guidelines and implementing quality-improvement initiatives, in which there has been a steady rise in survival in recent decades.[15,19–21] The main causes of paediatric IHCA are respiratory failure and shock.[11] Common causes of perioperative paediatric IHCA include hypoxia (e.g. airway management problems), bradycardia and haemorrhage.[22,23] Paediatric IHCA is most common in neonates, infants, and children with complex chronic conditions, especially congenital heart disease.[20,23,24]

The ERC guidelines address all aspects of resuscitation as outlined in the Chain of Survival which can be applied to resuscitation of patients of all ages (Fig. 1): prevent cardiac arrest, early CPR and defibrillation, advanced life support and post-resuscitation care, and survival and recovery.

In paediatric resuscitation, the initial phase of prevention is most important as cardiac arrest in children can be prevented by quick and effective treatment of a range of life-threatening illnesses. This approach, which is integral and crucial to paediatric resuscitation, is outlined in the sections of the prevention of cardiac arrest and on special circumstances of these ERC Guidelines 2025 PLS. The phases of paediatric basic life support (PBLS) and paediatric advanced life-support (PALS) are specifically addressed in separate sections and, in line with the chain of survival, this chapter also includes more extensive sections on post-resuscitation and post-discharge care than was included in previous paediatric guidelines.

These ERC recommendations have been formulated for healthcare systems (e.g. hospitals, manufacturers of devices, dispatch centres, emergency medical services and emergency departments),

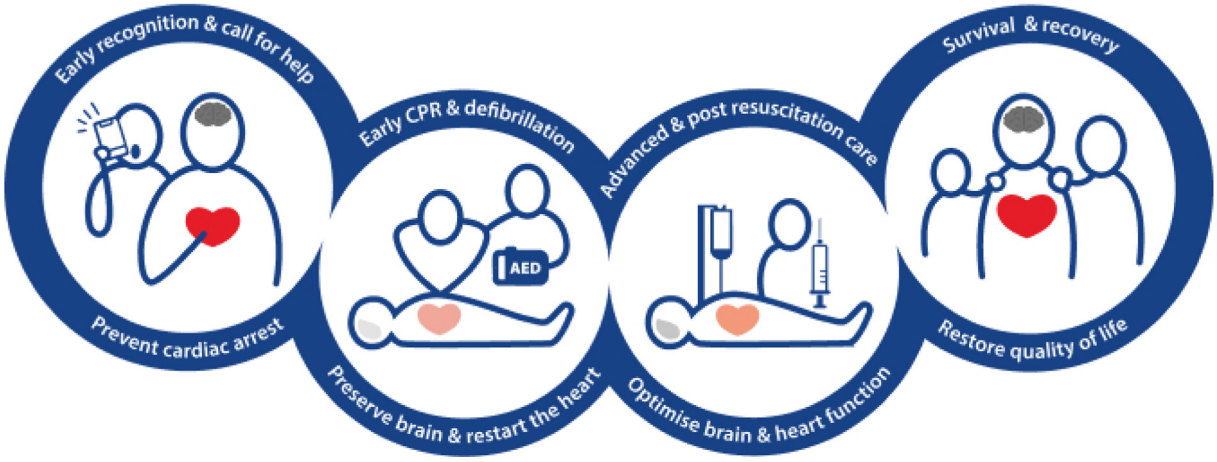


Fig. 1 – Chain of survival

healthcare professionals and the public. The detailed evidence underpinning these pragmatic recommendations is reviewed and discussed in the evidence supporting the guidelines section.

The ERC Guidelines 2025 PLS were drafted and agreed by the ERC PLS Writing Group members and the ERC Guidelines 2025 Steering Committee. These Guidelines were posted for public comment between 15 May and 30 May 2025. A total of 53 individuals submitted 89 comments, leading to 43 in the final version. Subsequently, the feedback was reviewed by the PLS writing group, and the Guidelines were thereafter updated where relevant. The ERC Guidelines 2025 PLS were presented to and approved by the ERC Board and the ERC General Assembly in June 2025. The methodology used for guideline development is presented in the Executive summary.[25] (Fig. 2 and Table 1)

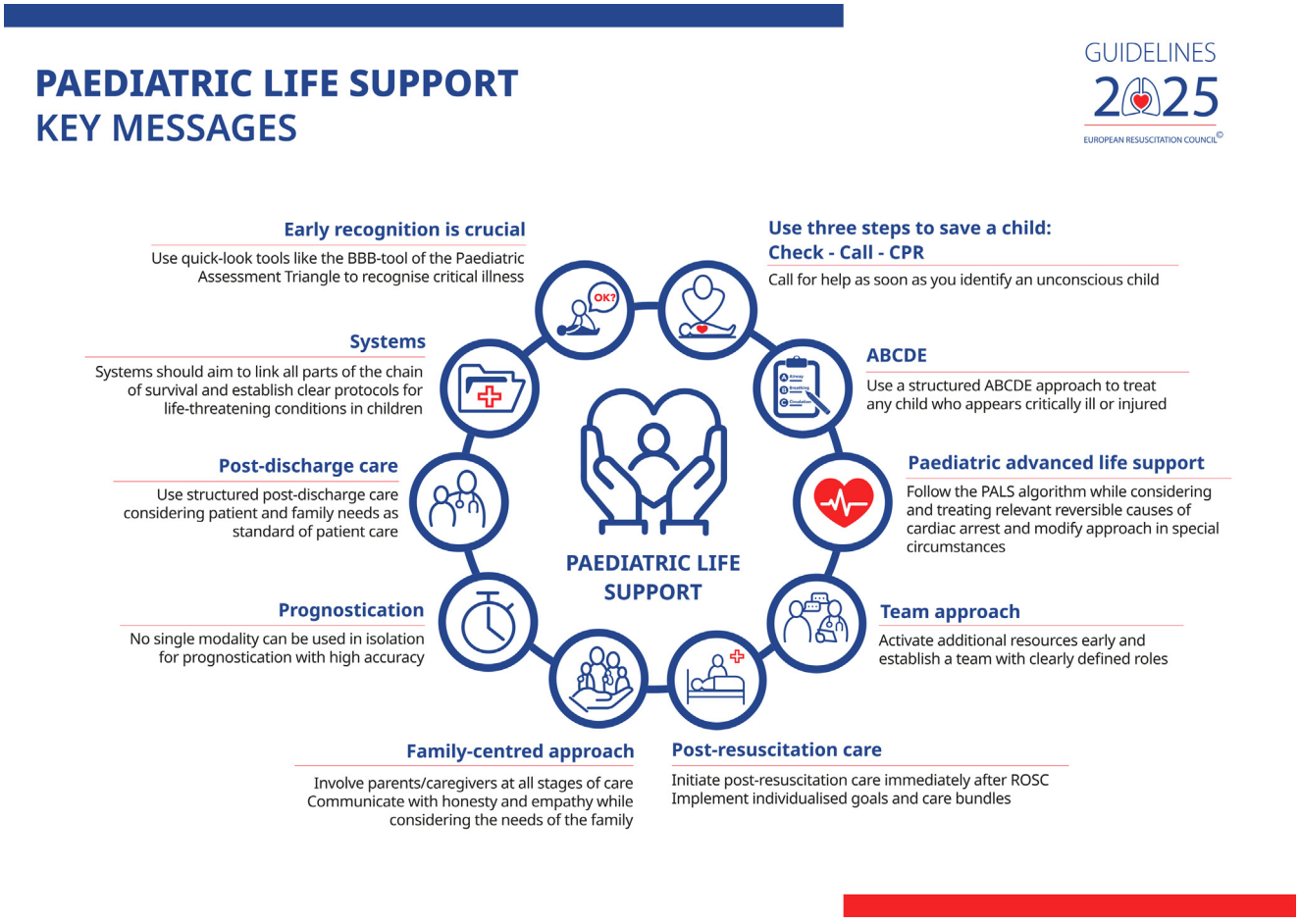


Fig. 2 – Paediatric Life Support – key messages

Table 1 – Comparison of ERC Guidelines Paediatric Life Support 2021 and 2025.

Topic	2021 Guidelines	2025 Guidelines
Recommendations for the public and systems	Not included.	Specific recommendations have been added for the public, parents/caregivers and community carers and for guideline implementation at systems level.
Prevention of cardiac arrest	Atropine could be considered as premedication before tracheal intubation. Recommended to avoid multiple attempts at tracheal intubation. Suggested phenytoin/fosphenytoin, valproic acid or levetiracetam as second line medication for seizures. Recommended treating hypoglycaemia with 0.3 g kg^{-1} glucose IV bolus.	Atropine is no longer recommended as premedication before intubation. Limit the number of tracheal intubations attempts to two. Recommends a new algorithm for seizures, with levetiracetam as the preferred second line medication. Hypoglycaemia is treated with 0.2 g kg^{-1} glucose IV bolus.
Paediatric Basic Life Support	Recommended calling for help before initiation of chest compressions and that the two-finger technique for infant chest compressions could be considered by a single rescuer.	Call for help and EMS as soon as cardiac arrest is suspected. The two-thumbs encircling technique for chest compressions in infants is recommended for all situations.
Foreign body airway obstruction	Recommended to perform Chest thrusts in infants using the two-finger technique.	Chest thrusts in infants should be performed using the two-thumbs encircling technique.
Defibrillation	Recommended using either the anteroposterior or anterolateral pad position in children.	The anteroposterior position for defibrillation pads is recommended for all infants and children weighing less than 25 kg. Use the anteroposterior or the anterolateral position in larger children and adolescents. Public access defibrillators should have a uniform pad size for cardiac arrest patients of all ages.
Special circumstances	Information on special circumstances was distributed throughout the guidelines. In cardiac arrest caused by hyperkalaemia use calcium, bicarbonate, and insulin with glucose. In hypothermic cardiac arrest, do not give adrenaline below 30 °C.	A specific new subchapter on special circumstances has been included. In cardiac arrest caused by hyperkalaemia use IV insulin with glucose and IV short acting $beta_2$-adrenergic agonists or a combination of these; calcium and bicarbonate should not be used. In hypothermic cardiac arrest, give a single dose of adrenaline below 30 °C, unless planning immediate extracorporeal life support.
Post-resuscitation care and prognostication	A short paragraph on post-resuscitation care and prognostication was included. Recommended targeting the 5^{th} percentile for blood pressure for age.	An extended subchapter on post-resuscitation care, including infographics for the pre-hospital and in-hospital approach to post-resuscitation care and prognostication has been included. Maintain the blood pressure above the 10th percentile for age (MAP and systolic BP).
Post-discharge care	Not included.	A new subchapter on post-discharge care has been added including an infographic.

Concise guidelines for clinical practice

Prevention of cardiac arrest

Cardiac arrest in infants, children and adolescents is often secondary to progressive respiratory or circulatory failure or to neurological emergencies. Therefore, the recognition and proper management of critically ill children remains the best way to prevent cardiac arrest.

Recommendations for caregivers and other untrained rescuers

- All parents and caregivers should be encouraged to learn basic recognition of critical illness and trauma and basic first-aid life-saving procedures.
- Simple recognition using triage tools and basic first-aid life-saving procedures should be taught to professional caregivers for children, including child minders, schoolteachers, first responders, lifeguards and coaches/trainers of children and adolescents.
- Immediately call for medical help or call the emergency medical service (EMS) if a child has signs or symptoms that might indicate critical illness such as those described in the BBB-tool namely:
  - **Behaviour**: A child who:
    - is not fully conscious or is difficult to rouse, floppy or rigid,
    - is having a seizure,
    - is confused, agitated, or interacting abnormally with the parents/caregivers,

- is crying inconsolably,
- is not able to move one or more limbs, and/or
- has severe pain or is unable to speak or walk, if previously able to do so.

- **Breathing**: A child who has difficulty breathing, such that they:
  - are unable to take a deep breath,
  - are working hard to take each breath (breathing fast, grunting, flaring of the nostrils, and indrawing between or under the ribs),
  - are making additional noises while breathing,
  - are breathing too fast, too slowly or irregularly, stops breathing, and/or
  - adopt an abnormal posture to aid breathing.
- **Body colour**:
  - The child's skin is cyanosed (blue), mottled, abnormally pale or greyish. Look at the hand palms, soles of the feet and mucosal membranes especially in children with darker skin tones.

- Parents/caregivers of children with specific chronic conditions (e.g. children who are dependent on medical equipment, who have a tracheostomy, cardiac conditions, malignancy, or who were born with a low birth weight) should have an emergency plan available for any sudden deterioration and caregivers should be familiar with this and trained in initial life-saving procedures.

Recommendations for healthcare professionals (Fig. 3)

- Identify children with an increased risk of cardiac arrest and formulate a care plan for these children.
- Use a dedicated quick-look tool (e.g. the above-mentioned BBB-tool or the paediatric assessment triangle) for the early recognition of a potentially critically ill child.
- Consider your own safety. Use appropriate personal protection equipment when indicated.
- Immediately perform an initial ABCDE assessment in any child who appears to be critically ill or severely injured (Fig. 3). Initiate life-saving interventions as soon as a problem is identified.
- Activate additional resources (e.g. personnel, equipment) and establish a team with clearly defined individual roles and responsibilities as soon as possible.
- Use cognitive aids such as displayed algorithms and checklists to decrease cognitive load.
- Reassess the child after any intervention or when in doubt.
- Ask caregivers for an estimate of the child's weight or estimate this using length-based methods, which should ideally be corrected for body-habitus.
- Use an individualised approach or modify interventions for children with chronic medical conditions or specific medical needs. Ask a parent/caregiver for relevant information about the condition if they have this.
- At all times allow parents/caregivers to stay with the child if this does not preclude their safety or the safety of the child or personnel.
- Include parents and those with parental responsibility in discussions and decision-making.
- Assign a dedicated team member to the care of parents or caregivers, and ensure they are fully informed at all stages.

Recognition of the critically ill or injured child.

- Airway
  - Check the patency of the airway and the presence of airflow using the look-listen-feel method.
  - Consider stridor or snoring to be a sign of partial airway obstruction.
  - Allow a conscious child to adopt the most comfortable position, do not force them to lie down.
- Breathing
  - Check for signs of respiratory insufficiency (Tables 2 and 3). Assess:
    - Work of breathing (respiratory rate, recession, grunting, nasal flaring, tracheal tug, positioning).
    - Effectiveness of breathing (chest expansion, character and strength of crying/speaking), auscultation (reduced air entry, symmetry, wheeze or crepitations), skin colour (cyanosis), arterial oxygen saturation.
    - Systemic signs (heart rate, conscious level).
  - Monitor arterial oxygen saturation by pulse oximetry (SpO_2) continuously. Be aware that a pulse oximeter can be less reliable in children with darker skin tones or poor peripheral perfusion.
  - Monitor capnography (end-tidal carbon dioxide, ($ETCO_2$)) in all patients with an advanced airway (i.e. a tracheal tube or supraglottic airway device (SGA)). Consider capnography in patients with non-invasive ventilation.
  - Consider point of care ultrasound (POCUS) of the lungs and blood gas analysis.
  - Use multiple variables to recognise respiratory failure as no single sign in isolation is indicative of this. Trends are more important than a single value.
- Circulation
  - Check for signs of cardiovascular insufficiency (Tables 2 and 3).
    - Cardiovascular signs (heart rate, pulse volume (peripheral and central), blood pressure, preload (jugular veins, liver span, crepitations).
    - Organ perfusion (capillary refill time, skin colour and temperature, urinary output, level of consciousness).
  - Attach an ECG-monitor, to assess the rhythm, and a non-invasive blood pressure (NIBP) monitor/device.
  - Consider serial lactate measurements if signs of shock are present.
  - Consider POCUS, which might help to distinguish the cause and type of shock.
  - Consider a 12-lead ECG.
  - Use multiple variables to recognise circulatory failure (shock) and the type of shock; no single sign in isolation is indicative of shock. Trends are more important than a single value.
- Disability
  - Check conscious level using the AVPU (Alert-Verbal-Pain-Unresponsive) scale, (paediatric) Glasgow Coma Scale (GCS) total score, or the GCS motor score, pupil size, symmetry, and reactivity to light and the presence of posturing or focal neurological signs.
  - Recognise seizures as a neurological emergency.
  - Check blood glucose.

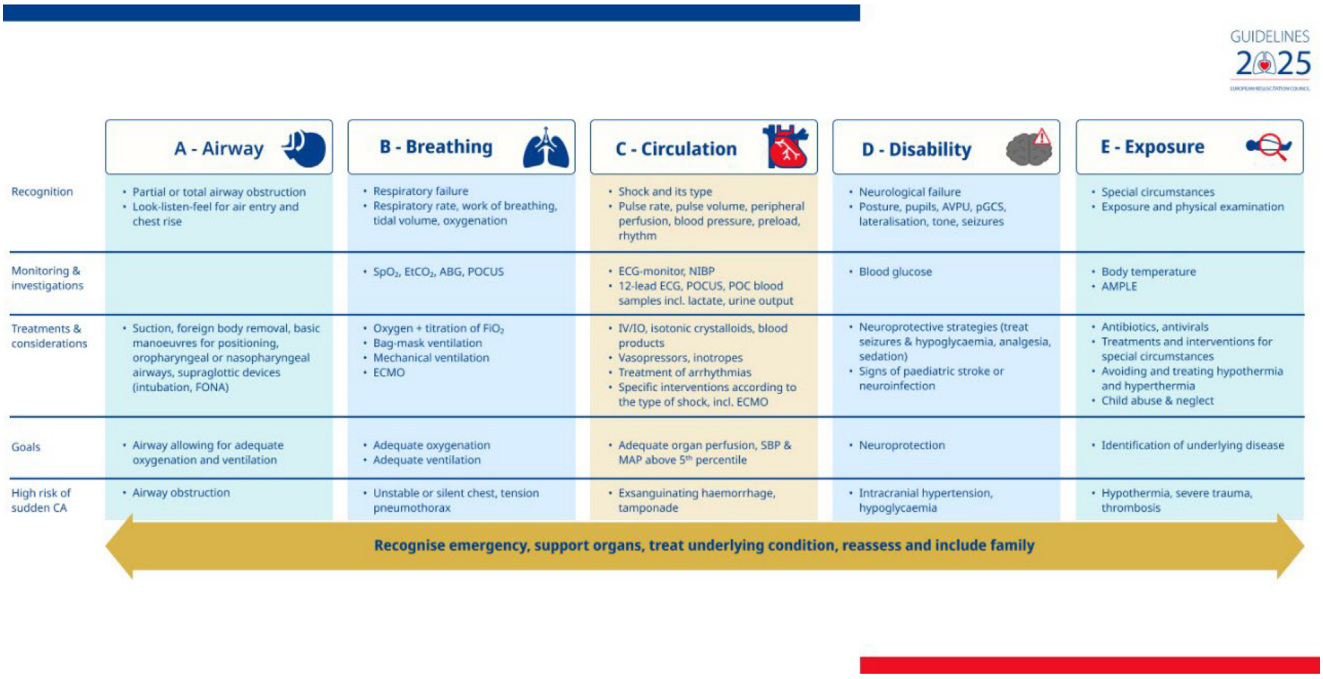


Fig. 3 – Management of critically ill/injured child using the ABCDE approach.
Abbreviations: FONA – front-of-the-neck airway, CA – cardiac arrest, SpO_2 – peripheral oxygen saturation, $EtCO_2$ – end-tidal carbon dioxide, FiO_2 – fraction of inspired oxygen, ABG – arterial blood gas, POCUS – point-of-care ultrasound, POC – point-of-care, ECMO – extracorporeal membrane oxygenation, ECG – electrocardiography, NIBP – non-invasive blood pressure, AVPU – Alert Voice Pain Unresponsive, pGCS – paediatric Glasgow coma scale, AMPLE – Allergy Medication Past history Last meal, Exposure/Environment

- Consider urgent brain imaging if neurological symptoms persist after ABC resuscitation.

- Exposure
  - Check body temperature.
  - Undress the child and look for rashes, injuries and signs of physical child abuse and neglect.
  - Look for signs and symptoms of potentially life-threatening conditions as described further below (e.g. anaphylaxis, sepsis).
  - Try to identify any underlying conditions that might require a specific approach (e.g. intoxication, underlying chronic conditions).
  - Use AMPLE (Allergy, Medication, Past history, Last meal, Eventd) to quickly establish a basic medical history.

Table 2 – Approximate normal values for respiratory rate, heart rate and blood pressure.
The values change continuously as the child grows. Use intermediate values for children between the specified ages in the table.[26–28]

Age	1 month	1 year	2 years	5 years	10 years	18 years
Upper limit of normal range for RR	60	50	40	30	25	20
Lower limit of normal range for RR	25	20	18	17	14	12
Upper limit of normal range for HR	180	170	160	140	120	100
Lower limit of normal range for HR	110	100	90	70	60	60
p50 for systolic BP	75	95	98	100	110	120
p10 for systolic BP	55	75	77	80	85	105
p5 for systolic BP	50	70	73	75	80	90
p50 for MAP	55	70	73	75	75	75
p10 for MAP	45	55	58	60	60	65
p5 for MAP	40	50	53	55	55	60

Abbreviations: RR = respiratory rate, HR = heart rate, BP = blood pressure, MAP = mean arterial pressure p50/p10/p5 = $50^{th}/10^{th}/5^{th}$ percentile of BP for the 50th percentile of child's height at that age

Table 3 – Clinical signs of respiratory and circulatory failure.
Individual deviations are common especially in children with chronic medical conditions. Be aware that cardiovascular collapse can also occur suddenly without any preceding symptoms or signs. Always use multiple variables to diagnose failure.

	Compensated	Decompensated (risk of cardiac arrest)
Respiratory failure	Tachypnoea Increased work of breathing Normal, increased or slightly decreased tidal volumes Wheezing Mild to moderate hypoxaemia (e.g. SpO_2 90-93% breathing air) Normocapnia or hypocapnia Agitation	Bradypnoea, irregular breathing Decreasing work of breathing Grunting Diminished chest excursions and/or air entry (silent chest) Severe hypoxaemia (SpO_2 <90% breathing air) Hypercapnia Decreased level of consciousness
Circulatory failure (shock)	Tachycardia Impaired peripheral perfusion Decreased peripheral pulsations Normal blood pressure Agitation	Bradycardia Diminished central pulsations Hypotension Decreased level of consciousness

- Be alert to conditions in which cardiac arrest is imminent such as: airway obstruction, flail chest, silent chest, tension pneumothorax, massive haemorrhage, cardiac tamponade, intracranial hypertension, hypoglycaemia with coma, hypothermia, severe trauma and thrombosis.

Principles of the management of the critically ill or injured child

- Airway
  - Establish airway patency to enable adequate oxygenation and ventilation.
  - Open the airway and keep it open. Use adequate positioning of the head and body alignment (head tilt and chin lift or jaw thrust), remove secretions and other obstructing materials by careful suctioning if necessary.
  - Consider a nasopharyngeal or oropharyngeal airway of the appropriate size in children with a decreased level of consciousness.
  - Use a supraglottic airway device (laryngeal mask, i-gel), when indicated, only if you are competent in its use.
  - Intubate the trachea of a child, when indicated, only if you are competent and experienced and have the necessary materials and medications immediately available and use a well-defined operating procedure.
    - Always have a plan for difficulties with the airway (e.g. SGA-insertion, additional expertise).
    - Preoxygenate the child before induction of anaesthesia, avoid distending the stomach.
    - Use sedative and neuromuscular blocking medication with a rapid onset of action, unless the child is deeply comatose.
    - Do not use atropine as premedication routinely.
    - The oral route for tracheal intubation is preferable during emergencies.
    - Use direct or video laryngoscopy for tracheal intubation depending on local protocols and rescuer experience.
    - Provide oxygen during airway management (apnoeic oxygenation, high-flow nasal oxygen) to avoid hypoxia during the procedure.
    - Do not attempt intubation more than twice and limit each attempt to 30–60 s. Monitor SpO_2, heart rate and blood pressure during intubation and stop the attempt immediately in case of bradycardia or oxygen desaturation. Immediately recommence bag-mask ventilation or insert an SGA to restore oxygenation.
    - Use cuffed tracheal tubes for all children. Monitor and limit cuff inflation pressure according to the manufacturer's recommendations.
    - Provide adequate analgosedation during and after intubation.
    - Confirm tube placement clinically and using $ETCO_2$ monitoring (providers with expertise may use POCUS in addition). Monitor SpO_2 and $ETCO_2$ continuously in all children with an advanced airway. Confirm the tube position with X-ray as soon as practicable.
  - Use a front-of-neck airway (e.g. cricothyroidotomy) only as a last resort option in cannot-ventilate-cannot-oxygenate situations. This should be performed by an individual trained in invasive airway techniques.
  - In children with tracheostomies, who develop difficulty breathing, suspect an obstruction of the tracheostomy tube.
    - Try to relieve the obstruction by suctioning the tracheostomy tube.
    - If a suction catheter cannot be passed, the tracheostomy tube should be removed immediately and replaced.
    - If a clean tube is not available, oxygen and ventilation via bag and mask should be given until the tube is cleaned and replaced.
    - If the child's upper airway is patent it may be possible to provide oxygen and bag-mask ventilation via the nose and mouth whilst the tracheal stoma site is occluded.
    - If the upper airway is not patent it may be possible to provide oxygen and bag-mask ventilation at the tracheostomy stoma site using a small face mask (or the end of an LMA used as a mask) over the stoma site.
    - In an emergency, tracheal intubation via the tracheostomy or upper airway (if patent) with a tracheal tube may be needed.
- Breathing
  - Aim for adequate oxygenation and ventilation.
  - Initially give 100 % oxygen for all children with respiratory, circulatory, or neurological failure.

- Titrate the fraction of inspired oxygen (FiO_2) as soon as the SpO_2 can be monitored and avoid sustained readings of 100 % (except in special circumstances, e.g. carbon monoxide intoxication, methaemoglobinaemia, cyanide poisoning or severe anaemia).
- In previously healthy children aim for an SpO_2 of 94–98 %. The goal is to achieve an SpO_2 of at least 94 % with the lowest possible FiO_2.
- Consider individualised targets for SpO_2 and $ETCO_2$ in children with specific conditions (e.g. cyanotic congenital heart defects, chronic respiratory failure).
- Consider high-flow nasal oxygenation or non-invasive ventilation in children with hypoxaemia not responding adequately to conventional oxygen therapy.
- Support inadequate spontaneous ventilation, using bag-mask ventilation as the first-line method.
  - Ensure correct head positioning, mask size and proper seal between the mask and the face.
  - Use a two-person approach (using both hands to hold the mask and to keep the airway open), especially if ventilation is difficult or when there is a risk of disease transmission. Consider airway adjuncts (e.g. oropharyngeal device).
  - Use an appropriately sized bag and sufficiently long inspiratory times to make the chest visibly rise (mild chest movements). Avoid hyperinflation and high peak inspiratory pressure.
  - Aim for a normal respiratory rate for the child's age (pragmatically use the following rates per minute: 25 in infants, 20 in children >1 y, 15 in children >8 y, 10 in children >12 y).
- Consider the early insertion of an SGA or tracheal tube in cases when bag-mask ventilation does not improve oxygenation or ventilation or when prolonged respiratory support is anticipated.
- Check air leak, signs of aspiration, efficacy of ventilation in patients with SGA or tracheal tube.
- In mechanically ventilated children:
  - Use tidal volumes of 6–8 ml kg^{-1} of ideal body weight and a respiratory rate at a low-normal range for the child's age (Table 2).
  - Start with a positive end expiratory pressure (PEEP) of 5 cm H_2O and adjust PEEP and FiO_2 to improve oxygenation, always titrating these to the minimum support needed to achieve the desired targets.
  - Individualise ventilator settings in specific conditions, seek the advice of a paediatric intensivist early if possible.
  - Minimise apparatus dead space, especially in infants.
  - Avoid both hyperventilation and hypoventilation. Monitor $ETCO_2$ and aim for normocapnia. Check partial pressure of carbon dioxide in arterial blood ($PaCO_2$) as soon as practicable to assess its relationship to $ETCO_2$.
- Use DOPES to help identify the cause of a sudden rapid deterioration in a ventilated child (bag-mask ventilation or mechanical ventilation):
  - Displacement (mask, SGA, tracheal tube).
  - Obstruction (secretions, tube, circuit, airway, head position).
  - Pneumothorax or other pulmonary pathology.
  - Equipment (disconnection, oxygen supply, tubing, valves, ventilator).
  - Stomach/stacking/sedation (abdominal distention, stacked breaths or insufficient sedation).

- Circulation
  - Aim for adequate organ perfusion.
  - In the case of circulatory failure (shock), do not spend more than 5 min (or two attempts) to establish intravenous (IV) access. Competent providers should use POCUS to guide IV cannulation.
  - Establish intraosseous (IO) access as a rescue alternative if IV access fails or when the chances for a successful IV-cannulation are considered minimal.
    - Use an IO-needle of appropriate size.
    - Provide effective analgesia (e.g. intranasal ketamine) unless the child is comatose.
    - Use manual infusion or a high-pressure bag for fluid infusion.
    - Monitor for signs of extravasation and displacement.
  - Give one or more fluid boluses of 10 ml kg^{-1} in children in hypovolaemic, obstructive or distributive shock.
    - Use balanced isotonic crystalloids as the first line choice of fluids. If unavailable, use normal saline, which may be the preferred fluid in diabetic ketoacidosis and severe traumatic brain injury.
    - Give repeated 10 ml kg^{-1} boluses, as necessary. A total of 40–60 ml kg^{-1} may be needed during the first hour of treatment of hypovolemic or distributive shock.
    - Reassess the child after each bolus looking for signs of fluid overload or cardiac failure (e.g. lung crepitations, increasing liver edge, raised jugular venous pressure).
    - If the signs of shock recede, continue maintenance fluids and rehydration at a slower pace.
    - Consider vasoactive medication and respiratory support if repeated fluid boluses are required.
  - Consider the need for fluids in cardiogenic shock on an individual basis. Fluids might still be needed but should be given more cautiously e.g. 5 ml kg^{-1} fluid bolus.
  - Assess the type of shock; hypovolaemic, cardiogenic, obstructive, distributive, or dissociative (POCUS may be of value for this).
  - Start vasoactive medication (inotropes and/or vasopressors depending on the type of shock) early, as a continuous infusion via a central or peripheral line, and not later than after three to four fluid boluses (30–40 ml kg^{-1}):
    - Pay attention to the proper composition, dilution, and dosing of fluids.
    - Use a dedicated line for vasoactive drug infusion whenever possible.
    - Titrate the infusion rate according to clinical and other signs (pulse, capillary refill time, urine output), not solely based on blood pressure targets, which may differ according to the pathology, age and response. Aim for the 5th percentile as a minimum.
    - Use noradrenaline as a first line vasopressor and adrenaline as a first line inotrope. Use milrinone as first-line inodilator.
    - Consider the use of POCUS, echocardiography, lactate and mixed venous oxygen saturation (SvO_2) to further guide clinical decision-making, if the expertise is available.
  - Treat arrhythmias if present (see below).
  - Initiate other specific treatments according to the type of shock (see below).
  - Seek expert advice on extracorporeal support (e.g. ECMO) in children with refractory shock or specific conditions (e.g. congenital heart disease).

- Disability
  - Aim for neuroprotection (see the section on post-resuscitation care).
  - Ensure adequate oxygenation, ventilation, and circulation.
  - Treat clinical and electroencephalographic seizures. Follow a time-critical protocol for the management of status epilepticus such as that suggested in Fig. 4.
  - Treat hypoglycaemia, orally, if possible, with 0.3 g kg^{-1} glucose as soon as this is detected. If oral intake is not possible, give an IV bolus of 0.2 g kg^{-1} glucose (2 ml kg^{-1} 10 % glucose) and re-check blood glucose after 5–10 min and repeat if necessary.
  - When IV glucose is not available, give glucagon as a temporary rescue measure: glucagon IM or SC, 0.03 mg kg^{-1} (or 1 mg if >25 kg or 0.5 mg if <25 kg) OR intranasally 3 mg if 4–16 yr.
  - Ensure (preferably continuous) analgosedation in children with discomfort or pain. Anticipate and prevent hypotension.
  - Consider the possibility of paediatric stroke or neuroinfection and quickly seek expert help.
- Exposure
  - Avoid hypothermia and hyperthermia and start specific measures if present.
  - Consider antibiotics and/or antiviral medication if a bacterial or viral cause of critical illness is likely (e.g. in sepsis, encephalomeningitis, severe pneumonia).
  - Protect the best interests of the child according to the local ethical and legal policies in case of a suspicion of inflicted trauma (child abuse and neglect).

Additional recommendations for time-critical interventions.

- In children with **severe acute asthma** (critical asthma syndrome):
  - Give 100 % oxygen.
  - Give (intermittent or continuous) short acting $beta_2$-adrenergic agonists via pressurised metered-dose inhalers with spacer or by nebulisation (e.g. salbutamol 100 μg per dose at 4–10 puffs every 20 min or by nebulisation with 100 % oxygen 2.5–5 mg in sterile 0.9 % sodium chloride in a volume suitable for the type of nebuliser, run until empty)
  - Give inhaled ipratropium with $beta_2$-adrenergic agonists as required in the following doses: children aged from 1 month to 5 years 125–250 μg (max 1 mg day^{-1}), from 6 to 11 years 250 μg (max 1 mg day^{-1}) and from 12 to 17 years 500 μg (max 2 mg day^{-1}).
  - Give prednisolone 1–2 mg kg^{-1} orally or IV (max. 40 mg) or dexamethasone 0.3–0.6 mg kg^{-1} (max. 16 mg) within the first hour.
  - Consider adding high dose inhaled corticosteroids in a severe crisis.
  - Consider IV magnesium sulphate 40 mg kg^{-1} (max 2 g) over 20 min in children who fail to respond to initial treatment.
  - Consider a loading dose of IV short-acting $beta_2$-adrenergic agonists (e.g. 5–15 μg kg^{-1} salbutamol over 10 min, max. doses of 250–750 μg have been used) which may be followed by an infusion depending on clinical severity (e.g. salbutamol 1–2 μg kg^{-1} min^{-1}). Monitor potassium levels, lactate, blood glucose and ECG.
  - Consider a trial of non-invasive ventilation provided the child still has sufficient respiratory drive.
  - Consider tracheal intubation and invasive ventilation (and anticipate potential serious side effects), or extracorporeal life-support in near fatal asthma (e.g. exhaustion, severe hypoxia despite high flow oxygen and adequate medication).
- In children with **septic shock**:
  - Obtain blood samples for blood culture and PCR if possible and start broad-spectrum antibiotics as soon as possible (within 1 h) after initial ABCDE management.
  - Consider hydrocortisone 1–2 mg kg^{-1} if the child is not responding to fluids and vasoactive support, and in children with specific pathologies (e.g. adrenal insufficiency) or who are receiving specific medications.
- In children with **cardiogenic shock**:
  - Seek the advice of a paediatric cardiologist early. Use echocardiography to guide treatment.
  - Start inotropic support and consider mechanical ventilation. Anticipate possible cardiac arrest during tracheal intubation, use medication with minimal cardiovascular side effects (e.g. ketamine and avoid propofol).
  - Consider IV furosemide only in children without concomitant hypovolaemia.
  - Consider extracorporeal life support in refractory cardiogenic shock.
- In children with **haemorrhagic shock**:
  - Control bleeding using pressure and tourniquets as indicated and activate local protocols for massive haemorrhage.
  - Minimise the use of IV crystalloid boluses (max. 20 ml kg^{-1}). Give blood products or full blood as soon as these are available.
  - Use vasoactive medication in fluid-refractory shock, especially when there is also a loss of sympathetic drive (e.g. during anaesthesia or analgosedation), or in children with concomitant traumatic brain injury. Target MAP to above the 50th percentile to attain sufficient cerebral perfusion pressure in traumatic brain injury. Support cardiac function if this is necessary to achieve MAP above the threshold.
  - Use a strategy that focuses on improving coagulation in children with severe blood loss.
  - Use tranexamic acid as soon as possible (at least within 3 h) in all children requiring transfusion after trauma or with life-threatening haemorrhage. Give a loading dose of 15–20 mg kg^{-1} (max. 1 g) IV over 10 min, followed by an infusion of 2 mg kg^{-1} h^{-1} for at least 8 h or until the bleeding stops.
- In children with circulatory failure due to **bradycardia**:
  - Seek the advice of a paediatric cardiologist early.
  - Improve oxygenation, ventilation, and circulation.
  - In patients with bradycardia and poor perfusion not responding to oxygenation and ventilation, start chest compressions.
  - Consider adrenaline as small IV bolus doses (e.g. 1–2 μg kg^{-1}) or as a continuous infusion.
  - Consider transthoracic pacing only in specific cases of bradycardia (e.g. complete heart block, sick sinus syndrome).
  - Consider atropine *only* in specific cases of bradycardia (e.g. induced by increased vagal tone or by a cardiac conduction disease); dose IV atropine 20 μg kg^{-1} (max. 0.5 mg).
- In children with circulatory failure due to **tachydysrhythmia**:
  - Seek the advice of a paediatric cardiologist early.
  - In patients with decompensated circulatory failure regardless of the origin of tachycardia (supraventricular or ventricular), perform immediate synchronised cardioversion starting with 1 J kg^{-1}, doubling the energy with each subsequent attempt up to a maximum of 4 J kg^{-1}. Have a 12-lead ECG running during the cardioversion attempt. If the child is not comatose, ensure adequate analgosedation according to local protocols.

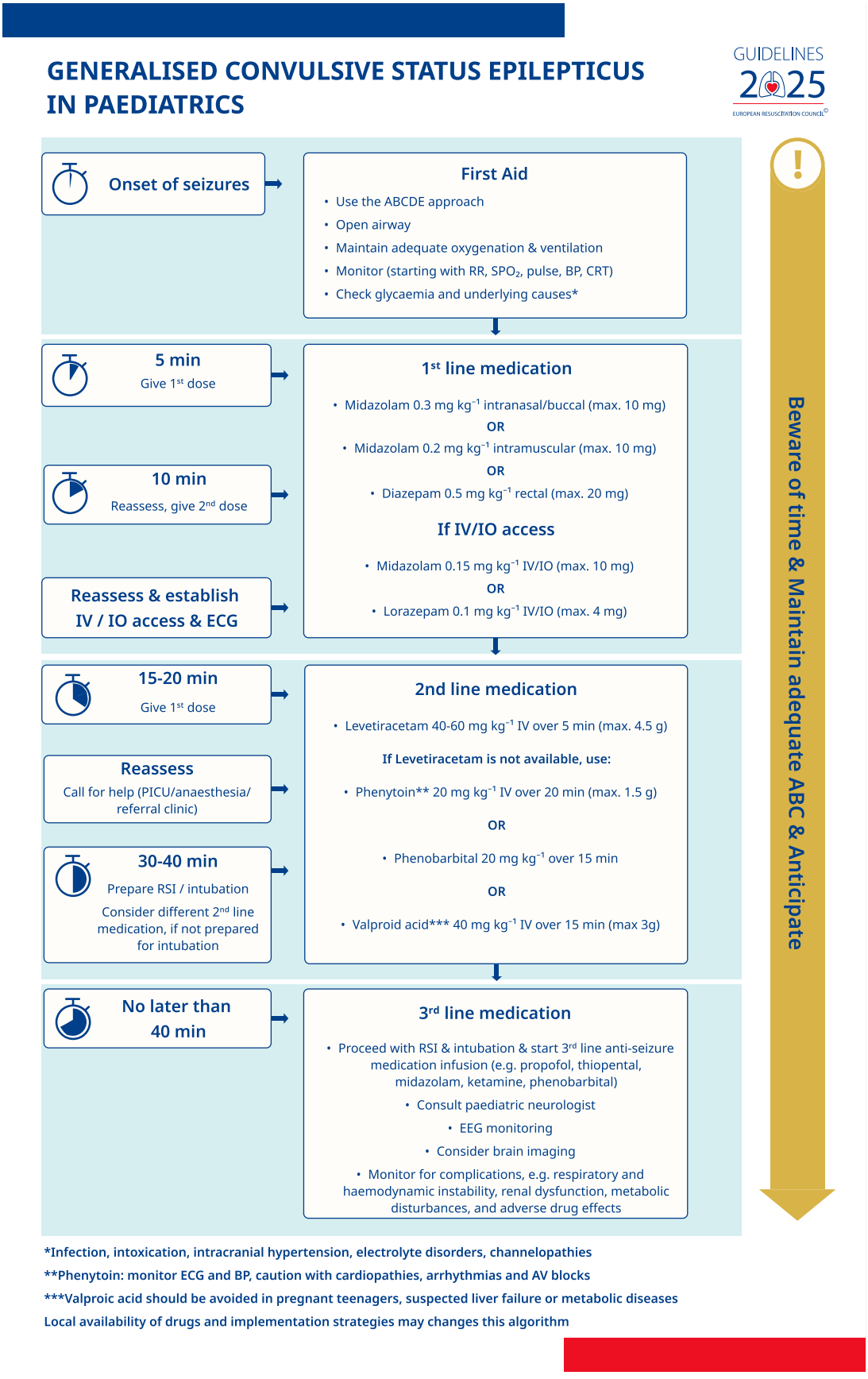


Fig. 4 – Algorithm for the management of generalized seizures in children.

Reassess signs of life and pulse after each attempt. While waiting for anaesthesia and the defibrillator, chemical cardioversion (see below) can be attempted but it should not delay the cardioversion attempt.

- In patients with narrow complex supraventricular tachycardia (SVT) who are not in decompensated circulatory failure:
  - Consider vagal manoeuvres (e.g. modified Valsalva or ice pack to the face).
  - Consider IV adenosine as a rapid flush of 0.1–0.2 mg kg^{-1} (max. 6 mg) via a large vein. Ensure a 12-lead ECG is running during the administration of adenosine. If the SVT persists, give a second dose of 0.3 mg kg^{-1} (max. 12–18 mg) after at least 1 min. If the SVT persists after the second dose, consider further doses of IV adenosine every 1–2 min increasing the dose in steps of 0.05–0.1 mg kg^{-1} until a maximum single dose of 0.5 mg kg^{-1} has been given.
  - Seek the advice of a paediatric cardiologist. Consider cardioversion or alternative medications (e.g. amiodarone), especially in children with sinus node disease, pre-excited atrial arrhythmias, a history of heart transplant or severe asthma.
- In patients with a wide QRS tachycardia who are not in decompensated circulatory failure:
  - Try vagal manoeuvres which might provide diagnostic insight (e.g. into an SVT with abnormal conduction).
  - Seek the advice of a paediatric cardiologist. Pharmacological treatment options include amiodarone, lidocaine, esmolol, magnesium sulphate, and procainamide.
  - In torsade-de-pointes VT, give IV magnesium sulphate 50 mg kg^{-1} (max. 2 g).
- In children with generalized **seizures** (Fig. 4):
  - Monitor the time from the start of the seizures closely. Manage ABC, monitor vital functions and ECG. Consider possible causes for seizures (e.g. infection, intoxication, metabolic disorders, hypoxia, hypoglycaemia, hyperthermia, intracranial hypertension, and channelopathies) and treat these appropriately. Anticipation is important when treating seizures as several interventions may be necessary.
  - Any seizure lasting 5 min or longer (status epilepticus) requires treatment with a benzodiazepine (first-line medication). Use the intravenous (IV) route if available. If an IV/IO access has not yet been established, use an alternative route (e.g. nasal, buccal or IM).
  - If the seizures continue, give a second dose of a benzodiazepine IV or IO after 5–10 min and prepare to administer a second-line medication.

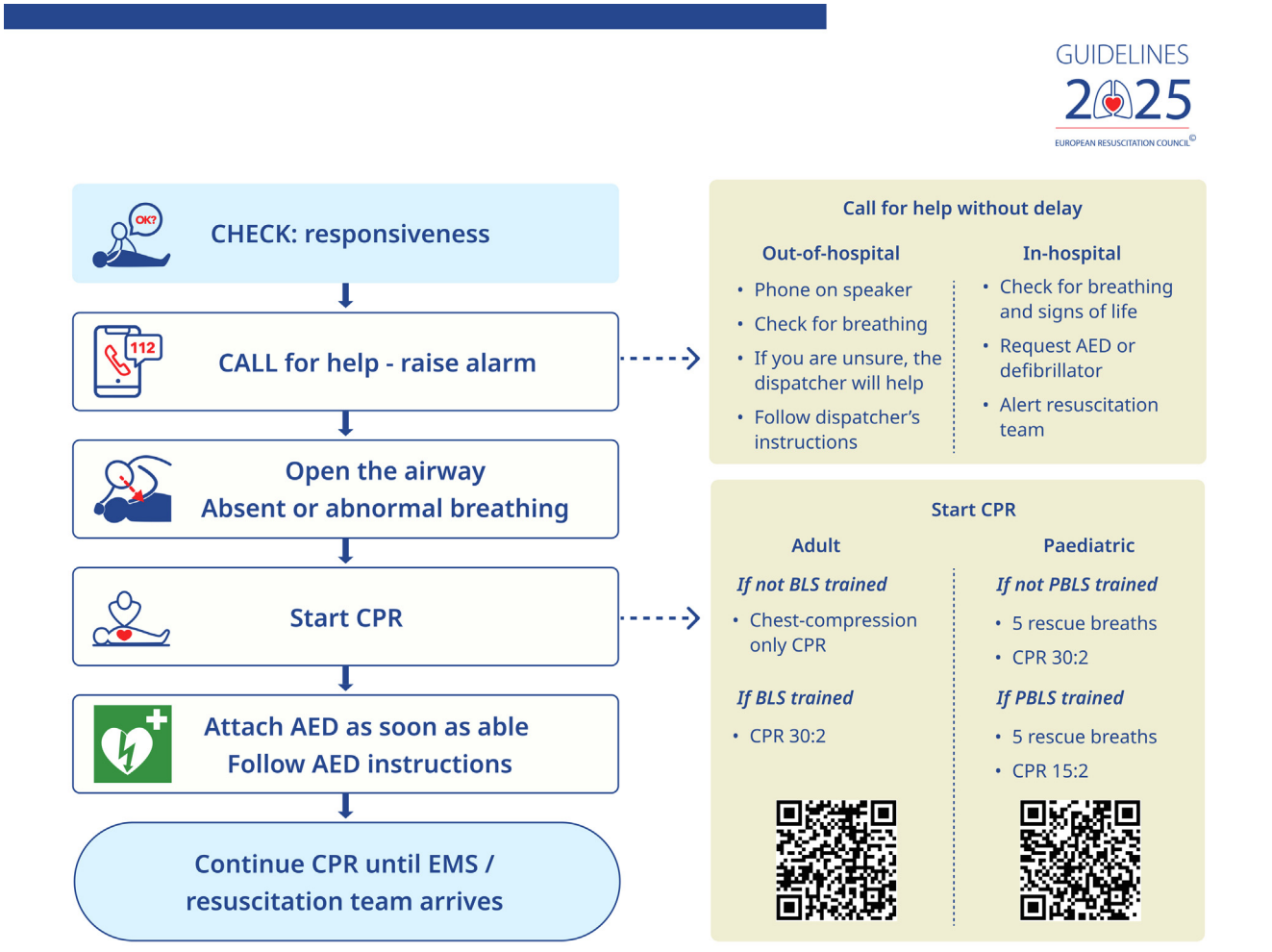


Fig. 5 – ERC Basic Life Support algorithm.

- If the seizures persist after two doses of the first-line medication (<15–20 min from the start of the seizures) give levetiracetam IV or IO 40–60 mg kg^{-1} (max. 4.5 g) over 5 min (second-line medication). If levetiracetam is not available, give phenytoin IV 20 mg kg^{-1} over 20 min or phenobarbital IV 20 mg kg^{-1} (max 1 g) by slow injection at a maximum rate of 1 mg kg^{-1} min^{-1} or valproic acid IV 20 mg kg^{-1} over 4 min as a second choice instead. Do not use valproic acid where there is the potential for pregnancy.
- If the seizures continue for ≥30 min despite the administration of a second-line drug (refractory status epilepticus), prepare for intubation and refer the child to the paediatric intensive care team. If you are not ready for intubation and anaesthesia, then giving another, different second line drug is an alternative.
- Start anaesthesia (e.g. with midazolam, ketamine, phenobarbital, thiopental, or propofol) within 40 min of the onset of seizures, with intubation and mechanical ventilation. Aim for termination of clinical seizures and burst suppression on electroencephalography (EEG). Monitor for respiratory and haemodynamic instability, metabolic disturbances, renal failure, rhabdomyolysis, and adverse drug effects.
- Seek the advice of a paediatric neurologist.
- Consider continuous EEG monitoring and brain imaging.

Other important peri-arrest situations are described below in the dedicated subchapter on Special Circumstances.

Paediatric basic life support (PBLS)

See Fig. 5.

Recommendations for untrained rescuers and dispatcher-assisted CPR

- If you encounter a child who appears to be unresponsive and you have no training in PBLS, ensure your own safety and that of the child and follow the **3 steps to save a life** (Fig. 6):
  - **Check** if the child reacts to a non-painful stimulus.
  - **Call** the EMS immediately if the child does not react and follow the dispatcher's advice.
  - **CPR**: Start CPR immediately following the instructions of the dispatcher.
- Dispatchers should encourage bystanders to perform both ventilation and chest compressions in children of all ages. They should actively ask about signs confirming that the ventilations are effective (e.g. whether the chest is moving).
- Dispatchers should use a 30:2 ratio for CPR instructions with 5 initial rescue breaths for untrained bystanders or bystanders trained only in adult BLS.
- If the bystanders are not willing or able to perform rescue breathing, dispatchers should encourage compression-only CPR in all children.
- Dispatchers should instruct bystanders to use age-specific techniques for chest compressions and breathing in infants, children and adolescents (see below).

Recommendations for those trained in PBLS (Fig. 5)

- Ensure your own safety and that of the child.
- Use verbal and tactile stimulation to assess responsiveness. Do not use painful stimuli.
- Call, or have someone call, the EMS immediately, using the speaker function of your mobile phone with video when possible. Follow the advice of the dispatcher who can help you to recognise if you need to start CPR. If you are trained in PBLS, check the breathing as described below, while waiting for the connection with the dispatcher.
- Use the head tilt chin lift manoeuvre to open the airway, assess breathing and look for signs of life for no longer than 10 s (Figs. 7 and 8).

QR code 1. Paediatric Life Support – open airway.

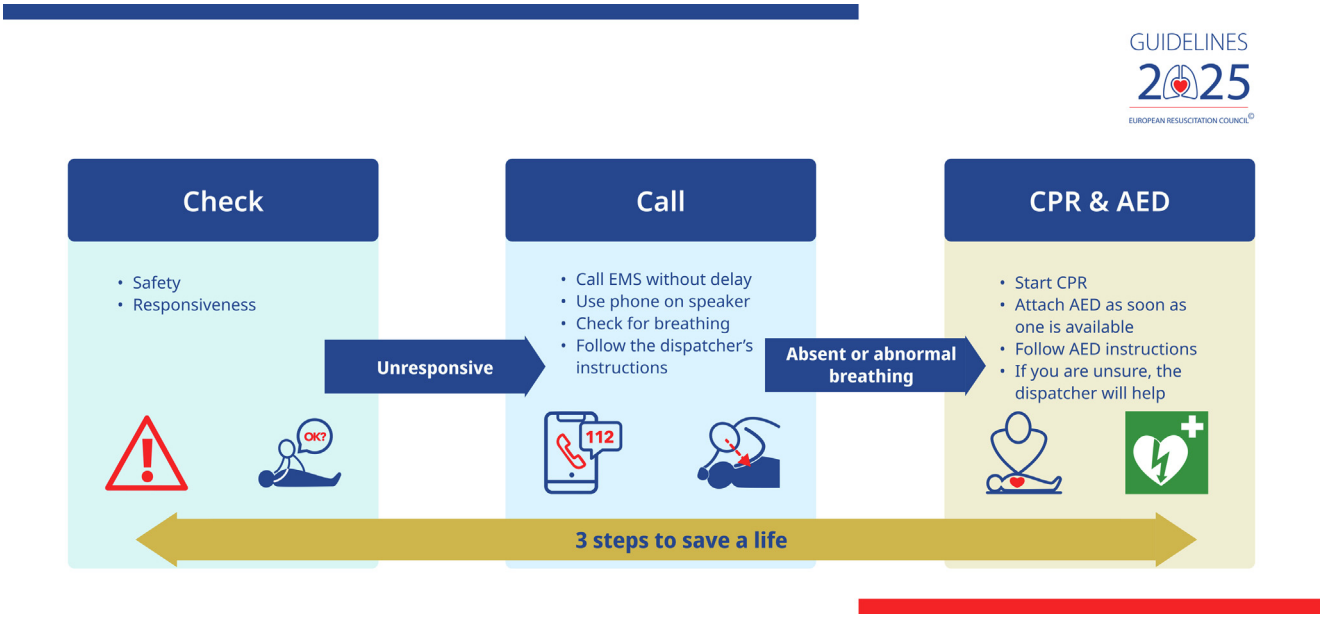


Fig. 6 – Three steps to save a life.

- Give five initial rescue breaths (Figs. 9 and 10).

QR code 2. Paediatric Life Support – rescue breaths.

- Immediately proceed with chest compressions (Figs. 11–13).

QR code 3. Paediatric Life Support – chest compressions.

- Continue CPR. Use a compression-to-ventilation ratio of 15:2 if you are specifically trained in PBLS to the level of the ERC PBLS-course or equivalent, otherwise use a ratio of 30:2.
- Focus on consistently high-quality compressions and effective ventilations. Minimise chest compression pauses.
- If a second rescuer is available, they should call the EMS while the first rescuer starts CPR, and then bring and attach an automated external defibrillator (AED) as soon as possible for children of all ages. Once attached, follow the instructions of the AED.
- If there is only a single rescuer, calling the EMS and starting CPR should be prioritised over fetching and attaching an AED.
- Do not interrupt CPR unless there are clear signs of life, or you are instructed to do so by the AED.
- In an unresponsive child who is clearly breathing effectively, keep the airway open by continued head tilt chin lift or positioning the child in a recovery position, especially if there is a risk of vomiting, but not in trauma.
- Check the breathing continuously or at least every minute if the child is placed in a recovery position. If in doubt about the stability of the position or the quality of the breathing, turn the child onto their back and open the airway with the head tilt chin lift manoeuvre.
- **Airway** and assessment of breathing:
  - Keep the head in the neutral position in infants by slightly tilting the head and lifting the chin with two fingers on the chin bone without pressing on the soft tissues (head tilt chin lift manoeu-



Fig. 7 – Opening airway in an infant – neutral position.

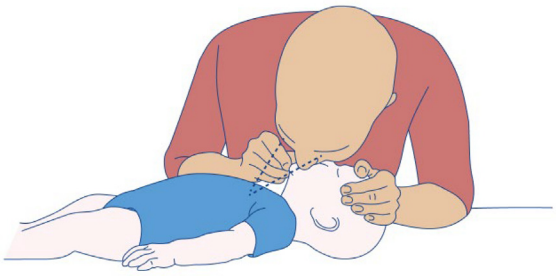


Fig. 9 – Rescue breathing in an infant – mouth-to-mouth-and-nose technique.



Fig. 8 – Opening airway in a child – 'sniffing position'.



Fig. 10 – Rescue breathing in a child – mouth-to-mouth technique.

vre) (Fig. 7). In older children, more head tilt will be needed (Fig. 8). In adolescents, full extension of the head is needed as in adults.
  - o Look for chest movement, listen and feel for the flow of air from the nose and/or mouth. If the chest is moving but there is no airflow, the airway is not open. Immediately try to improve the airway opening manoeuvre.
  - o If you have any doubt whether breathing is normal, act as if it were not normal.
- **Rescue breaths** without equipment**:**
  - o Ensure the airway is open and blow steadily into the child's mouth (or infant's mouth and nose) for about 1 s, sufficient to make the chest visibly rise and then allow the chest to fall back passively while you take your next breath (Figs. 9 and 10).
  - o If the chest does not rise, the airway may be obstructed:
    - Remove any visible obstruction in the mouth if it is easy to do so. Do not perform a blind finger sweep.
    - Reposition the head or adjust the airway opening method by further lifting the chin or tilting the head.
- Chest compressions:
  - o Perform chest compressions on a firm surface if immediately available. Remove clothes only if they hinder chest compressions.
  - o Perform chest compressions over the lower half of the sternum (breastbone) in all age groups.
  - o Use the two-thumb encircling method for chest compressions in infants (Fig. 11).

QR code 4. Two-thumb encircling technique.

  - o Use the one-hand or two-hand technique in children older than 1 year, or when unable to give high-quality chest compressions with the two-thumb-encircling technique (Figs. 12 and 13).

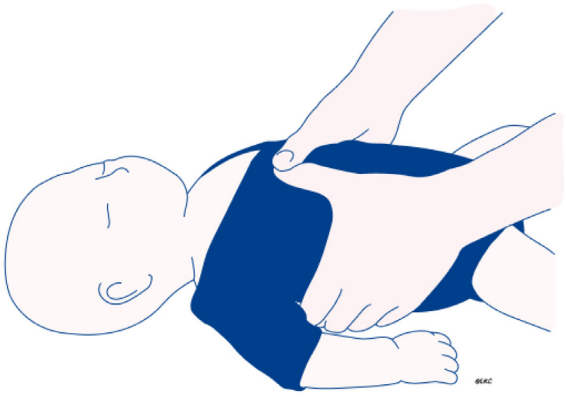


Fig. 11 – Chest compressions in an infant – two-thumb encircling technique.

QR code 5. One-hand or two-hand technique in children.

  - o Deliver high-quality chest compressions as defined by:
    - Rate of 100–120 min^{-1}.

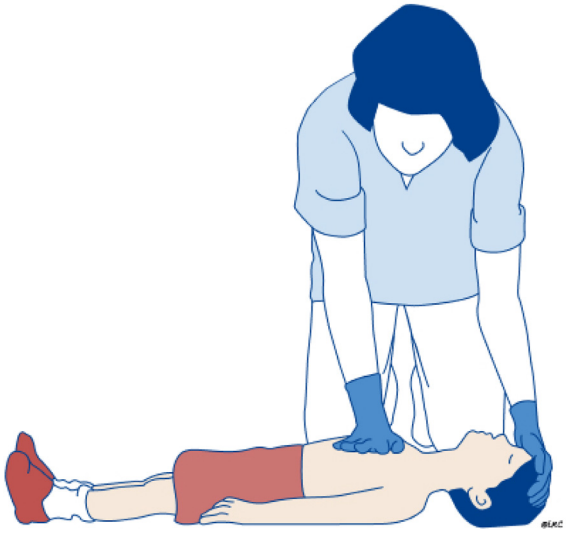


Fig. 12 – Chest compressions in a child – one-hand

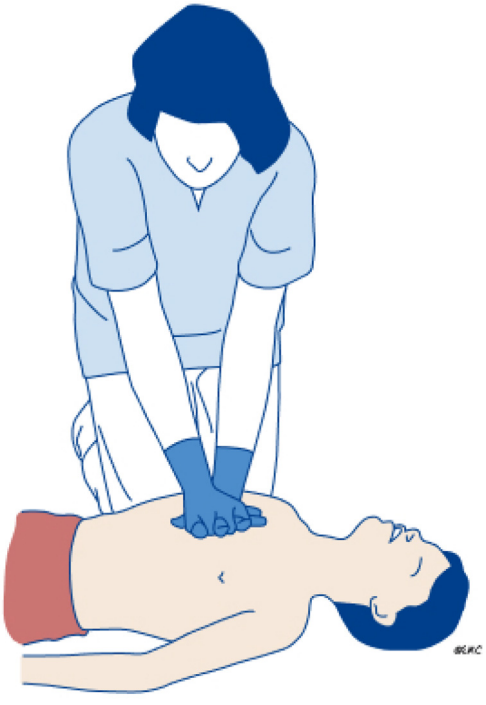


Fig. 13 – Chest compressions in a child – two-hands technique.

- Depress the chest by *at least* one third of the antero-posterior dimension. Use the adult depth recommendation of 5–6 cm in adolescents and do not exceed a depth of 6 cm at any age.
- Avoid leaning by releasing all pressure between compressions and allow the chest to rise again completely (chest recoil).
- Do not interrupt chest compressions except when giving ventilations, or if you are instructed to do so by the AED.

- **Using an Automated External Defibrillator:**
  - Follow the instructions of the AED.
  - Apply the defibrillation pads with minimal interruptions in CPR (one person applying the pads, a second performing CPR).
  - Activate the paediatric mode, if available, in all infants and children weighing less than 25 kg (i.e. approximately 8 years of age). In larger children and adolescents, use the AED in standard adult mode. If the AED does not have instruction for children, use it in standard adult mode.
  - Place adult size defibrillation pads as follows (Figs. 14 and 15):
    - Use the antero-posterior position in infants and children weighing less than 25 kg: the anterior pad is placed mid-chest immediately left of the sternum and the posterior on the back placing the centre of the pad between the scapulae (shoulder blades).
    - Use either the antero-lateral or antero-posterior position in children weighing more than 25 kg and adolescents. In the antero-lateral position one pad is placed below the right clavicle and the other in the left axilla. If the antero-posterior position is used in adolescents, avoid placing the defibrillation pads over breast tissue.
  - Do not touch the patient while the AED is analysing the rhythm.
  - Restart chest compressions immediately after shock delivery.

Additional considerations for PBLS

- If they suspect a cardiac arrest or a critical situation, one person should call the resuscitation or emergency medical team, while the other person starts CPR as described above, using a compression-to-ventilation ratio of 15:2.
- Competent providers should use bag-mask ventilation with oxygen.
- If starting ventilations is not immediately possible (e.g. bag-mask ventilation is not immediately available and there is a contraindication to mouth-to-mouth ventilation), start chest compressions immediately and add ventilations as soon as possible.
- Competent providers can also use a pocket mask for rescue breaths to ventilate larger children when a bag and mask is not available.
- Activate the CPR mode on the bed to increase stiffness of the mattress (if the bed is equipped with this function).
- Over-the-head chest compressions can be used in certain specific situations such as limited space or limited personnel.
- The anterolateral pad position can be used by competent providers in children ≤25 kg when using paediatric pads provided these do not touch each other.
- A single rescuer without a mobile phone, should perform CPR for 1 min before going to seek help.

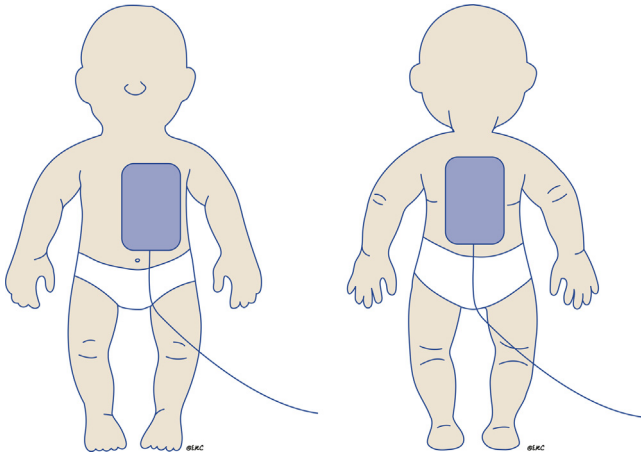


Fig. 14 – Antero-posterior position of the defibrillation pads in children up to 25 kg.

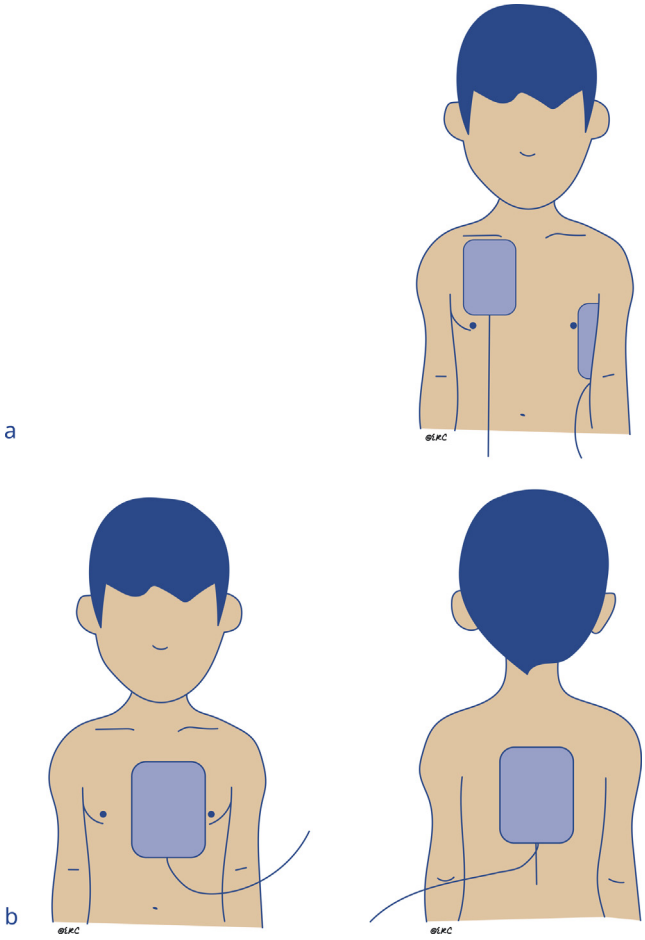


Fig. 15 – Antero-lateral (a) or antero-posterior position (b) of the defibrillation pads in children more than 25 kg.

Foreign body airway obstruction (Fig. 22)

- Suspect choking due to a foreign body if the child is unable to speak (children and adolescents) or cry aloud (infants or smaller children), especially during feeding, eating, or playing unsupervised.

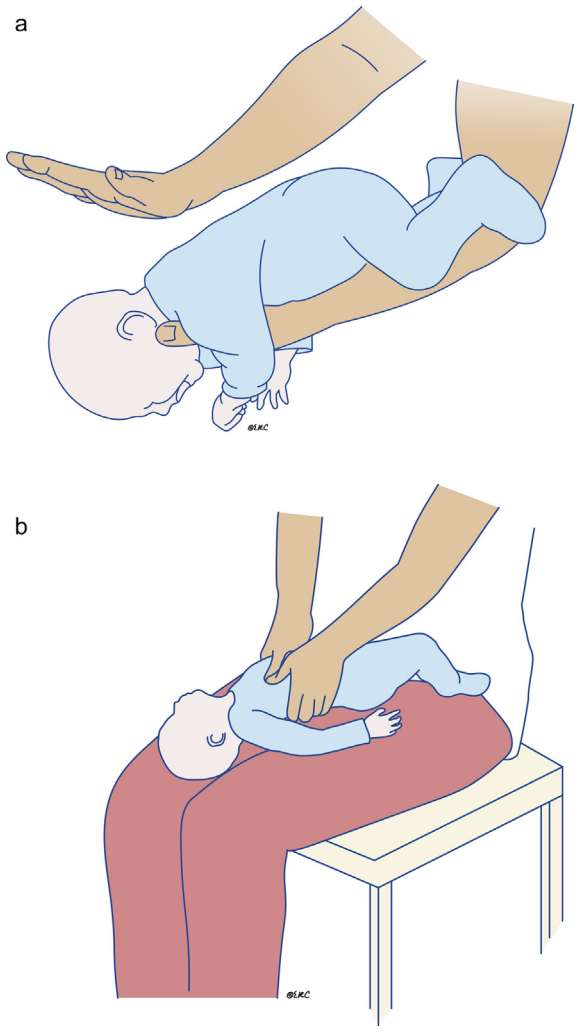


Fig. 16 – Back blows (a) and chest thrusts (b) in an infant.

- Call or have someone call the EMS as soon as possible.
- Encourage an older child or adolescent to cough.
- Give up to 5 back blows if coughing is not possible or becoming ineffective:
  - o Turn the infant face-down on your forearm with your forearm resting on your leg. Support the head of the infant with your hand. Try to hold the head below the level of the thorax (use gravity). Give a sharp blow between the shoulder blades (Fig. 16a). Repeat up to five times or until the obstruction is relieved.
  - o Lean children and adolescents forward and give blows between the shoulder blades (Fig. 17a). Repeat up to five times.
- Give up to five chest/abdominal thrusts if back blows are not effective:
  - o In infants (Fig. 16b):
    - ■ Turn the infant onto their back and lay them on your knees.

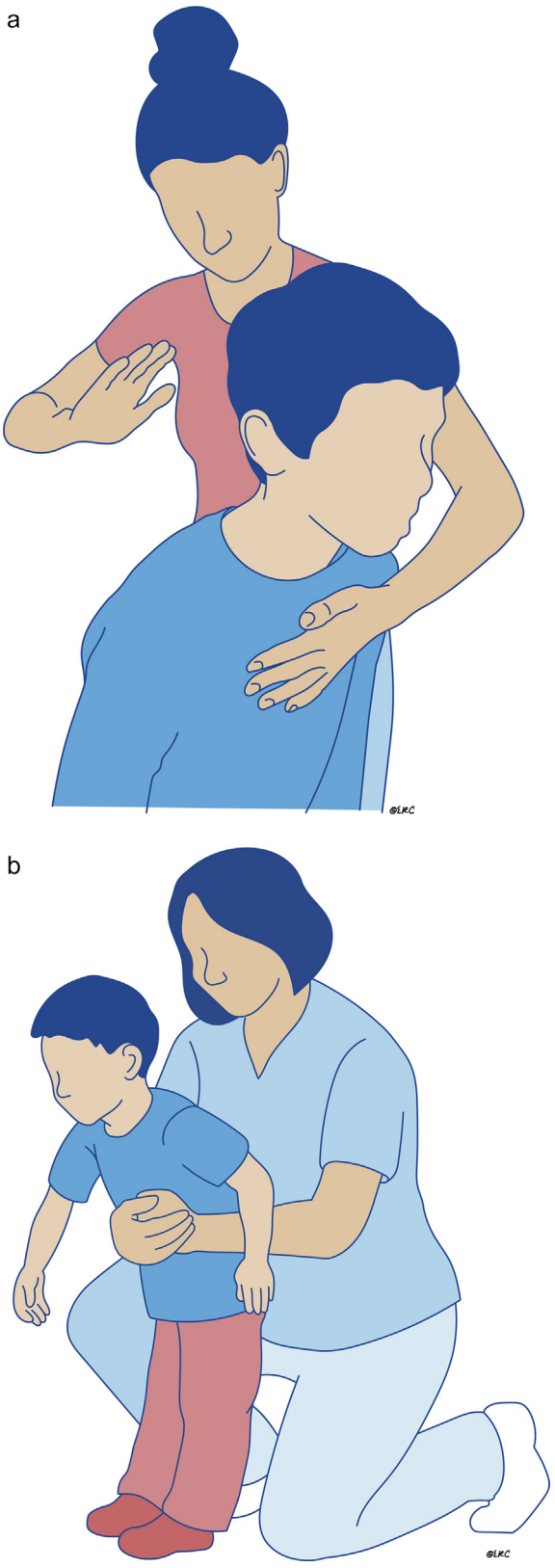


Fig. 17 – Back blows (a) and abdominal thrusts (b) in a child or adolescent.

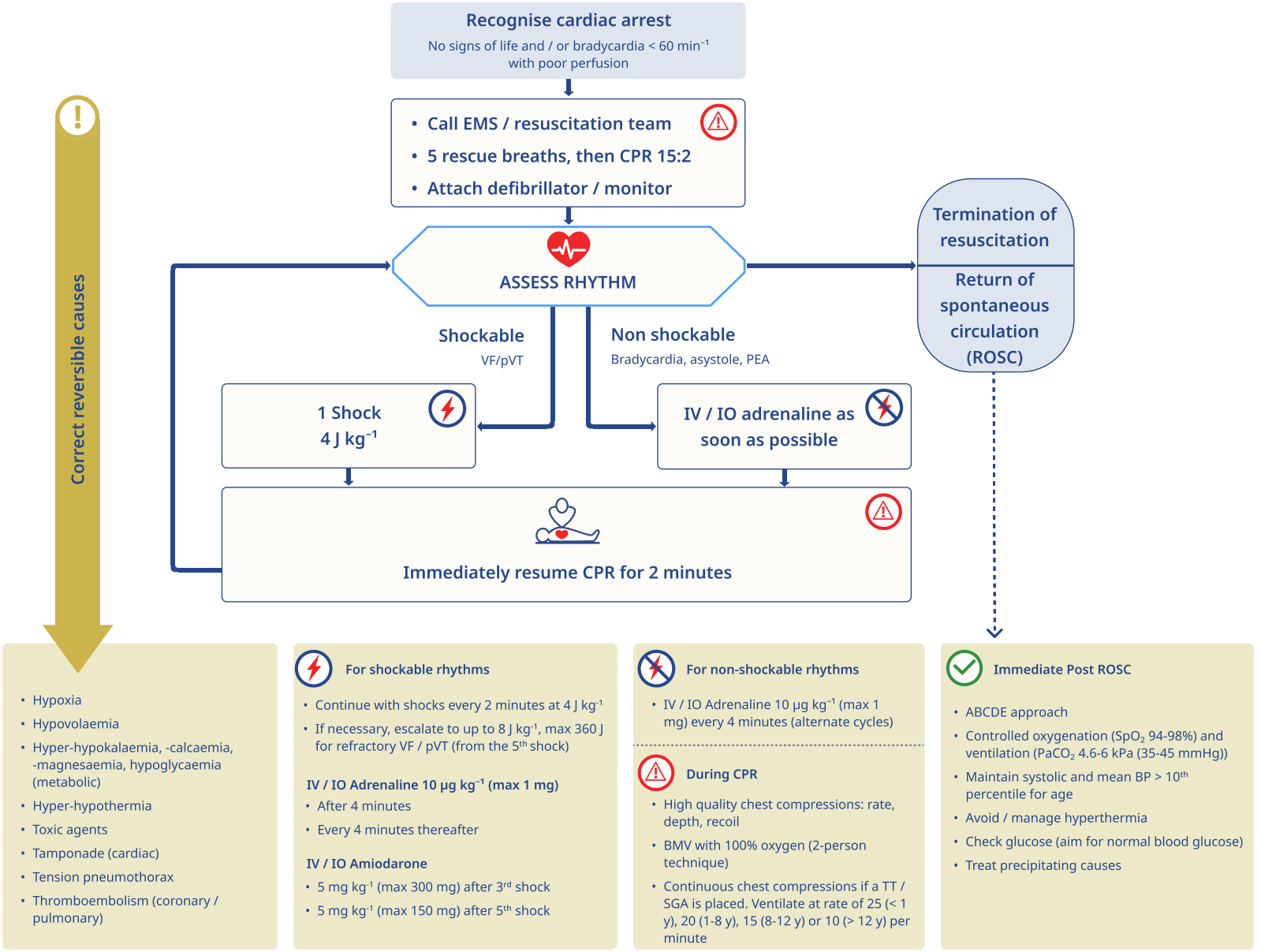


Fig. 18 – Paediatric Advanced Life Support algorithm.

- Use the two-thumbs encircling technique to perform chest thrusts as advised for chest compressions but compressing the sternum more sharply. Repeat up to five times or until the obstruction is relieved.

o In children and adolescents (Fig. 17b):
- Stand behind the child and put your arms around the upper part of their abdomen.
- Lean them forward.
- Clench your fist and place it between the navel (umbilicus) and the end of the breastbone (xiphoid).
- Grasp your fist with the other hand and pull sharply inwards and upwards.
- Repeat up to five times or until the obstruction is relieved.

o If the child is still conscious, repeat the back blows up to five times alternating these with up to five chest/abdominal thrusts.

o Stop back blows or chest/abdominal thrusts immediately if at any time there are signs of relief of the obstruction (coughing, loud breathing or crying).

- Do not use blind sweeps to clear the obstruction from the mouth but use a single sweep to remove a clearly visible obstruction.
- Call for help and the EMS as soon as practical (if not already done so), at the latest when the child loses consciousness.
- Start CPR immediately with five rescue breaths as soon as the child becomes unconscious.
- The ERC is unable to make a recommendation for or against the use of suction-based devices advertised and marketed for clearing a foreign body airway obstruction, as no high-certainty scientific evidence exists.

Paediatric advanced life support (PALS)

See Fig. 18.

- Use a team approach, define clear roles for each team member, consider and practice the choreography (i.e. the best way for your own team to resuscitate a child including roles and sequences of action). A possible team composition is illustrated in Fig. 19.
- Commence or continue with high-quality chest compressions and ventilations.

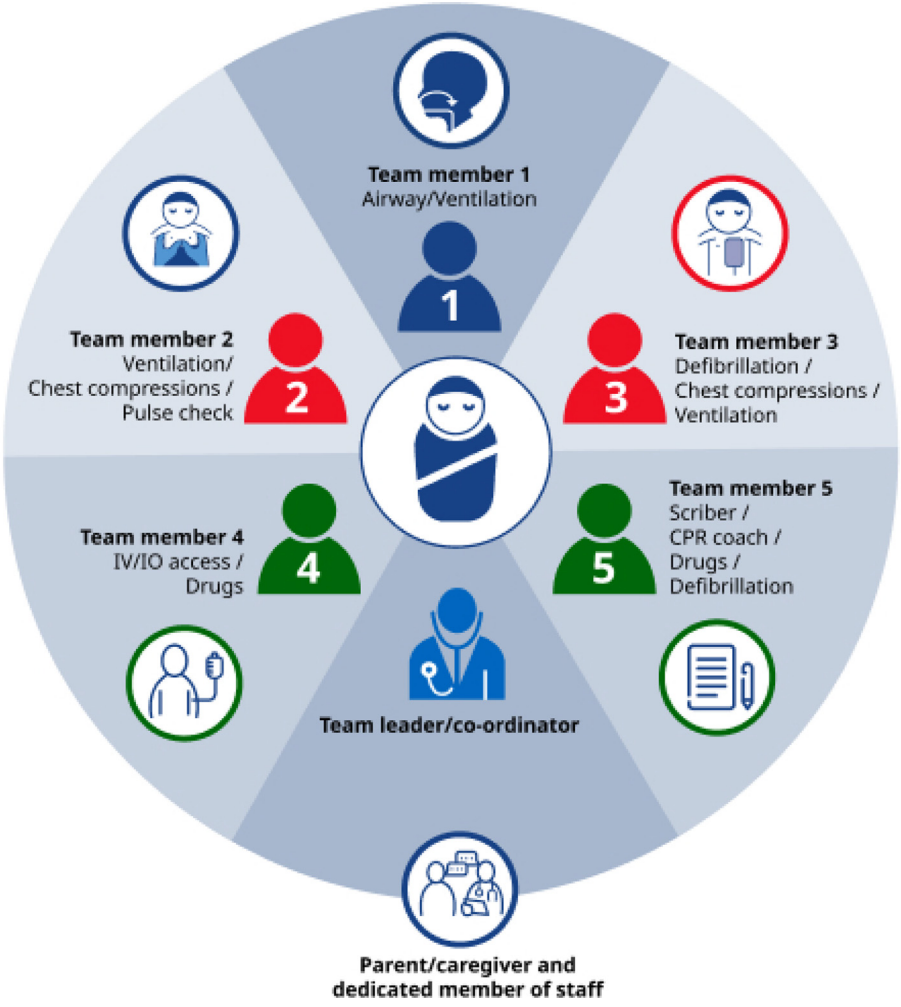


Fig. 19 – Suggested example of a composition of the resuscitation team.

The composition of the resuscitation team can be dynamic and influenced by various factors such as the type of rhythm, reversible causes, and available resources. Priorities during resuscitation are also subject to change as the situation evolves. Consistently, high-quality chest compressions and ventilations are essential and should be maintained throughout the entire resuscitation process to optimize outcomes.

- Recognise cardiac arrest on clinical grounds (e.g. no signs of life) or based on monitored vital signs (e.g. ECG, loss of SpO_2 and/or $ETCO_2$, loss of intra-arterial blood pressure trace).
- Importantly, chest compressions should also be started in children who become bradycardic (<60 per min) with signs of poor perfusion despite adequate respiratory support, even if there is still a detectable pulse.
- Apply cardiac monitoring as soon as possible, if not already in place, using self-adhesive defibrillator pads as the first choice as this allows for a shorter time to defibrillation in children who require it.
- Differentiate between shockable and non-shockable cardiac rhythms.
- **Non-shockable rhythms** are bradycardia (with poor perfusion), pulseless electrical activity (PEA) and asystole.
  - Obtain vascular access and give adrenaline IV/IO (10 μg kg^{-1}, max 1 mg) *as soon as possible* followed by a flush to facilitate drug delivery. Immediately attempt IO access if IV access is likely to be difficult.
  - Repeat adrenaline IV/IO every 4 min (i.e. *every other* 2 min cycle) unless being guided by intra-arterial blood pressure monitoring and the haemodynamic response.
  - Reassess the cardiac rhythm every 2 min (<5 s). If the rhythm has changed to an organised rhythm which could produce cardiac output, check for signs of life and feel for a central pulse (max. 5 s).
  - Change the person doing chest compressions at least every 2 min. Watch for fatigue and/or suboptimal chest compressions and switch rescuers earlier if necessary.
- **Shockable rhythms** are pulseless ventricular tachycardia (pVT) and ventricular fibrillation (VF).
  - As soon as identified, give one defibrillation shock (regardless of the ECG amplitude). If in doubt, consider the rhythm to be shockable.
  - If using self-adhesive pads, continue chest compressions while the defibrillator is charging.
  - Ensure that there is no leakage of oxygen around the chest during defibrillation. In small children the self-inflating bag may be very close to defibrillation pads; direct the oxygen exhaust away from the chest or disconnect the bag, if necessary, before charging the defibrillator. Do not disconnect the tracheal tube if a closed circuit is being used e.g. during mechanical ventilation.
  - Once charged, pause chest compressions, briefly check that the rhythm is still shockable (<5 s) and ensure *all* persons are clear of the child before giving a single shock.
  - Minimise pauses between stopping chest compressions, delivery of the shock and restarting chest compressions (<5 s).
  - Give one shock (4 J kg^{-1}, max. 120–200 J) and *immediately* resume CPR for 2 min.
  - Reassess the cardiac rhythm:
    - If the rhythm changes to an organised rhythm which could produce cardiac output, check signs of life and feel for a central pulse (<5 s)
    - OR
    - If a shockable rhythm persists, give a 2nd shock (4 J kg^{-1}) and immediately resume CPR for 2 min, then reassess and continue to repeat this cycle.
  - Give adrenaline (10 μg kg^{-1}, max. 1 mg) and amiodarone (5 mg kg^{-1}, max. 300 mg) IV/IO immediately after the third shock. Flush after each drug. Lidocaine IV (1 mg kg^{-1}) might be used as an alternative if amiodarone is not available or a local decision has been made to use lidocaine instead of amiodarone.
  - Give a second dose of adrenaline (10 μg kg^{-1}, max 1 mg) and amiodarone (5 mg kg^{-1}, max 150 mg) IV/IO immediately after the fifth shock.
  - Unless there are clear signs of life adrenaline IV/IO should be repeated every 4 min (i.e., *every other* 2 min cycle) unless being guided by intra-arterial blood pressure monitoring and the haemodynamic response.
  - Change the person doing compressions at least every 2 min. Watch for fatigue and/or suboptimal compressions and switch rescuers earlier if necessary.
- CPR should be continued unless:
  - An organised rhythm is recognised at a rhythm check and is accompanied by signs of return of spontaneous circulation (ROSC), identified clinically (e.g. eye opening, movement, normal breathing) and/or by monitoring (e.g. $ETCO_2$, SpO_2, blood pressure, echocardiogram) and/or presence of a palpable central pulse.
  - Perfusion is restored by extracorporeal cardiopulmonary resuscitation.
  - Criteria for withdrawing resuscitation are met (see the ERC Guidelines 2025 Ethics in Resuscitation).[29]

Defibrillation during PALS

- Manual defibrillation is the recommended method for PALS. If this is not immediately available an AED can be used.
- Proper planning before each defibrillation will minimise hands-off time.
- Defibrillation pads should be positioned either in the antero-lateral and antero-posterior position (Figs. 14 and 15).
  - Avoid contact between defibrillation pads as this can cause charge arcing.
  - In the anterolateral position, one pad is placed below the right clavicle and the other in the left axilla.
  - In the anteroposterior position the anterior pad is placed mid-chest immediately left of the sternum and the posterior in the middle of the back between the scapulae.
  - Use the anteroposterior position in infants and children who can easily be turned onto their side for pad placement and in whom the anterolateral position is more difficult to achieve without contact between the defibrillation pads.
  - Use the anterolateral position in larger children as this leads to less interruption of chest compressions than the anteroposterior position. Avoid breast tissue in adolescents.
- Defibrillation with self-adhesive pads is standard, use it if available, if not, use paddles with preformed gel pads (this demands specific choreography of defibrillation).
- Use 4 J kg^{-1} as the standard energy dose for the initial shocks. It seems reasonable not to use doses above those suggested for adults (120–200 J, depending on the type of defibrillator).
- Increase the energy dose – stepwise increasing up to 8 J kg^{-1} (max. 360 J) for refractory VF/pVT (i.e. more than five shocks are needed).

- Charge the defibrillator with the defibrillation pads or paddles on the chest. Continue chest compressions while the defibrillator is charging when using defibrillation pads.
- If any period of ROSC is achieved and the child goes back into a shockable rhythm, use the defibrillation energy dose that was previously successful.

Oxygenation and ventilation during PALS

- Effective oxygenation and ventilation combined with high-quality chest compressions are essential during CPR to generate sufficient coronary perfusion to restart the heart.
- Oxygenate and ventilate with a bag and mask, using 100 % oxygen. Do not titrate FiO_2 during CPR.
- Intubate the child only if you are experienced and competent and have all the necessary equipment. If not, continue to ventilate using a bag and mask or insert an SGA. Ensure the chest moves during ventilation. If not, adjust the airway or ventilation technique.
- Use a tracheal tube or SGA if CPR is required during transport; when prolonged resuscitation is anticipated or when it is impossible to ventilate with a bag and mask. Call for expert help if this is not already present.
- Do not interrupt chest compressions during airway management. Use $ETCO_2$ monitoring to ensure correct ventilation when a tracheal tube or SGA is in place.
- Avoid hypo- or hyperventilation.
- Give continuous chest compressions when the airway is secured with a tracheal tube or SGA and ventilate without pausing chest compressions. Pausing only briefly for each rhythm check.
- Ventilate at the lower limit of the normal rate for age e.g. pragmatically use breaths min^{-1}: 25 (infants), 20 (>1 y), 15 (>8 y), 10 (>12 y).
- If there is doubt about the effectiveness of ventilation (e.g. high air leak, diminished air entry into lungs) during continuous chest compressions return to a chest compression to ventilation ratio of 15:2.
- For children who go into cardiac arrest on a mechanical ventilator, either disconnect the ventilator and ventilate with a self-inflating bag/anaesthetic bag (depending on expertise) or continue to ventilate with the mechanical ventilator (ensuring the child is adequately ventilated). In the latter case, ensure that the ventilator is in a volume-controlled mode, that triggers and limits are disabled, and that the ventilation rate, tidal volume and FiO_2 are appropriate for CPR. There is no evidence to support any specific level of PEEP during CPR. Always consider ventilator dysfunction as a possible cause of cardiac arrest.
- Titrate FiO_2 to an SpO_2 of 94–98 % after ROSC.

Measurable factors during PALS

- **Capnography:** Use $ETCO_2$ monitoring once a tracheal tube or an SGA is in place to assess the quality of chest compressions and to help verify ROSC.
- **Invasive blood pressure:** If an intra-arterial line is in situ during CPR, monitor the diastolic blood pressure values in response to chest compressions and medication (adrenaline). Aim for an intra-arrest diastolic blood pressure of at least 25 mmHg for infants and at least 30 mmHg for children and adolescents.
- **Point-of-care ultrasound:** Use POCUS only if you are competent in its use during CPR and it does not compromise the quality of chest compressions.
- **Point-of-care blood analysis:** Check at least glucose, potassium, haemoglobin, lactate and blood gas analysis, and treat as appropriate.

Extracorporeal CPR

- Consider extracorporeal CPR (ECPR) as an *early* intervention for selected infants and children with IHCA (e.g. children with cardiac conditions in the paediatric intensive care unit, perioperative children) and OHCA (e.g. a refractory shockable rhythm) in settings where resources allow ECPR.

Reversible causes of paediatric cardiac arrest

- Seek and identify any reversible cause for cardiac arrest early and treat appropriately.
- Use the mnemonic '4H4T' (Table 4)

Cardiac arrest and its prevention in special circumstances

The recommendations in this section are primarily aimed at healthcare professionals.

Anaphylaxis

- Identify and treat anaphylaxis as soon as possible to prevent cardiac arrest – typically an acute onset of cutaneous, respiratory, circulatory and/or severe gastrointestinal symptoms.
- Discontinue administration of any potential allergen, if possible.
- Immediately administer 0.01 mg kg^{-1} = 10 μg kg^{-1} (max. 0.5 mg) adrenaline (1 mg ml^{-1}) *intramuscularly* (IM) into the anterolateral mid-thigh.
- Pragmatically one can use the following doses of adrenaline according to the child's age:
  - 0.15 mg at 1–5 years,
  - 0.3 mg at 6–12 years and
  - 0.5 mg if older than 12 years.

  An age-appropriate autoinjector can also be used.
- Repeat this dose of IM adrenaline every 5 min if symptoms persist.
- Assess ABCDE and position the child according to the presenting features (supine for shock, but the sitting position may optimise respiratory effort). Reassess ABCDE frequently.
- Give 100 % oxygen to children with respiratory distress and those receiving more than one dose of adrenaline.
- Consider early tracheal intubation in case of respiratory compromise and in anticipation of airway oedema. Airway management can be difficult, and the early involvement of a competent practitioner is mandatory.
- Establish vascular access and give crystalloid fluids 10 ml kg^{-1} as required to treat shock.
- Give inhaled short-acting $beta_2$-agonists for bronchospasm *in addition* to intramuscular adrenaline.
- After treatment, observe the child for at least 6–12 h.
- Consider second-line medications, such as antihistamines (for cutaneous symptoms) and steroids (only if there is concurrent asthma), when the initial reaction is under control.
- Seek expert advice (e.g. of a paediatric intensivist) if the child requires more than two doses of adrenaline with ongoing symptoms.
- Try to identify the allergen and take blood for serum tryptase analysis.

Table 4 – Reversible causes of cardiac arrest.

Consider	Identification	Treatment in cardiac arrest
Hypoxia	History/clinical exam/SpO_2 and/or PaO_2 pre-arrest or intra-arrest.	Ventilate with 100% oxygen. Insert an advanced airway if bag-mask ventilation is inadequate. Ensure adequate movement. Check for leaks, air entry, abdominal distention, or stacked breaths if an advanced airway is in situ.
Hypovolaemia	History (sepsis, haemorrhage, diarrhoea, anaphylaxis) POCUS.	Fluid boluses 10 ml kg^{-1} isotonic crystalloid or blood products for major haemorrhage.
Hyper-/hypokalaemia and other metabolic derangements	***Hyperkalaemia***	
	History (massive haemolysis, tumour lysis syndrome, crush syndrome, acute or chronic renal failure, malignant hyperthermia, specific intoxications). Blood gas analysis with electrolytes.	In cardiac arrest with severe hyperkalaemia (>6.5–7 mmol l^{-1}), give 0.1 unit kg^{-1} short acting insulin (max 10 units) with 5 ml kg^{-1} 10% glucose (max 250 ml) as an IV bolus and an IV/IO infusion of a short acting $beta_2$-adrenergic agonist (e.g. salbutamol 5 μg kg^{-1}). Consider extracorporeal potassium removal.
	Hypokalaemia	
	History (diarrhoea, vomiting, diabetes insipidus, specific medications, hyperaldosteronism). Blood gas analysis with electrolytes.	In cardiac arrest associated with severe hypokalaemia (<2.5 mmol l^{-1}), give 1 mmol kg^{-1} (max 30 mmol) potassium at 2 mmol min^{-1} for 10 min followed by the rest of the dose (if necessary) in 5–10 min. Repeat, if necessary, until the serum potassium is >2.5 mmol l^{-1}. Consider magnesium for concomitant hypomagnesaemia.
	Hypoglycaemia	
	History and blood analysis.	Give an IV bolus of 0.2 g kg^{-1} glucose (e.g. 2 ml kg^{-1} 10% glucose) and re-check blood glucose after 5–10 min. Repeat if necessary.
	Other metabolic derangements	
	History and blood analysis.	Correct calcium, magnesium and other metabolic derangements.
Hypo-or hyperthermia	***Hypothermia***	
	History/situation and core temperature.	Modify the PALS algorithm: • <30 °C: give a single dose of adrenaline unless planning immediate initiation of extracorporeal life support. Give a maximum of three shocks if a shockable rhythm is present; if this is ineffective, delay further attempts until core temperature >30 °C. • 30–35 °C: adrenaline IV/IO every 8 min (6–10 min), second dose amiodarone IV/IO after 8 min, normal interval of defibrillation (every 2 min). • >35 °C: normal algorithm. • Consider transport to a centre for extracorporeal life support. • >32 °C: warm using external rewarming methods (hypothermia is unlikely to be the primary cause of cardiac arrest). • <32 °C: use active external and internal rewarming methods including extracorporeal techniques.

(*continued on next page*)

Table 4 (continued)

Consider	Identification	Treatment in cardiac arrest
	Hyperthermia	
	History and core temperature.	External cooling. If drug mediated, consider antidotes or other treatments.
Thromboembolism	History (children with indwelling central lines, cardiac conditions, cancer, recent trauma, recent surgery) and POCUS.	Consider IV thrombolysis.
Tension pneumothorax	History (trauma, positive pressure ventilation, acute severe asthma exacerbation) Examine for symmetrical air entry and POCUS.	Needle thoracocentesis/thoracostomy (trauma).
Tamponade	History (cardiac surgery, penetrating chest trauma, acute viral pericarditis) and POCUS.	Pericardiocentesis/thoracotomy (trauma).
Toxic agents	History. Pre-arrest ECG, blood gas analysis electrolytes.	Specific measures (safety, antidotes, decontamination, enhanced elimination). Consider ECPR.

Traumatic cardiac arrest

- Identify and treat reversible causes to prevent cardiac arrest.
- Ensure proper team collaboration.
- *Additional recommendations for PBLS in traumatic cardiac arrest*
  - Follow standard CPR, start by opening the airway and ventilate.
  - Competent providers open the upper airway with a jaw thrust and minimise spinal movement without hampering CPR.
  - Stop significant external bleeding immediately with manual pressure, haemostatic dressing or tourniquet.
  - Use an AED only if there is a high likelihood of a shockable rhythm (e.g. following electrocution).

PALS in trauma

- Professional rescuers should look for and treat reversible causes. Use the acronym 'HOTT' to identify reversible causes: **H**ypotension, **O**xygenation (hypoxia), **T**ension pneumothorax and cardiac **T**amponade). In cardiac arrest, treating these has priority, or should run concurrently with, chest compressions and the administration of adrenaline IV/IO.
- Use POCUS when available to diagnose reversible causes.
- The optimal sequence of action will depend upon the setting and the number of rescuers, but consider:
  - Correct hypoxia. Open the airway using a jaw thrust manoeuvre and minimise spinal movement, without hampering CPR. Ensure adequate ventilation and intubate the child as soon as the expertise and equipment are available. Use an SGA if intubation is not possible.
  - Correct hypovolaemia with intravascular fluid replacement, including early use of blood products in haemorrhagic shock.
  - Relieve a suspected tension pneumothorax with a bilateral finger thoracostomy prior to chest drain placement.
  - Perform a resuscitative thoracotomy, if competent, for a cardiac tamponade. Otherwise, perform pericardiocentesis via a mini-thoracotomy or insert a wide-bore drain, preferably guided by POCUS.
- Attach an AED directly if there is a high likelihood of a shockable underlying rhythm such as following electrocution or in cardiac contusion. Otherwise, HOTT has priority over the AED.
- Consider a resuscitative thoracotomy (e.g. for penetrating chest injuries) provided the expertise, equipment and systems are in place.
- High-quality resuscitation is the standard in cardiac arrest due to a medical cause coincidental to the trauma or to a non-hypovolemic, non-obstructive aetiology (e.g. isolated traumatic brain injury, cardiac contusion, or asphyxia) or due to electrocution.

Drowning

- Reverse hypoxia and treat respiratory failure early to prevent cardiac arrest following drowning.
- Manage cardiac arrest following drowning with standard PALS with additional attention to reversing hypoxia and hypothermia.
- Remove the child as quickly and safely as possible from the water.
- Do not enter the water unless you are trained to rescue a person from the water.

- Try to reach the child from the land and provide a flotation device such as a lifebuoy or other rescue equipment.
- Start ventilation in the water if you are trained to do so and have a floatation device and the child is unconscious and not breathing.
- Start standard PBLS with five rescue breaths as soon as it is safe to do so (e.g. on land or on a boat).
- Give 100 % oxygen as soon as it is available. Intubate the child if the expertise and equipment are available.
- Attach an AED after drying the chest. Uninterrupted CPR and oxygenation take priority over the AED.
- Assess ABCDE and stabilise the child if not in cardiac arrest. Prevent cardiac arrest by identifying and treating respiratory insufficiency and hypothermia.
- Rewarm a hypothermic child immediately and simultaneously with the stabilisation. Treat hypothermia in a child with an intact circulation as follows:
  - Monitor the core temperature with a thermometer suitable for low temperatures.
  - Handle the child gently in a horizontal position to reduce the risk of cardiac arrest (especially VF).
  - Start rewarming if <35 °C and rewarm at a rate of at least 1 °C h^{-1}. Aim for normothermia but stop active rewarming at 35 °C to avoid overshoot hyperthermia.
  - Use active external rewarming applied to the trunk (chest, abdomen, back and axillae – not the extremities) with e.g. a hot-air blanket, radiant warmer, warmed blankets or hot packs, applied according to the manufacturers' instructions.
  - Do not place warm devices directly on the skin to prevent burns. Avoid rubbing and massaging of the extremities.
  - Do not use a warm shower or warm water immersion for rewarming a child with a decreased level of consciousness.
  - Give warmed and humidified 100 % oxygen and warmed IV/IO fluids (39–42 °C) to prevent further heat loss and to compensate for the vasodilatation during rewarming but avoid fluid overload by careful haemodynamic monitoring.
- Look for and treat a possible underlying cause of drowning (e.g. arrhythmia, epilepsy, intoxication, or trauma).
- Check blood glucose and electrolytes.
- Follow the PALS Guidelines modified for hypothermic arrest if cardiac arrest occurs (see below).

Hypothermic cardiac arrest

- Individualise approaches depending on the cause of cardiac arrest: accidental hypothermia, or other possible causes such as drowning, suffocation, intoxication.
- Start standard CPR in every case of hypothermic cardiac arrest as soon as possible (e.g. before full extrication from an avalanche or in the water).
- If standard CPR is not possible and the child is deeply hypothermic (<28 °C) consider delayed or intermittent CPR.
- Modify the standard PALS-algorithm according to the core temperature. The revised Swiss Staging for Hypothermia can be used when the core temperature cannot be measured.
- Start rewarming the child as rapidly as possible while monitoring the core-temperature as soon as this is practicable.
- Below 30 °C give a single dose of adrenaline unless planning immediate initiation of extracorporeal life support. Do not give amiodarone until the temperature is above 30 °C. Prolong the administration intervals of resuscitation medication while the core temperature remains between 30 °C and 35 °C (i.e. adrenaline every 8 min, second dose of amiodarone after 8 min).
- Attempt defibrillation a maximum of three times if a shockable rhythm is present under 30 °C. If this is ineffective, delay further attempts until the core temperature exceeds 30 °C. Then use the standard sequence of defibrillation (every two minutes).
- Transport a child considered to have a chance of a favourable outcome from hypothermic cardiac arrest as soon as possible to an appropriate centre for extracorporeal life support.
- Extracorporeal life support is potentially indicated in all children with hypothermic cardiac arrest who do not achieve ROSC in the field.
- Hypothermic patients with risks factors for imminent cardiac arrest (e.g. P or U on the AVPU scale, associated trauma, ventricular arrhythmia, or hypotension) should also be transported to an extracorporeal life support centre.
- Stop resuscitation if ROSC is not achieved within 30 min when cardiac arrest is due to trauma or asphyxia (i.e. avalanche burial for >60 min, core temperature $\geq$30 °C and an obstructed airway).

Hyperthermia/heat stroke

- Identify patients with exertional or environmental hyperthermia or heat stroke (core temperature above 40 °C, not due to fever) as soon as possible. Look for an elevated body temperature associated with confusion, agitation or disorientation which can progress to coma and/or seizures.
- Remove the child from the heat source and/or stop exercise and loosen or remove clothing.
- If the temperature is above 40 °C, start cooling aggressively preferably using immersion up to the neck in cold/cool water.
- Activate the EMS at the same time as initiating cooling.
- Monitor the core temperature to prevent overcooling. Aim to reduce this by about 0.1–0.2 °C min^{-1}. If the core temperature cannot be measured, cool for 15 min or until neurological symptoms subside.
- Hydrate orally if possible, or intravenously. Give room-temperature intravenous fluids as an adjunct to cooling and avoid fluid overload.
- Monitor symptoms and vital signs including mental status.
- Start resuscitation if circulatory collapse supervenes (often around 41 °C) and follow the standard PALS Guidelines while continuing cooling.
- Stop aggressive cooling (e.g. cold-water immersion) when core temperature reaches 39 °C. Stop all active cooling at 38 °C but continue to monitor core temperature.
- Stabilise the child according to the ABCDE-method.
- All children with heat stroke should be admitted to a paediatric intensive care unit for continued monitoring in anticipation of sequalae and complications.

In the case of malignant hyperthermia (MH) stop all potential triggering agents immediately (e.g. anaesthetics), cool the child actively,

ensure adequate oxygenation and ventilation, correct severe acidosis and hyperkalaemia, and administer dantrolene.

Tension pneumothorax

- Suspect tension pneumothorax especially in trauma, following central venous cannulation and during positive pressure ventilation.
- Use clinical signs to diagnose a tension pneumothorax. POCUS is helpful but is not necessary to make the diagnosis.
- Perform a needle thoracocentesis in the fourth or fifth intercostal space in the anterior axillary line or second intercostal space in mid clavicular line; followed by chest drain insertion usually in the axilla.
- In trauma, perform a finger thoracostomy in the fourth or fifth intercostal space in the anterior axillary line, followed by emergency chest drain insertion.
- Perform bilateral thoracostomies in traumatic cardiac arrest with or without signs of a tension pneumothorax.

Cardiac tamponade

- Suspect cardiac tamponade especially after cardiac surgery, in penetrating chest trauma and pericarditis.
- Use clinical signs and POCUS to recognise cardiac tamponade which is most common post cardiac surgery and in penetrating chest trauma and some viral illnesses.
- Perform urgent pericardiocentesis, mini-thoracotomy, resuscitative thoracotomy or re-sternotomy depending on the setting and available expertise.

Pulmonary thromboembolism

- Suspect PE in case of tachycardia, tachypnoea and hypoxia, especially in children with central lines, cardiac conditions, cancer, unilateral limb swelling, recent trauma/surgery, prior thromboembolism, anaemia and/or leucocytosis.
- Consider echocardiography if the expertise (e.g. a paediatric cardiologist) is available.
- For thrombolytic therapy refer to local protocols and call for expert help. Consider systemic or catheter-directed administration of thrombolysis which is more effective than systemic anticoagulation.
- Consider extracorporeal life support and surgical embolectomy when thrombolysis fails, or the child progresses towards cardiac arrest.
- In cardiac arrest due to pulmonary thromboembolism, consider thrombolysis, e.g. IV alteplase 0.3–0.5 mg kg^{-1} (max 50 mg) over 2 min, which may be repeated after 15 min.

Toxic agents

Prevention of cardiac arrest

- Provide supportive care based on the ABCDE approach to prevent cardiorespiratory arrest whilst awaiting toxin elimination. Look for evidence of non-accidental trauma.
- Provide early advanced airway management if decreased conscious level.
- Administer IV boluses of 10 ml kg^{-1} isotonic crystalloids for hypotension. Noradrenaline may be required if hypotension persists.
- Perform a 12-lead ECG in certain poisonings (e.g. antipsychotics, 3,4-methylenedioxymethamphetamine (MDMA) and other amphetamines) or in children with altered consciousness, abnormal heart rate or blood pressure. Cardiovert life-threatening tachyarrhythmias.
- Take blood for electrolytes, blood glucose and blood gas analysis and correct any abnormalities. Take blood and urine for toxicological analysis.
- Check for and correct hyperthermia (ecstasy, cocaine, salicylates) and hypothermia (ethanol, barbiturates).
- Take a thorough history (families, friends, EMS crew) and perform a complete physical examination to identify diagnostic clues (e.g. odours, needle puncture marks, pupils, tablet residues).
- Administer antidotes, where available.
- Consult a regional or national poisons centre for information on treatment.

Cardiac arrest

- Suspect toxic agents as an infrequent cause of cardiac arrest after more common causes have been excluded.
- Provide standard PBLS and PALS.
- Do not use mouth-to-mouth ventilation in the presence of chemicals such as cyanide, hydrogen sulphide, corrosives and organophosphates.
- Exclude all reversible causes of cardiac arrest, including electrolyte abnormalities which can be indirectly caused by a toxic agent.
- Be prepared to continue resuscitation for a prolonged period while the toxin concentration falls.
- Consult regional or national poison centres for information on treatment.
- Consider ECPR for selected patients when conventional CPR is failing.

Hyperkalaemia

- Suspect hyperkalaemia in children with massive haemolysis (neonates), cellular lysis (tumour lysis syndrome, crush syndrome), in acute or chronic renal failure, malignant hyperthermia, or specific intoxications.
- Stop all exogenous sources of potassium including fluids containing potassium when hyperkalaemia is detected. Use normal saline if fluids are needed.
- If severe hyperkalaemia is confirmed (>6.5 mmol l^{-1} or >7.0 mmol l^{-1} in neonates younger than 96 h):
  - Treat the underlying cause if possible.
  - Administer rapidly acting insulin 0.1 U kg^{-1} (max. 10 U) with 10 % glucose 5 ml kg^{-1} (max. 250 ml) over 30 min followed by a glucose containing infusion. Check potassium and glucose every 15 min for 4 h.
  - Administer short acting $beta_2$-adrenergic agonists preferably as inhalation/nebulisation (e.g. salbutamol 2.5–5 mg, repeat up to five times).
  - If inhalation is not possible, give short-acting $beta_2$-adrenergic agonists IV (e.g. salbutamol 5 μg kg^{-1} over 5 min). Repeat if insufficient effect is seen within 15 min, up to a maximum total dose of 15 μg kg^{-1}.
  - In patients with conduction abnormalities on the ECG consider 10 % calcium gluconate, 0.5 ml kg^{-1}, max. 20 ml.

- Prepare a potassium removal strategy (e.g. binding agents, furosemide in well-hydrated children with preserved kidney functions, dialysis).

- For cardiac arrest caused by severe hyperkalaemia (usually above 6.5–7 mmol l^{-1}):
  - Give 0.1 unit kg^{-1} short acting insulin (max 10 units) with 5 ml kg^{-1} 10 % glucose (max 250 ml) as an IV bolus, followed by blood potassium and glucose monitoring and a glucose containing infusion as needed. Higher concentrations of glucose solutions may be used via a central line (e.g. 2.5 ml kg^{-1} 20 % glucose or 1 ml kg^{-1} 50 % glucose).
  - Do not use calcium in children in cardiac arrest.
  - Continue high-quality PALS and consider ECPR.

Other metabolic derangements

- Hypokalaemia: give 1 mmol kg^{-1} (max 30 mmol) potassium at 2 mmol min^{-1} for 10 min followed by the rest of the dose (if necessary) in 5–10 min in children with severe hypokalaemia (<2.5 mmol l^{-1}) with life-threatening symptoms or in cardiac arrest. Repeat, if necessary, until the serum potassium is >2.5 mmol l^{-1}. Follow this with an IV infusion (e.g. 0.5 to 1 mmol kg^{-1} h^{-1}, maximum 20 mmol h^{-1}, depending on the potassium level for 1–2 h). Consider magnesium sulphate 30–50 mg kg^{-1} IV for concurrent hypomagnesaemia.
- Hypoglycaemia: Treat hypoglycaemia <3.9 mmol l^{-1} with symptoms, or <3.0 mmol l^{-1} if asymptomatic. Give an IV bolus of 0.2 g kg^{-1} glucose (e.g. 2 ml kg^{-1} 10 % glucose) and re-check the glucose after 5–10 min. Repeat as needed.
- In other metabolic derangements (hypocalcaemia, hypercalcaemia, hypomagnesaemia, hypermagnesaemia): Correct the metabolic derangement during cardiac arrest, while continuing high-quality CPR. Consider extracorporeal life support.

Cardiac arrest in children with congenital heart disease

- Follow the standard PALS algorithm with additional considerations for pulmonary hypertension, obstructed cardiac shunt or if the child is attached to a defibrillator and has a witnessed shockable rhythm.

Pulmonary hypertension

- Suspect pulmonary hypertension in children with congenital heart disease or chronic lung disease but also as a primary disease.
- Anticipate and prevent pulmonary hypertensive crises by avoiding triggers such as pain, anxiety, excessive tracheal tube suctioning, hypoxia, hypercapnia, and metabolic acidosis.
- Treat pulmonary hypertensive crises with a high concentration of oxygen, adequate ventilation, analgesia and sedation and with muscle relaxation as necessary.
- Search for and treat other possible reversible causes of increased pulmonary vascular resistance: inadvertent interruption of pulmonary hypertensive therapy, arrhythmia, cardiac tamponade, or drug toxicity.
- Consider inotropic and or vasopressor therapy to avoid or treat right ventricle ischaemia caused by systemic hypotension.
- Additional therapies, which are indicated if the crisis does not rapidly resolve or in the case of cardiac arrest, are inhaled nitric oxide (iNO) and/or intravenous prostacyclin.
- Consider extracorporeal life support if medical management is ineffective.

Cardiac arrest due to obstruction of a cardiac shunt

- Suspect acute obstruction due to thrombosis or mechanical kinking of connections between the systemic and pulmonary circulation in children with aortopulmonary shunts or patent ductus arteriosus stents as a cause of cardiac arrest.
- Give 100 % oxygen to maximise alveolar oxygenation.
- Consider hypovolaemia and treat this with intravascular fluids if necessary.
- Ensure an adequate systemic blood pressure to optimise shunt and coronary perfusion pressure with vasoactive agents and inotropes.
- Ensure adequate anticoagulation e.g. with a bolus of heparin 50–100 U kg^{-1} followed by a titrated continuous infusion.
- Call for immediate expert help and consider interventional catheterisation or surgery. In the direct post-operative period, immediate re-sternotomy may improve shunt perfusion.

Cardiac arrest in an ECG-monitored child attached to a defibrillator with a witnessed shockable rhythm

- As soon as a shockable rhythm is detected, give up to three quickly successive (stacked) shocks using the standard energy doses for the child's weight.
- Recharge the defibrillator and rapidly check for a rhythm change and signs of life after each defibrillation attempt and, if necessary, immediately give a further shock.
- Start chest compressions and give amiodarone if the third stacked defibrillation attempt is unsuccessful and continue CPR for 2 min.
- Give adrenaline after 4 min.
- The subsequent resuscitation follows the standard sequence of actions, i.e. giving a single shock every 2 min, adrenaline every 4 min and a second dose of amiodarone after the fifth shock.

Cardiac arrest in the operating room

- Clarify roles and procedures during the team briefing before high-risk cases to enable co-ordinated actions should cardiac arrest occur.
- Treat pre-arrest states such as hypoxia and hypotension aggressively. Ventilate with 100 % oxygen and give intravascular fluid and vasoactive agents.
- Recognise cardiac arrest early by continuous monitoring and a high index of suspicion, particularly during difficult airway management and massive bleeding.
- Start chest compressions if extreme bradycardia or hypotension (<5th percentile for age) occurs suddenly despite interventions, or the waveform capnography suddenly decreases.
- Inform the whole OR-team of the cardiac arrest.
- Call for help and for the defibrillator.
- Optimise the child's position and the height of the operating table to facilitate high-quality chest compressions.
- Ensure the airway is secure, review the $ETCO_2$ tracing, and deliver effective ventilation with 100 % oxygen.
- Follow the general PALS algorithm and focus initially on the most likely reversible causes: hypovolaemia (haemorrhage, anaphylaxis), hypoxia, tension pneumothorax, thrombosis (pulmonary embolism) and toxic agents (medication).
- Use POCUS, when the equipment and expertise are available, to help identify the cause and guide resuscitation, provided this does not compromise the quality of the resuscitation.

- Also consider causes specific to the operating room such as: gas embolism, bradycardia from axial nerve blocks, malignant hyperthermia, local anaesthetic overdose, and other drug errors.
- For hypotensive and/or bradycardic children in a pre-arrest state, give smaller incremental bolus doses of IV adrenaline initially (e.g. 1–2 $\mu g\ kg^{-1}$ intravenously). If the child progresses to cardiac arrest, give adrenaline according to the standard PALS-algorithm.
- If the facilities and expertise are available and conventional CPR is failing, consider early ECPR or open chest cardiac compressions as an alternative if ECPR is unavailable.

Post-resuscitation care

Post-resuscitation care starts immediately after return of spontaneous circulation (ROSC) is achieved.

Recommendations for health care providers in the pre-hospital setting and limited-resource healthcare (Fig. 20)

- The general ABCDE principles described in the section on the prevention of cardiac arrest also apply to post-resuscitation care.
- Ensure adequate oxygenation and ventilation.
- Intubate the trachea only if you are competent and equipped to do so safely.
- Always use analgosedation and muscle relaxants for intubation unless the child is deeply comatose (GCS 3). Provide 100 % oxygen during intubation.
- Monitor $ETCO_2$ continuously if an advanced airway is in place.
- Titrate FiO_2 to achieve a peripheral oxygen saturation of 94–98 % as soon as reliable measurement is available. When ABG-analysis is available aim for normoxaemia.
- In the absence of ABG-analysis, aim for a normal respiratory frequency for the child's age and mild chest movements.
- Monitor capnography and aim for normocapnia. When ABG-analysis is available, confirm normocapnia.
- Use tidal volumes of 6–8 ml kg^{-1} of ideal body weight, and PEEP of 5 cm of H_2O for mechanical ventilation in previously healthy children.
- Use the minimum airway pressures needed to achieve oxygenation and ventilation goals, adjusting these in special circumstances (e.g. chronic lung disease).
- Check for signs of shock and treat it immediately if present. Treat shock with fluids, vasoactive medication or inotropes or combinations of these.

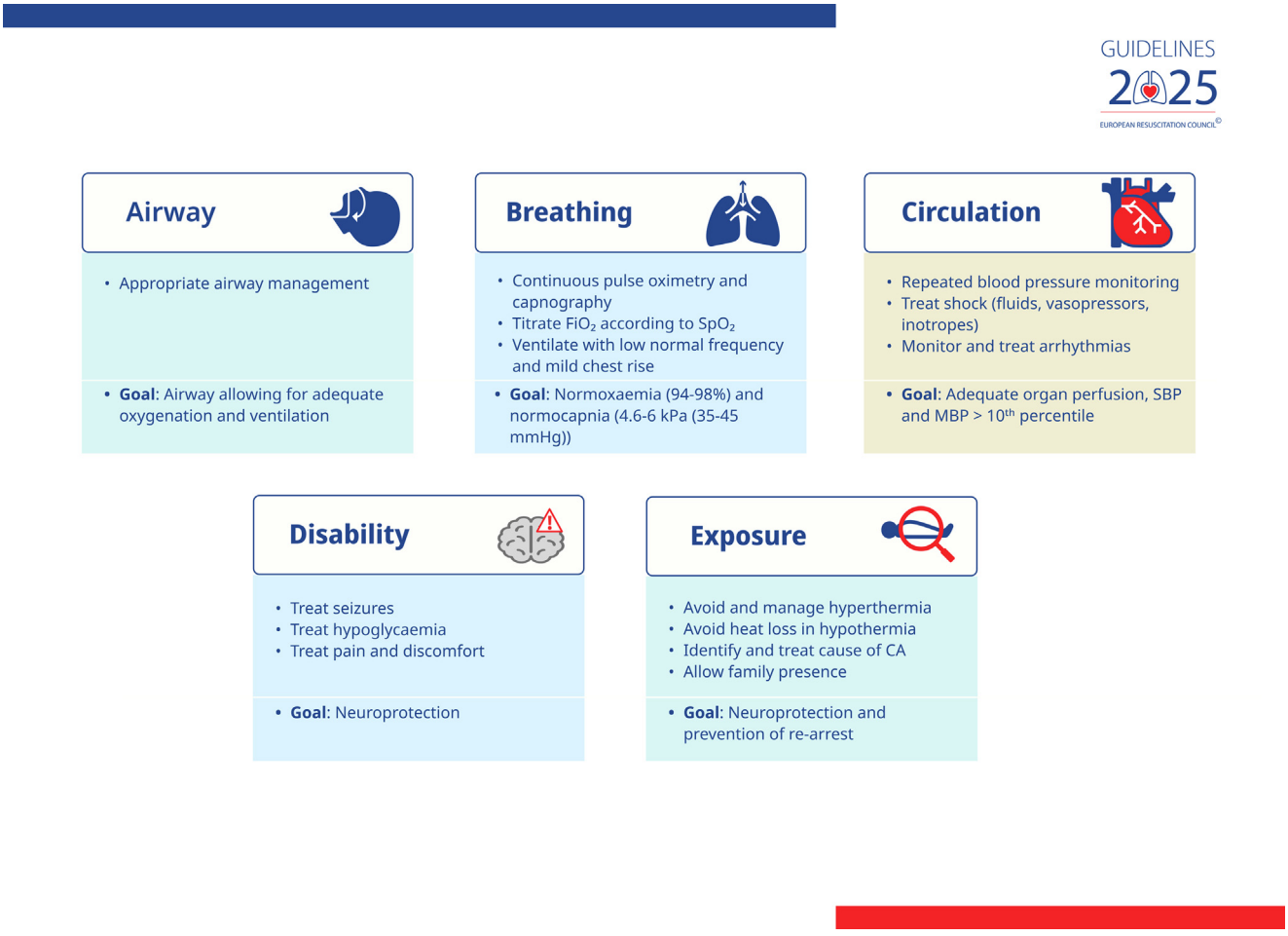


Fig. 20 – Immediate post-resuscitation care.

FiO_2 – fraction of inspired oxygen, MBP – mean blood pressure, SBP – systolic blood pressure, SpO_2 – peripheral oxygen saturation, CA - cardiac arrest.

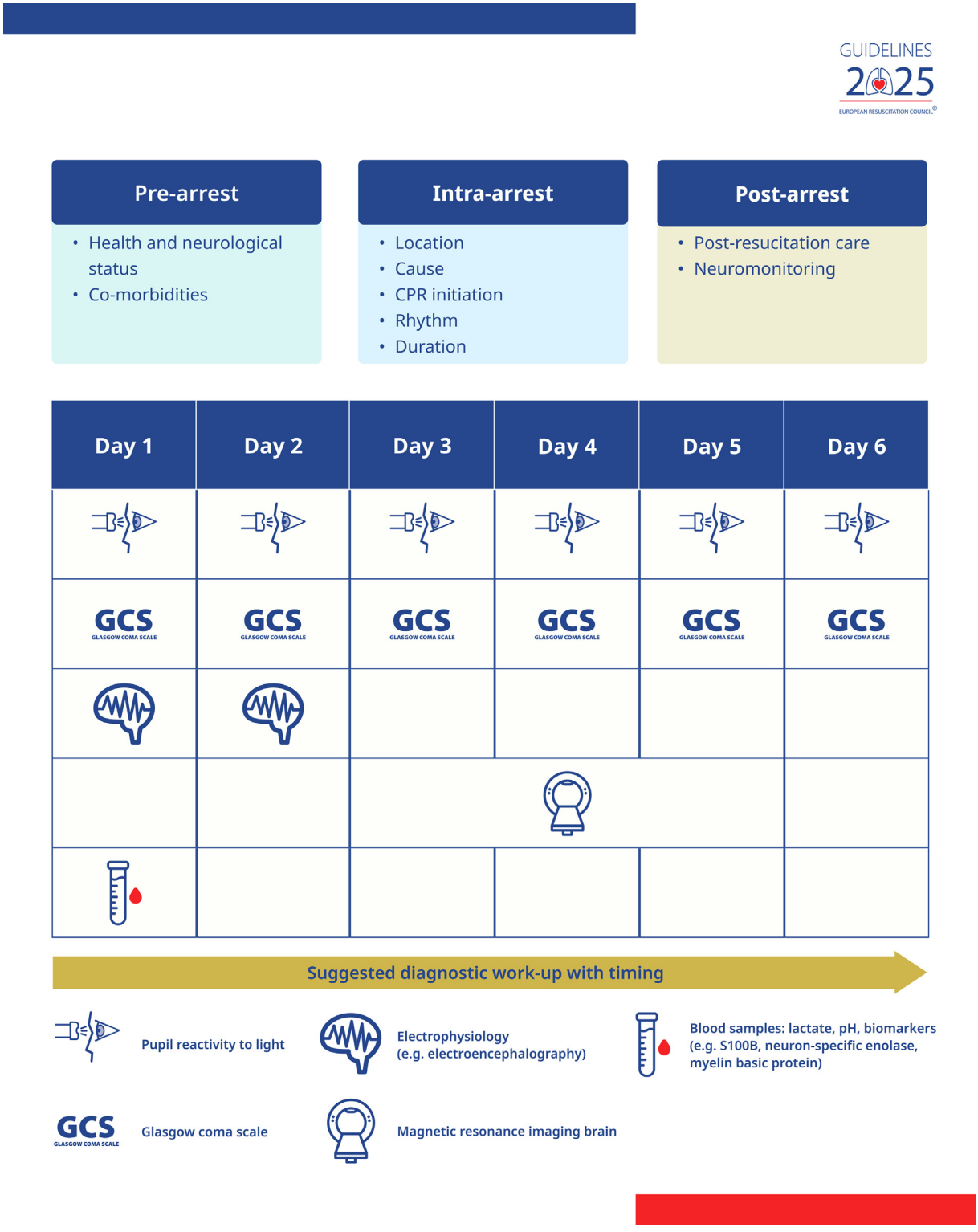


Fig. 21 – Prognostication after paediatric cardiac arrest.
Disclaimer: NO single modality can be used in isolation for prognostication with high accuracy. The overall quality of evidence for individual tests is very low for all outcomes primarily due to a very serious risk of bias.

- Aim for a systolic and mean arterial blood pressure above 10th percentile for child's age.
- Treat seizures immediately if they emerge.
- Check blood glucose after cardiac arrest and treat hypoglycaemia.
- Use analgesia and sedation to treat pain and discomfort after cardiac arrest in children of all ages. Avoid bolus medications that can cause sudden drops or rises in blood pressure.
- Always treat hyperthermia or fever with active cooling.
- Try to establish the cause of cardiac arrest and treat it to avoid re-arrest.
- Enable parental or caregiver presence during the pre-hospital care or transport whenever this can be done safely.

Recommendations for health care providers in a hospital (Fig. 23)

- Use individualised goals and bundles of care rather than specific single targets during post-resuscitation care. Treat underlying disease(s) as well as post-cardiac arrest syndrome.
- Establish invasive arterial blood pressure monitoring and central venous access with SvO_2 measurement as a minimum in all sedated or comatose children.
- If no individualisation is needed, continue targeting normoxaemia, normocapnia, and maintain systolic and mean arterial blood pressure above 10th percentile for at least 24 h after cardiac arrest.
- Use available non-invasive or invasive techniques to diagnose the probable cause of cardiac arrest as well as to make individualised decisions in the management of post-cardiac arrest syndrome.
- Diagnose, monitor, and treat pain, discomfort and delirium.
- Keep temperature control as an integral part of post-resuscitation care for at least 24 h after cardiac arrest. Avoid fever for at least 72 h.
- Prevent, diagnose, and treat acute kidney injury or renal failure.
- Optimise nutrition.
- Start rehabilitation early.
- Allow unrestricted access of primary caregivers to the child as a part of family-centred care. Be sensitive to cultural and religious issues.
- Communicate clearly and honestly with parents/caregivers while also paying attention to their understanding and needs; decision-making should be shared. Involve concerned stakeholders (e.g. extended family, religious support) in the communication.
- Seek the assistance of specialised multidisciplinary teams early (e.g. paediatric neurologists, psychologists, paediatric palliative care team, social workers and, if necessary, an interpreter) to address the needs and concerns of the child, parents, family and other caregivers.
- In case of cardiac arrest, whether fatal or not, use a standardised diagnostic protocol to identify the cause. If the cardiac arrest might have been due to an inherited condition, such as certain arrhythmias and cardiomyopathies, ensure appropriate screening of family members to prevent cardiac arrest in future patients.

Prognostication after cardiac arrest

- Avoid both false optimism and false pessimism, and prevent individual suffering, increased healthcare costs, impaired daily skills and reduced ability to participate in society (education, labour).

Recommendations for health care professionals

- Delay prognostication in children with a decreased level of consciousness or who are sedated for at least 72 h following cardiac arrest.
- Use a multimodal approach to prognostication. Accurate prognostication for both good and poor outcomes involves:
  - Pre-arrest: knowledge of the child's baseline health and neurological status
  - The context of the cardiac arrest: e.g. location of the cardiac arrest, bystander BLS, first rhythm, cause of cardiac arrest and duration of the cardiac arrest.
  - Post-cardiac arrest care: a comprehensive assessment supplemented with repeated evaluations.
- Combinations and timing of investigations and signs predicting good outcomes differ from those predicting poor outcomes (see Fig. 24). No single modality can be used in isolation for prognostication with high accuracy.
- Use the suggested standardised minimal set of diagnostic modalities for better comparability and research (see Fig. 21).
- Visual aids and presentations might help parents/caregivers to understand certain specifics of prognostication enabling them to participate better in the decision-making.

Post-discharge care

- Assess outcomes with standardised measurements using validated instruments and involve paediatric psychologists, neurologists, rehabilitation physicians and/or intensivists in post-discharge care (see Fig. 25).
- Plan and discuss the post-discharge care with caregivers before hospital discharge.
- Organise multidisciplinary post-discharge care to minimise the number of hospital visits for the child and family.
- Consider a virtual consultation when an on-site visit to an outpatient clinic is challenging due to financial, travel or work limitations.
- Screen patients, parents/caregivers, and family members for symptoms of post-intensive care syndrome regularly and refer to a professional (e.g. psychologist) as soon as any physical or mental health issues arise.
- Seek and signpost supportive structures for patients and parents/caregivers, such as parent groups, cardiac arrest survivors' groups and bereavement groups.

System-level recommendations and recommendations for implementation

Recommendations for general public

- All parents and caregivers should be encouraged to learn the basic recognition of signs and symptoms of critical illness and trauma in children, basic first-aid life-saving procedures and PBLS.
- PBLS, simple recognition triage tools and basic first-aid life-saving procedures for paediatric emergencies should be part of training for professional caregivers of children (e.g. child minders, schoolteachers, first responders, lifeguards, and coaches/trainers of children and adolescents). Priority should be given to the training of those who take care of children with an increased risk of an acute life-threatening event.
- Facilities should be in place to manage acute life-threatening events in children, including trauma, in settings in which there is an increased risk of these events, such as sporting events, swimming pools and other areas of open water. These facilities must include equipment, protocols, systems, and trained personnel.

- Children who live near water should be taught to swim before they are allowed to play unsupervised.
- In settings where heat stroke might occur, e.g. sports events in a warm climate, facilities for the management of hyperthermia, including a method for rapid cooling should be available.
- Every child who has had an anaphylactic reaction should carry an adrenaline auto-injector of the appropriate dose, which the caregivers and the child, if old enough, should be able to use.

Recommendations for all healthcare systems

- All systems caring for children should aim to link all parts of the chain of survival (prevention of cardiac arrest, early call for help, PBLS, PALS, post-resuscitation care and post-discharge care).
- As well as individual technical and non-technical skills, the safe and effective management of an acute life-threatening event or cardiac arrest requires an institutional safety culture embedded in everyday practice through continuous education, training, and multidisciplinary cooperation.
- All systems should promote the use of protocols and bundles of care for life-threatening conditions (e.g. for cardiac arrest, sepsis, anaphylaxis, status epilepticus) and should evaluate protocol adherence aiming for improvements in care.
- All systems caring for children should adopt standardised drug calculations and provide cognitive aids (algorithms, tapes, posters, applications) and standardised drug and equipment labelling and handling to avoid medical errors. All personnel should be trained accordingly. Cognitive aids used should be easily accessible.
- All systems should aim to identify children who may be at increased risk of cardiac arrest such as very small and preterm infants, children with a sudden unexplained death in family, siblings of children who died from sudden infant death syndrome (SIDS) and children with specific congenital abnormalities, primary arrhythmia syndromes, cardiomyopathies, channelopathies and coronary artery abnormalities. Systems should ensure that a plan is in place to care for these children.

Recommendations for emergency medical systems and dispatch systems

- Dispatch systems should implement instructions for dispatcher-assisted CPR specific for children.
- Ensure clear and effective communication so that emergency personnel are dispatched promptly to a critically ill or injured child or a child in cardiac arrest.
- Pre-hospital emergency medical systems should train all professionals in the recognition and initial management of critically ill and injured children to prevent cardiac arrest, including field triage.
- Pre-hospital emergency medical systems should train all professionals in PBLS.
- Emergency healthcare responders should be available at all times and must be trained in PALS and suitably equipped to respond to a paediatric cardiac arrest.
- Emergency responders' PALS skills should include bag-mask ventilation, IV/IO access, administration of adrenaline, rhythm recognition, use of a defibrillator/AED and knowledge and understanding of the PBLS and PALS algorithms including choking. Training should also include communication with parents/caregivers.
- Emergency medical systems should have set training schemes to improve skill retention and teamwork. They should develop clear protocols and communication plans to facilitate the transportation of children with a cardiac arrest.
- There should be systems, including protocols, to guide communication between pre-hospital teams and hospital teams to prepare them to receive the child.
- There should be systems, including protocols, to guide the transport of parents/caregivers when possible.
- Children sustaining a cardiac arrest should be transported to a hospital with a paediatric intensive care unit.
- Certain specific subgroups of patients should be transported directly to specialised paediatric intensive care units with facilities for extracorporeal life support.
- Consultation with specialists (e.g. via telemedicine) should be encouraged when there are uncertainties regarding the management or transport of a child.

Recommendations for hospital departments and resuscitation teams

- Emergency departments treating children should implement triage systems specific for, or adapted to children and should train personnel in their use. They should monitor and evaluate the effectiveness of their triage protocols.
- Hospitals should train all healthcare professionals who are involved in the care of children (including those who only occasionally treat them) in the recognition and initial management of critically ill or injured children.
- All health care professionals involved in the care of children should be able to perform PBLS.
- Systems should exist to activate personnel skilled to establish IO access in less than 5 min.
- Use paediatric early warning systems as part of an overall in-hospital response system, not as a stand-alone measure.
- Each hospital caring for children should have a resuscitation team (and/or clinical emergency team) trained in PALS. Its members should have pre-designated roles. These individual roles should cover all the required interventions and competencies to resuscitate a child effectively and efficiently. Shared leadership should be considered.
- Each hospital should set training requirements for members of the resuscitation team to improve skill retention and teamwork.
- Each hospital should have a designated method of summoning the resuscitation team, which can be audited.
- Ideally, members of the resuscitation team should meet once or twice a day at the beginning of each shift (team huddle) to get to know each other, discuss role allocation and any patients of concern in the hospital.
- Members of the resuscitation team should be given time to debrief after critical events both to support staff and to enhance performance.
- Standardise resuscitation trolleys across the hospital and train staff in their contents and use of equipment. Trolleys should be checked frequently.

- Provide easy bedside access to cardiac arrest algorithms both electronically and on paper, and display these on the resuscitation trolley and in all areas where cardiac arrest might occur. Provide handheld cards and/or electronic tools for staff.
- Every child who has a reduced level of consciousness after cardiac arrest should be admitted to a paediatric intensive care unit, if possible, for post-resuscitation care.
- Hospitals offering extracorporeal life support, should establish institution-specific protocols for cardiac arrest in children during or after cardiothoracic surgery, and other children with cardiac arrest or peri-arrest conditions.
- There should be a clear protocol, based on these Guidelines, for the management of perioperative cardiac arrest in every operating room.
- Hospitals, department and paediatric intensive care units should investigate and employ ethical, guideline-based and reliable prognostication methods.
- Allow sufficient dedicated time for physicians to talk with parents/-caregivers about care and prognostication.
- Family-centred care and a shared approach to decision-making should be considered the standard of care in the best interest for the child.
- Include all cardiac arrest survivors and their families in post-discharge care. Offer specific care to families of non-survivors, including bereavement care and psychological support.
- Aim for well-coordinated family-centred post-discharge care, using e.g. family liaison staff to limit the burden for cardiac arrest survivors and their families.

Recommendations for manufacturers of medical devices

- Manufacturers of AEDs and defibrillation pads should standardise pictograms for positioning the defibrillation pads for infants and children so that they are in line with current resuscitation guidelines.
- Manufacturers of public access defibrillators should aim for the simplest and quickest possible ways to attenuate energy levels in case the AED is used in younger children (preferably a paediatric button with only one size of defibrillation pads).

Recommendations for low resource settings

- Aim for the highest possible level of care within the specific context.
- Prioritise implementation of recommendations according to the expected benefit for the overall outcomes (e.g. training many in simple procedures rather than buying expensive advanced equipment).
- Modify recommendations taking the availability of personnel and equipment into account.
- Adjust recommendations to the typical patient-population and specific setting.
- Where possible, critically ill and injured children should receive specific *paediatric* care, as recommended in these Guidelines. Where this is not possible, arrange for the most appropriate care, considering the child's age, condition and circumstances.

Evidence informing the PLS guidelines

For these evidence-informed guidelines, our recommendations are grounded in a comprehensive analysis of the available evidence. In instances where no modifications were made to the Guidelines or no new relevant evidence was identified, no additional commentary has been provided.

Prevention of cardiac arrest

Cardiac arrest in infants, children and adolescents is often secondary to progressive respiratory, circulatory, or neurological failure caused by critical illness or trauma, while a primary cardiac aetiology is less common.[11,16,23,30,31] Cardiac arrest might therefore be prevented in some children by earlier recognition, preventative measures and improved management of critical illness and trauma.[10,17,19,20,32] There has been no recent ILCOR CoSTR on cardiac arrest prevention in children, therefore the ERC Writing Group Paediatric Life Support compiled their own reviews of the evidence.

Recommendations for caregivers and other untrained rescuers

The identification of children with critical illness at risk of cardiac arrest is not easy, especially for untrained rescuers. The recommendations for caregivers and untrained rescuers are based on quick-look clinical triage protocols, which need to be reworded for non-professionals. The ERC recognises that the use of some of these protocols might lead to over-triage but consider this to be a reasonable approach as under-triage at this level probably carries a higher risk for children. The suggested signs in these protocols include symptoms of respiratory and circulatory failure and neurological emergencies. Children with chronic medical conditions, chronic illnesses, and those dependent on medical technology are at increased risk of unexpected deterioration.[24] The ERC recommends that the parents/caregivers of these children should be trained in basic life-saving procedures according to the specific needs of their child, including PBLS. They should also have an emergency plan for a sudden deterioration of their child.

Recommendations for healthcare professionals

The sequence of actions in the recognition of a critically ill or injured child should include a dedicated quick-look tool for the rapid detection of a child at risk of cardiac arrest.[33] Rescuers should always consider their own safety and use appropriate personal protective equipment before approaching a critically ill or injured child. The ABCDE system is a widely recognised priority-based method for assessing critically ill patients and is designed to identify and manage life-threatening conditions quickly and improve quality of care by breaking down the response to a complex clinical situation into manageable steps.[34] Whenever resources allow, a dedicated team should be summoned in response to the recognition of a critically ill child. Effective teamwork and the use of structured and standardised communication (e.g., SBAR, Situation-Background-Assess ment-Recommendation) should establish a shared mental model within the team.[35] Both leadership and followership are important parts of effective teamwork. Two small studies show improved patient outcomes (fewer non-ICU cardiac arrests and unplanned ICU admissions) after the implementation of a rapid response team.[36,37] Dedicated cognitive aids appear to improve outcomes and decrease cognitive load for healthcare providers in time-critical situations and help establish a shared mental model.[38,39]

It is important to know the weight of the child when delivering care, especially when giving medications, but weighing the child can be problematic in an emergency. Ideally, the child's weight as reported by the parents/caregivers is often the most accurate and we recommend using this when available. When this is not available, other methods can be considered. Generally, a length-based

method, corrected for body habitus, is more accurate than a formula. Due to increasing obesity among children and adolescents worldwide, age-based formulas tend to underperform in estimations of actual body weight, compared with emergency tapes with or without correction for body habitus.[40–50] Overall performance of the Broselow tape remains high, with most studies reporting a PW20 (the percentage of all estimates within 20 % of the measured weight) above 80 % in healthy children aged 0–12 years, in all countries studied. In chronically ill, severely underweight, and severely obese children, accuracy is below 80 %.[41,48] The PAWPER, PAWPER XL and PAWPER XL-MAC are length-based methods corrected for body habitus, developed and validated in South Africa. They outperformed all other length-based methods in children from 1 to 18 years old, with PW20 ranging from 84 % to 100 %, regardless of body type.[48,51–55]

In most resuscitation situations, ideal body weight is the preferred weight utilised because volume of distribution is deemed the most important pharmacokinetic factor affecting the therapeutic effect of a given dose of a drug. Drugs used in resuscitation are largely hydrophilic (adrenaline, calcium, potassium, salbutamol, magnesium, adenosine) with fewer being lipophilic (amiodarone). A hydrophilic drug should be dosed according to ideal (not actual) body weight. Children with a high body mass index (BMI) have a similar volume of distribution for hydrophilic medications as children with a BMI in the normal range. These medications are not distributed in the excess tissue, which is usually extra fat tissue. Therefore, if hydrophilic drug doses are calculated for actual body weight (e.g. using a length-based method corrected for body habitus) then there is a chance the dose will be too high, exposing the child to potential toxicity.

Parental/caregiver presence is important for the care of a critically ill child. This should be considered standard care unless the safety of the child, caregiver or personnel cannot be guaranteed.[56–58]

Recognition of critically ill or injured child. Signs of respiratory and circulatory failure are long established although the threshold values of measured vital signs are still under discussion because of increasing amounts of data being gathered from children measured in different settings.[26–28] No new evidence was found to change the previous recommendations regarding threshold values for children of different ages. We added (rounded) values for the 10th percentile of blood pressure as we recommend aiming for this during post-resuscitation care. These values offer reasonable sensitivity and specificity for use in emergency settings.

Although the most accurate way to determine normal values is through detailed percentile charts, these are impractical in emergencies. Mobile applications and other cognitive aids—such as resuscitation tapes displaying estimated values—can be helpful, but they have not been validated and may be based on older, less accurate data derived from relatively small paediatric samples.

The most typical signs of respiratory failure in children, as well as the most common conditions associated with imminent cardiac arrest, can be identified through a thorough ABCDE assessment. It is important to emphasise that no single value or sign is sufficiently sensitive; assessment must always include multiple signs. Distinguishing compensated from decompensated respiratory and circulatory failure is not easy as deterioration takes place on a continuum. Progression to cardiac arrest can occur very quickly even from the compensated phase, especially in infants.

The ERC recommends monitoring pulse oximetry continuously in all critically ill and injured children. Hypoxia is common in critically ill children and is strongly associated with death, especially in lower resource settings.[59,60] Pulse oximetry together with clinical examination can help detect the most severely ill children and improve outcomes.[61,62] One study found that children with severe hypoxaemia (SpO_2 < 90 %) and children with mild/moderate hypoxaemia (SpO_2 90–93 %) had an increased risk of death.[63] Professionals should be aware that SpO_2 values might be overestimated in children with a darker skin tone.[64]

Use $ETCO_2$ to continuously monitor the position of a tracheal tube or supraglottic airway; this will enable immediate detection of a dislodgement or obstruction and provides some indication of quality of ventilation. In patients with traumatic brain injury, using $ETCO_2$ to prevent hyperventilation or hypoventilation decreased mortality.[65]

Although the evidence for the use of $ETCO_2$ monitoring in non-invasive ventilation is limited, it is widely used during periprocedural sedation to detect respiratory adverse events in non-intubated patients.[66–69] Various factors influence the difference between $PaCO_2$ and $ETCO_2$ such as ventilation-perfusion mismatch. Therefore, blood gas analysis (arterial or capillary) should be performed to identify the difference.[70,71]

Many providers underestimate face mask leaks and miss partial or complete airway obstruction resulting in low delivered volumes.[72] Respiratory function monitoring (devices that calculate or display mask leak, inspired and expired tidal volume, flow rate, respiratory rate, peak inflation pressure etc.) can replace imprecise visual estimation of tidal volumes (i.e. by observing chest movements), however, there is insufficient data to recommend its use in clinical practice.[72] Point-of-care lung ultrasound performed by trained individuals can be useful in distinguishing different causes of respiratory failure (e.g. pneumothorax, atelectasis) in the emergency setting and guiding therapy.[73–76]

The proper assessment of the circulatory status includes recognising shock and determining its type, because time-critical interventions differ according to the type.[77] Hypovolaemic (including haemorrhagic) and distributive shock are the most common types in children, while cardiogenic shock is present in 5–10 %, and obstructive and dissociative shock are rare, although the latter can be more prevalent in limited resource settings (e.g. malaria).[78] Non-invasive blood pressure (NIBP) monitoring remains important, although hypotension is a very late sign of circulatory failure in children. Accurate measurement in children requires use of the correct cuff size and is most accurately measured in the upper arm.[79,80] Lower accuracy was noted in neonates with a mean arterial pressure below 30 mmHg.[79] Specific point-of-care tests (lactate, POCUS/echocardiography, troponin I) can help guide time-critical interventions in shock and potentially improve outcomes.[81,82]

Recognition of a neurological emergency remains unchanged because no new relevant evidence to change our recommendations was found. Brain imaging in children with severe neurological symptoms has been given more emphasis to reduce delays in the identification of time-critical emergencies (e.g. meningitis, encephalitis, seizures and stroke).

Examination of the whole body (the “E” of the ABCDE-approach) can reveal indications of underlying disorders and specific conditions, which require modifications of the initial approach (e.g. signs of sepsis, thrombosis, or intoxication). Child abuse and neglect is underdiagnosed in emergency settings and action is needed to improve recognition and outcomes.[83] Unfortunately, during the ABCDE-approach there are few signs or symptoms indicating child

abuse and clinicians need to be alert to the possibility of child abuse to help identify children at risk.[84,85]

Management of the critically ill or injured child.

Airway

No new evidence was found to change the airway recommendations. The main goal of airway management is oxygenation and ventilation. Where prolonged ventilation is anticipated, competent providers should place a supraglottic airway (SGA) or tracheal tube. However, bag-mask ventilation remains the first-line method for ventilation because studies of early placement of an advanced airway in the pre-hospital setting have shown either no benefit or harm.[86] Pre-hospital use of SGAs is recommended over tracheal intubation if an advanced airway is required, as SGAs have been shown to be at least non-inferior to intubation.[87]

Tracheal intubation remains the preferred method for the definitive management of the airway in critically ill or injured children.[88] Intubation-related adverse events are more common with multiple attempts and are commonest in neonates and infants.[89–92] Prolonged intubation attempts are common in stressful situations and the time spent during attempts is often underestimated.[93] In line with anaesthesiology guidelines, we recommend having a 'plan B' for difficult airway situations. Use pre-oxygenation, continue oxygen insufflation during intubation, use rapidly acting sedative and neuromuscular blocking agents and limit the number and duration of attempts.[94–96] Most anaesthetic medications are associated with vasodilation, which might induce bradycardia and cardiovascular collapse, especially in hypovolaemia or sepsis.[97] Recent studies failed to show any benefit of atropine premedication before intubation, and this is not recommended.[98,99] The use of video laryngoscopy by trained providers reduces the incidence of failed intubation and complications, especially in infants.[100] Cuffed tracheal tubes are safe for use in infants and children and reduce leaks. Monitor the cuff pressure to reduce damage to the tracheal mucosa.[101,102] The formula for the internal diameter of cuffed tubes (age/4 + 3.5 mm) in children up to 8 years remains valid.[103,104] Broselow tapes should not be used in isolation to estimate tracheal tube size in children weighing >18 kg.[105,106] POCUS seems able to predict the size of the tracheal tube reliably but requires expertise and equipment. POCUS will estimate the internal diameter of the trachea, which determines the maximum safe external diameter of the tracheal tube, not its internal diameter. Malposition of the tracheal tube is common and checking the correct position using a combination of techniques is mandatory (clinical examination, chest X-ray, POCUS, $ETCO_2$).[107]

The safe emergency management of a difficult airway consists of a planned stepwise approach focused on ensuring oxygenation and starting with non-invasive techniques.[108] Where bag-mask ventilation fails or following unsuccessful intubation, an SGA can often be used to secure the airway quickly and simply.

A cannot-ventilate-cannot-oxygenate situation occurs when bag-mask ventilation, SGA and intubation are unsuccessful in achieving oxygenation. This can quickly cause cardiac arrest. An invasive airway technique (front-of-neck airway) may be required. This is difficult in children, particularly infants, and the best technique is unknown. International guidelines vary and various techniques have been suggested.[109,110] A recent narrative review highlighted the extreme difficulty of needle cricothyroidotomy in young children and concluded that the scalpel-bougie tracheostomy should be preferred in children under 8 years of age and a surgical cricothyroidotomy considered in older children.[94] In the absence of conclusive evidence, expert providers should perform the technique in which they are trained, have the most experience with, have the appropriate equipment for and feel confident in.

Tracheostomy emergencies are largely preventable, but if they do occur, they must be managed quickly.[111,112]

Breathing

Oxygen saturation targets for critically ill children are not clearly defined and may need to be adjusted for specific conditions (e.g. chronic lung disease). A recent systematic review compared SpO_2 targets of 80–92 % with 92–94 % in children with respiratory distress. The lower targets were equivalent to the higher targets in terms of mortality, neurocognitive outcome and readmission or re-attendance. Using the lower targets admission rates were 40 % lower and hospitalisation duration was 10–18 h shorter.[113] A large randomised controlled trial (Oxy-PICU trial) in children ventilated in the paediatric intensive care unit found that conservative oxygen saturation targets (SpO_2 88–92 %) led to a slightly better outcome (duration of organ support or death) compared to liberal targets (SpO_2 > 94 %). However, the study excluded some important groups (brain pathology or injury, post cardiac arrest, pulmonary hypertension, sickle cell disease, uncorrected congenital heart disease and on long-term ventilation).[114] Whilst these studies are promising, further evidence is required to guide SpO_2 targets in critically ill children in different populations and settings. There is no evidence to guide pre-hospital SpO_2 targets, where measurement may be unreliable. Therefore, the ERC recommends a lower limit SpO_2 target of 94 % after initial resuscitation, which may be adjusted in specific situations (e.g. congenital heart disease). No studies of the optimal FiO_2 were identified, but to avoid hyperoxia, the lowest possible FiO_2 to achieve the required SpO_2 should be used.

Non-invasive ventilation can be delivered by bag-mask ventilation (preferably using two hands on the mask). High-flow nasal oxygenation, continuous positive airway pressure or non-invasive ventilation are reasonable options when conventional oxygen therapy is insufficient or additional ventilatory support is required.[115–118]

Circulation

Adequate organ perfusion is the main aim of circulatory support. Providers should not spend more than 5 min (or two attempts) on attempts to establish IV access. POCUS can be used to guide cannulation.[119] If the chances of IV access are considered minimal (shock, severe hypovolaemia, previously difficult cannulation), use a rescue alternative early. Intraosseous (IO) access is underutilised but is appropriate for patients of all ages in resuscitation and other critical care situations.[120,121] Providers should be trained in this technique. Signs of extravasation should be actively sought, and the cannulation site continuously monitored. Special attention must be given to infants, who experience more complications, particularly dislodgements.[120–122]

The previous ERC recommendation on fluid boluses remains unchanged. Further evidence supports frequent re-evaluation of the circulatory status to avoid fluid overload as well as the use of balanced solutions.[123,124] Cautious fluid administration is needed in cardiogenic or obstructive shock, although some extra fluid might be needed, especially in infants who have had feeding problems or if another type of shock is concurrent. Vasoactive and inotropic support is needed in fluid non-responsive and cardiogenic shock. The optimal time to start vasoactive support is not clearly defined, but possibly lies after 20–40 ml kg^{-1} has been given and evidence supports the use of vasoactive support.[125,126] A recent systematic review comparing different first-line vasoactive strategies on mortal-

ity supports this recommendation.[127] Combined regimens using more than one agent are increasingly used successfully.[128] A peripheral IV line can be used for short-term administration of vasoactive agents or inotropics.[129–133] Milrinone remains the most used inodilator with levosimendan as a promising alternative.[134–136] Extracorporeal life support should always be considered early as a rescue strategy for children with shock not responding to initial resuscitation.

Disability and exposure

Neuroprotection (as described in post-resuscitation care) is an important part of the initial management of neurological emergencies. Attention needs to be given to sedation and pain management, as pain management is often poor.[137] The ERC emphasises the importance of recognising seizures as a neurological emergency and acting quickly as delays in treatment are common and earlier treatment improves outcomes.[138]

Additional recommendations for time-critical interventions.

Severe acute asthma (critical asthma syndrome)

Critical asthma syndrome is an umbrella term for all forms of asthma with a high probability of mortality.[139] As asthma still causes significant morbidity and mortality, timely aggressive treatment is needed.

The PLS WG have based their recommendations on the recent overview of Cochrane reviews and the updated Global Initiative for Asthma recommendations.[140,141] Recognition of severe asthma is primarily based on clinical signs, brief history, and oxygen saturation. Hypoxaemia is a sign of decompensated respiratory failure, which might induce agitation, irritability and decreased consciousness. The differential diagnosis includes pneumonia, pneumothorax, cardiac failure, laryngeal obstruction, pulmonary embolism, foreign body aspiration and anaphylaxis.

High-dose inhaled short-acting beta$_2$-adrenergic agonists (e.g. salbutamol) are safe, but can cause side effects (electrolyte disorders, hyperlactatemia, hypotension, arrhythmia, transient hypoxia). Ipratropium bromide when given with short-acting beta$_2$-adrenergic agonists for moderate-severe exacerbations is associated with fewer hospitalisations and greater improvement compared with short-acting beta$_2$-adrenergic agonists alone.

Systemic steroids are indicated within the first hour. Oral steroids are as effective as intravenous. High dose inhaled steroids may be added in a severe crisis. IV magnesium may result in reduced hospital admission in children who fail to respond to initial treatment and have persistent hypoxaemia; isotonic magnesium sulphate might be used as a nebulised solution. There is no evidence for an added benefit of IV short-acting beta$_2$-adrenergic agonists, but in children with near fatal asthma, this may be the only way to administer bronchodilation. Side effects of IV administration include electrolyte disorders, dysrhythmias and cardiovascular failure in pre-existing cardiac disorders, so expert advice and continuous monitoring are required. A loading dose of 15 μg kg^{-1} IV salbutamol can be considered, but there is no consensus on the maximum recommended loading which varies from 250 μg to 750 μg.[142] Severe exhaustion, deteriorating consciousness, poor air entry (silent chest), severe hypoxaemia not responding to treatment, and cardiopulmonary arrest are indications for tracheal intubation. Mechanical ventilation of a child with severe asthma is extremely challenging and requires expert advice.

Septic shock

Early identification and treatment (including antibiotics) of sepsis and septic shock are essential parts of care bundles and are associated with improved outcomes.[143] Stress-dose corticosteroids may be considered in children with sepsis-associated organ dysfunction and/or septic shock that is unresponsive to fluids and requiring vasoactive support. Children who are at high risk for adrenal insufficiency, such as those with chronic or recent treatment with steroids or those with congenital or acquired adrenal insufficiency, should receive a stress dose of hydrocortisone early.[144,145] For more details, we recommend specific guidelines for management of sepsis that will be published in 2025.

Cardiogenic shock

Cardiogenic shock is infrequently present in children but can have devastating impact. Causes are heterogeneous, ranging from myocarditis, systemic inflammatory syndromes to cardiomyopathies, arrhythmias and congenital heart diseases, including acute decompensation of the underlying disease. Signs and symptoms can be non-specific especially in the infant (difficulty with feeding, irritability, crepitations and enlarged liver edge) and a high level of suspicion is necessary.

Treatment needs expertise and will depend on the underlying cause and needs to be individualized, however in critically ill children, starting inotropic medication is usually necessary. Furosemide IV should only be considered in children with adequate hydration. Fluids administration might also be indicated, but this needs to be cautious. Mechanical support and extra corporeal life support (e.g. ECMO) might be needed in a subgroup of these patients.[146]

Haemorrhagic shock

The PLS WG did not find any evidence to change the recommendation to limit the administration of crystalloid fluids and start the transfusion of blood products as early as possible. Vasoactive agents play a role in achieving blood pressure targets where fluids or blood alone are not sufficient, particularly in severe traumatic brain injuries when maintaining the blood pressure above the 50th percentile is recommended.[147] Addressing coagulation is a critical component of trauma care and must be started early. The specific strategy depends on factors beyond the scope of these Guidelines. We did not find evidence to change our current recommendation regarding tranexamic acid, and recent studies confirm its safety.[148,149]

Circulatory failure due to bradycardia

Atropine use across all paediatric ages declined following the ERC 2010 guidelines.[150] Bradycardia is rare in out-of-hospital cardiac arrest and adherence to the recommended management is poor.[151] The ERC recommends that rescuers primarily focus on treating respiratory and circulatory failure before treating bradycardia directly. Administration of atropine in these situations is likely to be ineffective and may be harmful as the temporary increase in heart rate may increase oxygen consumption, thereby accelerating the depletion of already highly limited oxygen reserves in decompensated cardiac failure. Furthermore, reducing parasympathetic drive may exacerbate pathologies involving catecholamine-mediated mechanisms (e.g. Takotsubo cardiomyopathy).

Nonetheless, atropine (20 μg kg^{-1}, max. 500 μg) probably has a role in managing bradycardia caused by increased vagal tone. In line with the updated ILCOR CoSTR, the ERC recommends starting CPR in children with bradycardia and poor perfusion who do not respond to oxygenation and ventilation.[152] The role of adrenaline and transthoracic pacing was found to be unclear in the ILCOR CoSTR. In the non-randomised retrospective studies of patients receiving CPR for bradycardia with poor perfusion, adrenaline either had no effect on survival or was associated with a worse outcome. The ERC recommends considering adrenaline (10 μg kg^{-1}) in children with bradycardia and poor perfusion based on expert opinion. Similarly, the ERC recommends

considering transthoracic pacing in selected cases where bradycardia is caused by complete heart block or sinus node dysfunction.

Circulatory failure due to tachycardia

There is limited evidence for the treatment of unstable tachycardia. For in-depth information about subtypes, diagnosis and preventive treatment option, consult the European Society of Cardiology guidelines.[153,154] In haemodynamically unstable children with either a narrow QRS tachycardia or any persistent wide QRS tachycardia, the first choice for treatment is immediate synchronised cardioversion at a starting energy of 1–2 J kg^{-1} body weight and doubling the energy with each attempt up to 4 J kg^{-1}. A systematic review in neonates confirmed that doses between 0.25 and 3 J kg^{-1} are efficient with the highest first dose being 1 J kg^{-1} and a failure rate of 20.3 %.[155] In children with haemodynamically stable supraventricular tachycardia, the first-line treatment is a vagal manoeuvre (success rate 27–53 %) followed by IV adenosine (first dose 0.1–0.2 mg kg^{-1}, maximum 6 mg, followed by 0.3 mg kg^{-1}, maximum 12–18 mg), which had a success rate of 96 %.[156] Most children will require further treatment with a medication with a longer half-life either because of failure of the first-line manoeuvres or because of recurrence of the arrhythmia.[157,158] Repeated doses of adenosine may increase catecholamine levels, making termination more difficult. In such cases, the child may need additional antiarrhythmic medication before repeating adenosine administration.[158] Alternative medications include calcium channel blockers, beta-blockers, flecainide, procainamide, amiodarone, dexmedetomidine, ivabradine and digoxin. Each of these medications has specific side effects and contraindications and should only be used as guided by a paediatric cardiologist.[157–162]

Seizures

There is no clear evidence of superiority of one benzodiazepine over another in the first line treatment of status epilepticus.[163] If a child already has IV access in place and a seizure is ongoing at 5 min, an IV benzodiazepine should be given. If the child has no IV access, priority is given to stopping the seizures so alternatives routes for benzodiazepine administration are advocated rather than spending time trying to gain IV access. Intranasal and buccal routes are recommended (e.g. intranasal or buccal midazolam).[164]

For second-line treatment of benzodiazepine-refractory status epilepticus, levetiracetam offers comparable efficacy to phenytoin and fosphenytoin, with superior safety outcomes.[165–167] Studies suggest that high-dose levetiracetam (e.g. 60 mg kg^{-1} IV) is more likely to stop seizures than standard doses.[168] In settings where seizures persist beyond 40 min, the use of anaesthetic medications like midazolam, ketamine or propofol is indicated.

Paediatric basic life support (PBLS)

Paediatric basic life support (PBLS) differs slightly from adult BLS in terms of aetiology, epidemiology and physiology.

Public recommendations and dispatcher-assisted CPR. The ERC considered alterations of the standard PBLS algorithm, which might improve the performance of untrained rescuers and how to communicate this to the public using the simplest possible message.[12,169] Recommending three simple steps (Check – Call – CPR) for this group, emphasises simplicity while remaining consistent with the recommendations for all age groups. The three steps are also the first part of the chain of survival (early recognition, calling for help, early CPR).

Chest compressions with ventilation are considered standard CPR and this is associated with improved neurological outcomes in children of all ages when compared with compression-only CPR and is recommended by ILCOR and the ERC.[170–172] ILCOR also recognised that bystanders are frequently willing to provide CPR in children, often including ventilation, as they are often the child's primary caregivers.[173] Therefore, the ERC recommends that bystanders perform chest compressions and ventilations in all children. If a bystander is not willing or able to provide ventilation, the ERC recommends that dispatchers encourage bystanders to perform chest-compression only CPR as this is superior to no CPR.[12,172]

Use of dispatcher-assisted CPR for children was strongly recommended by ILCOR, despite limited evidence in children.[174] Paediatric specific instructions should be tailored to specific age groups.[175] The ERC recommends that dispatchers use a simplified protocol with a compression to ventilation ratio of 30:2 for rescuers not specifically trained in PBLS, starting with five rescue breaths, as this decreases the number of switches between compressions and ventilations and simplifies the guidance given to bystanders by using the same ratio as in adults.[176] Untrained bystanders are generally able to deliver effective ventilations when guided by dispatchers, although ventilation in infants seems more challenging.[177] Checking for the effectiveness of ventilation might improve bystanders' quality of ventilations during dispatcher-assisted CPR. As hypoxia is a frequent cause of cardiac arrest in infants and children, efforts to improve ventilation quality seem justified.

The effect of video assisted CPR for untrained rescuers is not clear in paediatric cardiac arrest.[178,179] Therefore, the ERC cannot make recommendations on this until more paediatric data is available.

Recommendations for those trained in PBLS. This section refers to rescuers who are trained in PBLS at least to the level of the outcomes of the PBLS-course of the ERC. In line with the ILCOR CoSTR on the recognition of cardiac arrest, the ERC recommends that pulse check alone is inaccurate for the diagnosis of cardiac arrest.[180] Therefore, the recognition of cardiac arrest should be based on the recognition that the child is unresponsive, not breathing normally and shows no other signs of life.

The ILCOR CoSTR on starting CPR in adults and children found no evidence that either the ABC or CAB approach is superior to the other in terms of improving clinical outcomes in children.[181] The ERC recommends starting CPR with five rescue breaths. Manikin studies found that only 50–72 % of rescuers with limited experience succeed in delivering two correct ventilations out of five.[177,182] The recommendation for five attempts aims to increase alveolar ventilation before initiation of chest compressions, acknowledges this finding. Manikin studies suggest comparable or superior outcomes for mouth-to-mouth (or mouth-to-mouth-and-nose in infants) ventilation compared to bag-mask ventilation in healthcare professionals and first responders.[183–185] Consequently, the ERC recommends mouth-to-mouth ventilations when bag-mask ventilation is unavailable, or rescuers are not competent in its use.

The ILCOR CoSTR on compression to ventilation ratios addressed adult resuscitation and did not make any recommendation for children.[186] The ERC identified indirect evidence from one manikin study, which found no difference in compression depths and rates between a ratio of 30:2 or 15:2.[187] In the absence of any evidence

on outcomes, the ERC sees no reason to change the recommended compression:ventilation of 15:2 for children for those trained in PBLS. Minimisation of chest compressions pauses is recognised as important for outcomes.[188] Therefore, the ERC recommends not to interrupt CPR unless there are clear signs of life and to minimise pauses in chest compressions (<5 s) during resuscitation.

For single rescuers, the ERC considers CPR to be more important than fetching an AED as non-shockable rhythms are more common in all paediatric age groups and retrieval of the AED would further increase no-flow time.[189] If more than one rescuer is present, one person should start CPR, while a second person calls the EMS and fetches and attaches the AED as soon as possible. AEDs are rarely used in infants in whom the overall incidence of shockable rhythms is low.[190] However, survival is greater in cardiac arrest with a shockable rhythm when bystanders use an AED.[172,191] Based on expert opinion and in line with ILCOR, the ERC recommends the inclusion of children over 1 year of age into public access defibrillation programs, both to simplify the recommendations and to increase AED use in this age group, especially in systems with first responders.[171,192] When using an AED without energy attenuation in small children, the energy delivered will be higher than that recommended for manual defibrillation, but we consider the potential benefit of an early defibrillation attempt to be greater than the risk of harm through defibrillation using a higher energy.[193,194]

In case of respiratory arrest with signs of life, the ERC recommends ventilating at a normal respiratory rate for the child's age to avoid hypoventilation and hyperventilation. The recommendation to use either continued head tilt chin lift or a recovery position for unconscious, spontaneously breathing children is in line with the recent ILCOR CoSTR.[171,195] When a recovery position is used, the breathing should be checked at least every minute to recognise deterioration (e.g. airway obstruction, inadequate or agonal breathing). The detection of cardiac arrest and breathing difficulties is more quickly achieved in the supine position using continued head tilt chin lift.[196] A recovery position is not ideal in traumatic injuries to the spine, hip or pelvis or if the child's breathing is not normal.[195]

Skills for PBLS. Airway positioning for specific age groups was not reviewed by ILCOR but the ERC considered the long-established standards and continues to recommend the neutral position of the head for infants and slight extension for older children with optimal angles ranging from −1° to 13° in pre-school children to 16° in school children (Figs. 7 and 8).[197] Adolescents usually need more extension, like adults. To achieve the neutral position in infants the head usually needs to be tilted back a little because the head adopts a natural flexed position in unconscious supine infants. Adding chin lift further decreases the possibility of airway obstruction by preventing occlusion caused by the soft tissues and relaxed muscles in unconscious patients.

Look-listen-feel is an established technique for detecting breathing in all age groups.

The technique for ventilation in children, as described earlier in these Guidelines, was not reviewed by ILCOR and we have not changed our recommendation. Ventilation during resuscitation, especially in infants, is not an easy skill to master and rescuers often use excessive peak pressures.[184] Training in ventilation techniques improves the ability to deliver the correct volume.[177]

In line with the ILCOR CoSTR, the ERC recommends that chest compressions be performed on a firm surface when this is practical, provided this does not delay starting CPR.[198,199] The quality of chest compressions depends on the technique, compression point, rate, depth, recoil and the duration of pauses. An ILCOR CoSTR on hand position during chest compressions only made recommendations for adults.[200] The optimal compression point (hand, finger or thumb position for compressions) is unknown and might differ between individual patients. In the absence of data, the ERC continues to recommend the lower half of the sternum as the location for chest compressions in children. In line with, a neonatal ILCOR CoSTR and other systematic reviews, the ERC recommends the two-thumb encircling technique for chest compressions in infants (Fig. 11).[201–204] The two-thumb-encircling technique results in consistently greater chest compression depth, less fatigue and a higher proportion of correct hand placement compared to the two-finger technique.[201–204] A manikin study found a slightly decreased minute ventilation when using two-thumbs compared to two-fingers but the effect on patient outcome is unclear.[205] The two-thumb-encircling technique can be used for dispatcher-assisted CPR, including advice for untrained single rescuers, as it appears to be easier to explain to bystanders than the two-finger technique.[206] Modifications of the two-thumb technique have not been shown to be superior.[207,208] technique in children 1–8 years of age leads to more efficient compressions and less fatigue that the one-hand technique.[209] The ERC therefore continues to recommend using either one hand or two hands to perform chest compressions in children aged 1–8 years. In adolescents, using two hands is necessary and the technique of chest compressions is the same as for adult patients.

The 2021 recommendation on compression depth was partially based on a scoping review suggesting improved ROSC and survival with better chest compressions depth compliance.[210] The ERC recognises that the ILCOR CoSTR recommended age-related absolute compression depths of 4 cm and 5 cm can only be approximations, as the anteroposterior diameter of the thorax increases continuously during growth. Studies have indicated that at most ages these depths exceed the measured one-third of the anteroposterior diameter of the thorax and for infants in particular they may exceed one half of the anteroposterior diameter.[211–213] Also, aiming for one third of the diameter in children older than 12 years can generate a depth of more than the recommended adult limit of 6 cm.[212] Recent evidence suggests that targeting "*at least* one third of the anteroposterior diameter" leads to deeper and more adequate chest compressions in manikin studies than targeting absolute values of 5 or 4 cm.[214,215] Chest compression depth is commonly too shallow in children.[216,217] Therefore, the ERC recommends depressing the lower half of the sternum by *at least* one third of the anteroposterior diameter of the chest. In adolescents, the compression depth should be the same as for adults, i.e. 5–6 cm. No evidence was found to change the recommendation to fully release pressure after each compression. The velocity of release was not associated with ROSC.[218,219] Recent studies support the current advice to keep pauses in chest compressions as short as possible (<5 s).[220,221]

There is no evidence to change the recommended anatomical position of defibrillation electrodes as described in these Guidelines (Figs. 14 and 15).[222] The use of larger defibrillation pads and the anteroposterior position enables more current to flow through the chest but the significance of this for outcomes remains unknown.[223] Based on expert opinion and conformity the ERC recommends that defibrillation pads be placed in the anteroposterior position when the paediatric mode of an AED is activated (i.e. up to 25 kg). In larger

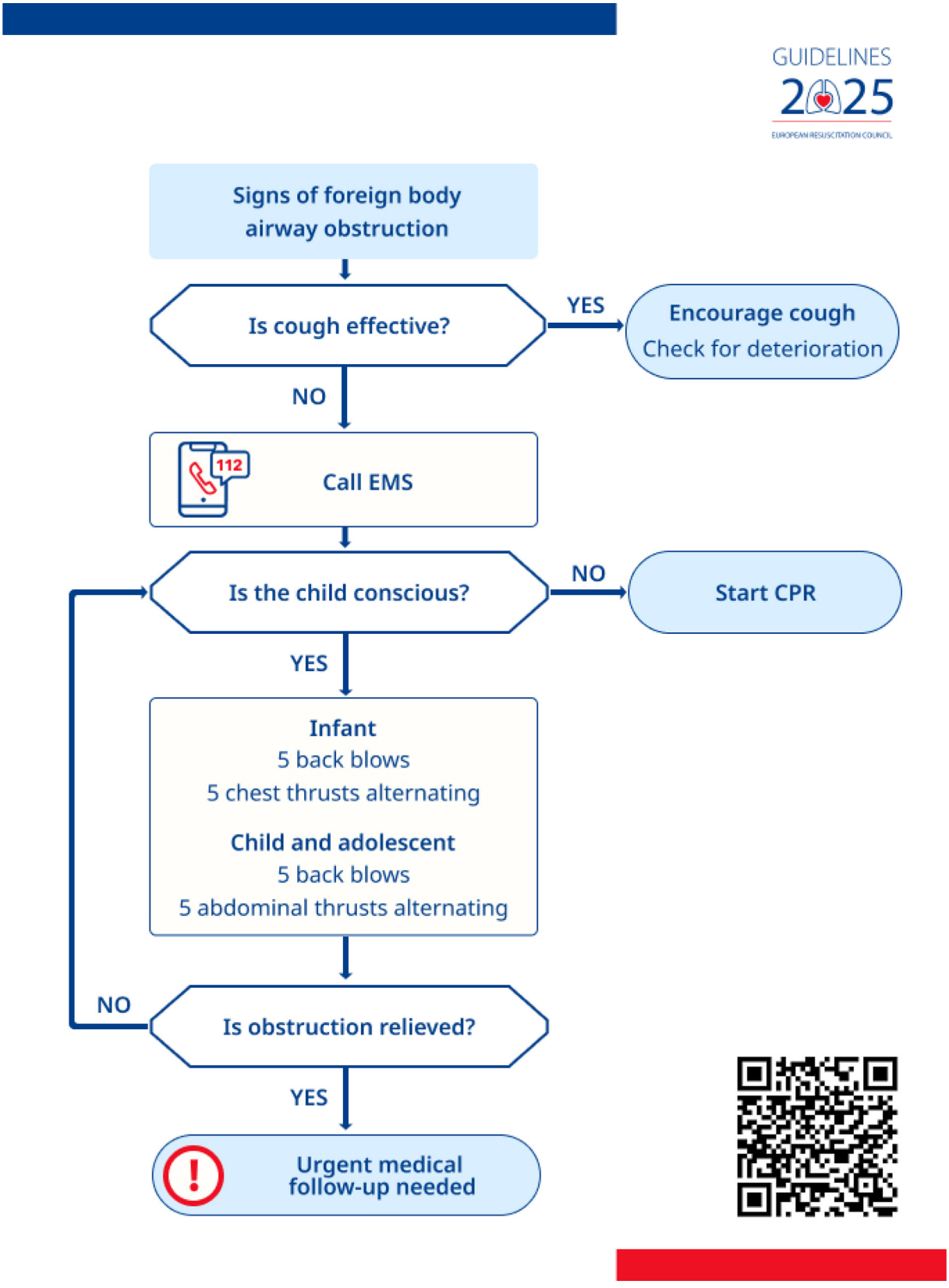


Fig. 22 – Algorithm for paediatric foreign body airway obstruction

children, the defibrillation pads can also be used in the anterolateral position as in adults provided they can be placed without touching each other. Turning larger children for the application of the posterior pad is likely to be more difficult, possibly causing a longer pause in chest compressions and inaccurate placement of the posterior pad.

Children at high risk of cardiac arrest (cardiomyopathies, myocarditis, channelopathies, congenital heart disease, autonomic nervous system dysfunctions) might benefit from AED placement in the home whilst awaiting defibrillator implantation where these resources are available.[224]

Considerations for algorithm deviations. Based on ILCOR evidence, the ERC recommends that if a person is unwilling or unable to give rescue breaths immediately (i.e. unwilling to give mouth-to-mouth and/or no bag and mask is available), they should start chest compressions immediately and ventilation should be added as soon as practicable. This reduces the delay in starting chest compressions.[181]

The jaw thrust manoeuvre can be a better method of opening the airway than the head tilt chin lift in trained rescuers, especially in trauma patients. The jaw thrust also seems to be the most effective method of keeping the airway patent during bag-mask ventilation.

Healthcare providers can use bag-mask ventilation with oxygen for PBLS if they are trained. They can also use a pocket mask in older children and adolescents. Most rescuers require both hands to hold the airway open when using the face mask with jaw thrust.[225]

In line with the updated ILCOR CoSTR, the ERC recommends activating the CPR mode to increase mattress stiffness if available for in-hospital cardiac arrest.[199] For healthcare systems that are already using backboards routinely during CPR, there is insufficient evidence to suggest against their continued use. Conversely, there is insufficient evidence, and some concerns about harm, to justify their introduction in systems which do not already use them.

A simulation study suggests that effective chest compressions can be given using the two-thumb encircling technique 'over the head' of the infant, which might be applied by trained professionals in a limited space environment.[226] Chest compressions in infants while walking are not recommended, except in exceptional circumstances, as the quality of the compressions is limited.[227]

Only a lone rescuer without a readily available phone, should perform CPR for one minute before going to seek help. There is no new evidence to justify changing this historical recommendation and this situation is becoming much less common.

Foreign body airway obstruction. Foreign body airway obstruction is a relatively frequent emergency, especially in young children. Early removal of the foreign body by bystanders is associated with improved survival with good neurological outcome.[228,229] Most events occur during eating and are often witnessed.[228] Simple bystander interventions are effective in more than 75 % of cases and improve survival when performed prior to the cardiac arrest.[229,230] Abdominal and chest thrusts or compressions are less effective as a first intervention than back blows and are associated with both a lower chance of success and more intervention-associated injuries.[229] However, abdominal thrusts might be more effective in children than in adults.[231] Therefore, the ERC continues to recommend starting with back blows and alternating these with abdominal thrusts (in older children) or chest thrusts/compressions (in infants, Figs. 16 and 22). We recommend using the two-thumb encircling technique for chest thrusts in infants rather than the previously recommended two-finger technique. This recommendation is made because the two-thumb-encircling technique leads to deeper compressions and generates a higher pressure than the two-finger technique, is easier for the dispatcher to explain to bystander, and its use simplifies teaching as only one skill is required for both CPR and choking.

The ERC reviewed the evidence regarding suction-based devices marketed and advertised as airway clearance devices. Until more data from industry-independent studies are available, the ERC like ILCOR, cannot issue a recommendation for or against the use of these devices due to insufficient high-certainty scientific evidence.[228,232] The rational for that is discussed in more detail in the ERC Guidelines 2025: First Aid.[233]

Paediatric Advanced Life Support

Recognition of cardiac arrest. The public should identify the need for resuscitation by the combination of unresponsiveness and absent or abnormal breathing. For healthcare professionals' recognition of cardiac arrest should be based on clinical assessment (absence of signs of life) or monitored vital signs such as ECG changes, loss of SpO_2 and/or $EtCO_2$, or a sudden drop in blood pressure. Importantly, CPR should also be initiated in children who develop severe bradycardia with signs of very poor perfusion despite adequate respiratory support, as this can quickly deteriorate into cardiac arrest. If there is a change to an organised rhythm, which could produce cardiac output during PALS, healthcare professionals may use signs of life with ancillary observations including a pulse check, blood pressure, SpO_2, waveform and POCUS during PALS to determine ROSC. If a manual pulse-check is used this should be kept as short as possible, and certainly not longer than 5 s.[220]

The usefulness of a manual pulse check as an indication for starting CPR and to detect cardiac output during pauses in CPR was reviewed in the 2025 ERC guideline process. An ILCOR CoSTR concluded that palpation of a pulse is unreliable as the sole determinant of cardiac arrest and the need for chest compressions.[180] The authors recommended that clinicians should begin or continue CPR unless they can palpate a pulse within 10 s. An ILCOR CoSTR found one case series, which showed good accuracy of POCUS by trained providers to detect pulses during paediatric cardiac arrest but considered this insufficient evidence for a treatment recommendation.[180] In adults, pulse assessment with POCUS might be superior to manual assessment for the prediction of ROSC and during cardiac arrest.[234,235] However, this does not imply a clinical advantage nor is there evidence from paediatric studies. It is conceivable that patients with pulses that are only detectable with POCUS have insufficient circulation to justify stopping or not starting resuscitation. In summary, the ERC does not recommend changing the status of the pulse check in paediatric resuscitation.

Previous guidelines recommended that bradycardia with signs of poor perfusion, even with a palpable pulse, should be treated by immediate CPR.[68] ILCOR recently carried out a scoping review for studies of the treatment of children with bradycardia and poor perfusion.[152] In almost all studies, on univariate analysis, survival to hospital discharge rates were higher when cardiac arrest was due to a first documented rhythm of bradycardia with poor perfusion (43–77 %) compared with PEA or asystole. Patients who receive CPR for bradycardia with poor perfusion and maintained that rhythm had higher survival rates than those who progressed to pulselessness. ILCOR found no data to support any recommendation for atro-

pine, adrenaline or transcutaneous pacing. The ERC considers that the potential benefits of early CPR outweigh the low risk of harm from inadvertent CPR. The ERC recommends starting CPR for children with bradycardia and poor perfusion who do not respond to oxygen and ventilation. There are currently no studies on the impact of chest compressions on survival in children with very low-flow shock states without bradycardia (e.g. supraventricular tachycardia).

Defibrillation. No new paediatric evidence on the use of defibrillation electrodes was identified. We based our recommendation on an ILCOR CoSTR on paddle/pad position and size in adults and children.[222] No new paediatric evidence was found.[216] Therefore, all recommendations are based on indirect evidence from adults, all of which was of low certainty.

Paddles are still in use in some limited resource settings. Some feedback devices for chest compression metrics, an AED and preemptive placement of a defibrillator require the use of defibrillation pads. The anteroposterior position and charging of the defibrillator during chest compressions are more difficult to achieve with paddles. If firmly applied there is little difference in transthoracic impedance between paddles and defibrillation pads.[223] The ERC therefore recommends that defibrillation pads be preferred over paddles; paddles may be used only if defibrillation pads are unavailable.

Currently the anteroposterior position is recommended for small children and the anterolateral position for older children. It seems that the anteroposterior position is at least non-inferior to the anterolateral position.[236,237] On the other hand, turning the child to apply defibrillation pads in the anteroposterior position could be more difficult with larger children and adolescents particularly if there is a limited number of rescuers. Although paediatric data are lacking, evidence from adults suggests that changing the vector of defibrillation may improve outcome and defibrillation success in refractory VF.[238,239] In older children, this would involve replacing the defibrillation pads (i.e. moving them from the anterolateral to the anteroposterior position).

Shockable rhythms Data on paediatric defibrillation is limited and challenging to interpret[240] The ERC recommends 4 J kg^{-1} for the first and subsequent shocks and considering higher energy levels for a refractory shockable rhythm (up to 8 J kg^{-1} after 5 attempts).

An ILCOR CoSTR and a registry study found greater survival to hospital discharge in children with VF who received an initial energy dose of 1.7–2.5 J kg^{-1}, compared with those receiving >2.5 J kg^{-1}.[241,242] However, this study was comparing standard practice for their setting (i.e. 2 J kg^{-1} in North America) with non-standard care, which might be a confounder. The ERC does not consider that the evidence is sufficient to justify a change in the current recommendation of 4 J kg^{-1} as the standard energy dose for shocks. It seems reasonable not to use doses above those suggested for adults. Consider escalating doses, increasing stepwise up to 8 J kg^{-1} if more than five shocks are needed.

No studies were identified which specifically addressed the timing of shocks and of rhythm checks in children. One registry study found that increasing chest-compression pause duration was associated with a lower chance of ROSC and survival.[220] This confirms the current advice to keep pauses for rhythm checks to a minimum. No new evidence was found concerning the effect of CPR before defibrillation.

Oxygenation and ventilation during PALS

A recent ILCOR CoSTR did not identify further evidence on oxygen titration.[201] Therefore, the ERC continues to recommend using 100 % oxygen.

The ERC recommends the two-hand technique for bag-mask ventilation to enhance effectiveness. If only two rescuers are available, this means that the person responsible for chest compressions also assists with ventilations, which might increase chest compression pauses. If more rescuers are present, assign the roles of airway management and chest compressions to separate persons, minimising pauses in compressions and ensuring continuous, high-quality CPR.

ILCOR recently published a CoSTR on advanced airway management during ALS.[243] The ERC follows that recommendation for the use of bag-mask ventilation by professionals during paediatric OHCA. There is currently a lack of high-quality evidence to recommend or discourage the use of bag-mask ventilation over tracheal intubation or supraglottic airway devices (SGA) during paediatric IHCA. The ERC emphasises that effective ventilation and oxygenation and high-quality chest compressions are essential in order to achieve ROSC. The ERC therefore recommends that healthcare providers transition to advanced airway management (SGA or tracheal tube) when the necessary resources and expertise are available for placement without disrupting chest compressions.

ILCOR has also reviewed ventilation rates during paediatric cardiac arrest, without identifying any relevant literature.[38,244] Based on expert opinion, ventilation rates should be close to age-appropriate respiratory rates, and hypoventilation and hyperventilation should be avoided, in paediatric resuscitation with an advanced airway. Positive pressure ventilation with an advanced airway in place can be asynchronous (at the age-dependent rate stated in the sequence of actions) and chest compressions continuous (pausing only every 2 min for rhythm check). However, the ERC recommends that rescuers should stop continuous chest compressions and return to a compression:ventilation ratio of 15:2, when there is doubt about the effectiveness of ventilation.

Medications during PALS

Vasoactive medication. Evidence remains very weak for the optimal dosing interval of adrenaline during CPR in children.[38,201,245] The ERC continues to recommend adrenaline as soon as possible in paediatric cardiac arrest with a non-shockable rhythm, ideally within the first three minutes. The dosing interval remains 3 to 5 min during PALS. In patients already receiving a vasoactive drug infusion at the start of CPR, a shorter interval (less than 3 min) seems to be associated with higher ROSC and improved survival to hospital discharge with favourable neurological outcome.[245] Pragmatically, the ERC recommends adrenaline administration every 4 min (or every other cycle) – which still falls into the 3–5 min interval – and giving the first dose of adrenaline after 4 min in shockable rhythms. Other vasoactive medications (vasopressin, terlipressin, milrinone, noradrenaline) have been used, but the evidence for their use remains very weak and we currently advise using them only in controlled research settings.[38]

Antiarrhythmic medications. We did not find any new evidence that would justify changes in the current recommendations on amiodarone and lidocaine as described in the sequence of actions.

Sodium bicarbonate. The ERC considered a meta-analysis and a secondary analysis of a prospective non-randomised controlled trial when recommending not routinely using sodium bicarbonate in cardiac arrest.[246,247] Both studies reported decreased survival to hospital discharge with the use of sodium bicarbonate during paediatric resuscitation.

Magnesium. No new high-quality evidence on this topic was found other than a single inconclusive registry study.[248] The ERC recommends not routinely using magnesium during paediatric cardiac arrest. Magnesium is indicated in documented hypomagnesaemia or torsade de pointes VT regardless of the cause.

Calcium. As no new evidence was identified, the ERC continuous to recommend not routinely using calcium for infants and children with cardiac arrest in the absence of hypocalcaemia, calcium channel blocker overdose or hypermagnesaemia.

Measurable factors during paediatric PALS

Blood pressure. Previous ERC guidelines did not recommend for or against the use of diastolic blood pressure to guide resuscitation efforts in children in cardiac arrest due to lack of evidence.[68] A recent ILCOR CoSTR on intra-arrest blood pressure found only five observational trials.[249] While intra-arterial blood pressure monitoring is generally available only in high-resource settings, children with invasive blood pressure monitoring are at higher risk of suffering cardiac arrest, thus making a recommendation valuable.[250,251] The ERC recommends targeting an intra-arrest diastolic blood pressure of $\geq$25 mmHg for infants <1 year and $\geq$30 mmHg for children 1–18 years with intra-arterial blood pressure monitoring in place at the time of cardiac arrest.

End-tidal CO_2 monitoring. Existing paediatric data indicate that capnography may enhance the quality of CPR, improve adherence to resuscitation guidelines and help to detect ROSC.[252–255] However, no specified values have been established to guide intra-arrest therapies or to indicate whether to stop or continue CPR.[253] Data from a large multicentre study suggests targeting an intra-arrest $ETCO_2$ > 20 mmHg is associated with higher blood pressure and survival to hospital discharge.[253]

Near-infrared spectroscopy. Although an ILCOR evidence update and a multicentred study suggest an association between higher intra-arrest cerebral oxygenation and improved resuscitation outcomes, the evidence was insufficient to make a recommendation for or against routine use of cerebral near-infrared spectroscopy during paediatric cardiac arrest.[201,256]

Point-of-care ultrasound. An ILCOR evidence update identified two small studies on point-of-care ultrasound (POCUS) which included paediatric cardiac arrests one of which was a small case series describing the feasibility of POCUS during cardiac arrest to assess ventricular contractility and pericardial effusion.[257] The ERC recommends that if POCUS (as defined by in the evidence update) can be performed by experienced personnel without interrupting CPR, it may be considered as an additional diagnostic tool when clinical suspicion for a specific reversible cause is present.

Point-of-care blood analysis. No new evidence was identified on this topic. The ERC recommends not using specific values as indicators of when to initiate or stop resuscitation efforts. When treatable metabolic derangements are discovered, these should be corrected.

Extracorporeal cardiopulmonary resuscitation (ECPR)

Little new high-quality evidence concerning the use of ECPR in paediatric cardiac arrest was identified in a recent ILCOR CoSTR and a systematic review.[201,258] The primary outcome in these publications was survival to hospital discharge, and neurological outcomes were rarely reported.

ECPR is a resource intensive therapy and success relies on hospital-level factors such as experience in extracorporeal life support implementation and availability of a 24/7 multidisciplinary response team. In line with the recent ILCOR CoSTR, the ERC recommends considering ECPR as an early intervention (e.g. within 5–10 min. of the start of CPR) for selected infants and children (e.g. those with cardiac conditions) with IHCA refractory to conventional CPR in settings where ECPR programmes have been implemented and perform well.[201] There is insufficient evidence in paediatric OHCA to make a treatment recommendation. However, the successful use of ECPR in OHCA in cases of shockable rhythms, drowning or severe hypothermia has been reported recently. The ERC acknowledges recent developments and agrees that in specific cases and when resources are available, ECPR is an option to improve survival.

Cardiac arrest in special circumstances

Anaphylaxis

The most common triggers for anaphylaxis in children in Europe are food (including cow's milk, egg, nuts and fish – 65 %), insect venom (20 %) and medications (5 %). No obvious trigger can be found in up to 30 % of cases.

An ILCOR CoSTR found no new studies relating to the recognition of anaphylaxis.[171] Important symptoms are an acute onset (minutes to hours) of breathing difficulties, wheezing or coughing, swelling of the face and other body parts, shock, confusion or floppiness in young children, diarrhoea, nausea, vomiting and abdominal pain. Anaphylaxis can present in a single organ-system and cutaneous signs are absent in 10–20 % of cases.[259] First responders can be trained to recognise anaphylaxis.

If anaphylaxis is suspected the EMS should be activated. All children who have had an anaphylactic reaction should be evaluated by a physician (e.g. a paediatrician or emergency physician). If symptoms resolve completely in the pre-hospital setting after a single dose of adrenaline, then admission to hospital is not always needed.[259] Elevation of the lower extremities can increase venous return and cardiac output, but can also compromise ventilation.[260]

The ERC recommends intramuscular adrenaline into the vastus lateralis of the quadriceps, which is effective and rapidly absorbed and preferred to subcutaneous or intravenous administration.[261] There is little evidence on outcomes using other routes of adrenaline administration in children including adrenaline nasal spray.[262] Prompt administration of adrenaline is critical. A second dose of adrenaline is required in 7–18 % of cases and should be given after 5 min if symptoms of severe anaphylaxis persist.[263] Delayed administration of adrenaline is associated with protracted reactions,

hypotension, and fatal outcomes. Refractory anaphylaxis, requiring more than two doses of adrenaline with ongoing symptoms, occurs in 1 % of cases and requires specialist in-hospital treatment often with an adrenaline infusion.

The ERC recommends not giving steroids in anaphylaxis except when this is associated with asthma, as there is no good evidence that they are helpful.[261,264,265] Intravenous glucagon may have a role when there is an inadequate response to adrenaline, particularly in patients on beta-blockers.[259]

As half of the patients who have a biphasic reaction will do so within 6–12 h, prolonged observation (12–24 h) is advised in children with a history of a biphasic or protracted anaphylactic reaction or asthma, those who needed more than one dose of IM adrenaline, or when adrenaline was first administered more than 60 min after the onset of symptoms.[68]

Identification of the allergen is important in avoiding future reactions. Appropriately timed serum tryptase analysis can confirm the diagnosis of anaphylaxis. The serum concentration peaks at 1–2 h after the reaction and often normalises within 6–8 h. All children should be referred to an allergist for ongoing management of their allergy and be prescribed two adrenaline auto-injectors and instructed in their use.[259,266–269]

Traumatic cardiac arrest

Cardiac arrest is rare in paediatric trauma but may be the cause of 10–40 % of all paediatric OHCAs. Survival is very poor at 2–5 %, but good or moderate outcomes have been reported in survivors.[270–274] Chest compressions are less effective in hypovolaemia and cardiac tamponade, and their effect on outcome of traumatic cardiac arrest is unclear.[270,275–280] Therefore, professional rescuers should prioritise the detection and treatment of potentially reversible causes. Use the acronym HOTT: **H**ypotension, hypoxia (**O**xygenation), **T**ension pneumothorax and cardiac **T**amponade).[281] This should take priority over or run concurrently with CPR. There is insufficient evidence to support a trauma-specific resuscitation protocol for ambulance personnel.[275,282]

Stopping significant external bleeding can be lifesaving and has priority over starting chest compressions in an unresponsive child. Direct manual pressure, haemostatic or pressure dressings, a pelvic binder and tourniquet can all be effective.[283,284] In the case of a tourniquet, preferably use a manufactured windlass device and apply this above the injury, but not over a joint. Tighten the tourniquet until the bleeding stops and note the time of its application. Only a trained healthcare professional should remove the tourniquet. Manual pressure to the brachial or femoral artery might not be effective.[285] Intravascular fluid replacement to correct haemorrhagic shock should include blood products as soon as these are available.

Minimise spinal movement provided this does not hamper resuscitation efforts (e.g. by compromising the airway). Cervical collars are not advised. Investing time in immobilisation may be detrimental in the case of penetrating trauma, particularly if a resuscitative thoracotomy is indicated.[285,286]

The place of adrenaline in traumatic cardiac arrest is controversial. A systematic review and meta-analysis of studies, mainly in adults, found that adrenaline did not improve ROSC benefit or short-term survival.[287] Adrenaline might be more beneficial in specific cases, like vasoplegia from spinal injuries.[276] In the absence of clear outcome data, the ERC continues to recommend adrenaline IV/IO in traumatic cardiac arrest in children but emphasises the priority of stopping significant bleeding and treatment of reversible causes (HOTT) over the administration of adrenaline.

Shockable rhythms are rare, occurring in 2–7 % of paediatric traumatic cardiac arrest and may be associated with a better outcome.[276,279] A shockable rhythm may be secondary to hypoxia or hypovolaemia, which needs to be treated first to improve the chance of successful defibrillation. Therefore, priority should be given to HOTT over attaching an AED except in electrocution or cardiac contusion.

In a traumatic tension pneumothorax, finger thoracostomy seems more effective than needle thoracocentesis and has a low risk of major complications.[288]

A resuscitative thoracotomy is time sensitive and has a better outcome in penetrating injuries compared with blunt trauma.[289] Resuscitative thoracotomy requires that specific expertise, equipment and systems are in place but is probably the best option for a traumatic cardiac tamponade. If not available, cardiac tamponade should be treated by a pericardiocentesis either via a subxiphoid mini-thoracotomy or by inserting a wide-bore drain. If available, POCUS should be used to guide percutaneous pericardiocentesis.

There is insufficient experience with extracorporeal life support in paediatric traumatic cardiac arrest to make recommendations for or against indications and techniques.

Drowning

Drowning is the process of experiencing respiratory impairment from submersion/immersion in a liquid, usually water and is a major cause of paediatric morbidity and morbidity worldwide.[290] The prevention of cardiac arrest is focused on reversing hypoxia, treating respiratory failure with potentially non-compliant lungs and dealing with hypothermia. The management of cardiac arrest involves reversing hypoxia and hypothermia. Attention should be given to a possible underlying cause of drowning such as arrhythmia, epilepsy, intoxication or trauma.

The following considerations are taken from the recent ILCOR CoSTR on drowning.[201]

Hypoxia is the primary mechanism leading to cardiac arrest in children following drowning and needs to be treated as soon as possible. Ventilation of the child's lungs while they are still in the water is feasible for those specifically trained in this technique but should not delay other interventions.[291,292] Drowning in infants mostly occurs in the home or in small bodies of water where rescue times are short, so rapid removal from the water might be the best option.[293]

The ventilation-first strategy (ABC) is the standard in paediatric CPR and emphasises the importance of reversing hypoxia. There is no evidence that another approach is superior.[292,294] Those trained should give mouth-to-mouth, pocket mask or bag-mask ventilation. Ventilation via a tracheal tube optimises oxygenation and might overcome increased airway resistance and decreased lung compliance. Early tracheal intubation by those competent in the technique is recommended.[295]

Starting high-quality CPR to correct hypoxia takes priority over attaching an AED. The incidence of a shockable rhythm following drowning has been estimated at 2–14 % and it is uncertain whether this is associated with a better outcome.[281,294–299]

Drowning is often associated with hypothermia, which can be defined as a core temperature below 35 °C. Severe hypothermia

(<28 °C) may cause cardiac arrest. There is no recent ILCOR CoSTR on accidental hypothermia in children not in cardiac arrest. The ERC recommendations are based on previous guidelines and expert consensus.

Remove wet clothing. Active external rewarming is usually sufficient when the core body temperature is above 30 °C. Active internal rewarming is indicated when core body temperature is less than 30° C. During rewarming, vasodilation occurs, with possible hypotension, requiring infusion of warmed intravenous fluids but avoiding fluid overload. Rapid rewarming with a warm shower or warm-water immersion of a child with circulation is potentially harmful because of hypotension and core temperature after-drop. There is no evidence for a specific rewarming rate for hypothermic children with circulation, but one study in adults suggests increased mortality (at all ages with an initial temperature 30.5 °C) with slower rewarming at <1°C h^{-1}.[300–302] In children with severe hypothermia and intact circulation warm saline lavage of the left pleural space, bladder, stomach or peritoneum has been reported, but no comparative studies are available in children.

There is increasing experience with extracorporeal life support for hypothermic cardiac arrest or severe respiratory failure following drowning but there are insufficient data to guide recommendations on selection criteria or the timing for initiating these techniques.[303]

Although lower core temperatures are generally associated with longer immersion times and a worse prognosis, hypothermia may in rare cases have a neuroprotective effect after drowning, especially when hypothermia occurs early and rapidly and precedes hypoxia.[293,304–306]

Hypothermia

It is difficult to measure core body temperature correctly in the pre-hospital environment. Therefore, the simplified revised Swiss Staging system is recommended to estimate the core body temperature in case of accidental hypothermia.[307] The risk of cardiac arrest increases with decreasing core temperature. Risk factors associated with cardiac arrest are decreased level of consciousness (P or U in the AVPU scale) and cardiovascular instability (usually defined as ventricular arrhythmia or systolic hypotension). A combination of passive and active rewarming techniques should be started in the pre-hospital environment in all cases of hypothermia.[306]

Successful outcomes have been described in children with hypothermic cardiac arrest receiving very prolonged CPR with a core temperature as low as 10 °C.[304,305] Centralisation of the circulation in hypothermia may be neuroprotective. Recent guidelines and reviews support the use of prolonged resuscitation when necessary.[68,308–311] Consequently, the ERC recommends starting CPR as soon as possible in all children in hypothermic cardiac arrest and not to use a cut-off temperature for the decision to start resuscitation.

There are no observational or randomised studies on defibrillation or the administration of medications in severe hypothermia in children. Therefore, the recommendations of the ERC are based on recent guidelines for patients of all ages.[309,311] These recommend that only a single dose of adrenaline should be given while the core temperature remains below 30 °C, unless planning imminent initiation of extracorporeal life support. Defibrillation may be ineffective at low temperatures but shockable rhythms can be defibrillated once the core-temperature is above 30 °C.[312] The ERC recommends that a maximum of three attempts should be made while the core temperature <30 °C. As in previous ERC guidelines we continue to recommend that any child who has a chance of a favourable outcome in hypothermic cardiac arrest should be quickly transported to a specialised centre where rewarming should be performed with extracorporeal life support.[68,311] At that time, prognostication using the Hypothermia Outcome Prediction after Extracorporeal life support (HOPE) score was only recommended for adults.[313] Since then, the HOPE-score has also been tested in a subgroup of children but the evidence supporting its use in children remains limited.[314,315]

A recent rapid review on rewarming young children after drowning-associated hypothermic cardiac arrest suggests that extracorporeal life support should be used to resuscitate children who do not achieve ROSC in the field and to use external rewarming for children with ROSC.[316] A strategy for extracorporeal life support based on slow, prolonged, high-flow rewarming at an experienced centre may prevent end-organ failure, preserve heart function and improve survival even after prolonged resuscitation. The optimal rate of rewarming is unknown.[301] Where the facilities and expertise are available, ECPR might also be initiated in the pre-hospital setting.

It has been suggested, based on a case-report analysis that, if ALS with rewarming does not result in ROSC, therapy might be withdrawn when the core temperature has reached 34 °C.[301] A recent evidence-based guideline suggests stopping resuscitation if ROSC is not achieved within 30 min in hypothermic cardiac arrest associated with trauma or asphyxia (e.g. avalanche burial >60 min, core temperature $\geq$30 °C and a non-patent airway); thus, in such circumstances ECPR is contraindicated. In all other circumstances, and in the light of the increasingly successful use of ECPR, the ERC is currently unable to make a recommendation on criteria for the withdrawal of resuscitation in hypothermic cardiac arrest in children.

Cardiac arrest associated with septicaemia

Sepsis is a common cause of shock in children and may lead to cardiac arrest which generally has a poor outcome. There is currently no evidence to recommend a deviation from the standard PALS algorithm for cardiac arrest caused by sepsis. Early source control and antibiotic therapy is important. Cardiac arrest occurring shortly before or during cannulation for extracorporeal life support should not preclude its initiation. High flows on extracorporeal life support (greater than 150 mL kg^{-1} min^{-1}) might improve outcomes in children with sepsis.

Tension pneumothorax

Tension pneumothorax is less common in children than in adults and is mainly seen in ventilated children, in trauma and following central venous cannulation.[317] A tension pneumothorax should be diagnosed clinically and rapidly (respiratory distress, chest pain, unilateral absent lung sounds, tachycardia, and a rapid haemodynamic collapse). Point-of-care ultrasound helps diagnosis but should never delay treatment.[311,318] Needle thoracocentesis remains the first choice in non-traumatic tension pneumothorax as a temporary measure to buy time for chest drain placement. In traumatic tension pneumothorax, especially pre-hospital, finger thoracostomy is more efficient than needle thoracocentesis, with fewer reinterventions and a low complication rate.[288,319] Needle thoracocentesis must not delay finger thoracostomy.[320] In traumatic cardiac arrest, treatment of tension pneumothorax has priority, as untreated it will prevent successful resuscitation.

Cardiac tamponade

Cardiac tamponade is uncommon in children but occurs in penetrating chest trauma, post cardiac surgery and acute pericarditis. Point-

of-care ultrasound in competent hands is helpful in the diagnosis.[257] Pericardiocentesis is relatively safe and highly effective procedure in experienced hands.[321] Depending on the cause (e.g. traumatic/non-traumatic/post-cardiac surgery) and the available expertise, alternative therapies include mini-thoracotomy, emergency or resuscitative thoracotomy or re-sternotomy.

Pulmonary embolism

ILCOR recently reviewed the evidence on pulmonary embolism in paediatric cardiac arrest.[322] Pulmonary embolism is being increasingly reported in children either because there has been a true increase in incidence or because of increased awareness following the covid pandemic.[323–325] The clinical diagnosis is challenging, and the use of POCUS/echocardiography during cardiac arrest is of uncertain value.[326] Pulmonary embolus presents in children with tachycardia, tachypnoea, hypoxia, unilateral limb swelling, recent trauma or surgery, prior thromboembolism, cancer, anaemia and leucocytosis.[327]

Thrombolysis is generally more effective than systemic anticoagulation alone but there is insufficient paediatric evidence to make definitive recommendations on indications, medications, timing, dose or strategy in children.[328,329] Based on a recent narrative review, the ERC suggests considering IV alteplase in a child in cardiac arrest due to pulmonary embolism.[329] Catheter-directed thrombolysis is associated with lower mortality and fewer complications in adults and is preferable to systemic therapy for those on extracorporeal life support.[330,331] Surgical embolectomy is an established treatment option in adults.[332] Extracorporeal life support has been used successfully in children.[333] There are no comparative trials of surgical embolectomy or extracorporeal life support with thrombolysis in children.

Toxic agents

Intoxication is an uncommon cause of cardiac arrest in children but the incidence of intoxication generally is increasing worldwide.[334] In younger children, intoxication is mostly caused by accidental ingestion of substances in the home (cleaning agents, parent's medication, batteries). In adolescents, self-poisoning with therapeutic or recreational drugs is more common (alcohol, amphetamines and analgesics, including opioids).[335] Carbon monoxide poisoning can occur at any age. In healthcare settings, accidental overdosing or drug interactions are not infrequent. Life-threatening cardiovascular events associated with intoxication are rare but more common in adolescents and are associated with metabolic acidosis and a prolonged QT-interval. Intoxication with opioids and sympathomimetics have the highest mortality.[334]

The cornerstone of therapy is supportive using the ABCDE approach in a critical care setting, with correction of hypoxia, hypotension, and acid/base and electrolyte disorders. Manage seizures promptly with benzodiazepines (avoid phenytoin in intoxication).[336] Early advanced airway management is required when there is airway obstruction (e.g. due to depressed consciousness) or inadequate breathing, and to prevent aspiration of gastric contents. Drug-induced hypotension usually responds to fluid therapy. Occasionally vasopressors (e.g. noradrenaline) or inotropes may be required (e.g. in beta-blocker and calcium channel blocker overdose). Transcutaneous pacing may be effective for severe bradycardia caused by intoxication.

There are few specific therapies that are useful immediately, but consider the following for specific intoxications:

- Haemodialysis (methanol, ethylene glycol, salicylates, lithium).
- Charcoal haemoperfusion (carbamazepine, phenobarbital, phenytoin, theophylline).
- Lipid emulsion, e.g. Intralipid®, (local anaesthetics).
- Naloxone (opioids).
- Alkalinisation to an arterial pH of 7.45–7.55 with sodium bicarbonate (tricyclic antidepressants with ventricular conduction abnormalities).
- Acetylcysteine (paracetamol).
- High-dose atropine (organophosphates and nerve gases)

A thorough history is important to determine the toxic agent(s) and how much was ingested. Consider non-accidental trauma particularly when the history is inconsistent. Consider child neglect if there have been repeated accidental ingestions.

In the event of cardiac arrest, resuscitation may be required over a prolonged period, as the toxic agent may be metabolised or excreted during extended life support measures. Extracorporeal removal (e.g. dialysis) or extracorporeal life support should be considered in refractory shock and cardiac arrest when conventional CPR is failing.[337–339]

Hyperthermia/heat stroke

Hyperthermia can result from exertion in a warm environment (most often in older children and adolescents), or from environmental heat exposure in children who are unable to escape the hot environment or who have a disorder of thermoregulation. This needs to be distinguished from fever, which is a physiological response usually to infection. Cardiovascular collapse from hyperthermia commonly occurs at around 41 °C, so active cooling should be initiated earlier to prevent this.[285]

No recent paediatric evidence was found for major changes to the management of hyperthermia. Recent ERC, ILCOR and American Heart Association guidelines recommend immediate cooling by removing the child from the heat-source, stopping excessive heat generation (e.g. through exercise), loosening or removing clothing, external cooling and hydration.[171,285,302,340] Standard resuscitation should be started where necessary. These measures should be initiated concurrently with activation of the EMS. Active cooling is associated with a lower mortality in severe hyperthermia compared with no active cooling.[341] Protocols describe the pre-hospital management of hyperthermia and the duration of cold-water immersion.[342–345] Key is early identification, rapid cooling with standard resuscitation when indicated and early transport for more advanced support.

Core temperature monitoring is required to guide cooling and prevent hypothermia. The rectal site is ideal for this in the pre-hospital setting. In the hospital, the oesophageal, bladder or intravascular temperature can be used depending on the setting. The aim is to reduce the core temperature by 0.1–0.2 °C min^{-1} and the goal is 38 °C when cooling measures should be stopped and monitoring continued.

Cooling methods were reviewed by ILCOR in 2020.[346] Aggressive cooling by immersion in cool/cold water or ice water is the best technique for decreasing body temperature and should be initiated as soon as possible, ideally within the first 30 min.[346–348] Immerse the child from the neck down in a tub of cold water (1–26 °C). Ice water is ideal, but even lukewarm water is helpful. Immersion is uncomfortable and leads to shivering, agitation and combativeness. Meticulous care is needed. Benzodiazepines might be used (e.g., midazolam 0.05–0.1 mg kg^{-1} IV) to provide sedation and reduce shivering.

Hypothermia is a real risk when cooling aggressively, especially in infants and small children. Gentle handling and careful monitoring (which can be challenging) are needed to prevent overcooling.[349,350] In the hospital, once core temperature starts decreasing, evaporative cooling may be preferrable to immersive cooling as it facilitates monitoring and reduces the risk of overcooling. Suitable methods are misting with water and fanning with cool air, wrapping the child in a wet sheet or using ice packs applied to the neck, axillae and groin, avoiding direct skin contact. If cold-water immersion is not feasible or too risky (e.g. in infants), initiate an alternative cooling method such as evaporative cooling. Gentle oscillation in cold water on a tarpaulin might also be a feasible and effective alternative to immersive cooling in the pre-hospital setting or emergency department.[351,352]

Rehydration is often necessary. Cool intravascular fluids are not superior to cold-water immersion for cooling.[353] Transpulmonary cooling by cold air inhalation is inferior to ice-water immersion.[354] Antipyretic medication is ineffective in heat stroke. Various other cooling methods have been described but there is too little evidence to advocate one over the other.[355–365]

All children with heat stroke should be admitted to a paediatric intensive care unit for continued monitoring. Complications include seizures, multiorgan failure with rhabdomyolysis, hyperkalaemia, hypocalcaemia, hyperphosphataemia and other electrolyte imbalances, renal and hepatic injury, disseminated intravascular coagulation, cerebral and pulmonary oedema, and cardiogenic shock.

Malignant hyperthermia is a special case of life-threatening hyperthermia associated with anaesthesia. Treatment involves immediate cessation of the triggering agent(s), active cooling, adequate oxygenation and ventilation, correction of severe acidosis and hyperkalaemia and immediate administration of dantrolene according to local protocols. (e.g. an initial dose of 2.5 mg kg^{-1}).

Hyperkalaemia

Treatment of hyperkalaemia should be directed at prompt recognition and appropriate treatment of the underlying cause. An ILCOR CoSTR on the treatment of hyperkalaemia found evidence that treatment with IV insulin and glucose or inhaled or IV $beta_2$-adrenergic agonists causes an acute reduction in potassium values (in the range of 0.7–1.2 mmol l^{-1}). [366,367] It was not clear whether this resulted in improved clinical outcomes. Only a few studies have compared different treatment strategies. One meta-analysis, in adults, compared IV salbutamol to the combination of IV salbutamol and 10 units of insulin and found the combination therapy was more effective in lowering potassium values.[366] This suggests prioritising treatment with IV salbutamol either alone or in combination with insulin and glucose. The rationale for giving calcium during cardiac arrest caused by hyperkalaemia is based on the presumed ability to prevent arrhythmias. Although calcium is widely recognised and used for this indication, the ILCOR CoSTR did not find any clinical evidence to support this. One adult study found a lower unadjusted rate of ROSC with the administration of calcium and one paediatric study, which included children in cardiac arrest with hyperkalaemia found those treated with calcium had worse outcomes.[368,369]

The ILCOR CoSTR did not find any evidence for a potassium lowering effect of bicarbonate in non-hyperkalaemic cardiac arrest but no studies in children were identified. The role of bicarbonate for non-toxicological metabolic acidosis is questionable.[366,370]

The ERC considers treatment with IV insulin and glucose and $beta_2$-adrenergic agonists to be a reasonable approach to lowering potassium in children with and without cardiac arrest. In cardiac arrest, high-quality resuscitation is mandatory and may be prolonged considering the time that may be needed to lower the potassium. Extracorporeal life support can be considered.

Other metabolic derangements

In severe hypokalaemia (<2.5 mmol l^{-1}), or hypokalaemia with arrhythmias, an intravenous potassium infusion of 1 mmol kg^{-1} h^{-1} over 1–2 h is safe and effective in young children.[371] In cardiac arrest with hypokalaemia the ERC recommends rapid administration of IV potassium 1 mmol kg^{-1} at a rate of 2 mmol min^{-1} for 10 min (maximum 20 mmol). When required, continue the dose for another 5–10 min (maximum total 30 mmol) until the serum potassium value is above 2.5 mmol. Repeat if necessary.[311,372] Co-existing depletion of magnesium is common and it must be replaced to enable the successful treatment of hypokalaemia (30–50 mg kg^{-1}).[373]

Treat hypoglycaemia (blood glucose < 3 mmol l^{-1} or <3.9 mmol l^{-1} with symptoms) immediately via the oral route, if possible, with 0.3 g kg^{-1} glucose.[374,375] If oral intake is not possible, give an IV bolus of 0.2 g kg^{-1} glucose (e.g. 2 ml kg^{-1} 10 % glucose) and re-check blood glucose after 5–10 min (or 15 min in case of oral administration) repeating the dose if necessary and starting a maintenance infusion containing glucose. When IV/IO glucose is not available, and oral administration is not possible, providers may administer glucagon intramuscularly, intranasally or subcutaneously.[375,376]

The ERC did not review other rarer metabolic derangements but recommends correcting those that might potentially cause critical illness or cardiac arrest (e.g. hypocalcaemia, hypercalcaemia, hypermagnesaemia).

Cardiac arrest in children with congenital heart disease

Children with congenital heart disease are prone to acute cardiac events including an obstructed cardiac shunt, pulmonary hypertension and a shockable rhythm occurring in a monitored child attached to a defibrillator. The latter two situations can also occur in children without primary cardiac disease in other settings, and the approach to those is similar to that described in these Guidelines.

The standard PALS Guidelines should be followed in infants and children with a single ventricle anatomy with special consideration of possible pulmonary hypertension and an obstructed shunt.[201] There is increasing experience with extracorporeal life support, but no studies comparing it with standard CPR in children with single ventricle physiology. The ERC recommends considering extracorporeal life support if resuscitation is failing. In some cases, extracorporeal life support may be a bridge to a ventricular assist device and heart transplantation.

Pulmonary hypertension

The treatment of acute pulmonary hypertension in these Guidelines is based on a recent ILCOR CoSTR.[377] Pulmonary hypertension occurs in congenital heart disease, chronic lung disease and as a primary disease. These children are at risk of pulmonary hypertensive crises, which can rapidly lead to acute right ventricular failure, acute left ventricular preload reduction and cardiac arrest. Standard CPR may be less effective in pulmonary hypertension as increased pul-

monary vascular resistance impedes left heart filling and limits coronary perfusion during chest compressions.[378]

Cardiac arrest caused by a suspected obstruction of a cardiac shunt

The creation of artificial connections between the systemic and pulmonary circulation (e.g. aortopulmonary shunts and patent ductus arteriosus stents) are important procedures in congenital heart disease. The management described in these Guidleines of life-threatening obstruction (due to thrombosis or mechanical kinking) of a shunt is based on a recent ILCOR CoSTR.[379]

Cardiac arrest in an ECG-monitored child attached to a defibrillator with a witnessed shockable rhythm

Self-adhesive defibrillation pads may be attached to a child in the intensive care unit, operating room or catheterisation laboratory or elsewhere, such that the child can be defibrillated as soon as a shockable rhythm is detected. In this setting it is potentially beneficial to attempt defibrillation up to three times immediately, before starting CPR (the 'stacked-shock strategy'). The ERC acknowledges that there are no paediatric data on this strategy in this specific situation and emphasises that the 'stacked shock' strategy in other circumstances is no longer recommended. Our recommendation is based on expert opinion. However, it is considered unlikely that chest compressions will improve the already very high chance of ROSC, as the heart is believed to be more readily defibrillated in the first moments of a shockable rhythm. This is supported by the survival rate of >95 % of potentially lethal arrhythmias in patients with an implantable defibrillator. Using this stacked-shock strategy, IV amiodarone is given according to the number of defibrillation attempts (i.e. after the third attempt) and IV adrenaline according to the time since the arrest (i.e. the first dose after four minutes).

Cardiac arrest in the operating room

In case of paediatric cardiac arrest in the operating room, follow the standard PALS algorithm, with particular emphasis on the common reversible causes in this setting (hypoxia, hypovolaemia from bleeding or anaphylaxis, tension-pneumothorax and thrombosis) as well as causes specific to the operating room.

No recent systematic review specifically addressed perioperative paediatric cardiac arrest. The recommendations are therefore based on the ERC Guidelines 2025 for adult Advanced Live Support.[380]

Cardiac arrest occurs in 3–12 children per 10.000 procedures under anaesthesia and is more common in children <1 year and those with severe underlying disease and/or undergoing emergency surgery.[381–385] Respiratory and circulatory problems are the main causes e.g. laryngospasm, difficult airway, blood loss and arrythmias. Rarer causes are hyperkalaemia from transfusion of stored blood and medication- and equipment related issues.[381,382,386] Cardiac arrest directly related to anaesthesia is rare (0.1–3.4 per 10.000 anaesthetics). Anaesthesia-related cardiac arrest has a lower mortality than other peri-operative cardiac arrests. The limited data on neurocognitive outcome in survivors of perioperative cardiac arrest suggests an incidence of 24 % for temporary, and 6 % for permanent harm.[383]

Standard operating room monitoring allows shockable rhythms and asystole to be quickly recognised, but it can be difficult to differentiate between severe shock and PEA. Recently it has been suggested to start chest compression in adults if the patient remains hypotensive despite intervention.[387] Pragmatically, the PLS WG recommends starting chest compressions in children if the blood pressure or the heart rate remains below the 5th percentile of the normal range for age.

In pre-arrest states in adults, initial incremental boluses of 50–100 μg IV adrenaline have been proposed rather than the standard 1 mg bolus, which in this situation might induce severe hypertension or tachyarrhythmias.[23] Similarly lower doses of IV adrenaline might be tried in children, for example 1–2 $\mu g\ kg^{-1}$. If a low-dose adrenaline bolus fails, the standard doses of intravenous adrenaline should be given.[388,389]

When the likelihood of cardiac arrest is high, the child should be attached to a defibrillator in standby mode using self-adhesive pads before induction of anaesthesia. Defibrillation should then be performed immediately if a shockable rhythm occurs, before starting CPR, as described above.

Ensure high-quality PALS. Current data suggests that mechanical ventilation yields a similar PaO_2 to manual ventilation with a self-inflating bag.[390–393]

Chest compressions are optimally performed in the supine position, but in case of a cardiac arrest in the prone position with a tracheal tube in place, CPR can be initiated before turning the child if immediate supination is not possible.[394,395] Consider simultaneous left lateral decubitus and Trendelenburg positioning in cases of massive gas embolism, provided this does not impede adequate chest compressions.[396–398] Open cardiac compressions should be performed only by those appropriately trained.

Prioritise the identification and treatment of reversible causes. If available, consider the use of ultrasound (transthoracic/transoesophageal) to help determine the cause.[399] If arrest is due to significant blood loss, chest compressions are effective only if the circulating volume is replaced simultaneously, and haemorrhage control (e.g. surgery, endoscopy, endovascular techniques) is initiated immediately.[399]

Stop the surgery unless it addresses a reversible cause of the cardiac arrest. It may be necessary to cover the surgical field to facilitate access to the patient and adequate resuscitation.

If cardiac arrest occurs during laparoscopic or robotic surgery, release the pneumoperitoneum and deflate the abdomen to enhance venous return during CPR, unless the pneumoperitoneum is essential to the treatment of the surgical cause of the cardiac arrest (e.g. bleeding), in which case use the minimum necessary intra-abdominal pressure. If cardiac arrest occurs during thoracoscopy, stop CO_2 insufflation and rule out contralateral pneumothorax. In both cases, consider gas embolism as a possible cause of the cardiac arrest.

Extracorporeal life support should be considered in cases where conventional CPR is failing or when prolonged resuscitation is required.

Successful management of intraoperative cardiac arrest requires not only individual technical and non-technical skills but also an orchestrated team approach, an institutional safety culture embedded in everyday practice through continuous education, training and multidisciplinary cooperation.[38,39,400,401] Institutional protocols for responding to potential cardiac arrest situations (e.g. massive transfusion protocols) and checklists will help to optimise the response to cardiac arrest in the operating room.[38,39]

Post-resuscitation care

The ERC considered the ILCOR CoSTRs on paediatric post-resuscitation care and ILCOR recommendations for a paediatric car-

diac arrest core outcome set as well as recent literature in areas that ILCOR did not address.[8,38,171,402–407] Possible differences in the organisation of healthcare systems were considered as were the needs of patients, caregivers and families of survivors and non-survivors. Comments from representatives of the community advisors were also included.[408]

Recommendations for health care providers in the pre-hospital setting

The general recommendations about ABCDE principles in the section on cardiac arrest prevention also apply to post-resuscitation care.

Healthcare providers can consider inserting an advanced airway after ROSC if the child's level of consciousness and respiratory effort do not quickly improve. Early tracheal intubation is not always necessary as evidence shows that early tracheal intubation in the field is not better than delayed tracheal intubation.[409] Tracheal intubation should always be performed by a competent healthcare professional using a structured approach with proper equipment and monitoring.

We recommend continuing with a high FiO_2 immediately after ROSC until the arterial blood oxygen saturation can be monitored reliably – the FiO_2 can then be adjusted. Hypoxaemia has been consistently associated with worse outcomes post-cardiac arrest in children while hyperoxaemia has less of an association with outcomes.[410,411] However, the ERC recommends avoiding sustained SpO_2 values of 100 % (with a few exceptions such as carbon monoxide poisoning, severe anaemia and methaemoglobinaemia). To limit possible oxidative stress, in the absence of blood gas analysis, SpO_2 should be targeted at 94–98 %.

If the child's lungs are ventilated mechanically, to avoid hyperventilation, the ERC recommends initially using a low-normal respiratory frequency and aiming for mild chest movements. Once tidal volume can be measured, the ERC recommends a tidal volume of 6–8 ml kg^{-1} of ideal body weight and PEEP of 5 cm H_2O and to avoid high airway pressures, and then further adjusting the ventilator settings to optimise ventilation. Seek expert help from a paediatric intensivist in children with complex medical needs.

After an advanced airway has been secured, use capnography to continuously monitor for effective ventilation. Measure arterial blood gases as soon as practicable – as $ETCO_2$ values do not reliably reflect blood CO_2 values – and target normocapnia.[412] Use individualised $PaCO_2$ targets in specific situations (lung diseases with chronic hypercapnia, single ventricle physiology).[403]

Healthcare professionals should use multiple clinical signs and measurements, not just blood pressure, to evaluate the child's circulatory status, because normotensive shock is frequently present after cardiac arrest.[405,413] In the pre-hospital setting, the ERC emphasises the importance of using the correct blood pressure cuff size and performing frequent measurement of NIBP. Aim for a systolic and mean arterial blood pressure above the 10th percentile for the child's age. There is insufficient evidence for recommendations on specific treatments to achieve these targets (fluids, vasoactive medication, inotropes). A blood pressure that is too high may cause or worsen myocardial dysfunction.[405]

Treat seizures as soon as they arise, as recommended by an ILCOR CoSTR.[38] Check the blood glucose and treat any hypoglycaemia because it is associated with unfavourable outcomes in critically ill children.[405] Provide analgesia and sedation to treat pain and discomfort. Even short periods of low blood pressure below the 5th percentile are associated with worse outcomes after cardiac arrest.[414] Therefore, the ERC recommends avoiding boluses of medications that might cause sudden changes in blood pressure and to use continuous IV administration of analgosedation whenever possible. A body temperature above 37.7 °C is associated with worse out-

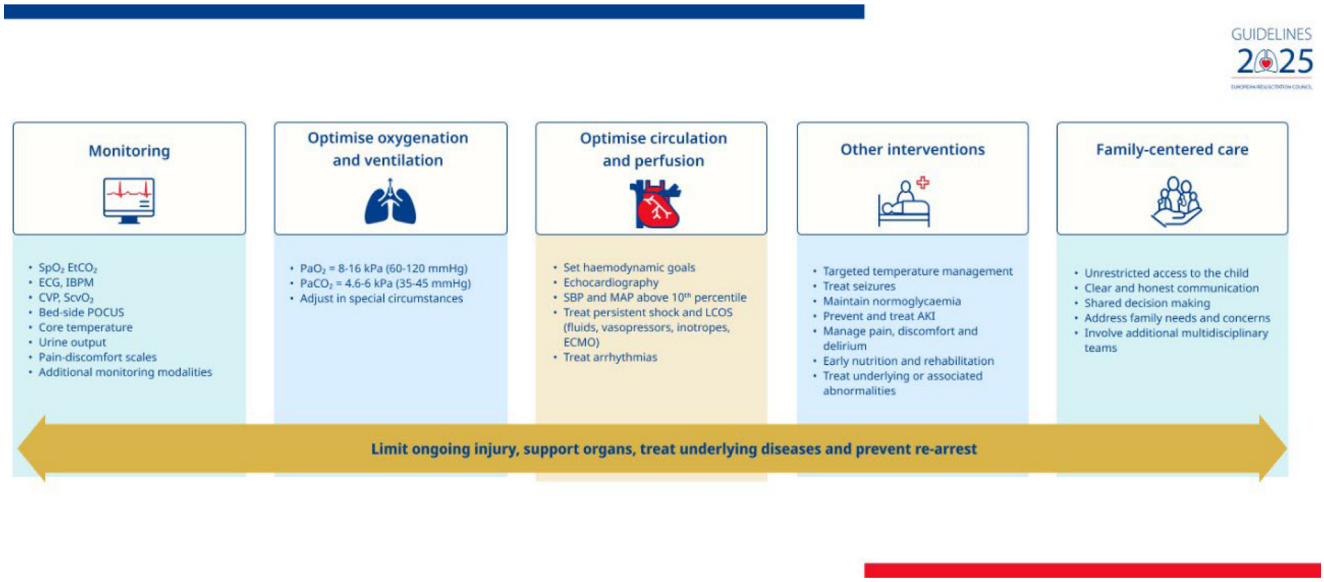


Fig. 23 – In-hospital post-resuscitation care.

AKI – acute kidney injury, CVP – central venous pressure, ECG – electrocardiography, ECMO – extracorporeal membrane oxygenation, $EtCO_2$ – end-tidal carbon dioxide, IBPM – invasive blood pressure monitoring, LCOS – low cardiac outcome syndrome, MAP – mean arterial blood pressure, $PaCO_2$ partial arterial pressure of carbon dioxide, PaO_2 – partial arterial pressure of oxygen, POCUS – point-of-care ultrasound, SBP – systolic blood pressure, $ScvO_2$ – central venous oxygen saturation, SpO_2 – peripheral oxygen saturation.

GUIDELINES 2025

Prognostication diagnostic modalities associated with GOOD outcome (a)

Modality	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
	Bilateral reactive pupillary light response ≤ 12 hours					
GCS	M ≥ 4 at 6 hours					
	Sleep spindles and continuous cortical activity ≤ 24 hours	Presence of N20 response on SSEP at 24-72 hours				
				Normal brain MRI at 4-6 days		
	lactate < 2mmol L^{-1} ≤ 12 hours, normal s100b, NSE or MBP					

Prognostication diagnostic modalities associated with POOR outcome (b)

Modality	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
		Absence of pupillary light reactivity at 48 and 72 hours				
GCS						
		Presence of status epilepticus, burst suppression*, burst attenuation* or GPEDs between 24 and 72 hours				
		Loss of GWM differentiation on CT scan at 24 hours		Abnormal MRI showing high ischemic burden on ADC mapping ≥ 72 hours		

*despite low levels of sedatives

Fig. 24 – Prognostication modalities associated with good (a) and poor (b) outcomes.

Disclaimer: NO single modality can be used in isolation for prognostication with high accuracy. The overall quality of evidence for individual tests is very low for all outcomes primarily due to a very serious risk of bias. Abbreviations; GPED – generalised periodic epileptiform discharges, GWM – gray-white matter, ADC – apparent diffusion coefficient, SSEP – somatosensory evoked potentials, NSE – neuron-specific enolase, MBP – myelin basic protein.

comes in patients after cardiac arrest and should be always avoided after ROSC.[415]

The presence of the parents/caregivers during pre-hospital care and transportation is legally and ethically justified provided this does not jeopardise their safety or that of the child or care team. It is also perceived as important by parents or other caregivers and improves psychosocial outcomes in family members regardless the outcome of the child.[408,406]

Recommendations for in-hospital health care providers

In-hospital, specific paediatric intensive care approaches are used during the acute and post-acute post-resuscitation care phases and for the treatment of post-cardiac arrest syndrome (Fig. 23). These comprise a variety of diagnostic and therapeutic options usually organised in care-bundles, where more contextualised and individualised care goals can be used based on the child's history, the specific context and the resources available. Multiple treatment modalities might be necessary to treat underlying disease and/or post-cardiac arrest syndrome including airway management, ventilatory support and circulatory support with fluids, blood products, vasoactive medication and inotropes, and extracorporeal life support.[405]

Target normoxaemia and normocapnia.[68,410,411,413,415–418] Patients with hypoxaemia (<8 kPa, 60 mmHg) are less likely to survive to hospital discharge while hyperoxaemia has no effect on outcomes.[410,411] Compared with hypercapnia, patients with normocapnia are more likely to survive to hospital discharge whereas hypocapnia does not affect outcome.[411] No evidence for targets in specific patients (e.g. congenital heart disease, chronic lung disease with chronic hypercapnia) although individualisation of care is recommended by ILCOR.[403] There is insufficient evidence for a firm recommendation for how long oxygenation and ventilation targets should be maintained post-ROSC, but at least 24 h seems reasonable.[405]

Monitor blood pressure (BP) continuously via an arterial catheter in all patients who remain comatose after ROSC. Post cardiac arrest hypotension occurs in more than 50 % of patients and contributes to secondary brain injury through cerebral hypoperfusion.[405] Causes of low blood pressure include myocardial dysfunction, inflammatory response, and vasoplegia.[413,416] Hypotension in the first 24 h after ROSC is associated with poor outcomes.[68] The optimal BP target (systolic, diastolic or mean pressure) is unknown, but there is evidence that even short periods of a BP slightly below the 5th percentile are associated with unfavourable outcomes.[414] One observational study suggests that systolic BP above the 10th percentile is associated with favourable outcomes. Conversely, a blood pressure that is too high is detrimental because it can cause myocardial dysfunction and increase cerebral blood flow.[419] Until further evi-

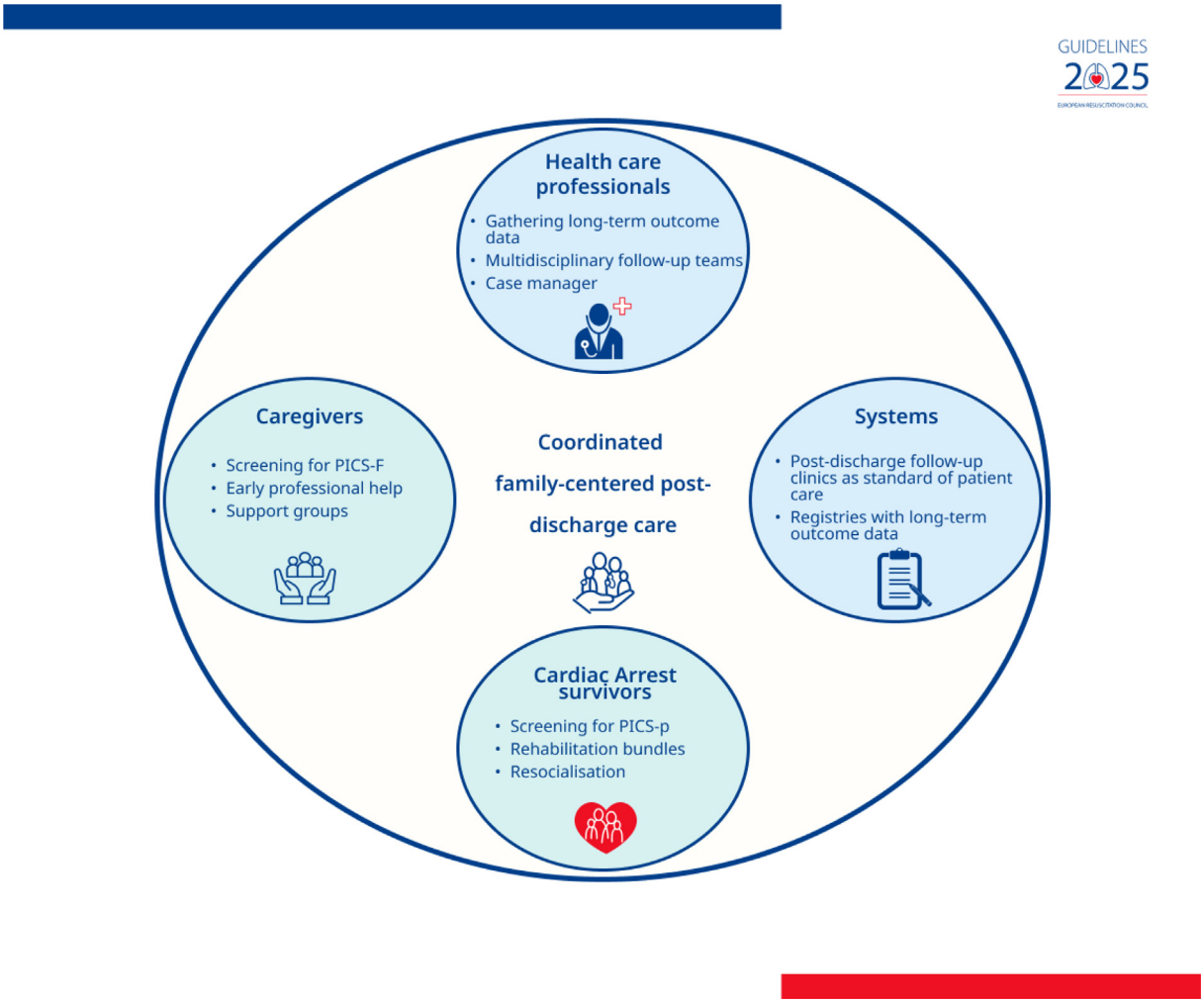


Fig. 25 – Post-discharge care.

Abbreviations: PICS-F – post-intensive care syndrome family, PICS-p – post-intensive care syndrome paediatrics.

dence is available, ILCOR recommends maintaining a systolic BP above the 10th percentile.[38,404] Newer studies have focused on mean arterial blood pressure targets and cerebral blood flow.[414,420,421] Pragmatically, the ERC recommends targeting mean arterial blood pressure to above the 10th percentile. There is insufficient evidence for an ERC recommendation on the optimal strategy to achieve this blood pressure target (fluids, vasoactive medication, inotropes, mechanical support). Higher blood pressure targets, (above the 50th or 80th percentile), are justifiable in certain cases, especially following cardiac arrest associated with severe traumatic brain injury.[147]

A 2019 ILCOR CoSTR acknowledged the benefits of temperature control as a neuroprotective strategy following paediatric cardiac arrest but was unable to recommend a specific target as the evidence was neither in favour or against hypothermic (32–34 °C) vs. normothermic (36–37.5 °C) temperature control.[171,402] Hyperthermia (>37.5 °C) has been consistently associated with worse neurological outcomes.[422,423] Maintaining normothermia reduces metabolic stress on the injured brain. Hypothermic temperature control has been associated with improved long-term health-related quality of life in paediatric cardiac arrest survivors, further supporting its role in post-cardiac arrest care, even in the absence of a clear survival benefit.[424,425] Hypothermic temperature control requires specialised paediatric neurocritical care to ensure safety, proper sedation, treatment of possible side effects (coagulopathy, bradycardia, metabolic disturbances, infection), and safe rewarming strategies.[405] In settings without such resources, strict normothermia and fever prevention remain the standard of care.

There is no evidence on which to base recommendations about the duration of temperature control. In line with a recent ILCOR evidence update on temperature control, the ERC recommends maintaining normothermic or hypothermic temperature control for at least 24 h, and avoiding fever for at least 72 h, after ROSC.[171,415]

Clinical and electroencephalographic seizures are common manifestations of post–cardiac arrest brain injury in children, with an incidence of approximately 10–40 %, and are associated with poor neurological outcome.[426,427] The ERC and ILCOR currently recommend prompt treatment of seizures following ROSC, but not the prophylactic use of antiseizure medication. This recommendation is based on indirect evidence from adults, children with traumatic brain injury and neonatal hypoxic-ischemic encephalopathy.[38]

The ERC emphasises the importance of high-quality intensive care management of children after cardiac arrest (see Fig. 23). This includes multimodal monitoring; non-invasive or invasive techniques to diagnose and treat underlying conditions as well as post cardiac arrest syndrome, pain, discomfort and delirium, and acute kidney injury, as well as early optimal nutrition, and rehabilitation.

The ERC recommends family-centred care with unrestricted access of parents/caregivers to the child, honest and clear communication, and the early involvement of the specialised assistance of multidisciplinary teams (e.g. paediatric neurologists, paediatric psychologists, paediatric palliative care team, social workers, child-life specialists and, if necessary, an interpreter) to address additional needs of the child and family.[408]

Prognostication after cardiac arrest

The accurate prediction of good outcome is important to patients, parents/caregivers and healthcare providers. A predicted good outcome would justify continued intensive care treatment. Accurate prediction of poor neurological outcome is crucial to avoid false pessimism as well as to justify withdrawal of life sustaining therapy.

The usefulness of blood biomarkers, clinical examination, electrophysiology and neuroimaging for the prediction of neurological outcomes after ROSC has been reviewed in two ILCOR CoSTRs and a systematic review.[201,428,429] The ERC recommends that future outcome studies should ideally be assessed using the Pediatric Core Outcome Set in Cardiac Arrest and should include long-term outcomes in terms of morbidity, functional health and quality of life, and the impact on the family.[406] Visual aids and presentations can help families to better understand the prognostication terminology and enable them to be better involved in the decision-making process.[430]

The ERC advises healthcare providers to use multiple pre-, intra-, and post-cardiac arrest variables for prognostication in the post-cardiac arrest phase and to delay prognostication in children with a depressed level of consciousness for at least 72 h. Single variables should never be used for prediction of good or poor outcomes.[201,428] These variables include pre-arrest factors (child's baseline health and neurological status), the context of the cardiac arrest (location, PBLS initiation, first rhythm, cause, duration), and post-cardiac arrest care (comprehensive assessment with repeated evaluations).

The ERC recommends including a set of diagnostic modalities in the post-resuscitation care work-up in paediatric intensive care units that can be also used for prediction, and which enable standardisation and better comparability of future research. The minimal set would include pupil reactivity to light at days 1–6, Glasgow Coma Score or its motor score component on days 1–6 and basic available blood biomarkers on day 1 (pH, lactate). Extended investigations should also include additional blood biomarkers of neurological damage such as S100B (a calcium binding protein primarily found in astrocytes), NSE (neuron-specific enolase), MBP (myelin basic protein) on day 1, electrophysiological studies (EEG, somatosensory evoked potentials, SSEP) on day 1 and 2, and brain imaging by magnetic resonance between day 3 and 5. The modalities and timings were chosen so that they allow for both multimodal prognostication for good as well as for poor outcome. Suggested results of these investigations that can be used as components of multimodal approach to prognostication are shown in Fig. 24.[428] The overall certainty of evidence for individual tests is very low for all outcomes.

Post-discharge care

The occurrence and severity of sequelae in paediatric cardiac arrest survivors, both short-term and long-term, are major concerns for patients, families, and healthcare providers worldwide. Little is known about the long-term outcomes of cardiac arrest survivors. Long-term follow-up is crucial to identify problems and to counsel children and parents/caregivers. The goal is to improve long-term outcome in cardiac arrest survivors by early therapeutic interventions and reduce the societal impact (e.g. health care costs, unemployment).

The sequelae of cardiac arrest can have a major impact on all family members. Parents/caregivers and extended family members may suffer from psychosocial sequelae both before and after hospital discharge of the child. They will have to cope with grief and trauma caused by the child's hospital admission, the cardiac arrest event itself and its sequelae. Family dynamics may change, and parents/-

caregivers may not be able to return to their jobs, with all the financial consequences that this entails.

Considering the greater life expectancy for children, the relative costs for society in terms of loss of potential productivity, associated health care costs, and the emotional burden for the family are significant.[8]

No scientific evidence has been found on post-discharge care in children, except a systematic review on the family needs of cardiac arrest survivors.[408]

The ERC together with community advisors agreed that post-discharge care should ideally be organised for all cardiac arrest survivors and their families as part of standard patient care. Specific care should also be organised for families of non-survivors (i.e. bereavement support, psychology).

Standardisation of care will also increase the quality of outcome data and minimise selection bias in future research, and the development of evidence-based post-discharge guidelines has been suggested.[431] Several barriers to this exist, including low cardiac arrest survival rates for paediatric OHCA, small homogeneous cohort sizes, and few national or international cardiac arrest registries that collect data on long-term outcomes in different domains (e.g. physical, neuropsychological, functional health and health related quality of life). International research collaborations are necessary to improve post-discharge care.

The ERC recommends a specific set of actions to improve care after discharge, which are based on expert consensus and the advice of community advisors representing families of both survivors and non-survivors. The ERC recognises that this type of care is difficult to organise because it requires personnel and financial resources and dedicated teams to provide multidisciplinary follow-up programmes. Planning of post-discharge care should start before discharge of the child. Well-coordinated on-site family-centred care is preferred, using case managers such as family liaison teams to improve adherence to post-discharge care and lower the burden on families. Virtual consultation should be considered when hospital visits are difficult to organise. Patients and families should be screened for symptoms of post-intensive care syndrome and referred for professional help as soon as physical or mental health issues are detected. Signposting supportive structures for families of survivors and non-survivors is also important.

System-level recommendations and recommendations for implementation

Recommendations for the public

The most common witness in paediatric resuscitation is a parent or caregiver and the most common location is at home.[172] Less commonly, cardiac arrests also occur during physical exercise and at school.[17] In adolescents, violence, drug misuse, mental health and traffic accidents are prevalent but potentially preventable causes.[17] A community-based approach to cardiac arrest prevention is justified and should be aimed mostly at caregivers of children and primary health care providers.[10] Specific preventative interventions targeted at lower socioeconomic populations and ethnic minorities might be especially effective as there is increased probability of arrest in these groups compared with the general population.[14,432] Communities should be involved in training in the recognition and management of cardiac arrest and in first aid interventions.[433] Every child who has had an anaphylactic reaction should have two auto-injectable adrenaline devices prescribed and receive instructions on how to use it (child and caregivers). There is no specific age at which children can be expected to use the adrenaline auto-injector themselves but children of secondary school age are generally mature enough to do this.[171,259,266–269]

The ERC recommends systematic training in PBLS for all persons caring for children, from parents and caregivers to teachers, child minders, lifeguards, first responders and coaches/trainers. Paediatric cardiac arrest is a low frequency high-stakes event. Mistakes and substandard performance are common in simulations of paediatric resuscitation and training remains the cornerstone of potential improvements in outcomes.[434–437] CPR training is widely recognised to improve CPR skills and improve survival.[438] Training of the general population has been associated with improved overall bystander CPR rates and survival outcomes.[439] The best timing for training of parents might be during antenatal classes, as almost a half of all paediatric cardiac arrests happen at home during the first year of life.[172,432] Swimming lessons can reduce the incidence of drowning.[440–443]

Recommendations for all health care systems

The best outcomes are achieved when all the links in the chain of survival are working effectively together and are coordinated over space and time.[444] Healthcare systems should use regular system audit and improvement strategies focussed on the chain of survival to continually improve patient care and outcomes.[444] The ERC recommends systematic training in the recognition of critically ill or injured children and in PBLS at all levels of care, including training those who only occasionally care for children. Training healthcare professionals may improve outcomes and low-dose high-frequency training seems to be an efficient way to improve skills.[401,438,445] Improvement in outcomes and competence after publication of guidelines and standardisation of training are well documented.[446]

The ERC recommends systematic training in PALS at all levels from EMS systems and pre-hospital care to hospital staff, particularly focusing on those who treat critically ill children. The ILCOR CoSTR on team competencies in resuscitation education concluding that teaching these skills can improve resuscitation performance in the areas of leadership, communication, decision-making, task management and CPR quality.[400] Further evidence demonstrates that training in teamwork with an emphasis on leadership skills, planning, and structured, uniform communication is associated with shorter chest compression pauses.[220,447–449]

A well-structured resuscitation team and an easily accessible activation system are essential for ensuring a seamless transition from PBLS to PALS.[450,451] Team members should ideally have predesignated roles and shared leadership can be considered in some teams e.g. when using a CPR coach (a team member with responsibility for ensuring the team maintain high-quality CPR). [401,452]

To strengthen the link between PBLS and PALS, institutions should view these as phases in a continuum and establish clear protocols for transitioning from one to the other. The necessary teamwork for this should be incorporated into training programs.[453] Ensuring that professional PBLS providers understand the PALS algorithms, including indications for advanced airway management, vascular access and medication administration, supports a more coordinated approach to paediatric resuscitation. Clear communication is also necessary and training in structured handover of information is invaluable.[454]

Several conditions are recognised as risk factors for cardiac arrest and identifying them might prevent this. These include preterm and very small babies, children with a family history of sudden unexplained death, siblings of children who died of sudden infant distress syndrome (SIDS), congenital abnormalities, primary arrhythmia syndromes, cardiomyopathies, channelopathies, and coronary artery abnormalities.[455–459] Integrating genetic testing and advanced electrophysiological evaluation might identify children at high risk for cardiac arrest.[460] Exercise-related cardiac arrest is rare and pre-participation screening does not seem to be cost-effective. If implemented, then targeting adolescents rather than younger children seems reasonable.[461]

Recommendations for emergency medical systems and dispatch systems

Field triage is important for all pre-hospital systems to identify critically ill or injured children and to transport them to the most appropriate facilities.[462] Transportation to lower-than-required level paediatric or adult trauma centres is associated with increased mortality and morbidity.[463] However, current protocols do not accurately discriminate between patients at low and high risk, so specific paediatric triage tools are needed to ensure that the right child is transported to the right hospital.[463,464]

Recommendations for transportation

No studies were found specifically addressing the topic of transportation of children to cardiac arrest centres after cardiac arrest.[38] The ERC recommends, based on expert opinion, that children sustaining cardiac arrest should be preferably transported to hospitals with a paediatric intensive care unit where a multimodal approach to post-resuscitation care is available.

The ERC recommends that EMS systems should establish communication strategies and plans to aid seamless transportation and hand-over of children in or after cardiac arrest. Standardisation of hand-over protocols improves outcomes on all levels – patients, providers and organisations.[465]

The ERC recommends that multiple transfers between hospitals be avoided, as this is associated with lower long-term survival in critically ill children.[466] The ERC also acknowledges that in certain situations it may be preferable to transport the child to the closest hospital for stabilisation before transfer to a paediatric intensive care centre. All transfers of critically ill children should be carefully planned to ensure safety. Children with complex medical conditions need more specialised care, which is usually only available in a tertiary centre.[432] Centres with facilities for extracorporeal life support or other specialised paediatric care (cardiac, cardiothoracic surgery, trauma) are preferable for certain children (hypothermia, poisoning, trauma, refractory cardiac arrest).

Recommendations for hospitals, departments and teams

The use of paediatric early warning systems was recommended in an ILCOR CoSTR as these can reduce adverse events, although false alarms are frequent.[451,467,468] The ERC recommends implementing paediatric early warning systems, not as a stand-alone measure, but as part of a broader clinical response system which might be modified for use in different settings or added to existing triage systems.[469]

The ERC recommends that hospitals train healthcare providers in the recognition and management of critically ill/injured children, PBLS and PALS. Bag-mask ventilation is the most time-critical intervention and every healthcare professional involved in the care of seriously ill children should be competent in this technique. The ERC recommends that systems enable IO access within 5–10 min in children who require this, as IV access can be challenging.[143]

ILCOR has identified ten key steps to improve IHCA outcomes, emphasising the importance of structured resuscitation systems.[401] The ERC recommends the implementation of those, which include dedicated resuscitation teams whose members have predefined roles, comprehensive training programs, standardised equipment and protocols, efficient alarm systems and regular team briefings.

The ERC recommends standard operating procedures for post-resuscitation care in hospitals, departments and paediatric intensive care units. Standardisation improves patient outcomes by reducing unnecessary variability and enhancing efficiency and quality of care.[470] However, successful implementation requires the flexibility to adapt to individual patient needs.[471]

An ILCOR CoSTR recommended that extracorporeal life support, when considered, should be accompanied by institution-specific algorithms which ensure that healthcare teams can rapidly identify suitable candidates, streamline the initiation process and optimise resource allocation, in order to enhance outcomes.[258]

Recommendations for manufacturers of medical devices

In line with ILCOR, the ERC recommends inclusion of children in public access defibrillator programs and standardisation of AED pad size for infants, children and adults.[192,222] The paediatric mode of an AED should be simple to activate (e.g. by pushing a button rather than by using a key or switching the electrode pads), as rescuers find this easier.[472,473] In line with an ILCOR CoSTR, the ERC recommends that manufacturers standardise pictograms for pad position in line with the ERC recommendations. The ERC recommends that manufacturers of publicly available AEDs use one universal size of the pad for cardiac arrest patients of all ages and a simple method of attenuating the energy level for infants and children weighing less than 25 kg.

Recommendations for low resource setting

These Guidelines indicate where access to paediatric specialty care should be provided e.g. paediatric cardiologist, paediatric neurologist. The ERC recommends that systems strive for the highest possible level of care but recognise that different modifications and prioritisation may be needed depending on available resources. For example, access to a paediatric specialist is important but where this is not available another competent doctor may be consulted, or remote advice and telemedicine may also be useful. For a detailed definition on resuscitation in low resource settings, we refer to the ERC Guidelines 2025 Systems Saving Lives.[474]

System-level considerations

Dispatch-assisted CPR may be incorporated into any EMS in any setting although this requires training of personnel. AED deployment in communities is cost-effective for adult OHCA and may be extended to paediatric OHCA.[475] Life support training is considered a cost-effective method to enable providers to deliver the highest possible level of care and improve survival outcomes.[201,438] Life support training can be conducted using low fidelity manikins.[476] Resuscitation education should be conducted in a low-dose, high-frequency manner enabling training activities during clinical working

hours.[401,445,477,478] Where there are limited training opportunities, training of specific caregivers and healthcare professionals (e.g. resuscitation teams or others with a high likelihood of encountering cardiac arrest) may be prioritised. Targeted life support training of lay persons in areas with a lower socioeconomic status might be considered as these areas have a higher incidence of cardiac arrest with poorer outcomes.[479,480] Training of lay people is most effective when there is an effective chain of care following the resuscitation. In any setting, consider allocating designated staff who can respond to emergencies and cardiac arrest.

Prevention of cardiac arrest

In limited resource settings, the most cost-effective ways to detect clinical deterioration and establish appropriate responses should be considered. These may include the use of low-cost equipment to detect vital sign changes and educating families to react appropriately to certain signs (e.g. high fever, abnormal breathing and decreased consciousness).[433]

The use of pulse oximetry and oxygen is considered a highly cost-effective strategy to prevent deterioration among children.[113,481,482] Isotonic saline may be used as an alternative to balanced crystalloids for fluid treatment when these are unavailable for financial or logistic reasons.[483] In the absence of a clinical emergency team, consider establishing a small team or alternate track-and-trigger response.[401]

Paediatric Life Support

For foreign body airway obstruction, we recommend prioritising basic manoeuvres first in all settings. When starting CPR, prioritise bag-mask ventilation, intubation is not associated with improved survival outcomes.[484] Prioritise the availability of oxygen and a bag and mask. Tracheal intubation with a regular direct laryngoscope is an acceptable alternative when video laryngoscopes are not available.

Self-adhesive pads are recommended for defibrillation, paddles may be used where such defibrillation pads are unavailable.[222] Adult defibrillation pads may be used on a child with the defibrillation pads in an anteroposterior position when paediatric pads are unavailable.

Following cardiac arrest, children should ideally be transferred to a centre with facilities for paediatric intensive care. If this is not possible, children should be treated in a setting capable of intensive care monitoring for 24–72 h. Prioritise careful management of oxygenation, ventilation, circulation and temperature because these are the basic tenets of post cardiac arrest care.[68,405] Where expertise is not available on-site, consider telemedical consultation with an expert(s) (e.g. paediatric intensivist).[485]

Collaborators

The following individuals contributed as collaborators to the 2025 version of these Guidelines as community advisors: **Josephine Wren** and **Eleni Tsoni**.

Declaration of competing interest

Declarations of competing interests for all ERC Guidelines authors are displayed in a COI table which can be found online at https://doi.org/10.1016/j.resuscitation.2025.110767.

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Practice Guideline

European Resuscitation Council Guidelines 2025 Newborn Resuscitation and Support of Transition of Infants at Birth

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Abstract

These European Resuscitation Council (ERC) Guidelines 2025 on Newborn Life Support are based on the International Liaison Committee on Resuscitation (ILCOR) Consensus on Science wtih Treatment Recommendations (CoSTRs) for Neonatal Life Support. These Guidelines present a logical approach to resuscitation and support of transition to extra-uterine life, for both preterm and term newborn infants. These Guidelines include factors before birth, training and education, thermal control, management of the umbilical cord after birth, initial assessment, airway, breathing and circulation assessment and interventions, emergency vascular access, low resource and out of hospital settings, communication with parents, and considerations on withholding and discontinuing life sustaining treatments. Life support guidelines for older infants and children are covered in the ERC Guidelines 2025 Paediatric Life Support.

Introduction and scope

The ERC Guidelines 2025 on Newborn Life Support (NLS) include both resuscitation at birth and support of transition from fetus to newborn infant across all gestational ages (GA). Newborn resuscitation differs fundamentally from resuscitation in every other age group due to the unique physiological transition from intrauterine to extrauterine life. The adaptation at birth requires a complex interplay of respiratory, cardiovascular, and metabolic changes, making timely and appropriate intervention crucial. It primarily focuses on supporting postnatal transition, with establishment of lung aeration, effective breathing or ventilation, and optimising pulmonary blood flow.

The evidence to support newborn resuscitation remains limited, with many recommendations extrapolated from animal studies, observational data, or expert consensus. The ERC NLS Writing Group recognises these challenges but has aimed to develop clear, evidence-informed guideline recommendations that balance scientific rigor with practical applicability. By emphasising consistency, simplicity, and effective education, they serve as a foundation for improving newborn resuscitation practices across diverse healthcare environments.

Abbreviations: CPR, Cardiopulmonary resuscitation, C:V, Compression to ventilation (ratio), CI, Confidence intervals, CoSTR, Consensus on Science and Treatment Recommendations, CPAP, Continuous positive airway pressure, DCC, Delayed cord clamping, ECG, Electrocardiography, FRC, Functional residual capacity, GA, Gestational age, HCP, Health care professional, HR, Heart rate, HIE, Hypoxic ischemic encephalopathy, ICC, Immediate cord clamping, IO, Intraosseous, IV, Intravenous or intravascular, NICU, Neonatal Intensive Care Unit, NLS, Newborn Life Support, FiO_2, Fractional inspired oxygen concentration, OR, Odds ratio, PLS, Paediatric Life Support, SpO_2, Peripheral oxygen saturation, PEEP, Positive end-expiratory pressure, PPV, Positive pressure ventilation, RCT, Randomized controlled trial, ROSC, Return of spontaneous circulation, s, Second (s), SGA, Supraglottic airway device, UVC, Umbilical venous catheter

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The ERC Guidelines 2025 NLS are based on the International Liaison Committee on Resuscitation (ILCOR) Consensus on Science and Treatment Recommendations (CoSTRs) for Newborn Life Support.[2–6] For the purposes of these Guidelines, the ILCOR recommendations were supplemented by focused literature reviews undertaken by the ERC NLS Writing Group for topics not reviewed by ILCOR CoSTRs. When required, the Guideline was informed by expert consensus of the ERC NLS Writing Group. The ERC Guidelines 2025 NLS were drafted and agreed by the ERC NLS Writing Group members and the ERC Guidelines 2025 Steering Committee. These Guidelines were posted for public comment between 15 May and 30 May 2025. A total of 69 individuals submitted comments, this feedback was reviewed by the NLS writing group. The Guidelines were thereafter updated where relevant, resulting in 40 changes in the final version. The ERC Guidelines 2025 NLS were presented to and approved by the ERC Board and the ERC General Assembly in June 2025. The methodology used for guideline development is presented in the Executive summary.[7]

For consistency, the ERC Guidelines 2025 NLS describe a baby at birth as a 'newborn infant' and a baby or a neonate as an 'infant' throughout this guideline. The term 'mother' is used to describe the person giving birth, the term 'parents' is used to describe the caregivers.

Newborn life support or paediatric life support?

In agreement with the ERC Guidelines 2025 Paediatric Life Support (PLS) Writing Group, the ERC recommends the following:

- Use the ERC Guidelines 2025 NLS immediately after birth irrespective of birth location (i.e. hospital or home birth)
- The ERC Guidelines 2025 NLS can also be used during Neonatal Intensive Care Unit (NICU) stay, especially in preterm infants or term infants with primary respiratory problems.
- Use the ERC Guidelines 2025 PLS[1] after first hospital discharge.
- Using the ERC Guidelines 2025 PLS[1] during first hospital stay after birth is also reasonable in the following circumstances:
  - after cardiac surgery,
  - in known cardiac arrhythmia, and
  - In other non-respiratory cardiac arrests
- Develop local policies defining which guideline to use for which infants, applicable to the healthcare setting. Factors to take into consideration include:>
  - individual NICU case-mix,
  - algorithm familiarity and training, and
  - human and organisational factors
- Teams may initiate resuscitation using the guideline they are most familiar with (NLS or PLS) and summon appropriate help and switch guideline if needed, in a timely and coordinated manner.

Preterm infants at the threshold of viability

The ERC Guidelines 2025 NLS apply predominantly to management of infants with gestational age (GA) $\geq$ 25 weeks. Until more evidence from trials including the most preterm infants is available, the ERC

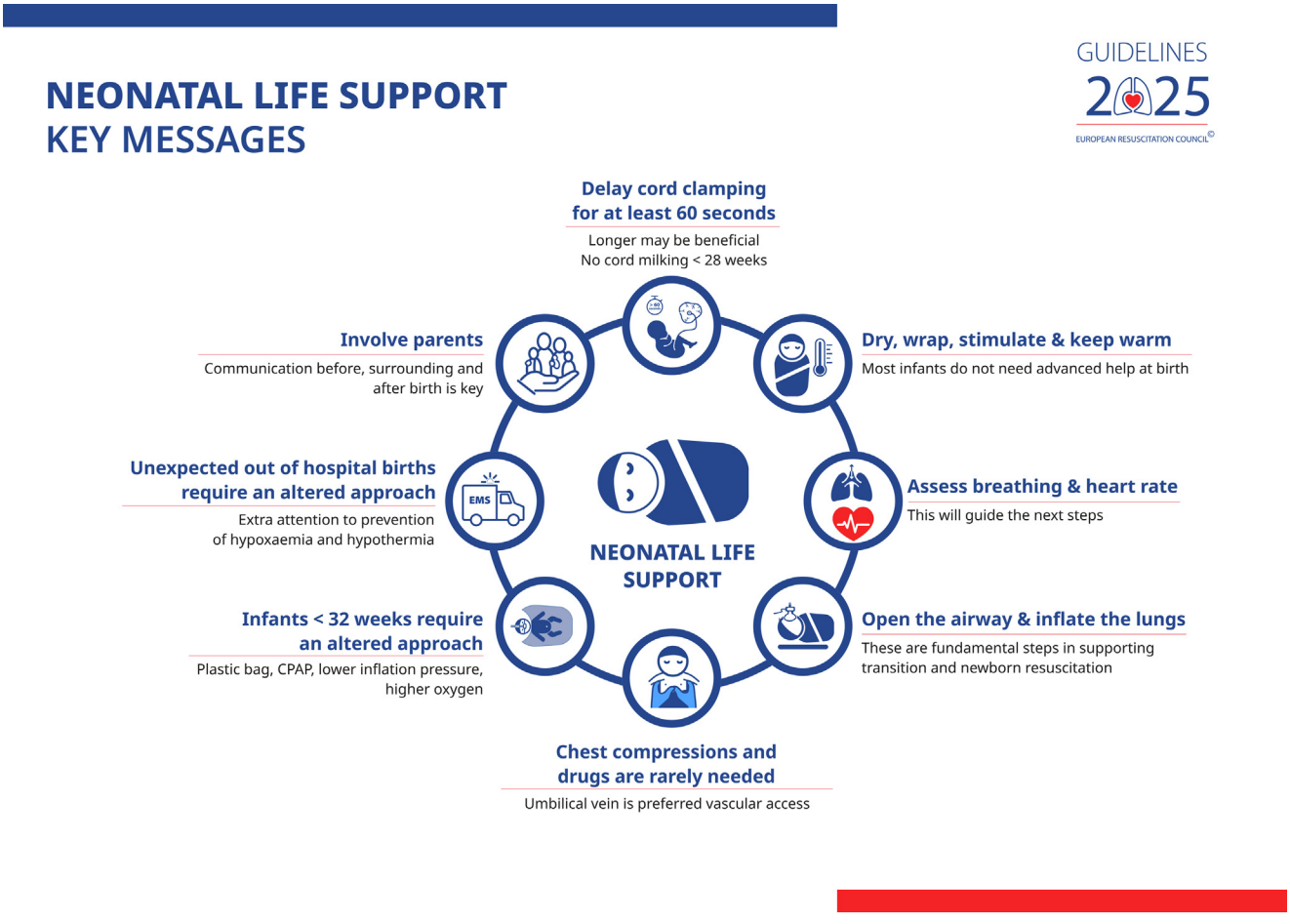


Fig. 1 – Neonatal life support – key messages.

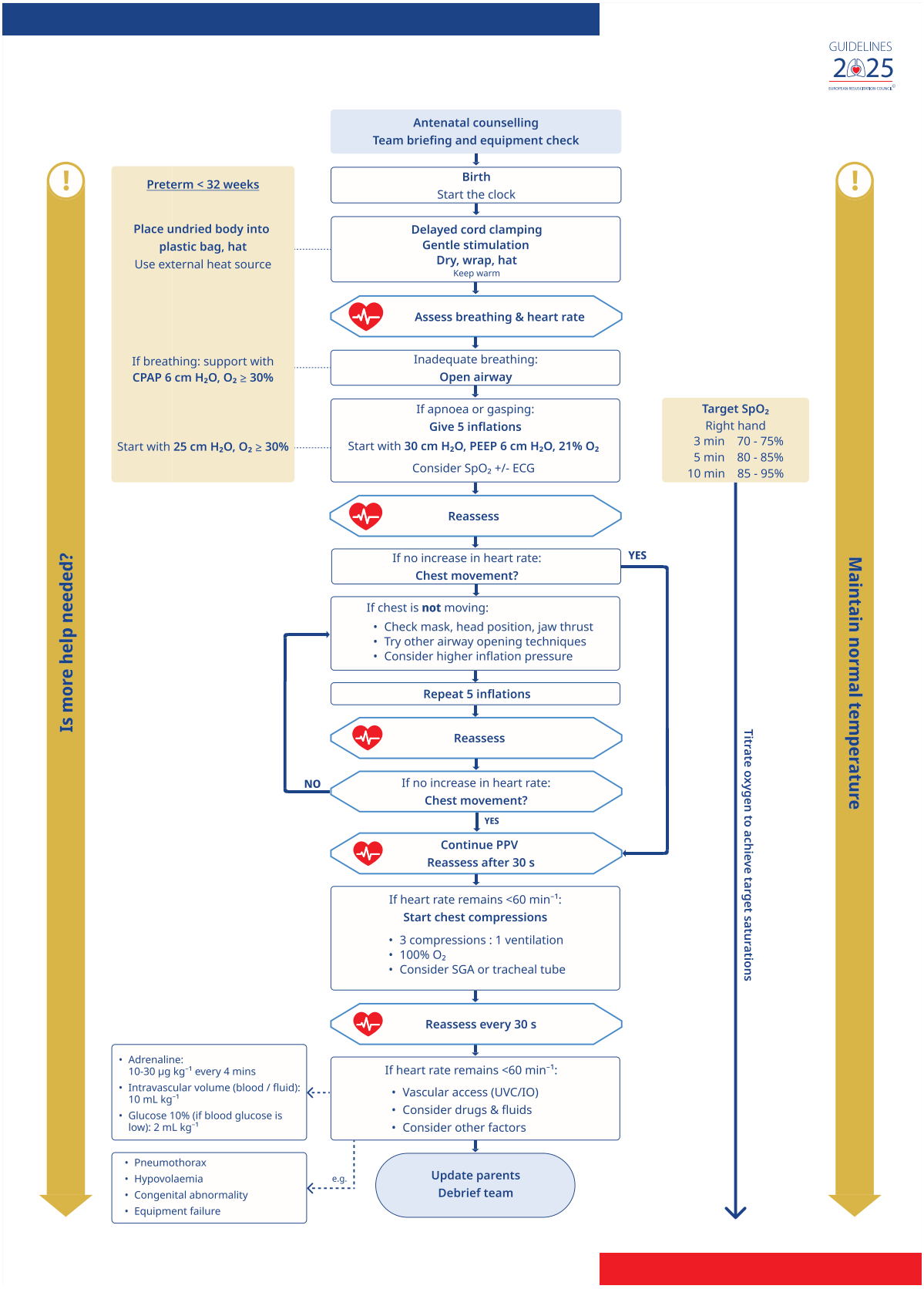


Fig. 2 – Neonatal Life Support algorithm. CPAP: continuous positive airway pressure; ECG: electrocardiography; IO: intra-osseous needle; PEEP: positive end-expired pressure; PPV: positive pressure ventilation; SGA: supraglottic airway; SpO2: peripheral oxygen saturation; UVC: umbilical venous catheter.

Table 1 – Key changes in NLS 2025 Guidelines.

Topic	ERC 2021 NLS Guidelines	ERC 2025 NLS Guidelines
When to use Newborn Life Support (NLS) or Paediatric Life Support (PLS) algorithms	Not included	The NLS and PLS Writing Groups have included aligned statements relating to when it might be appropriate to use either resuscitation algorithm. Both writing groups consider it reasonable for teams to initiate resuscitation of an infant outside the delivery area using the guideline most familiar to them (either NLS or PLS) whilst summoning appropriate help and switching algorithm in a timely fashion if necessary.
Applicability of Guidelines to the most preterm infants at the limits of viability	Not included	The Guidelines acknowledges the paucity of resuscitation data available from extremely preterm infants especially <25 weeks and cautions that this guideline is based upon evidence from predominantly older gestational ages, which limits applicability to extremely low gestational ages
Telemedicine	Not included	Telemedicine can provide remote advice and health systems should consider how this can be used.
Environment and equipment	All equipment must be regularly checked and ready for use. Where possible, the environment and equipment should be prepared in advance of the birth of the infant.	Equipment should be easily accessible and organised in a standardised way. Consider human factor elements when organising equipment and training to maximise efficiency and to minimise time delays.
Delayed cord clamping (DCC)	Where immediate resuscitation or stabilisation is not required, aim for delayed cord clamping of at least 60 s. A longer period may be more beneficial.	Although recommendations about delayed cord clamping have not changed significantly, there is even more emphasis on the importance of delayed cord clamping for all newborn infants, especially preterm infants. In newborn infants needing resuscitation, clamp the cord <30 s to minimise delay to necessary interventions.
Cord milking	Where delayed cord clamping is not possible consider cord milking in infants >28 weeks gestation	The guideline reinforces **not** milking the cord in preterm infants <28 weeks and focusses on trying to perform delayed cord clamping if possible. Cut cord milking is acknowledged as a reasonable alternative if >28 weeks and delayed cord clamping not possible.
Initial assessment – colour	As part of initial assessment, observe tone (& colour).	There is a reduced emphasis on skin colour during initial assessment. This reflects the subjective nature of detecting cyanosis or pallor especially in different skin tones.
Initial assessment – heart rate (HR)	Determine the heart rate with a stethoscope and a saturation monitor +/- electrocardiogram (ECG) for later continuous assessment.	The guideline recognises the increasing role for ECG as a continuous method of HR evaluation which is more precise than other methods. However, auscultation with a stethoscope remains a reasonable first option.
Airway management	If there is no heart rate response and the chest is not moving with inflations consider a 2-person facemask support if single handed initially Securing the airway via tracheal intubation or insertion of a laryngeal facemask.	Use the two-person method of airway support (jaw thrust) if sufficient providers are available as this approach is more effective than single person technique. A supraglottic airway should be considered if facemask ventilation is ineffective.
Airway – no chest wall movement – increasing pressures	If there is no heart rate response and the chest is not moving with inflations, consider a gradual increase in inflation pressure	If there is no HR response, the chest is not moving with inflations and airway opening techniques are ineffective, increase inflation pressure. Reduce inflation pressure when chest movement seen and clinical improvement.

Table 1 (continued)

Topic	ERC 2021 NLS Guidelines	ERC 2025 NLS Guidelines
Airway – video laryngoscopy	The use of video laryngoscopy may aid endotracheal tube placement.	Use video laryngoscopy if available. This reflects evidence of increased first attempt success in tracheal intubation when video laryngoscopy is used. A conventional direct laryngoscope should be available as an alternative.
Breathing – CPAP/PEEP	In spontaneously breathing preterm infants consider CPAP using either facemask or nasal interface. Use PEEP at minimum of 5–6 cm H_2O when providing positive pressure ventilation (PPV) to these infants.	Apply appropriately fitting **nasal interface or a facemask** connected to a device for providing positive pressure ventilation. CPAP and PEEP is now recommended at a level of **6 cm H_2O.**This guideline acknowledges that CPAP may be considered in infants >32 weeks GA with respiratory distress if they require supplemental O_2.
Breathing – Initial oxygen concentration	Infants ≥32 weeks needing respiratory support: start with 21 % O_2. Infants >28 weeks but <32 weeks start with 21–30 % O_2. Infants <28 weeks gestation start with 30 % O_2	Initial oxygen concentration according to gestation has been simplified: Infants ≥32 weeks needing respiratory support: start with 21 % O_2 Infants <32 weeks: start with ≥30 % O_2
Breathing – Oxygen target saturations	Aim to achieve target SpO_2 >25th percentile for healthy term infants. **Time after birth: target SpO_2** • 2 min: 65 % • 5 min: 85 % • 10 min: 90 %	SpO_2 target ranges incorporating newer data from preterm infants in addition to the established data from mostly term infants before DCC was standard practice now result in a target range of acceptable SpO_2 **Time after birth: target SpO_2** . • 3 min: 70–75 % • 5 min: 80–85 % • 10 min: 85–95 %Reduce O_2 if saturations exceed 95 %
Circulation	If chest compressions are required consider securing the airway, ideally with a tracheal tube.	When chest compressions are performed, a supraglottic airway or tracheal tube should be considered, depending on training and experience.
Drugs – Adrenaline	An intravenous dose of adrenaline of 10–30 μg kg^{-1} (0.1–0.3 mL kg^{-1} of 1:10,000 adrenaline [0.1 mg/mL]) every 3–5 min.	The time intervals of intravenous or intraosseous adrenaline have been simplified: 10–30 μg kg^{-1} (0.1–0.32 mL kg^{-1} of 1:10,000 adrenaline [0.1 mg/mL]) every 4 min.
Drugs – Sodium Bicarbonate	Sodium bicarbonate may be considered in a prolonged unresponsive resuscitation with adequate ventilation to reverse intracardiac acidosis.	Removed from 2025 guideline
Drugs – Naloxone	A dose of naloxone may help in the few infants who, despite resuscitation, remain apnoeic with good cardiac output when the mother is known to have received opioids in labour.	Removed from 2025 guideline
Glucose	An intravenous dose of 2 mg kg^{-1} (2 mL kg^{-1} of 10 % glucose) is suggested in a prolonged resuscitation to reduce the likelihood of hypoglycaemia	There is greater emphasis on checking blood glucose during resuscitation and treating only if it is low, rather than empirical treatment of presumed hypoglycaemia during resuscitation. The guideline acknowledges the potential for harm from both hypoglycaemia and hyperglycaemia. The bolus glucose has been aligned with ERC 2025 guideline PLS.
Low resource and remote settings	Not included	The guideline considers out of hospital births as low resource settings, especially when unexpected and/or preterm birth. Includes a section on identifying and managing the common problem of hypothermia and safe transfer to hospital.
Parent input into Guideline 2025	Not included	Guideline has been developed with input by a parent organisation in relevant sub-sections

NLS Writing Group recommends caution when applying the recommendations in these Guidelines to them.[8]

Local approaches should be defined.

Standardised gestational age cut-off across the Guideline

To ensure consistency and practical applicability, the ERC NLS Writing Group standardised the gestational age (GA) cut-off across all subtopics. Although many ILCOR reviews on preterm infants focus on infants <34 weeks, most studies include predominantly infants <32 weeks, therefore 32 weeks was adopted as a pragmatic cut-off. This aligns with the ERC Guideline 2021 NLS[9] and common clinical thresholds for determining the appropriate level of perinatal care.

Key messages and key changes

Key messages are presented in Fig. 1. Summary of key changes is presented in Table 1 and the Neonatal Life Support Algorithm is shown in Fig. 2.

Concise guidelines for clinical practice

Factors before birth

Staff attending births in hospitals

Any infant may develop problems during birth. Local guidelines should indicate who should attend births taking into consideration identified risk factors (Fig. 3).

As a guide:

- An interprofessional team with appropriate experience and training in NLS proportionate to the expected risk should attend the birth.
- Neonatal staffing levels should acknowledge the potential need to deliver unexpected support in the delivery area.
- A process should be in place for rapidly mobilising extra team members with adequate resuscitation skills for any birth.

Telemedicine

- Consider the use of collaboration through telemedicine, as it facilitates providing remote advice.

Equipment and environment

- Regularly check all equipment to ensure it is ready for use.
- Ensure that equipment is easily accessible and organised in a standardised way.
- Consider human factor elements when organising equipment to maximise efficiency and minimise time delays.
- Resuscitation should take place in a warm, well-illuminated, draught-free area with a flat resuscitation surface and an external heat source, e.g. a radiant heater (see thermal control).

Briefing

- Team briefing is important and should be performed before birth.
- The purpose of briefing is to:

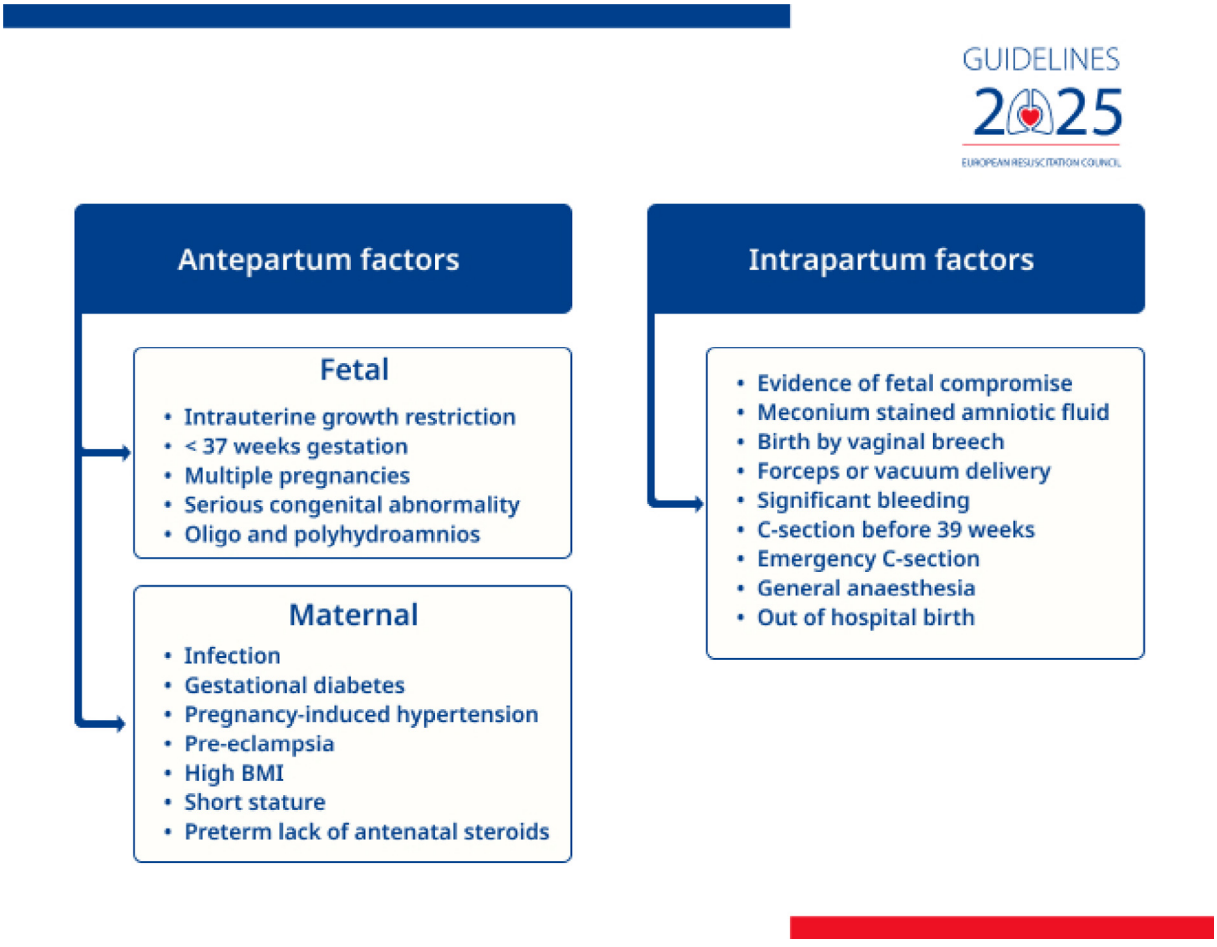


Fig. 3 – Common factors associated with the need for stabilisation, or resuscitation at birth BMI: body mass index.

- Review available clinical information
- Assign roles and tasks
- Check equipment and presence of personnel
- Prepare the family

- Use a checklist and/or cognitive aid to facilitate all of the above, reduce mental load, and enhance safety.

Education

- Institutions or clinical areas where births may occur should provide sufficient opportunities and resources for healthcare professionals involved in neonatal resuscitation to receive regular training, maintaining up-to-date knowledge as well as technical and non-technical skills.
- The content and organisation of such educational programmes may vary according to the needs of the providers and the local organisation.
- Undertake training at least once per year to prevent skill decay, preferably supplemented with more frequent short-duration booster sessions (e.g. every 3–6 months). For more information on education see ERC Guidelines 2025 Education for Resuscitation.

Thermal control

Standards

- Maintain the temperature of newborn infants between 36.5 °C and 37.5 °C.
- Monitor the infant's temperature regularly or continuously after birth.
- Record the admission temperature as a prognostic and quality indicator.
- Rewarm infants who are hypothermic after birth; avoid hyperthermia.
- In appropriate circumstances, therapeutic hypothermia may be considered after resuscitation (see post-resuscitation care).

Environment

- Protect the infant from draughts. Ensure windows are closed and air-conditioning appropriately programmed.
- In infants >28 weeks, keep the delivery area at 23–25 °C.
- In infants ≤28 weeks, keep the delivery area at >25 °C.

Newborn infants ≥32 weeks

- Dry the infant immediately after birth and remove wet towels.
- Cover the infant's head with a hat, and the body with >dry towels.
- If no intervention is required, place the infant skin-to-skin with mother – or let her do so herself- and cover both with towels.
- Ongoing careful observation of mother and infant is required, especially in more preterm and growth restricted infants to ensure they both remain normothermic.
- Consider the use of a plastic bag/wrap if skin-to-skin care is not possible.
- Place the infant on a warm surface using a preheated radiant warmer, if support of transition or resuscitation is required.

Newborn infants <32 weeks

- Dry the infant's head and cover with a hat.
- Put the infant's body in a plastic (polyethylene) bag or wrap without drying.
- Use a preheated radiant warmer.
- Consider the use of additional measures during delayed cord clamping to ensure thermal stability (e.g. increasing room temperature, warm blankets, and thermal mattress).
- Be careful to prevent hypothermia during skin-to-skin care during assisted transition, especially in the more preterm and/or growth restricted infants.
- Consider the use of heated humidified respiratory gases for infants receiving respiratory support.
- Be aware of the risk of hyperthermia when multiple heat-preservation interventions are used simultaneously.

Management of the umbilical cord

- Ideally, delayed cord clamping is performed in all births, after inflation of the lungs and before uterotonics are given.

Cord clamping

- Discuss the options for managing cord clamping and the rationale with parents and team before birth.
- Perform thermal management, tactile stimulation and initial assessment during delayed cord clamping.
- Newborn infants without need for support: facilitate at least 60 s of delayed cord clamping.
- Newborn infants in need of resuscitation: clamp the cord < 30 s to minimise any delay to necessary interventions.

Table 2 – Assessment of breathing and heart rate.

	Assessment	Intervention
Breathing assessment		
Regular	Satisfactory	None required
Slow, gasping or grunting	Inadequate	Assess – may require intervention
Not breathing	Absent	Intervention required
HR assessment		
>100 min^{-1} (fast)	Satisfactory	None required
60–100 min^{-1}	Inadequate	Assess – may require intervention
<60 min^{-1}(very slow or absent)	Emergency	Intervention required

- If stabilisation with intact cord can be safely undertaken, longer delayed cord clamping is preferred, especially in infants <34 weeks.

Cord milking

- Do **not** milk the cord in preterm infants <28 weeks.
- Consider intact cord milking as an alternative in infants ≥28 weeks, but only if delayed cord clamping cannot be performed.

Initial assessment

- Perform initial assessment as soon as possible after birth, ideally during delayed cord clamping, drying and wrapping to:
  - Identify the need for support and/or resuscitation
  - Aid decisions relating to the appropriateness and duration of delayed cord clamping.
- Assess: (Table 2).
  - Breathing
  - Heart rate (HR)
  - Muscle tone
- Provide thermal management and tactile simulation during delayed cord clamping and assessment.
- Reassess breathing and HR frequently to assess any response and determine if further interventions are required.

Breathing

- Note presence or absence of breathing.
- If breathing: note the rate, depth, symmetry and work of breathing.

Heart rate

- Initial HR assessment can be performed with a stethoscope.
- Continuous HR assessment methods (pulse oximetry, electrocardiography (ECG)) are preferred when interventions are indicated or during stabilisation of preterm newborn infants.
- Do not interrupt resuscitation to place pulse oximetry or ECG.

Response to tactile stimulation

- Gently stimulate the newborn infant by drying them, and rubbing the soles of the feet or the back.
- Avoid more vigorous methods of stimulation, especially in preterm infants.

Muscle tone & skin colour

- A very floppy infant is likely to need breathing support.
- Hypotonia is common in preterm infants.
- Do not use colour to assess oxygenation.

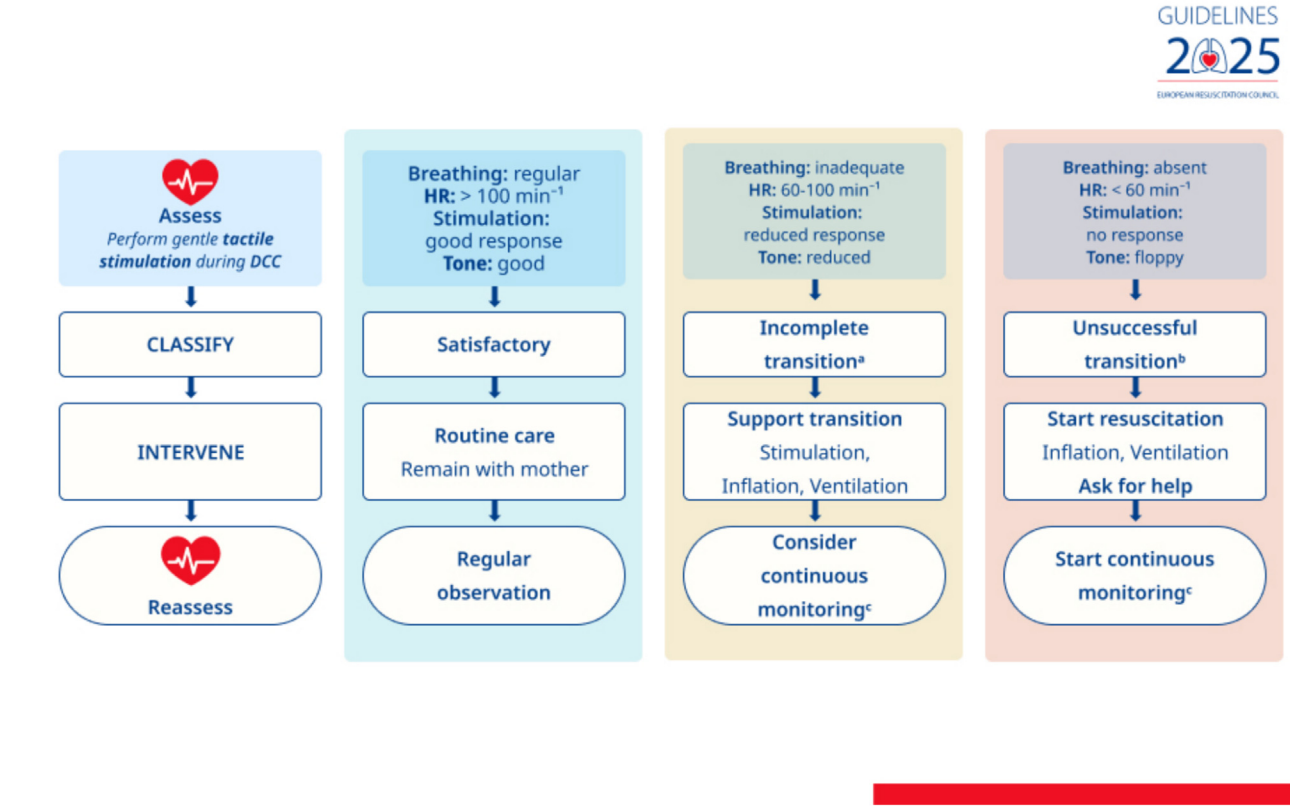


Fig. 4 – Initial assessment and interventions. DCC: delayed cord clamping; HR: heart rate; SpO2: peripheral oxygen saturation; ECG: electrocardiography. [a] Slow HR may indicate hypoxia, so airway and breathing require support. Ventilatory support will likely be adequate for a higher HR and adequate transition. [b] HR suggestive of significant hypoxia, so airway and breathing support required urgently. [c] SpO2 +/- ECG.

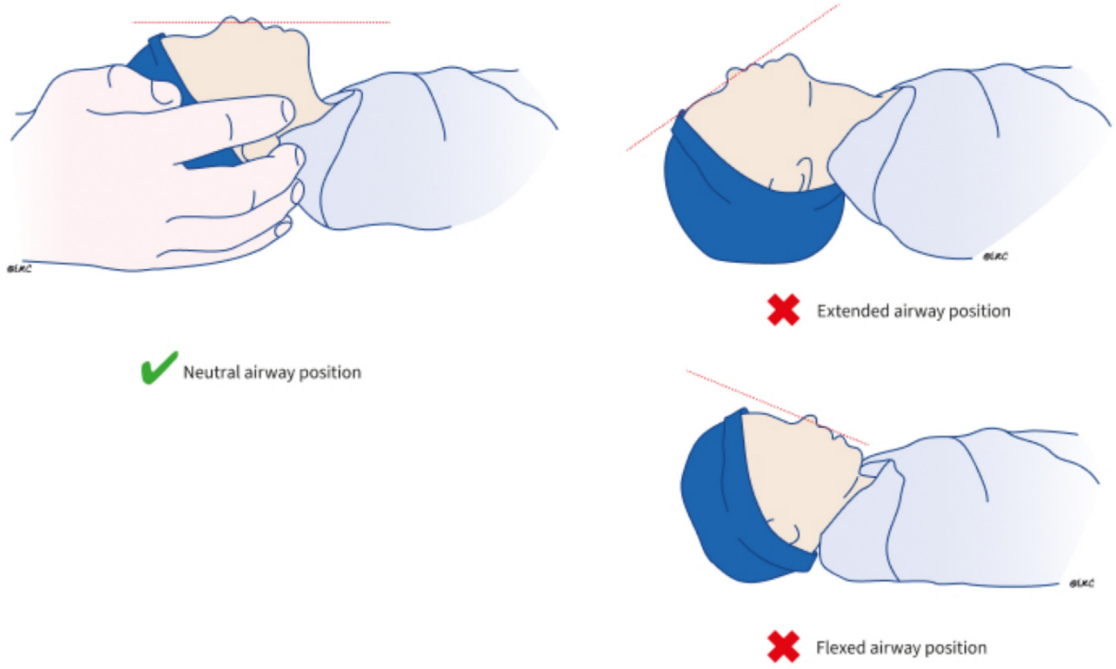


Fig. 5 – Head positions. Head needs to be in a neutral position. Face is horizontal.

- Interpret pallor within clinical context, as it may have several causes such as acidosis, asphyxia, blood loss, or chronic anaemia.

Classification according to initial assessment

- Based on the initial assessment, further actions can be implemented guided by the NLS algorithm (Fig. 2). These are summarised in Fig. 4.

Newborn life support

- Ensure the airway is open and the lungs are inflated.
- Do not undertake subsequent interventions before the airway is open and the lungs have been inflated.
- Following initial assessment, start respiratory support if the infant is not breathing regularly or the HR is <100 min^{-1}.

Airway

- Assess the effect of each airway technique by observing for chest movement and assessing HR.

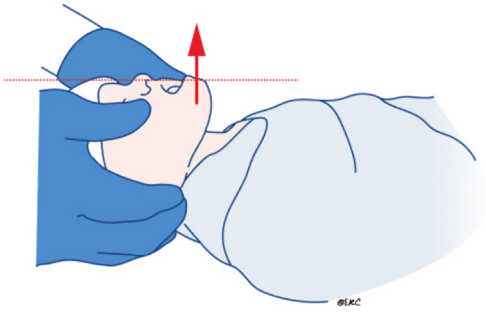


Fig. 6 – Jaw thrust. Jaw thrust = pushing the lower jaw forwards with pressure from behind, enlarges the pharyngeal space.

Position

- Place the newborn infant on their back with the head supported in a neutral position (Fig. 5).
- Gently push the lower jaw forwards with pressure from behind (jaw thrust) to open the airway (Fig. 6).

Two-person method

- Use the two-person method of airway support (jaw thrust) as this approach is more effective than single person jaw thrust.

Suction

- Do not routinely suction meconium or amniotic fluid from infant's' airways because it delays initiating ventilation.
- Consider physical airway obstruction if lung inflation is unsuccessful despite alternative airway opening techniques.
- Perform suction under direct vision.
  Rarely, with no response to inflations and no chest wall movement, an infant may require tracheal suctioning to relieve an airway obstruction below the vocal cords.

Airway devices

- Use airway devices only if competent personnel are available and trained in the appropriate equipment; if not continue with facemask ventilation and call for help.

Supraglottic airway devices. Consider using an appropriate size supraglottic airway device (SGA) (see manufacturer's instructions for use):

- When facemask ventilation is ineffective;
- As an alternative for facemask ventilation if SGA size permits;
- When a more definitive airway is required as an alternative to tracheal intubation;
- Where tracheal intubation is not possible or deemed unsafe because of congenital abnormality, a lack of equipment, or a lack of skill;

- When chest compressions are performed.

Nasopharyngeal and oropharyngeal airway devices.
- Consider nasopharyngeal or oropharyngeal airway devices, especially when facemask ventilation may be difficult (e.g. micrognathia).
- Use oropharyngeal airway devices with caution in infants < 34 -weeks. They might contribute to airway obstruction.

Tracheal tube. Consider tracheal tube placement:
- When equipment and skills permit;
- When facemask or SGA ventilation are ineffective;
- With prolonged ventilation;
- When suctioning the lower airways (removal of presumed tracheal blockage);
- When chest compressions are performed.

When performing tracheal intubation:
- Have a range of different sized tubes available
- Use video laryngoscopy or, if unable, direct laryngoscopy
- Use exhaled CO_2 detection and clinical assessment to confirm tracheal intubation
  - Be aware that exhaled CO_2 detection may be false negative in low or no cardiac output states at birth
- Use appropriate imaging to confirm correct tube position
- If available, respiratory function monitoring may be used to help confirm tube position within the airway and assist adequate ventilation (expired tidal volume 4 to 8 mL kg^{-1} with minimal leak).

Breathing
- Inflate the lungs when the newborn infant is not breathing using a facemask or nasal interface.
- Nasal interfaces used to provide positive pressure ventilation (PPV) may vary: single or binasal prongs, short or long prongs, or nasal mask.

Assisted ventilation

Lung inflation.
- If apnoeic, gasping or not breathing effectively, start PPV as soon as possible to inflate the lungs – ideally within 60 s.
- Apply appropriately fitting nasal interface or a facemask connected to a device for providing positive pressure ventilation.
- Give 5 inflations with an inflation time up to 2–3 s.
- Infants <32 weeks: starting inflation pressure 25 cm H_2O.
- Infants ≥32 weeks: starting inflation pressure 30 cm H_2O.
- Consider pulse oximetry ± ECG (Table 3).

Assessment.
- During lung inflations: look for chest movement.
  - Visible chest movement during inflations indicates a patent airway and delivered volume.
  - Failure of the chest to move may indicate that the airway is not open, or that insufficient inflation pressure/volume is delivered.
- After lung inflations: check HR
  - An increase in HR within 30 s of positive pressure ventilation, or a stable HR >100 min^{-1}, usually confirms adequate ventilation/oxygenation
  - HR <100 min^{-1} or decreasing usually suggests continued hypoxia and almost always indicates inadequate ventilation

If there is a HR response.
- Continue uninterrupted positive pressure ventilation until the infant begins to breathe adequately and the HR >100 min^{-1}.
- Aim for a positive pressure ventilation rate of 30 ventilations min^{-1} with an inflation time of approximately 1 s.
- Adapt inflation pressure based on clinical observation (chest movement and HR).
- Reassess breathing and HR every 30 s, until the newborn infant is deemed stabilised.
- Consider inserting SGA or tracheal tube if apnoea continues.

If there is no HR response. If there is **no** HR response **and** the chest is not moving with inflations:
- Call for help.
- Recheck equipment.
- Perform airway opening technique of choice.
- If the airway opening techniques are ineffective in inflating the lungs, increase inflation pressure.
- Repeat inflations after every airway opening technique or after increasing inflation pressure.
- Re-assess chest movement and HR after inflations until visible chest movement **or** HR response.
- Reduce inflation pressure when chest movement is seen and clinical improvement.
- If being used, check with a respiratory function monitor that expired tidal volume is within target range (4–8 mL kg^{-1}, depending on gestational age).

Without adequate lung inflation, chest compressions will be ineffective:
- **Confirm effective ventilation** through observed chest movement or other measures of respiratory function.
- **Then** progress to chest compressions, if the HR remains <60 min^{-1}.

Continuous positive airway pressure (CPAP) and positive end-expiratory pressure (PEEP)
- Use either nasal interface or a facemask as device-patient interface to deliver CPAP or PEEP.
- Start with CPAP at 6 cm H_2O as initial breathing support in:
  - Spontaneously breathing infants <32 weeks with respiratory distress
  - Spontaneously breathing infants ≥32 weeks with respiratory distress requiring supplemental O_2
- In infants needing positive pressure ventilation, start with PEEP at 6 cm H_2O.

Table 3 – Inflations, inflation pressure, positive end-expiratory pressure and initial oxygen.

GA	Inflations	PIP	PEEP	O_2
≥32 weeks	5 x up to 2–3 s	30 cm H_2O	6 cm H_2O	21 %
<32 weeks	5 x up to 2–3 s	25 cm H_2O	6 cm H_2O	≥30 %

Ventilation devices

- Use appropriately sized nasal interface or facemask.
- Ensure effective seal with minimal force on the facemask.
- Where possible, use a T-piece resuscitator capable of providing either CPAP or positive pressure ventilation + PEEP when giving ventilatory support, especially in the preterm infant.
- Self-inflating bags should be available as backup:
  - Take care not to deliver excessive volumes and pressures.
  - Be aware that CPAP might not be effectively delivered even when a PEEP valve is used.

Oxygen

- Use pulse oximetry and O_2 blenders during resuscitation or stabilisation in the delivery area.
- Check O_2 and saturations every 30 s.
- Titrate inspired O_2 to achieve target SpO_2 between the 25th–75th percentile (Fig. 7).
- Infants ≥32 weeks needing respiratory support:
  - Start at 21 % O_2
- Infants <32 weeks:
  - Start at ≥30 % O_2
  - Avoid SpO_2 <80 % and/or bradycardia at 5 min of age

Circulation

Chest compressions

- Start chest compressions if the HR remains <60 min^{-1} after at least 30 s of effective ventilation.
- When starting chest compressions:
  - Increase O_2 to 100 %
  - Call for experienced help if not already summoned
  - Anticipate the need to secure the airway and establish vascular access for medication
- Use a 3:1 compression-to-ventilation ratio (C:V), aiming for 90 compressions and 30 ventilations (120 events) per minute.
- Use the two-thumb-hands-encircling-technique with overlapping or adjacent thumbs to deliver chest compressions.
- Compress to a depth of one-third of the anterior-posterior chest diameter.
- Allow full chest recoil between compressions.
- Re-assess HR every 30 s.
- If HR <60 min^{-1}, secure the airway with an SGA or tracheal tube (if competent and not already done) with minimal interruptions to ongoing chest compressions.
- After SGA placement or tracheal intubation continue with the 3:1C:V ratio.
- Titrate O_2 against the oxygen saturation once a reliable value is achieved (Table 4)

Table 4 – Target oxygen saturation ranges. Derived from Dawson et al. 2010 and Wolfsberger et al. 2024, and consensus within the NLS WG.[10–12]

Time after birth	SpO_2 [%]
3 min	70–75
5 min	80–85
10 min	85–95

- Discontinue chest compressions if the HR is >60 min^{-1}; check for output (e.g. auscultation, pulse check, pulse oximetry, signs of life).

Vascular access

Umbilical venous access.

- Use the umbilical vein for rapid emergency vascular access during resuscitation at birth.
- Perform emergency umbilical venous catheter (UVC) placement under clean rather than sterile conditions to ensure timely vascular access is secured.
- Consider the use of emergency umbilical venous catheter until some days after birth as it may still be achievable.

Intraosseous access.

- Use intraosseous (IO) access as an alternative method of emergency vascular access for medication and fluids.
- Consider device-specific weight limitations for IO related equipment.
- Ensure there is no extravasation when administering medication and fluids.
- Do not aspirate bone marrow; even when correctly positioned, it is often not possible.

Support of transition/post-resuscitation care.

- If venous access is required following resuscitation, peripheral access may be adequate unless multiple infusions and/or vasopressors are required in which case central access may be preferred.

Medication during resuscitation at birth

Resuscitation medication may be considered where, despite adequate control of the airway, effective ventilation, and chest compression for at least 30 s, HR remains <60 min^{-1} and is not increasing.

Adrenaline

- Umbilical venous catheter or IO is the preferred route.
  - Give 10–30 μg kg^{-1} (0.1–0.3 mLkg^{-1} of 1:10,000 adrenaline [0.1 mg/mL])
  - Give subsequent doses every 4 min if HR remains <60 min^{-1}
- If no umbilical venous catheter/IO access but intubated:
  - Give intra-tracheal adrenaline at dose of 100 μg kg^{-1} (1 mL kg^{-1} of 1:10,000 adrenaline [0.1 mg/mL])
  - If HR remains <60 min^{-1}: as soon as umbilical venous catheter/IO access is obtained, immediately give a dose via this route, irrespective of when the intra-tracheal dose was given

Glucose

- If possible, check the blood glucose value during resuscitation.
- If blood glucose is low: give glucose 200 mg kg^{-1} (2 mL/kg of 10 % glucose).

Intravascular volume replacement

- Give 10 mL/kg of group O Rh-negative blood or isotonic crystalloid solution if suspected blood loss or in a newborn infant unresponsive to other resuscitative measures.

Absence of an adequate response despite appropriate resuscitation measures

- Consider other factors which may be impacting the response to resuscitation, and which require addressing such as the presence

of pneumothorax, hypovolaemia, congenital abnormalities, equipment failure.

Low resource or remote settings

- Births outside the hospital may be considered birth in a remote or lower resource setting, and not all hospitals have the same resources.
- HCPs have to adapt according to available resources. Focus needs to be on prevention or treatment of hypothermia and hypoxia within the existing possibilities.

Planned home births

- Ideally, two trained HCPs should be present at all home births.
- Have at least one HCP competent in providing inflations, PPV and CC to the newborn infant.
- Have a minimum set of equipment of an appropriate size for the newborn infant available.
- Have a clear plan of who will attend, what equipment will be available, and how transfer will be arranged if newborn support is required and agreed this with parents when formulating the home birth plan.
- HCPs attending home births should have pre-defined plans for unexpected or difficult situations, including knowing how to communicate with receiving healthcare facilities for the mother and newborn infant.

Unexpected births outside the hospital

- Emergency services should be prepared and trained for such events and carry appropriate equipment, especially related to thermal care and support of airway and breathing.
- Equipment to support thermal care and oxygenation should be available.

Temperature control out of hospital

- Involved HCPs should have a heightened awareness of the increased risk of hypothermia in infants born (unexpectedly) out of hospital.
- They should perform regular temperature checks and intervene if the temperature is too low.
- Most interventions for infants born in hospital (see temperature management) can also be applied outside the hospital.
- If possible, place compromised, preterm (<37 weeks), and/or growth restricted infants in a preheated incubator for thermal control and transport.

Post-resuscitation care

- Once effective ventilation and circulation are established, the infant should be cared for in or transferred to an environment in which close monitoring and anticipatory care can be provided.

Glucose management

- Measure blood glucose values early and regularly until they have stabilised in the normal range; especially in newborns resuscitated at birth, those at risk of hypoxic-ischaemic encephalopathy (HIE), and/or receiving intravenous glucose.
- Avoid hypoglycaemia, hyperglycaemia, and large swings in blood glucose value.

Thermal care

- Monitor the infant's temperature frequently or continuously after resuscitation.
- Maintain temperature between 36.5 °C and 37.5 °C and rewarm if the temperature is below this.

Therapeutic hypothermia

- Consider inducing therapeutic hypothermia (33–34 °C) *after* completion of resuscitation and detailed assessment of potentially eligible infants with clinical, biochemical, and (if available) neurophysiological evidence of HIE.
- Use appropriate eligibility criteria and strictly defined protocols to guide the cooling process; inappropriate application of therapeutic hypothermia may be harmful.
- Arrange safe transfer to an appropriately equipped facility where monitoring and treatment can be continued.
- Monitor (rectal) temperature during transport and, if available, apply active cooling with a servo-controlled device while transferring the infant.

Oxygenation & ventilation

- Consider additional monitoring of post-ductal oxygen saturation to identify pulmonary hypertension.
- Avoid hypoxia and hyperoxia.
- Avoid inadvertent hypocapnia during mechanical ventilation.

Documentation & Prognostication

- Keep an accurate time-based record of the infant's clinical state, interventions and responses during resuscitation to facilitate retrospective review.
- Record APGAR scores.

Clinical team debriefing

- Use performance-focused, interdisciplinary/interprofessional team debriefings following resuscitation or other non-routine situations to optimise individual and team performance as well as systems issues (e.g., emergency supplies, equipment).

Communication with parents

Where intervention is anticipated

- The decision to attempt resuscitation of an extremely preterm or clinically complex infant should be taken in close consultation with the parents and senior paediatricians, midwifes, and obstetricians.
- Discuss the options, including the potential need and magnitude of resuscitation and the likely prognosis before birth, so that an individualised management plan can be agreed.
- Ensure concise and factual documentation of discussions is recorded in mother's notes before birth and in the infant's notes after birth.

For every birth

- If parents want and resources allow, enable parents to be present during the stabilisation or resuscitation.
- Consider the views of the resuscitation team, parents and circumstances.
- Ensure that parents are fully informed about the progress of the care provided to their infant.
- Identify a member of healthcare staff to support parents and be aware that witnessing the resuscitation of their infant will be distressing for them.
- Encourage parents to hold or touch their infant as soon as possible after resuscitation; this should be facilitated especially when the resuscitation was unsuccessful.

- Ensure an accurate record is kept of the resuscitation and of any subsequent parental communication.
- Provide an explanation of any procedures and why they were required.
- Facilitate further discussions later to enable parents to reflect and to aid their understanding of events.
- Provide additional support for parents following resuscitation at birth.

Discontinuing or withholding resuscitation

- Use national or regional outcomes and guidelines to interpret these recommendations
- When discontinuing, withdrawing or withholding resuscitation, care should be focused on the comfort and dignity of the infant and family and should ideally involve senior paediatric/neonatal staff.

Discontinuing resuscitation

- If the HR remains absent despite ongoing resuscitation, review clinical factors (for example potential reversible factors, gestation of the infant), effectiveness of resuscitation, and the views of other members of the clinical team about continuing resuscitation.
- If the HR of a newborn infant remains absent for more than 20 min after birth despite the provision of all recommended steps and exclusion of reversible causes, consider stopping resuscitation.
- For preterm infants (particularly extremely preterm), it may be appropriate to discontinue resuscitation earlier than 20 min. The decision should be individualised.
- Where there is partial or incomplete HR improvement despite apparently adequate resuscitative efforts, the choice is much less clear. It may be appropriate to take the infant to the intensive care unit and later consider withdrawing life sustaining treatment.
- Where life-sustaining treatment is withheld or withdrawn, infants should be provided with appropriate palliative (comfort focused) care.

Withholding resuscitation

- Decisions to withhold life sustaining treatment should be made in advance of birth together with parents in the light of regional/national evidence on outcome if resuscitation and active (survival focused) treatment is attempted.
- In situations where there is extremely high (e.g. >90 %) predicted neonatal mortality and unacceptably high morbidity in surviving infants, attempted resuscitation and active (survival focused) management is usually not appropriate.
- Resuscitation is nearly always indicated in conditions associated with lower (e.g. <50 %) neonatal mortality and what is deemed to be acceptable morbidity. This will include most infants with congenital malformations and most infants >24 weeks or above in high resource settings with access to neonatal intensive care.
- Resuscitation should usually be commenced in situations where there is uncertainty about the outcome and there has been no chance to have prior discussions with parents.
- In situations where there is high mortality (e.g. >50 %) and/or a high rate of morbidity, and where the anticipated burden of medical treatment for the child is high, parental wishes regarding resuscitation are usually supported. It may be appropriate to provide full resuscitation, to provide some measures (but withhold other interventions) or to provide comfort focused care. Provision of antenatal palliative care support can be beneficial to parents in the face of certain or uncertain poor outcomes.

Evidence informing the guidelines

Newborn life support or paediatric life support?

These ERC Guidelines 2025 NLS apply mainly to newborn infants at birth and in the immediate postnatal phase, i.e. during perinatal transition. There is no clear definition of when transition ends. Thus, evidence-based recommendations on when to convert from NLS to Paediatric life support (PLS) guideline are challenging to produce.

Epidemiology

Neonatal intensive care units (NICU) often set distinct age thresholds for admitting and keeping infants. Some transfer infants to paediatric units at 44 weeks' postmenstrual age,[13] whereas other NICUs transfer infants as late as 24 months.[14] Moreover, some NICUs operate separately from birthing hospitals, affecting the patient case-mix. Thus, the incidence of NICU resuscitation with chest compressions and/or adrenaline varies between 0.25 % and 1–2 % of infants,[15–18] and a significant proportion of CPR events in paediatric intensive care units (PICUs) is in infants <1 year of age.[19] Most NICU arrests are respiratory in origin,[17,18] with more respiratory-related instances including tracheal tube and airway complications in NICU resuscitation events compared with PICU/cardiac intensive care unit resuscitation events.[20] Pulseless electrical activity or asystole occurs in 13 % of NICU resuscitation events, while ventricular tachycardia or fibrillation incidents are rare in NICUs.[21]

Differences between NLS and PLS guidelines

Neonatal resuscitation guidelines prioritise ventilation to stabilise bradycardic or asystolic newborns.[9] Paediatric resuscitation guidelines emphasise chest compressions while managing ventilation carefully to prevent overventilation by the HCP.[22] The two Guidelines also diverge in areas such as thermal care for different maturity of newborns, synchronisation of breaths with compressions after tracheal intubation, and use of medications and adjunctive methods.[23] Unlike paediatric guidelines, neonatal guidelines omit management strategies for (septic) shock and arrhythmias other than bradycardia/asystole, leaving out rhythm evaluation and defibrillation.

Evidence informing the transition from NLS to PLS

Several approaches on the use of NLS or PLS have been suggested or are used, such as location-based, age-based, patient-based or provider-based approaches.[23] A location-based approach would be to take education and training implications into consideration by choosing guidelines based on location (e.g., NICU or PICU). Observational studies that found differences in outcomes after PICU versus NICU CPR events did not account for prematurity and low birth weight in infants in the NICU.[24] The presence of fluid-filled lungs only during immediate perinatal transition may provide a rationale for changing from the neonatal to paediatric resuscitation guideline using a time-based approach. For example, after the first 24 h of life,[23,25] or at 44 weeks postmenstrual age as a cut-off point. A patient-oriented approach may be to focus on the pathophysiology of the bradycardia or arrest, as in cases of congenital and acquired heart disease.[26] A provider-based approach may have many similarities with a location-based approach, but if HCP are trained in both NLS and PLS they can apply both.

In the absence of evidence, an approach to education and training tailored towards the decision to use one or both guideli-

nes based on individual unit case-mix and epidemiology of cardiac arrests may be reasonable. The ERC recommends creation of local policies applicable to the healthcare setting (good practice statement).

The most preterm infants at the limits of viability

Survival and outcomes of preterm infants continue to improve, especially for those born at extremely low gestational age (GA).[27] Following recently changed guidance concerning the initial stabilisation of the most preterm infants, i.e. those born below 25 weeks,[28,29] these infants are now increasingly being offered survival-oriented care.[30–32] However historically, trials in neonatal medicine have, almost without exception, excluded the most preterm infants.[33]

Consequently, the ERC NLS Writing Group cautions that recommendations given in the ERC Guidelines 2025 NLS are based on evidence from studies of higher GA infants and any extrapolation of such evidence to the most preterm infants will not fully take into account their distinct physiology and response to treatment.[34]

Implementation

The Utstein formula for survival identifies resuscitation science, efficient education and local implementation as key factors influencing outcomes.[35] To aid health care professionals, hospitals and policymakers in improving local implementation, a ten steps consensus based framework has been published recently.[36]

Factors before birth

Perinatal transition

Survival at birth involves major physiological changes during perinatal transition from fetal to newborn life. First, lung liquid-clearance and aeration need to occur after which pulmonary gas exchange can be established.[37] Most newborn infants transition smoothly, but some have problems with transition and without timely and adequate support might need resuscitation.[38–41] Approximately 11 % of all newborns receive interventions with large variation between hospitals (1.4–38.1 %).[42] Newborn infants born via caesarean section receive an intervention (19.6 %) more often than vaginally born infants (5.9 %), with most common interventions being CPAP (7 %), O_2 supplementation (8 %), suctioning (6 %) and non-invasive ventilation (4 %).[42] Less common interventions include tracheal intubation (1 %), cardiac compressions (0.1 %) adrenaline administration (0.1 %), intraosseous access (0.01 %) and SGA insertion (0.01 %).[42] Intervention frequencies varied considerably between hospitals and countries.[42] In preterm infants, the need for respiratory support is higher, with almost all infants born with a GA < 30 weeks receiving CPAP and/or positive pressure ventilation (PPV).[42]

Risk factors

Several maternal and fetal prenatal and intrapartum factors increase the risk for compromised transition and the need for resuscitation. A recent multicentre survey and an ILCOR evidence update confirm previously identified risk factors for needing assistance after birth.[42,43] There is no universally applicable model to predict risk for resuscitation or need of support during transition, and the list of risk factors in the guidelines is not exhaustive. Elective caesarean delivery at term, in the absence of other risk factors, does not increase the risk of needing newborn resuscitation.[44,45]

In accordance with the unchanged ILCOR recommendation, the ERC recommends that when an infant is delivered at term by caesarean section under regional anaesthesia an HCP capable of performing an initial assessment and assisted ventilation should be present at the birth. It is not necessary for a provider skilled in neonatal intubation to be present at that delivery.[43]

Staff attending births in hospitals

It is not always possible to predict the need for stabilisation or resuscitation before an infant is born. Therefore, the ERC recommends that those in attendance at birth need to be able to undertake initial resuscitation steps effectively. The experience of the team and their ability to respond in a timely manner can improve outcomes of term[46] and preterm infants.[47–49] It is essential that resuscitation teams can respond rapidly if not present from the beginning. In a simulation-based study on term neonatal resuscitation a significant increase in workload was demonstrated in 2-person teams compared to 3-person teams.[50] The ERC advises a process should be in place for rapidly mobilising extra HCPs with appropriate resuscitation skills.

Telemedicine

In hospitals with low birth rates, it can be difficult for staff to maintain neonatal resuscitation skills.[51–53] Video telemedicine may help address these challenges by providing immediate access to neonatal specialists, allowing a neonatologist to virtually assist with neonatal resuscitation at remote locations, which ultimately might improve patient outcomes.[54–57] Limited observational data suggests that video telemedicine may improve the quality of neonatal resuscitation and reduce the need for neonatal transfers and can be introduced without significant adverse effects.[54,58–62]

The ERC recommends that where the technology is available and/or access to a neonatologist is not immediately available, telemedicine use is considered.

Equipment and environment

Suggestions have been made on standardising an optimal layout of a resuscitation area,[63] but no published evidence has demonstrated improvement in patient outcome due to specific arrangements. However, some studies suggest a reduced retrieval time for emergency materials when organized according to specific frameworks such as the ABC protocol (airway, breathing, circulation),[64] task-based package approach,[65] or with a focus on emergency supplies or airway management.[49]

Briefing, debriefing & checklists

Briefing with role allocation and the use of checklists improve team functioning and communication and are suggested.[66,67] Evidence on the isolated impact of briefing on patient outcomes is challenging, as it is typically implemented within quality improvement bundles. However, an ILCOR scoping review (2021) on the effect of briefing and debriefing on the outcome of neonatal resuscitation concluded that 'improvements in the process of care (...), short term clinical outcomes and a reduction in communication problems' were associated with briefing and debriefing.[68,69] The use of checklists during briefings and debriefings may help improve team communication and process, but there is little evidence of effect on clinical outcomes.[70,71] The ERC recommends (de)briefing the team present at birth and suggests the use of cognitive aids.

Education

For an in-depth discussion on resuscitation education principles, see ERC Guidelines 2025 Education for Resuscitation. Research on educa-

tional methods in neonatal resuscitation is evolving, but due to study heterogeneity with non-standardised outcome measures, there is still little evidence on the effect of different educational modalities on clinical outcome.[72–74] Nevertheless, available studies on the clinical impact of neonatal resuscitation education are summarised in Table 5.

Frequency of training

Infrequent neonatal resuscitation training and rare clinical exposure lead to skills decay. Two observational studies using video analysis found that annual training may be insufficient,[85] as skills deteriorate within 3–6 months, highlighting the benefits of high-frequency, short-duration sessions.[40,86] After NLS courses significant knowledge and skill decay was found within three months, with technical skills declining faster than knowledge.[87] Another study focusing on neonatal ventilation skills, found that airway patency requires training every 4.5 months, and face-mask seal every 1.5 months.[85] The ERC recommends training at a minimum interval of 12 months, preferably supplemented with more frequent short booster sessions every 3–6 months.

Technical skills, behavioural skills and self-efficacy

Optimal newborn life support requires neonatal providers to possess not only technical expertise but also behavioural skills, including team collaboration competences, crisis resource management, and personal resilience.[88,89] A 2021 ILCOR systematic review about training of team competences in resuscitation found improved skills performance during clinical resuscitation and suggests its inclusion in basic and advanced life support courses.[5,90] Providers need strong confidence to perform NLS optimally, initiate and persist in resuscitation, and stay resilient under pressure.[91–93] Confidence can be achieved, among others, through practice and reflection, and observational learning, where participants are motivated to attain a similar level of performance as they observed in their peers.[91,94,95] The ERC recommends incorporating team collaboration competencies in newborn life support training.

System training

In situ neonatal simulation training is highly effective not only for training in human factors and teamwork, it also enables adaptation of team composition, the environment and equipment to create ideal circumstances for newborn resuscitation performance.[96–99] Simulation training may also be used to rigorously test new neonatal environments or procedures. The ERC recommends that simulation training forms part of resuscitation training.

Thermal control

The World Health Organization recommends keeping newborn temperatures between 36.5 °C and 37.5 °C.[100] Exposed, wet newborn infants cannot maintain their body temperature in a room that feels comfortably warm for adults. The mechanisms (convection, conduction, radiation, evaporation) and effects of hypothermia and how to avoid these have been reviewed elsewhere.[101,102]

Hypothermia may impair respiratory function, lower the arterial oxygen tension, cause elevated pulmonary vascular resistance, and increase the risk of metabolic acidosis, hypoglycaemia, and bradycardia.[101] Two recent systematic reviews showed associations between admission hypothermia and various morbidities (intraventricular haemorrhage, bronchopulmonary dysplasia, sepsis, retinopathy of prematurity) and mortality in very low birthweight infants (<1500 g) and very preterm infants, respectively.[103,104]

As the admission temperature of non-asphyxiated infants is associated with morbidity and mortality at all gestations and in all settings,[5,105,106] the ERC recommends recording temperature as both a predictor of outcome and a quality indicator.[9] A recent systematic review and network meta-analysis showed that (the combination of) plastic bags/wraps, plastic caps, thermal mattress, and heated humidified gases in the delivery room reduced major brain injury and mortality in preterm infants.[107] The ERC recommends that as a minimum, plastic bags/wraps and hats are used in preterm infants at birth, and where available heated humidified gases are also used at the earliest opportunity in preterm infants.

To align recommendations across the ERC Guideline 2025 NLS, we use 32 weeks as a pragmatic cut-off in our recommendations.

Temperature monitoring

Temperature monitoring is key to avoiding hypothermia. However, there is very little evidence to guide the optimal placement of temperature monitoring probes on the infant. In a study of 122 preterm infants (28–36 weeks) randomised to different sites for temperature monitoring, dorsal, thoracic, and axillary sited probes all had comparable temperature measurements.[108] There are no published studies comparing the use of rectal temperature probes. The ILCOR NLS Task Force does not specify the site where the temperature should be determined.[43,109,110]

In infants <1500 g immediately after birth, servo-controlled thermoregulation did not improve admission normothermia compared with using a radiant warmer in manual mode.[111] ILCOR stated that there is insufficient published human evidence to suggest for or against the use of a radiant warmer in servo-controlled mode compared with manual mode in infants <34 weeks directly after birth.[112] In newborns who are unintentionally hypothermic after birth, ILCOR concluded that there is insufficient evidence to recommend either a rapid (≥0.5 °C/hour) or slow (<0.5 °C/hour) rewarming rate.[113]

The ERC recommends that all newborn infants undergoing resuscitation and all preterm infants undergoing support of transition have their temperature monitored frequently or continuously during resuscitation until stabilisation.

Hyperthermia

Hyperthermia (≥38.0 °C) should be avoided, because it is associated with adverse effects.[9] Infants born to febrile mothers have a higher incidence of perinatal respiratory compromise, neonatal seizures, early mortality, and cerebral palsy.[114–116] Animal studies indicate that hyperthermia during or following ischaemia is associated with a progression of cerebral injury.[116]

Term and near-term infants ≥34 weeks

ILCOR treatment recommendation[110,117] suggests a room temperature of 23–25 °C in infants ≥34 weeks.[110,117] If support of transition or resuscitation is not required, immediate skin-to-skin care is good practice to maintain normothermia. A Cochrane review involving 46 trials and 3850 dyads of mothers with their (predominantly healthy term and some late preterm) newborns concluded that skin-to-skin contact may be effective in maintaining thermal stability and improve maternal bonding and breast-feeding rates.[118] Aligning with ILCOR, the ERC recommends skin to skin care, and in the situation where skin to skin care is not possible, and resuscitation is not required, to consider the use of plastic bags/wraps among other measures.

Table 5 – Summary of studies on effect of NLS training.

Reference	Study design	Setting	Intervention	Sample size	Results
Agudelo-Pérez (2022)[80]	Review 11 studies with NWKM level IV, all HBB studies; 8 pre-post intervention, 2 prospective cohort studies, 1 clinical trial;	LMIC	One-day trainings (HBB) in various intervals	n = 412,741 newborns	↓ overall neonatal mortality ↓ intrapartum stillbirth ↓ 1d-mortality
Bayoumi (2022)[75]	Pre-post intervention; 1 level III unit (18000/a births)	HIC	5 in-situ simulation trainings and 27 workshops in post-era (2016–2021)	n = 799 in courses, n = 1,199 newborns, n = 326 intubations	↑ success rate LISA ↓ duration of intubation
Bhatia (2021)[76]	Pre-Post intervention; tertiary unit with 3 sites (9000/a births), multidisciplinary	HIC	10–12 in-situ simulation workshops per year (2012–2018)	n = 445 HCW, n >40,000 newborns, n = 11,284 resuscitations	↓ perinatal mortality ↓ chest compressions, ↓ medication
Mayer (2022)[77]	Retrospective observation; 5 hospitals (2 district, 2 regional, 1 tertiary)	MIC	Annual one-day training (HBB, 2016–2020)	n = 4795 HCW, n = 123.898 newborns	↓ neonatal mortality
Mileder (2024)[72]	Pre-Post intervention; 1 level IV unit (3500/a births), multidisciplinary	HIC	41 in-situ simulation trainings in 4 months	n = 48 HCW, n = 28 resuscitations	↑ 5-minute Apgar score
Lima (2023)[83]	Pre-post intervention; 5 hospitals (secondary healthcare regions)	MIC	n = 700 training sessions in 106 NRP courses	n = 431 HCW	↓ neonatal mortality in DR
Lindhard (2021)[82]	Review 2 Studies with NWKM level IV Lebanon: pre-post intervention Mexico: pair-matched study	LMIC	Lebanon: QI with 10 ex-situ simulation workshops (22 hospitals, 3 years); Mexico: 2 simulation trainings (12 hospitals)	Lebanon: n = 256 HCW, n = 84,398 births; Mexico: n = 450 HCW;	↓ neonatal mortality, ↑ team performance
Patel (2017)[79]	Review 20 studies with NWKM level IV	LMIC	Variability in neonatal resuscitation training curricula, from basic to advanced life support	n = 1,653,805 newborns; variability in participants of the interventions	↓ neonatal mortality ↓ stillbirth mortality ↓ perinatal mortality
Schwindt (2022)[73]	Pre-Post intervention; 1 level II unit (2000/a births), multidisciplinary	HIC	11 in-situ simulation trainings in post-era (2015–2019)	n = 35 core and 200 additional HCW, n = 13,950 newborns, n = 826 resuscitations	↓ chest compressions
Vadla (2022)[78]	3-year prospective clinical observation study	LIC	High-frequency, self-guided skills training (simulator with automatic feedback)	n = 10,481	↓ time to first ventilation ↓ pauses in ventilation = neonatal mortality
Vadla (2024)[74]	Prospective observational study; 1 hospital site (3000/a births)	LIC	Annual one-day training (HBB 2nd, 2017–2021) + Low dose high frequency trainings	n = 12,983 newborns, n = 1,320 resuscitations	↓ neonatal mortality

Collected evidence from studies in neonatal settings[72–83] on the impact of simulation-based training, focusing on Kirkpatrick Level IV outcomes (clinical resuscitation outcomes) as defined by the New World Kirkpatrick Model.[84]

Abbreviations: HBB: Helping babies breathe; HCW: healthcare workers; HIC: high income country; LISA: less invasive surfactant administration; LIC: low income country; MIC: middle income country; NRP; Neonatal Resuscitation Program NWKM: new world Kirkpatrick model; PPV: positive pressure ventilation; QI: Quality improvement.

Preterm infants <34 weeks

For infants <34 weeks a room temperature of 23–25 °C is suggested.[109,112] For infants <28 weeks, room temperature should ideally be >25 °C.[101,102,119] The use of plastic bags or wraps (without drying) is advocated in infants <34 weeks. Further thermal control while using radiant warmers in the delivery area can be achieved with a combination of warmed blankets, cap, thermal mattress, heated humidified respiratory gases, and skin-to-skin care. With these interventions, both hypothermia and hyperthermia are possible and require attention.[112] Quality improvement programs, including the use of checklists, continuous feedback, and debriefing have shown to significantly reduce the incidence of hypothermia at admission in very preterm infants.[119,120]

Delivery or operating room cuddles

Following stabilisation after birth it may be possible to offer physical contact between the parents and their baby in the form of supervised skin-to-skin contact or a cuddle. Studies have considered the feasibility of a delivery room cuddle in relation to physiological variables (HR, temperature).[121,122] The effect of delivery room cuddles on thermoregulation was conflicting; with

some studies reported no difference[121–124] and others reported more hypothermia in infants who received skin to skin care after birth.[123–127] There is emerging evidence of positive effect on maternal bonding[121,128,129] and that delivery room cuddles may promote breast feeding in near term and term infants.[129] However, there is also evidence of potential risks including accidental extubation, disconnections, or apnoea.[116,119]

Current evidence is insufficient to provide a specific recommendation and there is no ILCOR evidence review on this topic. Discussing the possibility of a delivery room cuddle on an individual basis is reasonable, if the clinical team feels confident to support this. However, the practicality of offering this will not be clear until after their baby has been born. If a delivery room cuddle is impractical, encourage brief physical contact, e.g. touching their baby's hand as an alternative. Where resuscitation measures are required, this takes priority.

Umbilical cord clamping

There is no universally accepted definition of 'delayed' or 'deferred' cord clamping (DCC), only that it does not occur immediately after birth. Early or immediate cord clamping (ICC) has been defined as less then 30 s after birth, later or delayed cord clamping as >30 s after birth or when cord pulsation has ceased.[130,131] Physiological based cord clamping (PBCC) is not based on time, but on physiological parameters (i.e. when breathing has been initiated).[132,133] When possible, interventions for stabilising the infant may take place close to the mother with intact cord.[134]

The ERC recommends facilitating at least 60 s of DCC for newborn infants without need for support; and to clamp the cord <30 s to minimise delay in interventions in those in need for resuscitation. If intact cord stabilisation can be safely performed, longer DCC is preferred, especially in newborn infants <34 weeks.

Rationale: Experimental and observational studies

Although ICC was introduced as part of a package to reduce postpartum haemorrhage,[135] its impact was minimal and primarily associated with reduced birth weight.[136,137] Clamping the cord before lung inflation and the increase in pulmonary circulation has occurred results in reduced ventricular preload and increased left ventricular afterload,[138] impairing the circulation and causing hypoxia.[132,138] A second rationale for DCC is placental transfusion – blood redistribution from placenta to newborn which can account for up to 25 % of placental volume.[139,140] Gravity and uterine contractions do not drive this transfusion,[141,142] but spontaneous breathing of the infant might. Therefore, clamping should ideally be delayed until breathing has been established.[143]

Infants ≥34 weeks

A 2019 Cochrane review found that DCC compared to ICC increased birth weight, neonatal haemoglobin, and reduced iron deficiency at 3–6 months, without increasing polycythaemia.[144] A 2021 ILCOR meta-analysis of 33 trials in newborns ≥34 weeks confirmed these findings, showing no effect on mortality or need for resuscitation.[131] DCC improved early (≤24 h) and later (7 days) haematological and circulatory parameters, but had no impact on longer term anaemia, neurodevelopment, or phototherapy.[131]

Evidence on DCC in (near) term newborns needing resuscitation is limited. One study found no HR difference between cord intact resuscitation and ICC,[145] while two RCTs reported better vital parameters, higher Apgar scores, and reduced need for ventilation and/or chest compression.[146,147] Only one trial reported mortality with no difference.[147] Admission temperatures were similar across all three trials.[145–147]

Infants <34 weeks

Multiple trials have compared DCC with ICC in preterm infants. Most used DCC for 30–60 s, excluding infants needing immediate resuscitation. Studies using intact cord resuscitation applied longer clamping times. A 2021 ILCOR meta-analysis (infants <34 weeks) DCC (≥30 s) may slightly improve survival,[130] with better cardiovascular stability, less inotropic support, improved haematological indices, and fewer transfusions – without effects on prematurity complications (or adverse maternal outcomes). Subgroup analysis showed a possible positive link between survival and DCC duration.[130,148,149] A separate systematic review and individual participant data meta-analysis confirmed reduced mortality with DCC vs ICC, but no difference in morbidity or transfusion rates.[148]

A network meta-analysis comparing short (15–45 s), medium (45–120 s), and long (>120 s) cord clamping times with ICC and cord milking found the strongest survival benefit with longer delays (mortality OR 0.31, 95 % CI 0.11–0.80).[149] They concluded that for newborns requiring resuscitation/stabilisation, longer DCC is only feasible with intact umbilical cord.[149]

Three multi-centre RCTs on intact cord resuscitation have been completed. Two used fixed clamping times and one used physiological criteria. The VentFirst trial (<29 weeks) found no difference in intraventricular haemorrhage or mortality between 120 s DCC with intact cord ventilation vs DCC 30–60 s and ventilation afterwards.[150] No difference was reported in the composite outcome of death, severe intraventricular haemorrhage, and bronchopulmonary dysplasia between 3-minute intact cord resuscitation and cord milking.[151] In the ABC3 trial physiologically based cord clamping vs 30–60 s DCC showed no overall difference in intact survival, but improved outcomes in male infants and with increased intact cord resuscitation experience.[152]

Umbilical cord milking

Umbilical cord milking has been considered an alternative to DCC when DCC is not feasible.[153] In 'intact cord milking', the cord is milked 3–5 times before clamping, promoting faster blood transfer. In 'cut cord milking', a ~25 cm cord segment is milked after clamping, usually during resuscitation.[153] Experimental studies show intact cord milking causes significant fluctuations in cerebral blood flow.[154,155] A large clinical trial in preterm infants was stopped early due to increased risk of severe intraventricular haemorrhage in the <28 weeks GA subgroup who were randomised to umbilical cord milking.[156] Meta-analyses in preterm infants showed no differences in mortality or morbidity.[148,149] Umbilical cord milking reduced transfusion need compared to ICC, but to DCC. A recent cluster RCT in 1730 non-vigorous infants ≥35 weeks found no difference in mortality or NICU admission between intact cord milking and ICC.[157] The reported reduction in moderate-to-severe hypoxic ischemic encephalopathy (HIE) (RR 0.49, 95 % CI: 0.25–0.97) was based on unadjusted data and may reflect later clamping. The ERC recommends that for all infants the focus should be on DCC instead of umbilical cord milking. The ERC recommends avoiding cord milking in infants <28 weeks, acknowledging that intact cord milking is an alternative to DCC in infants ≥28 weeks, only if DCC cannot be performed.

Initial assessment

Breathing

Not crying may be due to apnoea and can function as a marker of inadequate breathing needing support.[158] In an observational study of almost 20,000 infants (>22 weeks GA) just after birth in a rural hospital setting, 11 % were not crying, around half of whom were assessed as

apnoeic. About 10 % of those assessed as breathing at birth became apnoeic. Breathing without crying compared to breathing and crying was associated with a 12-fold increase in morbidity.[158] The presence or adequacy of breathing effort in preterm infants can be difficult to assess as breathing can be very subtle and is often missed.[159,160] When breathing was perceived as inadequate infants were more likely to receive interventions.[161,162] The ERC recommends assessing rate, depth, symmetry and work of breathing.

Heart rate

HR is the most sensitive indicator of a successful response to resuscitation interventions.[145,163,164] There is no published evidence clearly defining the thresholds for intervention during newborn resuscitation. Historically, heart rates of >100 min^{-1} were pragmatically selected as reassuring and <60 min^{-1} as prompting interventions.[165] A 2023 ILCOR review found no new evidence on alternative HR thresholds.[166] In uncompromised breathing term infants undergoing DCC, the HR is usually above 100 min^{-1}.[164] In an observational study in resuscitated term/near-term infants, initial HRs at birth were distributed showing bimodal peaks around 60 and 165 min^{-1}.[167] In preterm infants <30 weeks the HR did not stabilise until it reaches approximately 120 min^{-1} and, in some, stability was only achieved once the HR was >150 min^{-1}.[168] A recent study in extremely or very preterm neonates with favourable outcome established that the 10th percentile of HR at 2, 5, 10, and 15 min after birth were 70, 109, 126, and 134 min^{-1} respectively, indicating varying expected HR values during the immediate postnatal transition period.[11]

Heart rate assessment. The main methods of HR assessment are auscultation, pulse oximeter, and ECG. The advantages and disadvantages of these are summarised in Table 6. Most studies excluded newborns who were bradycardic at birth, required resuscitation or were very preterm infants, which limits applicability of study results.[5,169,170] Auscultation by stethoscope is simple and enables rapid assessment of HR in any setting, including low resource settings (ERC practice statement). The 2024 ILCOR review suggests that if resources allow, ECG to continuously assess HR is reasonable, with pulse oximeter and auscultation as alternatives.[169,170] It is currently unclear if speed/precision of HR assessment at birth is associated with clinically important differences in interventions, performance or outcomes.[169,170] There is insufficient evidence to recommend the use of digital stethoscopes, Doppler ultrasound, dry electrode technology or other techniques to assess HR at birth.[169,170] The ERC recommendations align with ILCOR. Initial HR assessment can be done by auscultation; continuous HR assessment through ECG or pulse oximetry are recommended with ongoing resuscitation.

Tactile stimulation

ILCOR systematic reviews on both cord management and tactile stimulation suggest tactile stimulation immediately after birth in infants with inadequate breathing efforts, regardless of method of umbilical cord management.[161,183,184] Tactile stimulation should not delay the initiation of breathing support if required. The optimal type and length of tactile stimulation as well as differences in different gestational ages is unknown.[184] An RCT in a preterm population reported that repetitive stimulation improved oxygen saturations and reduced need for supplemental inspired oxygen.[185] Data from an observational study shows that tactile stimulation at birth is associated with more spontaneous breathing, especially if the cord was still intact.[158] The ERC recommends performing tactile stimulation on all newborn infants at birth, especially if breathing is inadequate, but it must not delay initiation of breathing support if required.

Colour

Healthy infants are cyanosed at birth, reflecting lower *in utero* saturations, but this improves within approximately 30 s of the onset of effective breathing.[160] Peripheral cyanosis is common and does not, by itself, indicate hypoxia. Persistent pallor despite ventilation may indicate significant acidosis, or, more rarely, hypovolaemia with intense cutaneous vascular vasoconstriction. Colour is an unreliable marker of oxygenation, and it should not be used to judge oxygenation.[186] The ERC recommends using pulse oximetry to measure oxygen saturations in preference to using colour as a proxy for oxygenation.

Airway

Airway obstruction is most commonly caused by suboptimal airway positioning, lack of pharyngeal tone, and adducted vocal cords, especially in preterm newborns.[187,188] There is no evidence that normal lung fluid and secretions cause obstruction.[189] In line with ILCOR, the ERC recommendation is not to routinely suction clear fluid from the oropharynx.

Position

With flexion and extension of the neck, the newborn airway can easily become occluded.[190] Evidence on the mechanisms of airway occlusion in the newborn is limited. A retrospective analysis of images of the airway of 53 sedated infants between 0–4 months undergoing cranial MRI indicates how, in extension, obstruction might occur through anterior displacement of the posterior airway at the level of the tongue.[191] Video review of airway position and airway obstruction also found hyperextension of the neck is associated with airway obstruction.[192] Therefore, the ERC recommends a neutral head position to ensure optimal airway patency in newborn infants.

Jaw thrust and two-person method

Studies in children demonstrate that anterior displacement of the mandible enlarges the pharyngeal space through lifting the epiglottis away from the posterior pharyngeal wall, reversing the narrowing of the laryngeal inlet.[193] Two-person manual ventilation techniques are superior to single handed airway support: it reduces facemask leak and is more effective,[190,194–196] which is recommended by the ERC.

Preterm newborns

Vocal cord adduction is a cause of airway obstruction at birth in preterm infants <30 weeks.[188] In an observational study of 56 preterm infants <32 weeks significant facemask leak (>75 %) and/or obstruction to inspiratory flow (75 %) were identified using respiratory function monitoring in 73 % of interventions during the first 2 min of PPV.[197] In an animal model of premature birth, phase contrast X-rays demonstrated that the larynx and epiglottis were predominantly closed (adducted) in those with un-aerated lungs and unstable breathing patterns, making intermittent PPV ineffective unless there was an inspiratory breath, and only opening once the lungs were inflated.[187] This may be an explanation for the challenges in inflating preterm infant lungs, but a solution for overcoming these phenomena is not yet known.

Table 6 – Heart rate assessment.

Method of HR assessment	Continuous HR monitoring?	Advantages	Disadvantages	Recommendations
Auscultation with stethoscope	No	Rapid assessment Cheap Simple Readily available in all settings	Intermittent HR monitoring Less reliable compared to other HR methods	Auscultation might be used for quick first assessment Auscultation reasonable alternative for HR assessment Auscultation (+/- pulse oximetry) should be used if ECG is unavailable, malfunctioning or PEA is suspected
Pulse Oximetry *Ideally placed on the right hand or wrist.*	Yes	Continuous HR monitoring Provides a measure of oxygenation and perfusion	May underestimate HR as ECG in first 2–5 mins Interference in values caused by: o Signal dropout o Movement o Hypoperfusion o Lighting Potential cost implication	Unclear whether connecting sensor to infant first or to the pulse oximetry first confers advantage
Electrocardiogram (ECG)	Yes	Continuous HR monitoring Faster and more accurate than pulse oximetry	May indicate a HR in absence of cardiac output May adhere poorly to infants with vernix Potential cost implication	Use of ECG is reasonable to assess HR after birth ERC recommends ECG should not replace pulse oximetry for further treatment, but used in addition

Sources for Table 6: [16,169–181,182]

Abbreviations: HR: heart rate; ECG: electrocardiogram; PEA: pulseless electrical activity.

Suctioning

Routine oropharyngeal and nasopharyngeal suctioning in newborn infants has not been shown to improve respiratory function, may delay other necessary manoeuvres and the onset of spontaneous breathing and is associated with adverse events.[198–202]

The ERC, following ILCOR, does not recommend routine intrapartum oropharyngeal and nasopharyngeal suctioning for newborn infants with clear or meconium-stained amniotic fluid.[189] If suctioning is attempted, in order to clear a presumed blocked airway, it should be undertaken under direct vision, ideally using a laryngoscope and a wide-bore catheter or Yankauer sucker. Bulb suctioning can be useful if no vacuum source is available. A meconium aspirator, attached to a tracheal tube, can clear thick material from the trachea, applied suctioning should not exceed 150 mmHg (20 kPa).[203,204]

Meconium

Lightly meconium-stained liquor is common and usually does not cause difficulty with transition. Non-vigorous newborns delivered through meconium-stained amniotic fluid are at significant risk for requiring advanced resuscitation and a neonatal team competent in advanced resuscitation may be required. Routine suctioning of non-vigorous infants can delay initiating ventilation and there is no evidence to support intrapartum suctioning nor routine tracheal intubation and suctioning of vigorous infants born through meconium-stained liquor.[205–207] Evidence from retrospective registry-based studies,[208,209] meta-analyses,[210–212] a post policy change impact analysis,[213] and ILCOR 2025[6] all support omitting suctioning in favour of immediate ventilation.

The ERC recommends against routine suctioning of either pharynx or trachea in newborn infants born through meconium –stained liquor and recommend providing standard NLS. If there is evidence of airway obstruction, the ERC recommends suctioning under direct vision in the first instance. Rarely, airway obstruction may occur below the level of the larynx, and this may require tracheal suctioning.

Airway devices

Supraglottic airway devices (SGA). SGAs are effective in newborns, particularly if facemask ventilation or tracheal intubation is unsuccessful or not feasible.[5] A systematic review showed that PPV with SGAs was more effective than bag-facemask ventilation in terms of shorter resuscitation and shorter duration of ventilation with less need for tracheal intubation.[214] Bag-facemask ventilation was effective in more than 80 % of enrolled infants. Efficacy of an SGA was comparable to tracheal intubation.

Aligned with ILCOR, ERC recommends using an SGA as a valid alternate airway device, particularly if tracheal intubation is unsuccessful or intubation skills are unavailable.[5,6]

Studies generally included infants with birth weight >1500 g or GA≥ 34 weeks, so evidence supporting SGAs in more premature infants is limited.[214,215] A 2024 Cochrane update found no or little difference in neonatal morbidities and mortality when giving surfactant via an SGA compared with a tracheal tube.[216] The SGA has not been evaluated in the setting of meconium-stained fluid, during chest compressions, or for the administration of emergency intra-tracheal medications. ILCOR considers it reasonable to use an SGA during chest compressions if tracheal intubation is not possible/unsuccessful (good practice statement)[6] and the ERC aligns with this.

Oropharyngeal airway. Although the oropharyngeal airway is effective in children,[217] there is no published evidence demonstrating effectiveness in maintaining airway patency at birth. In an RCT of 137 preterm newborns where gas flow through a facemask was measured, obstructed inflations were more common in the oropharyngeal compared to control group.[218] However, by helping lift the tongue and preventing it occluding the laryngeal opening, an oropharyngeal airway may facilitate airway support where difficulty is experienced and where other airway opening techniques, like jaw thrust, fail to improve ventilation.

Nasopharyngeal airway. A nasopharyngeal airway may help establish an airway where there is congenital upper airway abnormality[219] and has been used successfully in preterm infants at birth.[159,217–219]

Tracheal tube. Safe tracheal intubation is facilitated by well-trained clinicians with appropriate equipment, and the use of an intubation checklist.[220] Tracheal tube insertion depth and internal diameter can be estimated from birth weight or gestational age.[221–225] Neither provide a perfect estimate but weight might be slightly more accurate than GA.[224] Rules of thumb are less accurate in the youngest and smallest newborns.[224,225] Therefore, once insertion, confirmation of tracheal tube position by clinical assessment, appropriate imaging and the use of exhaled CO_2 detection is required.[226] Contingency plans should be made for an unexpectedly difficult airway. Declining intubation skills mean unsuccessful intubation is more common and safe airway management around intubation attempts is vital (Table 7).[227,228]

Video laryngoscopy. A 2024 ILCOR systematic review of video laryngoscopy versus direct laryngoscopy[229,230] found higher overall intubation success rates and higher first attempt success rates using a video laryngoscopy compared to a direct laryngoscope. These findings are confirmed by a 2025 systematic review.[231]

Where resources and training allow, the ERC recommends using a VL to intubate newborn infants, especially in settings where less experienced staff are intubating. Direct laryngoscopy remains a reasonable option, and such a laryngoscope should be available as a backup device.

Exhaled CO_2

Detection of exhaled CO_2 alongside clinical assessment is used to confirm tube placement in the trachea in newborn infants, even from >400 g.[9,232–235] Failure to detect exhaled CO_2 strongly suggests tube misplacement – no trace, wrong place.[233,236] However, studies relating to exhaled CO_2 have mostly excluded infants in need of extensive resuscitation. False negative CO_2 detection can occur in cases of poor or absent pulmonary blood flow, tracheal obstruction, low or absent cardiac output in resuscitation at birth and in birthweight <1500 g.[234,236] Where there is no CO_2 detection after tracheal intubation, tracheal tube position should be rechecked by VL or direct laryngoscopy by the most skilled person present as soon as possible to avoid unnecessary tracheal tube removal.

Like ILCOR,[235] the ERC recommends using exhaled CO2 detection combined with clinical assessment, to confirm tracheal tube placement.

Both qualitative (colorimetric) and quantitative (waveform) CO_2 detection methods have been successfully used in intubated newborn infants.[237] Colorimetric detection offers a simple, easy to use, cheap device where a colour change indicates exhaled CO2. Waveform detection provides a continuous graphical and numerical representation of exhaled CO2 throughout the respiratory cycle, allowing for continuous monitoring, but requires specialised equipment and power sources may not be readily available in all delivery area settings. Colorimetric detection failed to detect correct tube placement in one-third of delivery area intubation in very preterm infants in one study.[238] Although waveform capnography is more sensitive in adults, limited newborn data advise caution, especially if being used during resuscitation.[239–241]

Table 7 – Approximate tracheal tube size and lengths for oral and nasal intubation.[221–223]

Birthweight (grams)	Gestation (weeks)	Internal diameter (mm)	Oral intubation length (cm)	Nasal intubation length (cm)
500	23–24	2.5	6.0	7.0
750	25–26	2.5	6.5	7.5
1000	27–29	2.5	7.0	8.0
1250	30–32	2.5	7.5	8.5
1500	30–32	2.5/3.0	7.5	8.5
1750	33–34	2.5/3.0	8.0	9.0
2000	35–36	3.0	8.5	9.5
2500	36–37	3.0	9.0	10.0
3000	37–39	3.0/3.5	9.5	10.5
3500	39–41	3.5	10.0	11.0
4000	41–43	3.5	10.5	11.5

The ERC cannot recommend one method over the other.

Exhaled CO_2 can be used in non-intubated patients.[242–245] Exhaled CO_2 detector use with interfaces such as SGAs are standard in adult patients, but as newborn physiology differs markedly from that of older children and adults, practices of proven benefit for older patients may not apply to neonatal patients, especially during perinatal transition.

The ERC currrently cannot recommend the routine use of exhaled CO2 detection in non-intubated newborn infants in the delivery area.

Respiratory flow monitoring

Flow monitoring via a respiratory function monitor was reported in an RCT to confirm tracheal tube position faster and more reliably that end-tidal CO_2 detection, suggesting it may be used as an additional measure to assess correct tube or SGA placement.[246,247] One study reported higher quality of PPV at birth with less excessive tidal volumes and less leak when respiratory function monitoring was used.[248] However, an ILCOR systematic review[249] and a 2025 evidence update[6] found insufficient evidence to recommend for or against the routine use of respiratory function monitoring to guide PPV at birth, and ERC recommendations align with ILCOR.

Breathing

Initial inflations and assisted ventilation

Lung inflation must begin without delay in apnoeic or inadequately breathing newborn infants. An observational study in low-resource settings found a 16 % increase in morbidity/mortality for every 30 s delay in starting ventilation.[250] Optimal inflation pressure, inspiratory and expiratory times, and duration of PPV remain uncertain.

Facemask

Facemask ventilation is limited by leaks, often caused by poor facemask fit or suboptimal technique, both of which contribute to facemask leak which can be improved after training.[195,251] A clinical study demonstrated obstruction and/or leak >75 %) during initial ventilations in preterm infants.[197] An observational study in preterm infants <32 weeks suggested that the application of a facemask to support breathing might induce apnoea by triggering the trigeminocardiac reflex in spontaneously breathing infants. However, the significance of this is currently unclear.[252]

Nasal interfaces

While facemasks are most commonly used, nasal interfaces (single or binasal short or long prongs or nasal masks) have been found to be as effective as facemasks.[253,254] Emerging studies suggest nasal interfaces also reduce delivery room intubation and PPV use in infants <28 weeks).[255,256,257] The ERC recommends performing PPV using either a facemask or nasal interfaces.

Inflation duration

Initial inflations or spontaneous breathing establish functional residual capacity (FRC).[258,259] There is ongoing debate about the optimal inflation duration.[260–268] This should not be confused with sustained inflations (i.e. inflations $\geq$5 s), which are not recommended by ILCOR or the ERC.[9,43] Previous ERC guidance recommended (up to) 2–3 s inflations,[9] while other NLS guidelines around the world support shorter durations of inflations ($\sim$1 s).[12,269] Available evidence shows no clear advantage nor disadvantage of longer (2–3 s) over shorter ($\sim$1 s) inflations.[12,268,270,271]

As a HR response may not be seen until at least 20 s of PPV in bradycardic infants,[272,273] the number of inflations should vary depending on the length of inflation. Although there is no evidence to suggest superiority nor inferiority of 2–3 s over 1 s inflations, since the ERC has recommended inflation times of or up to 2–3 s since inception, this approach is used in NLS courses throughout Europe. Therefore, the ERC continues to recommend 5 inflations of up to 2–3 s based on pragmatic consensus.

Inflation pressure

Inflation pressures of 30 cm H_2O are usually sufficient to inflate the fluid-filled lungs of apnoeic term infants, based on historical cohort studies.[259,274,275] However, a prospective cohort study of 821 term and near-term infants resuscitated using bag-facemask ventilation found median peak pressures of 36 cmH_2O required for successful stabilisation.[276] For preterm infants, an initial inflation pressure of 25 cmH_2O is considered reasonable,[263,277–279] though higher pressures may be needed due to greater airway resistance. If no chest movement is observed, the ERC recommends increasing inflation pressures, regardless of GA, to achieve lung inflation.

Ventilation rate

Evidence on the optimal ventilation rate for newborn resuscitation is limited. In an observational study of 434 late preterm and term infants, ventilation at 30 breaths min^{-1} achieved adequate tidal volumes without hypocarbia, with the best CO_2 clearance at 10–14 mL/kg.[280] An observational study suggest that PPV rates >60 min^{-1} compared to rates <60 min^{-1} fail to achieve adequate tidal volumes.[281] Other studies suggest optimum rates for PPV are 30–40 min^{-1}.[259,274] The ERC recommends PPV rate of 30–40 min^{-1} once lungs have been inflated.

Effectiveness of inflations

The primary sign of adequate lung inflation is a rapid HR increase, usually within 20–30 s of onset of effective ventilations.[163,282,283] Chest wall movement usually indicates lung inflation, although this may be less obvious in preterm infants.[284] Excessive chest movements may indicate excessive tidal volumes, which should be avoided. If HR improves but breathing remains inadequate, PPV must continue.

Failure of the HR to increase is most often due to suboptimal airway control or inadequate ventilation.[195,251,285] Adjustments to head/airway position,[190] choosing alternative airway opening techniques, or increased inflation pressures may be needed.[276] In preterm infants, facemask pressure, glottal closure, or triggering the trigeminocardic reflex may impair PPV.[187,197,286,287] Although exhaled CO_2 monitoring can sometimes detect such obstructions and facemask leaks, current evidence is insufficient to recommend its routine use to assess quality of PPV.[245]

Sustained inflations >5 s

Animal studies suggested longer inflations may have physiological benefits,[288,289] but clinical benefits in human infants have not been demonstrated. In preterm infants, there is evidence of possible harm from sustained inflation >5 s.[290] A Cochrane systematic review found that sustained inflations (15–20 s) were not better than intermittent ventilation ($\leq$ 1 s) for reducing mortality, intubation, need for respiratory support or bronchopulmonary dysplasia.[291] An ILCOR review advises against routine use of sustained inflations >5 s in preterm infants receiving PPV at birth, due to a possible increase in mortality

in infants <28 weeks. ([266,268] ILCOR did not recommend a specific inflation duration for late preterm and term infants due to low-confidence in the estimates of the effect. The ERC guidance aligns with ILCOR and recommends against sustained inflations >5 s in preterm infants.

CPAP and PEEP

Successful respiratory transition at birth relies on alveolar aeration, lung inflation, and formation of FRC.[292] Most premature infants can breathe at birth but often struggle to obtain and maintain FRC.[293,294] (251) The need for respiratory support at birth is inversely correlated to GA.[295,296] Animal studies show that a few early inflations at high tidal volumes can cause lung injury and inactivate surfactant.[297,298] Preclinical studies demonstrated that applying CPAP or PEEP immediately after birth assists lung inflation.[299] Unlike CPAP, PEEP is only present during exhalation and is applied during manual or mechanical ventilation.[300] While other non-invasive respiratory supports are under investigation, CPAP remains the gold-standard for newborn infants <32 weeks.[301]

CPAP for infants <32 weeks. Large RCTs show that starting CPAP at birth, compared with intubation and ventilation, significantly reduces death and bronchopulmonary dysplasia.[302–306] An ILCOR systematic review recommends starting CPAP promptly in spontaneously breathing preterm infants with respiratory distress instead of TI and PPV.[6,43,307]. The ERC Guideline 2025 NLS align with this recommendation. Whilst some RCTs used CPAP levels up to 8 cmH_2O,[302,303] an observational study shows that levels of 5–6 cmH_2O are most commonly used in practice.[308] Comparative studies on optimal CPAP levels remain limited.[309,310] A 2021 Cochrane Review concluded that it was not possible to recommend a specific starting level.[310] Animal data suggest that CPAP at 15 cmH_2O (with O_2 60 %) improves lung inflation compared to 4–8 cmH_2O.[311] An ongoing trial is studying dynamic CPAP (8–12 cm H_2O) vs static CPAP (6 cm H_2O) at birth. (clinicaltrials.gov NCT04372953).

Until higher-quality evidence is available, and based on indirect measures showing better lung inflation at 6 cm H_2O,[301] aligning with the European Consensus Guidelines on the Management of Respiratory Distress Syndrome,[312] the ERC recommends starting CPAP at 6 cm H_2O in spontaneously breathing preterm infants <32 weeks.

CPAP for infants ≥32 weeks. The 2022 ILCOR CoSTR, states that there is insufficient evidence for or against routine CPAP in late preterm and term infants.[313] However, late preterm infants and term infants with conditions such as transient tachypnoea of the newborn, or those requiring supplemental O_2, may benefit from CPAP (good practice statement).[314] The ERC considers it reasonable to start CPAP at 6 cm H2O in newborn infants ≥32 weeks with respiratory distress needing supplemental O_2.

PEEP during PPV. Self-inflating bags can be equipped with PEEP valves to deliver defined PEEP during PPV, but cannot provide CPAP, even with attached bias gas flow.[315] ILCOR recommends using PEEP during initial PPV of preterm newborn infants at birth.[43] Accordingly, the ERC recommends starting with a PEEP of 6 cmH_2O in preterm newborn infants receiving PPV.

Assisted ventilation devices

Recent reviews summarize the principles of interfaces, devices and settings for delivering CPAP, PEEP and PPV during fetal-to-neonatal transition.[315,316] T-piece resuscitators deliver more consistent CPAP/PEEP compared to self-inflating bags.[315] ILCOR (2021) concluded T-piece resuscitators may slightly improve outcomes like survival, intraventricular haemorrhage and bronchopulmonary dysplasia over self-inflating bags.[317,318] Thus, the ERC recommends using T-piece resuscitators for PPV at birth, but self-inflating bags should be available as a backup if gas supply fails.

Oxygen

Term infants and late preterm infants ≥ 32 weeks

Lower inspired O_2 concentrations may result in suboptimal oxygenation where there is significant lung disease,[319] while higher O_2 may delay spontaneous breathing in term infants.[320] ILCOR recommended starting with 21 % O_2 in infants ≥35 weeks receiving respiratory support at birth, and advises against 100 % O_2.[43] An updated systematic review (2164 patients) demonstrated 27 % lower short-term mortality with 21 % O_2 vs 100 % O_2, without differences in neurodevelopment or hypoxic ischaemic encephalopathy (HIE).[321] For neonates born at 32–34^{+6} weeks, ILCOR found insufficient evidence for specific O_2 recommendations.[6] The ERC recommends starting with 21 % O_2 in infants ≥32 weeks and titrating O_2 to achieve target saturations.

Preterm infants <32 weeks

In preterm infants, higher supplemental O_2 improves breathing effort and oxygenation and results in shorter facemask ventilation and higher minute volumes.[286,322]

The NetMotion individual patient data network meta-analysis (1055 infants from 12 studies) suggested high O_2 >90 % may reduce all-cause mortality compared to lower O_2 (<30 % and 50–65 %).[323] An updated ILCOR study level meta-analysis found insufficient evidence to definitively recommend high (>50 %) vs low (≤50 %) O_2 (1804 infants from 16 studies + NetMotion, infants <35 weeks).[6,323,324] For infants <32 weeks, the ERC recommends starting resuscitation with ≥30 % O_2 and adjusting O_2 to achieve and maintain target saturations.

Target oxygen saturations

In 2010 target oxygen saturation curves were published, however, these data predated DCC and the majority of included infants were ≥37 weeks (Fig. 7).[10] In 2024, different saturation and HR references were published for infants <32 weeks stabilised according to more current guidelines. All included infants had favourable outcomes, defined as survival without cerebral injury (Fig. 8).[11]

Most (92 %) of the cohort received O_2 and CPAP (91 %).[11] Table 8 provides an overview of target saturation ranges that are also used in the Newborn Resuscitation Programme (NRP).[10–12]

A systematic review showed that failing to reach SpO_2 ≥80 % at 5 min doubled the risk of death and severe intraventricular haemorrhage in very preterm infants.[325]

Nearly all infants <32 weeks require supplemental O_2 after birth,[10,11,325] but achieving target saturations in the minutes after birth can be challenging; only 12 % reached 80 % SpO_2 at 5 min of life.[325] SpO_2 readings <60 % are considered inaccurate.[182] Dark skin tones may be associated with oxygen saturation discrepancies, with a higher incidence of occult hypoxaemia,[326] although limited data suggests that the discrepancy may be less pronounced in neonates.[327,328]

There is no direct evidence for the optimal oxygen saturations to strive for after birth. The ERC provides a consensus-based recom-

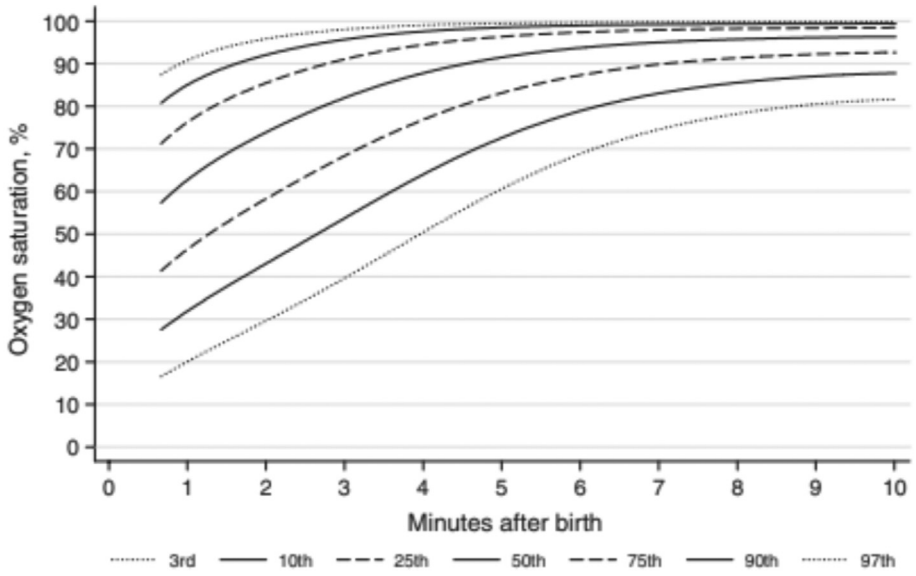


Fig. 7 – Oxygen saturations in healthy infants at birth without medical intervention (3rd, 10th, 25th, 50th, 75th, 90th, 97th centiles. Reproduced with permission.[299]

Table 8 – Overview of oxygen saturation target ranges.[10–12]

	Dawson[10]		Wolfsberger[11]		Dawson[10]		NRP[12]
	<32 weeks, n = 29		<32 weeks, n = 207		>=37 weeks, n = 308		
	P25	P75	P25	P75	P25	P75	
3 min	67	83	51	77	71	90	70–75
5 min	82	91	73	92	83	96	80–85
10 min	89	95	89	95	94	98	85–95

NRP: Newborn Resuscitation Program.

mendation on uniform oxygen saturation targets across all GAs, balancing out the perceived detrimental effects of hypoxia that may be worse than those for hyperoxia (Table 4).

Titration of oxygen

Timely adjustment in delivery of O_2 is critical to avoid hypoxia, hyperoxia and bradycardia. The ERC recommends reviewing O_2 every 30 s[329] and adjusting O_2 to achieve target SpO_2. There can be a delay between titration of intended O_2 and delivery of O_2 to the baby. One study suggests a T-piece resuscitator takes 19 s (IQR 0–57) to achieve the desired O_2 at the distal end,[330] and another that nasal interfaces may reduce this delay (Fig. 8).[331]

Cerebral tissue oxygenation monitoring

Using the same population of preterm infants, the application of different statistical methodology has resulted in differing conclusions.[332–334] The ERC, following the 2024 ILCOR recommendation, recommends that near infrared spectroscopy monitoring of cerebral oxygenation in the delivery room should only be considered where resources permit, preferably within structured research trials to help close knowledge gaps.[6,333]

Circulatory support

Circulatory support with chest compression is effective only after successful lung inflation and subsequent oxygen delivery to the heart. Ventilation may be compromised during chest compressions, so ensuring effective ventilation before starting chest compression is critical.[335]

Threshold for initiating and discontinuing chest compressions

The HR threshold to initiate chest compression at birth (<60 min^{-1}) was based on expert opinion and limited animal data.[166,336] No human studies have compared different HR thresholds for initiating chest compression in human newborns,[166] and current practice remains to start chest compression if HR is <60 min^{-1} after successful lung inflation.

In asystolic piglets, starting chest compression after 30 or 60 s of PPV resulted in comparable outcomes, however, delaying chest compression beyond 90 s worsened outcomes.[165] Two narrative reviews reconsidered the HR threshold for starting chest compression at birth,[336,337] suggesting chest compression could potentially be delayed an additional 30 s of PPV, if HR is rising after 30 s of ventilation, but still <60 min^{-1}, though more research is needed.

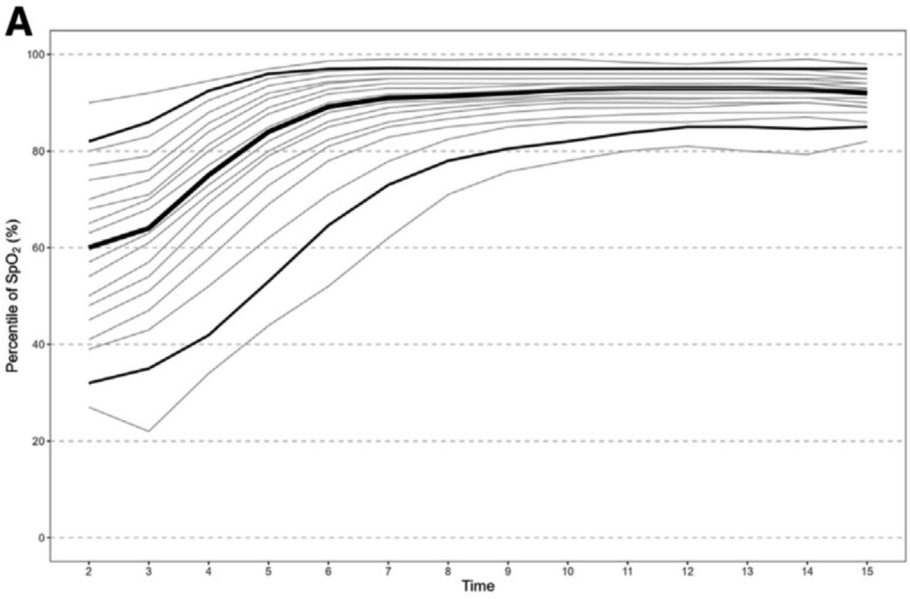


Fig. 8 – Oxygen saturations during the first 15 min after birth of infants <32 weeks with favorable outcome of SpO_2 (%); (10th, 50th, and 90th centile (bold lines); 5th, 15th, 20th, 25th, 30th, 35th, 40th, 45th, 55th, 60th, 65th, 70th, 75th, 80th, 85th, 95th centile (gray lines)). Reproduced with permission.[9]

The ERC recommends considering an additional 30 s of PPV when HR is still <60 min^{-1} but increasing. The ERC also recommends checking the HR every 30 s unless using continuous monitoring (pulse oximetry, ECG). Whilst chest compression may be discontinued when HR is >60 min^{-1}, a continued increase in rate and confirmation of cardiac output, e.g. auscultation, pulse check, pulse oximetry, signs of life, are necessary to truly demonstrate improvement. Stability often occurs only when HR exceeds 120 min^{-1}.[167,168]

Compression technique

ERC recommendations align with ILCOR, whose 2023 systematic review reaffirmed that for infants at birth, the two-thumb-hands-encircling-the-chest method should be used to deliver CC, because it results in improved compression depth, less fatigue, and better digit placement than the two-finger technique.[6,166] Two overlapping or adjacent thumbs should be placed on the lower third of the sternum from either the lateral or over-the-head position.[338,339] The over-the-head position may facilitate umbilical catheterisation. Alternative techniques were also considered but were not superior (Fig. 9).[166]

Compression depth

In a post-transitional piglet model, compressions of 25–40 % depth achieved ROSC, while 12.5 % compression depth did not.[340] Evidence in human newborn infants is lacking,[166] although deeper com-

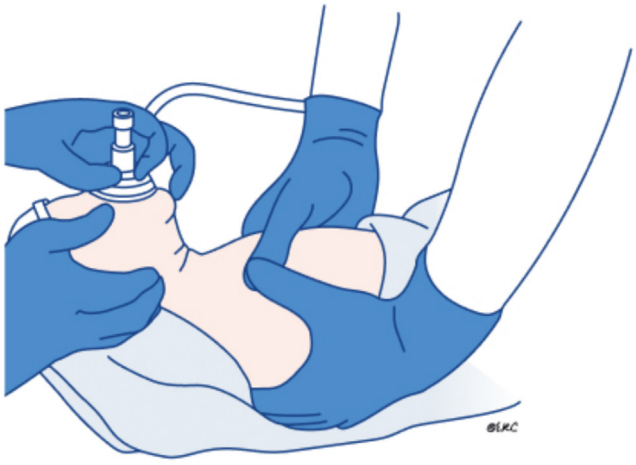


Fig. 9 – Two thumbs encircling technique for chest compressions.

pressions improved blood pressures in post-surgical infants.[341] Full recoil between compressions is important.[342–346] The ERC recommends compressing the sternum one-third of the anterior-posterior chest diameter (good practice statement), allowing full recoil between compressions.

Compression-to-ventilation ratio

ILCOR (2023) found insufficient evidence to change the recommended 3:1C:V ratio, aiming for 90 compressions and 30 ventilations per minute.[43,166] However, the quality of compressions and ventilations is probably more important than the rate.[347] Animal studies suggested chest compression with sustained inflations improved outcomes over 3:1C:V, but human trials remain inconclusive.[347–350] The ERC continues to recommend a 3:1C:V ratio for resuscitation at birth, even after securing the airway.

Supplemental oxygen during chest compressions

Available evidence remains insufficient to alter the recommendation of increasing O_2 to 100 % when starting chest compression (good practice statement).[9,166] No human studies have compared 21 % with 100 % O_2 (or any other O_2 concentration) during chest compression,[351] and animal studies reported no major differences in time to ROSC, mortality, inflammation, or oxidative stress between concentrations.[166,351] Both hypoxia and hyperoxia can be detrimental.[166,351] In a transitional term ovine model of asphyxia-induced cardiac arrest, 21 % O_2 was associated with lower cerebral oxygen levels and higher brain lactic acid after ROSC compared to be reported with the 100 % O_2.[352] Rapid weaning of inspired O_2 after ROSC may prevent hyperoxia and thereby possibly mitigate oxidate stress and organ damage. Thus, ERC recommends that, once HR recovers, O_2 should be actively reduced, guided by pulse oximetry (good practice statement).

Prompts and feedback devices

Earlier studies suggested exhaled CO_2 monitoring and pulse oximetry may be useful in detecting ROSC.[353–356] ILCOR reviewed 16 studies examining chest compression in relation to (audio)visual feedback devices, auditory feed forward devices, audiovisual prompts provided by a decision support tool, capnography, and blood pressure monitoring, but findings were difficult to compare due to heterogeneity.[166] Currently, ERC cannot recommend the clinical use of prompts or feedback devices to assess CC during neonatal resuscitation

Automated chest compression devices

Mechanical chest compression devices are used in adults but not yet in newborns.[357] In a neonatal asphyxiated piglet model, machine-delivered chest compression improved stroke volume and left ventricular contractility compared to manual chest compression.[358] More research is needed before clinical use in human newborn infants can be recommended.

Vascular access

Umbilical venous catheter (UVC) and intraosseous (IO) access

No new evidence was identified comparing umbilical venous catheter (UVC) route or use of intravenous (IV) cannulas against the intraosseous (IO) route in the newborn for drug administration in any setting in an ILCOR systematic review.[43] A systematic review on the use of IO in neonates in any situation identified one case series and 12 case reports of IO device insertion into 41 neonates delivering several drugs including adrenaline and fluid/blood.[359] First attempt success rates for IO varied from 50–86 %. Both UVC and IO access have complications associated and adverse events have been described.[43,360–363]

The actual route and method used may depend on local availability of equipment, training and experience.[43] There is limited evidence on the effectiveness of IO devices immediately after birth, or the optimal site or type of device,[364,365] although simulation studies undertaken in a delivery room setting suggest that the IO route can be faster to insert and use than UVC.[366,367] Proximal tibia is the anatomical site usually used in newborn infants, but proximal and distal femur may be feasible as well.[368,369] IO access might be possible in preterm infants. However, device-specific weight limitations must be considered. ERC recommends, in alignment with ILCOR, to use UVC as the primary method of vascular access at birth, and if UVC is not feasible, or birth occurs in another setting, the IO route is a reasonable alternative.

Peripheral access

No studies were identified reviewing the use of peripheral IV cannulation in infants requiring resuscitation at birth. A retrospective analysis of 61/70 stable newborn preterm infants in a single centre showed that peripheral IV cannulation is feasible and successful in most cases at first attempt.[370]

Medication

Medications are rarely indicated in resuscitation of the newborn infant.[42,371,372] Bradycardia is usually caused by profound hypoxia and the key to resuscitation is inflating the fluid filled lungs and establishing adequate ventilation. However, if the HR remains less than 60 min^{-1} despite effective ventilation and chest compressions, it is reasonable to consider the use of medication. Knowledge of the efficacy of medication in newborn resuscitation is largely limited to retrospective studies, as well as extrapolation from animals and adult humans.[373]

Adrenaline

A systematic review identified two observational studies involving 97 newborns comparing doses and routes of administration of adrenaline.[374] There were no differences between IV and endotracheal adrenaline for the primary outcome of death at hospital discharge, for failure to achieve return of spontaneous circulation, time to return of spontaneous circulation or proportion receiving additional epinephrine. There were no differences in outcomes between 2 endotracheal doses. No human newborn studies were found addressing IV dose or dosing interval (very low certainty evidence). Recent animal data show no differences in response to doses between 0.2, 0.4, or 0.8 IU/kg vasopressin, or 0.02 mg/kg adrenaline and support intravenous administration as the most effective route for adrenaline.[375] Despite the lack of newborn human data, it is reasonable to use adrenaline when effective ventilation and chest compressions have failed to increase HR above 60 beats min^{-1}.

ILCOR suggests that if adrenaline is used, an initial dose of 10–30 μg kg^{-1} (0.1–0.3 mL kg^{-1} of 1:10,000 adrenaline [1 mg in 10 mL]) should be administered intravenously.[6] If intravascular access is not yet available, endotracheal adrenaline at a larger dose of 50–100 μg kg^{-1} (0.5–1.0 mL kg^{-1} of 1:10,000 adrenaline [1 mg in 10 mL]) is suggested but should not delay attempts at establishing

vascular access.[376] If HR remains <60 min^{-1} further doses – preferably intravascularly – every 3–5 min are suggested. If the response to tracheal adrenaline is inadequate ILCOR suggests an IV dose is given as soon as vascular access is established regardless of the interval between doses.[5,6,43,377] In previous editions, an interval of 3–5 min was advised. For pragmatic reasons, ERC recommends using iv/io route preferably at a dose of 10–30 mcg kg^{-1} or an endotracheal dose of 100 μg kg^{-1}; and to repeat further doses of adrenaline every 4 min if required.

Glucose

Dysglycaemia (hyper or hypoglycaemia) is common during neonatal resuscitation and may be associated with poorer resuscitation outcomes. Hypoglycaemia is an important additional risk factor for perinatal brain injury.[378] The definition of hypoglycaemia in the context of resuscitation is unknown. Hyperglycaemia is a stress response and does not need to be corrected during resuscitation but may need to be addressed during post resuscitation care. Different amounts of bolus glucose have been published varying between 1 and 2 ml Kg^{-1}, with the majority advising 2 ml Kg^{-1} intravenously.[379–381] To align with these publications and the ERC 2025 Guideline PLS, the ERC recommendation is to check blood glucose during a prolonged resuscitation and if low, IV or IO glucose should be given as a 200 mg kg^{-1} bolus (2.0 mL kg^{-1} of 10 % glucose). After successful resuscitation formal steps to prevent both hypoglycaemia and hyperglycaemia should be instituted.

Intravascular volume replacement

Early intravascular volume replacement is indicated for newborns with blood loss who are not responding to resuscitation.[43] Therefore, if there has been suspected blood loss or the newborn appears to be hypovolaemic and has not responded adequately to other resuscitative measures then consider giving volume replacement with crystalloid or red cells. Blood loss causing acute hypovolaemia in the newborn is a rare event. There is little to support the use of volume replacement in the absence of blood loss when the newborn is unresponsive to ventilation, chest compressions and adrenaline. However, because blood loss may be occult and distinguishing normovolaemic newborns with shock due to asphyxia from those who are hypovolaemic can be problematic, a trial of fluid administration may be considered.[9,43]

The ERC recommends in the absence of suitable blood (i.e. group O Rh-negative blood), isotonic crystalloid rather than albumin is the solution of choice for restoring intravascular volume and to give a bolus of 10 mL kg^{-1} initially. If successful it may need to be repeated to maintain an improvement. When resuscitating preterm newborns, fluid is rarely needed and has been associated with intraventricular and pulmonary haemorrhages when large volumes are infused rapidly.[382]

Sodium bicarbonate

ILCOR concluded that a 2005 treatment recommendation on the use of sodium bicarbonate during prolonged resuscitation was not supported by a systematic review using contemporary ILCOR methods of evidence appraisal; consequently, the recommendation for the routine use of sodium bicarbonate has been withdrawn from the 2025 CoSTR.[6] Indeed, there may be harm associated with its use, as it is hyperosmolar and generates CO_2 which may impair myocardial and cerebral function.[383] Given insufficient data to recommend routine use of bicarbonate in resuscitation of the newborn the ERC has followed ILCOR's recommendation and removed it from the Guideline.

Naloxone

Naloxone is very seldomly used during newborn resuscitation (writing group experience). There is no high-certainty evidence for the use of naloxone during resuscitation.[384] Consequently, the ERC cannot recommend the use of Naloxone in that setting.

Low resource or remote settings

Infants born unplanned out of hospital are often in a remote area with lower resources and at higher risk of needing resuscitation. Resuscitation then needs to be provided by out of hospital practitioners, possibly with less experience of neonatal resuscitation. Stabilisation is followed by additional challenges of safe transfer to an appropriate healthcare facility. Hypoxia and hypothermia are common and should be anticipated and proactively managed.[105,385–387] Not all hospital settings have the same resources, and remote locations may benefit from use of telemedicine.

Planned home births

A systematic review of eight studies involving 14,637 low risk planned home births compared with 30,177 low risk planned hospital births concluded that the risks of neonatal morbidity and mortality were similar.[63] However, unplanned births are more at risk of needing resuscitation and despite risk stratification, infants born at home may still require resuscitation.[388] Those attending home births must have appropriate skills to manage this. Thermal care with a focus on prevention of hypothermia is essential irrespective of birth location.[387] This can be supported, by increasing room temperature in the birth location (e.g., turn heating up, close windows), use of warming mattresses or skin-to-skin contact. Plastic bags can be used for preterm babies as a useful thermal care adjunct alongside a heat source.

Post-resuscitation care

Glucose management

Hypoglycaemia may occur after perinatal asphyxia because of rapid glucose consumption during anaerobic metabolism, stress-induced hyperinsulinism, impaired gluconeogenesis, and concomitant risk factors.[389,390] Conversely, hyperglycaemia may result from endogenous stress hormone release, adrenaline administration, and reduced insulin sensitivity. Both hypoglycaemia and hyperglycaemia occur frequently after resuscitation: approximately 1 in 7 and 1 in 4 newborns in the first 6 h, increasing to 1 in 5 and 1 in 2 newborns at ≥24 h after birth, respectively.[389] Infants with hypoxic-ischaemic encephalopathy and severe acidosis are particularly at risk.

Animal studies suggest hypoxic cerebral injury is worsened by both hypoglycaemia and hyperglycaemia.[391,392,393] Research in human infants with hypoxic-ischaemic encephalopathy has revealed that initial hypoglycaemia and glycaemic lability are associated with more brain injury on MRI, lower cognitive scores, and poorer neurological outcome.[394–397] Hyperglycaemia and glycaemic lability were also associated with amplitude-integrated electroencephalographic evidence of worse global brain function and seizures.[398]

Hypoglycaemia and hyperglycaemia are associated with higher mortality rates, and (early) hypoglycaemia (≤12 h after birth) also causes more neurodevelopmental impairment in newborns treated with therapeutic hypothermia for moderate-to-severe hypoxic-ischaemic encephalopathy.[399,400] A systematic review and meta-analysis confirmed the association of hypoglycaemia and hypergly-

caemia with death and worse neurodevelopmental outcome in babies with neonatal encephalopathy.[401] Early hypoglycaemia and hyperglycaemia were independently associated with death and/or severe neurodevelopmental impairment at 18 months in infants with moderate-to-severe hypoxic-ischaemic encephalopathy, irrespective of cooling.[402] Fluctuating glucose levels in neonates with hypoxic-ischaemic encephalopathy also correlate with unfavourable outcomes.[403,404]

ILCOR concluded that evidence on glucose management is scarce.[389] Only two good practice statements could be issued and these are the ERC recommendations: 1) measure blood glucose concentration early and regularly after resuscitation until normoglycaemia is achieved; 2) titrate infusion of intravenous glucose against the infant's blood glucose values to avoid hypoglycaemia and iatrogenic hyperglycaemia. Although the optimal blood glucose target range for newborns with HIE is uncertain,[4,405] it seems appropriate to maintain blood glucose ≥2.6 mmol/l (47 mg/dL) (good practice statement).[390,400]

Thermal care

If therapeutic hypothermia is not indicated, hypothermia after birth should be corrected because of its association with poor outcomes.[117] Infants should be maintained within the normal temperature range (36.5–37.5 °C).[100,117]

Hyperthermia (≥38 °C) after cardiopulmonary resuscitation is also associated with unfavourable outcomes (death, moderate or severe disability) in neonates, children, and adults.[406–410] A secondary analysis of an RCT comparing whole-body cooling with standard care in term infants with hypoxic-ischaemic encephalopathy demonstrated that the risk of death or moderate-to-severe disability was increased 3.6–5.9-fold for every 1 °C increase in temperature.[411] Hyperthermia should thus be avoided.[412] The ERC recommends monitoring temperature and aiming for normothermia.

Therapeutic hypothermia

A Cochrane review including 11 RCTs comprising 1505 term and late preterm infants calculated that therapeutic hypothermia resulted in a statistically significant and clinically important reduction in the combined outcome of mortality or major neurodevelopmental disability to 18 months of age and concluded that newborn infants at term or near-term with evolving moderate-to-severe hypoxic-ischaemic encephalopathy (HIE) should be offered therapeutic hypothermia.[411] A more recent systematic review and meta-analysis including 29 RCTs with 2926 infants ≥35 weeks of gestation with HIE showed that therapeutic hypothermia diminishes the risk of neurological disability and cerebral palsy.[412] The overall effect of therapeutic hypothermia on mortality was uncertain.

Cooling should be performed in NICUs with the capabilities for multidisciplinary care, using clearly defined protocols. During transfer to a NICU, servo-controlled active cooling is the preferred method to maintain hypothermia in the desired range.[413] Treatment should commence within 6 h of birth, target a temperature between 33 °C and 34 °C, and continue for 72 h, with rewarming over at least four hours.[414] A clinical trial of 364 infants randomised to receive longer (120 h) or deeper (32 °C) cooling found no evidence of benefit of longer cooling or lower temperatures.[415] Animal data strongly suggest that the effectiveness of cooling is related to early intervention. Hypothermia initiated at 6–24 h after birth may have benefit, but there is uncertainty in its effectiveness.[416] Such therapy can be considered on an individual basis. Current evidence is insufficient to recommend routine therapeutic hypothermia for infants with mild HIE.[417]

The ERC recommends applying therapeutic hypothermia in term newborns (≥37 weeks) with evolving moderate-to-severe HIE in low- and middle-income countries as long as appropriate supportive neonatal care can be provided. There is insufficient evidence to offer a recommendation on therapeutic hypothermia in low- and middle-income countries for late preterm infants (34 to 37 weeks).

Oxygenation & ventilation

Evidence on oxygen targets in infants with perinatal asphyxia is lacking. It seems prudent to continuously monitor oxygen saturations and regularly draw arterial blood gases.[418] Considering the increased risk of pulmonary hypertension in infants with hypoxic-ischaemic encephalopathy, sometimes aggravated by therapeutic hypothermia, measurement of pre and post-ductal saturations is sensible.[419–423] Both hypoxaemia and hyperoxaemia can be detrimental.[424] The ERC recommends titrating O_2 to avoid hypoxaemia and hyperoxaemia, and to aim for normocapnia.

A review of nine retrospective studies reported that hypocapnia in newborns with HIE is associated with adverse short- and long-term outcomes.[425] A retrospective cohort study including 188 infants managed with therapeutic hypothermia for HIE showed that hypocapnia was associated with more severe brain injury on MRI in a dose-dependent fashion.[426] Targeting normocapnia appears sensible after neonatal resuscitation.[424]

Prognostication

The Apgar score was designed to focus attention on the newborn and to identify infants needing interventions.[427] Individual components of the score (e.g. breathing, HR) reflect the physiological relationships during postnatal transition. Lower scores at one minute are associated with more interventions at 5 and 10 min.[42] Although the overall Apgar score is widely recorded in clinical practice and for research purposes, its applicability has been questioned because of large inter- and intra-observer variations and racial bias.[428160,429,430] A retrospective study involving 42 infants (23–40 weeks) found a significant discrepancy (average 2.4 points) between retrospective video-based Apgar scores and scores applied by those attending the birth.[428] Individual components of the Apgar score are used to guide resuscitation, but the overall Apgar scores are not. Apgar scores are calculated after resuscitation and are often required by institutions and national registries.

Several studies have looked at the prognostic ability of clinical parameters, biochemical results, medication use, neuroimaging, and neurophysiological studies to predict neurodevelopmental outcomes of newborn infants (treated) with (hypothermia for) hypoxic-ischaemic encephalopathy.[431–438] However, a recent systematic review concluded that all clinical prediction models proposed so far have methodological limitations hampering their routine use in clinical practice.[439]

The ERC cannot recommend a specific clinical prediction model.

Clinical team debriefing

Debriefing after a resuscitation may help improve team performance in subsequent resuscitation events.[440] A meta-analysis revealed that team debriefings after simulated events outperformed non-debriefing teams by approximately 25 %.[441] Another meta-analysis of 61 studies evaluated the effectiveness of After-Action Reviews following training and clinical events, indicating an average improvement effect size of 0.79 (Cohen's d) in task performance, cognitive skills, attitudes toward training/learning.[442]

An ILCOR review on the effect of debriefing on clinical outcome (resuscitation skills and knowledge) and patient outcome (good neu-

rological outcome, survival at discharge, survival to hospital) found studies with no effect, but also improved favourable neurological outcome, survival to discharge, ROSC, chest compression depth, rate and fraction and adherence to guidelines. No undesirable effects from debriefing could be demonstrated. The ERC recommends post-event debriefing after neonatal cardiac arrest in settings that have adequate resources.[67]

Communication with the parents

The principles governing the need for good communication with parents are derived from clinical consensus and enshrined in published European guidance.[443,444] Mortality and morbidity for newborns varies according to region, ethnicity and to availability of resources.[445–447] Social science studies indicate that parents wish to be involved in decisions to resuscitate or to discontinue life support in severely compromised infants.[448,449] Local survival and outcome data are important in appropriate counselling of parents. The institutional approach to management (for example at the border of viability) affects the subsequent results in surviving infants.[450]

The ERC is supportive of family presence during cardiopulmonary resuscitation.[451] Healthcare professionals are increasingly offering family members the opportunity to remain present during resuscitation, and this is more likely if the resuscitation takes place within the delivery room. Parents' wishes to be present during resuscitation should be supported where possible.[43,452,453]

There is insufficient evidence to indicate an interventional effect from parental presence on patient or family outcome. Being present during the resuscitation of their baby seems to be a positive experience for some parents but there are concerns among professionals and family members that it may impair performance.[43,453]

In a single centre review of management of birth and resuscitation at the bedside, parents who were interviewed were supportive, but some found witnessing resuscitation difficult.[454] Clinicians involved felt the close proximity improved communication, but interviews suggested support and training in dealing with such situations might be required for staff.[455] In a retrospective survey of clinicians' workload during resuscitation the presence of parents appeared to be beneficial in reducing perceived workload.[456]

Qualitative evidence emphases the need for support during and after any resuscitation, without which the birth may be a negative experience with post traumatic consequences.[457,458] There should be an opportunity for the parents to reflect, ask questions about details of the resuscitation and be informed about the support services available.[452] It may be helpful to offer any parental witness of a resuscitation the opportunity to discuss what they have seen at a later date.[457,458]

Decisions to discontinue or withhold resuscitation should ideally involve senior paediatric staff.

The ERC recommends that where practically possible and parental inclination allows, parents should be supported and empowered to be present during the resuscitation of their newborn infant with appropriate support from staff. Decisions to discontinue or withhold resuscitation should involve senior paediatric staff.

Discontinuing or withholding treatment

Discontinuing resuscitation

Failure to achieve return of spontaneous circulation in newborn infants after 10–20 min of intensive resuscitation is associated with a high risk of mortality and a high risk of severe neurodevelopmental impairment among survivors. There is no evidence that any specific duration of resuscitation universally predicts mortality or severe neurodevelopmental impairment.

The outcomes of infants whose heart rate has been absent for longer than 10 min are not universally poor.[459–461] An ILCOR systematic review identified 13 studies involving 271 infants with at least 10 min of asystole, bradycardia or pulseless electrical activity. Of these infants, 70 % died, 18 % survived with moderate/severe neurodevelopmental impairment, and 11 % survived without moderate/severe impairment.[462] Another review identified 820 infants with absent heart rate >10 min after birth: 40 % survived; 21 % survived with moderate to severe neurodevelopmental impairment and 19 % without moderate or severe neurodevelopmental impairment.[463] A secondary analysis of the Optimising Cooling Trial, found that a 10-minute Apgar score of 0 alone did not predict well death or moderate or severe disability.[464] It can be helpful to consider clinical factors, effectiveness of resuscitation and the views of other members of the clinical team about continuing resuscitation.[465]

The ERC recommends discontinuing resuscitation after prolonged cardiopulmonary resuscitation if all recommended interventions have been applied and potentially reversible causes excluded. A reasonable time to consider this is around 20 min after birth.

In extremely preterm infants, prolonged resuscitation is associated with lower survival rates and higher morbidity; it may be appropriate to discontinue resuscitation sooner.[462,466] The decision should be individualized. The decision to cease resuscitation is a medical decision, but it is important, where possible, to give the family updates during the resuscitation and advance warning that there is a high chance the baby will not survive.

Withholding resuscitation

In situations where there is extremely high predicted mortality and severe morbidity in surviving infants, withholding resuscitation may be reasonable, particularly when there has been the opportunity for prior discussion with parents.[27–29,467,468] Examples from the published literature include extreme prematurity (GA <22 weeks and/or birth weight less than 350 g),[468] and anomalies such as anencephaly and bilateral renal agenesis. Withholding resuscitation and discontinuation of life-sustaining treatment during or following resuscitation are considered by many to be ethically equivalent and clinicians should not be hesitant to withdraw treatment when it would not be in the best interests of the infant.[469] The ERC recommends a consistent and coordinated approach to individual cases by the obstetric and neonatal teams which actively involves the parents. In conditions where there is low survival and a relatively high rate of morbidity, and where the anticipated burden to the child is high, parental wishes regarding resuscitation should be sought and supported.[444]

Declaration of competing interest

Declarations of competing interests for all ERC Guidelines authors are displayed in a COI table which can be found online at https://doi.org/10.1016/j.resuscitation.2025.110766.

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Practice Guideline

European Resuscitation Council Guidelines 2025 Special Circumstances in Resuscitation

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Abstract

These European Resuscitation Council (ERC) Guidelines 2025 on Special Circumstances in Resuscitation are based on the 2025 Consensus on Science with Treatment Recommendations (CoSTR) of the International Liaison Committee on Resuscitation (ILCOR), reviews by the expert writing group and relevant peer-reviewed literature. The guideline chapter provides guidance for laypeople and healthcare professionals on the modifications required to basic and advanced life support in adults for the prevention and treatment of cardiac arrest for in-hospital and out-of-hospital cardiac arrest. The ERC Guidelines 2025 Paediatric Life Support cover the special circumstances in children.

Keywords: Cardiac arrest, Special circumstances, Adults, Special causes, Special settings, Special patient populations

Introduction

Cardiac arrest, regardless of its aetiology, requires immediate intervention, involving rapid recognition, emergency request for assistance, and high-quality cardiopulmonary resuscitation (CPR), with minimal interruptions. Effective management involves the prompt identification and treatment of reversible causes, often summarised in the mnemonic '4Hs and 4Ts.' However, standard life support protocols are not universally applicable, as special circumstances need modifications to these guidelines. The ERC categorise these special circumstances into three parts:

1. Special causes leading to specific interventions.
2. Special settings where unique site factors or aetiologies require tailored approaches.

Abbreviations: ABC, Airway-Breathing-Circulation, ACE-I, Angiotensin converting enzyme inhibitors, AED, Automated external defibrillator, AFE, Amniotic fluid embolism, ALS, Advanced life support, BLS, Basic life support, CAB, Circulation - Airway - Breathing, CAD, Coronary artery disease, CKD, Chronic kidney disease, COPD, Chronic obstructive pulmonary disease, CPR, Cardiopulmonary resuscitation, CoSTR, Consensus on Science with Treatment Recommendations, DVT, Deep venous thrombosis, ECG, Electrocardiogram, ECMO, Extracorporeal membrane oxygenation, ECPR, Extracorporeal cardiopulmonary resuscitation, ED, Emergency department, EMS, Emergency medical services, ERC, European Resuscitation Council, $ETCO_2$, End tidal carbon dioxide, HCP, Healthcare professionals, HD, Haemodialysis, ICU, Intensive Care Unit, IHCA, In-hospital cardiac arrest, ILCOR, International Liaison Committee on Resuscitation, IM, Intramuscular, IV, Intravenous, LVAD, Left Ventricular Assist Device, MRA, Mineralocorticoid receptor antagonist, NIV, Non-invasive ventilation, OHCA, Out-of-hospital cardiac arrest, OR, Operating room, PAD, Public access defibrillator, PCI, Percutaneous coronary intervention, PE, Pulmonary embolism, PEA, Pulseless electrical activity, POCUS, Point of care ultrasonography, PPE, Personal protective equipment, RCT, Randomised controlled trial, REBOA, Resuscitative endovascular balloon occlusion of the aorta, ROSC, Return of spontaneous circulation, SCD, Sudden cardiac death, STEMI, ST-elevation myocardial infarction, TCA, Traumatic cardiac arrest, TOE, Transoesophageal echocardiography, VA-ECMO, Veno-arterial extracorporeal membrane oxygenation, VF, Ventricular fibrillation, VT, Ventricular tachycardia, WHO, World Health Organization

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3. Special patient populations, characterised by pre-existing conditions or comorbidities that require different modified treatment strategies.

These ERC Guidelines 2025 on Special Circumstances in Resuscitation are based on the 2025 annual Consensus on Science with Treatment Recommendations (CoSTR) of the International Liaison Committee on Resuscitation (ILCOR).[1] Many topics addressed in these Special Circumstances Guidelines were not part of the ILCOR review. Thus, several recommendations are based on consensus of the ERC Guidelines 2025 Special Circumstances in Resuscitation writing group based on additional systematic or scoping reviews or selected original articles Table 1. The broader methodology used for guideline development is presented in the Executive Summary.[2] These Guidelines were posted for public comments between 15 May and 30 May 2025. A total of 54 individuals submitted 66 comments, leading to 9 changes in the final version. Subsequently, the feedback was reviewed by the writing group, and the Guidelines was thereafter updated where relevant. The Guidelines were presented to, and approved by, the ERC Board and the ERC General Assembly in June 2025.

For the purpose of these Guidelines, the term CPR relates to the specific technical skills of cardiopulmonary resuscitation (e.g. performance metrics of chest compression and ventilation), whilst resuscitation is used as a generic term covering the broader range of skills and interventions. The term bystander is used to describe rescuers who happen to be at the scene to provide help, and the term first responder is used for those who have additional training and are alerted to attend the scene of a cardiac arrest. Healthcare Professionals (HCP) are defined as those who work in any healthcare sector (prehospital or in-hospital). Laypeople are persons not working in the healthcare sector. Basic Life Support (BLS) is defined as initiating the chain of survival, early high-quality chest compression, effective ventilation, and the early use of an AED. Any form of resuscitation education beyond BLS is described generically as advanced life support (neonatal, paediatric and adult life support). Where the term 'ALS' is used, this refers specifically to the ERC adult Advanced Life Support course.

The writing group of these ERC Guidelines 2025 on Special Circumstances in Resuscitation considered the recently introduced ERC approach to diversity, equality, equity, and inclusion and applied it whenever possible, recognising that this is a field for improvement in the development of evidence-informed guidelines. The ERC aims to advance resuscitation practices and improve patient care on a global scale (see Fig. 1). Table 1 showes changes in the ERC Resuscitation Guidelines Special Circumstances from 2021 to 2025.

Table 1 – This table provides a synopsis of the major changes in the ERC Guidelines 2025 Special Circumstances in Resuscitation. Guidance from the 2021 ERC Guidelines for Resuscitation that is not listed here is still valid and applicable.

	Summary of changes	
	ERC guidelines 2021	**ERC guidelines 2025**
Anaphylaxis	• There is no evidence that supports the routine use of either steroids or antihistamines	• Antihistamine administration should not delay the administration of adrenaline. • The ERC recommends against the routine use of corticosteroids.
Resuscitation in hyper/ hypokalaemia and other electrolyte disorders	• Protect the heart: Give 10 ml calcium chloride 10 % IV by rapid bolus injection. Consider repeating dose if cardiac arrest is refractory or prolonged.	• No evidence for or against use of IV calcium in hyperkalaemia. • ECG – record pre and post IV calcium. • Recommendation against the routine use of sodium bicarbonate in the treatment of hyperkalaemia in non-cardiac arrest cases. • Hyperkalaemia algorithm revised – emphasis on initiation of potassium-lowering treatments. Guidance in cardiac arrest added.
Hyperthermia, malignant hyperthermia and toxin induced hyperthermia		• Figure for treatment of malignant hyperthermia added. • Section on toxin-induced hyperthermia with table added.
Accidental hypothermia and avalanche rescue	• Scoring systems established	• Revised Swiss Staging for hypothermia, when core temperature cannot be measured. • Heart rate < 45/min as new high-risk criterion for hypothermia-induced cardiac arrest. • Criteria for qualification for extracorporeal life support do not apply for rewarming of arrested hypothermic patients, e.g. unwitnessed cardiac arrest, asystole as presenting arrhythmia. • New avalanche rescue algorithm. • BLS avalanche rescue algorithm for cases with insufficient personnel on site.

Table 1 (continued)

	Summary of changes	
	ERC guidelines 2021	**ERC guidelines 2025**
Pulmonary embolism		• Specific drug and dosage schemes added.
Coronary thrombosis	• Individualised approach concerning reperfusion strategy in NSTEMI patients was recommended. Brief evaluation to rule out non-coronary causes and performing urgent coronary angiography in case of suspected myocardial ischaemia were suggested.	• Assess 12-lead electrocardiogram after ROSC for ischaemic features and consider repeating if findings are inconclusive, since defibrillation and the time elapsed from ROSC may influence the results • High-certainty evidence from new RCTs discourages routine emergent/early coronary angiography in stable patients without ST-elevation or equivalent on ECG. Immediate angiography is recommended in case of haemodynamic instability or suspected ongoing ischaemia. • Indications for antiplatelet and anticoagulation treatment in this setting.
Toxic agents		• New update on intoxication with opioids.
Traumatic cardiac arrest	• New algorithm established • Invasive procedures introduced	• Algorithm clarified. • Role of chest compressions specified. • REBOA de-emphasised
Cardiac arrest in the catheterisation laboratory	• Mentioned but not specifically included in the management algorithm. • Point of care ultrasonography (POCUS) may be considered to identify reversible causes of cardiac arrest in this setting. • General recommendations were given to consider mechanical CPR, extracorporeal CPR and circulatory support devices in the catheterisation lab.	• Guidance on resuscitation team performance in the catheterisation lab: adequate radiation protective equipment, pre-alerting the surgical team if necessary, clearly defining roles and allowing the interventional cardiologist to focus on corrective procedures rather than leading CPR. • Specifies management of extreme bradycardia/ asystole complicating invasive procedures in the catheterisation lab, consider external or transvenous temporary pacing (included in the management algorithm). • Updated evidence on the role of POCUS and specific indications on the use of transoesophageal echocardiography in this setting. • Updated evidence on the role of mechanical CPR, extracorporeal CPR and circulatory support devices in the catheterisation lab, with specific indications for cardiac arrest in this setting. • New limited evidence on the use of intracoronary adrenaline as an alternative administration route for cardiac arrest in the catheterisation lab, highlighting the need for further research.
Drowning	• First responders not covered	• The introduction of the role of first responders in drowning resuscitation. • Clarifications regarding some topics such as the role of bystanders during rescue, spinal stabilisation, and the emphasis on ventilation by bystanders and first responders.
Cardiac arrest in the operating room	• Less detailed	• Sudden decrease in systolic pressure < 50 mmHg despite interventions is criterion to initiate chest compressions. • Lower initial IV adrenaline dose and increment dosing for perioperative cardiac arrest. • Early ECPR for patients with delayed ROSC. • Open chest compressions as an option solely for trained healthcare professionals. • Emphasis on human factors development.
Local anaesthetic systemic toxicity	• No treatment algorithm	• New detailed algorithm.
Resuscitation in cardiac surgery and Left Ventricular Assist Device patients	• LVAD patients not covered	• Revised algorithm for cardiac arrest after cardiac surgery. • Addition of cardiac arrest algorithm in Left Ventricular Assist Device patients.

(*continued on next page*)

Table 1 (continued)

	Summary of changes	
	ERC guidelines 2021	**ERC guidelines 2025**
Cardiac arrest in sports	• Short overview	• More robust and comprehensive data on incidence and survival. • Characterisation of causes by age group (±35 years). • Awareness about risk in recreational and non-elite athletes. • Specific guidance for high-attendance or televised events.
Resuscitation during transport	• Limited to team approach in EMS	• New subchapter Emergency Medical Services includes initial approach of two-member ALS crews, HEMS and air ambulances and the use of arterial line in the prehospital setting. • Inflight cardiac arrest is now expanded by CPR in microgravity.
Asthma & COPD		• New shortened algorithm
Resuscitation in haemodialysis patients	• Focus on haemodialysis unit	• Now focusing on haemodialysis patients rather than on the. • Infographic of resuscitation whilst on dialysis.
Resuscitation in obese patients		• No differences – Standard BLS and ALS recommended.
Resuscitation in patients with pectus excavatum	• Not addressed	• Reduced chest compression depth to 3–4 cm. • Increased force is required to deliver effective chest compressions in case of Nuss bar correction. • Use of anteroposterior pad placement for defibrillation.
Resuscitation during Pregnancy	• Defines maternal cardiac arrest as occurring during pregnancy and up to 6 weeks post-partum. • Recommends manual left uterine displacement; left lateral tilt discussed with caveats. • Recommends delivery within 5 min of collapse if no ROSC. • Use of 4Hs and 4Ts.	• Addendum to the ALS algorithm introducing maternal reversible causes ("4P" – (pre-eclampsia/ eclampsia, puerperal sepsis, placental/ uterine issues, peripartum cardiomyopathy) • adds global mortality statistics and highlights that pregnancy may not be clinically obvious • Suggests manual displacement as preferred, due to practicalities. • De-emphasises 5 min; emphasises immediate preparation for resuscitative hysterotomy. • Practical recommendation to remove fetal monitors to prevent burns. • IV/IO access above diaphragm when possible.

Concise guidelines for clinical practice

General recommendations

- Initiate resuscitation following the standard ALS algorithm in cardiac arrest.
- Always address hypoxia, hypovolaemia, electrolyte disorders, hypothermia, cardiac tamponade, tension pneumothorax, thrombosis, and toxic agents.
- Where appropriate, prioritise treating reversible causes, even if chest compressions are briefly interrupted.

Special causes

Management and prevention of cardiac arrest due to anaphylaxis

- Prompt recognition of anaphylaxis is crucial.
- Recognise anaphylaxis by the presence of airway, breathing, or circulation problems with or without skin and mucosal changes.
- Remove or stop the trigger if immediately feasible.
- Immediately inject intramuscular adrenaline 0.5 mg at first suspicion of anaphylaxis and repeat if no improvement occurs within 5 min.
- Give an IV crystalloid fluid bolus early and monitor the response.

Hyper/hypokalaemia and other electrolyte disorders

Hyperkalaemia (Fig. 2)

- Shift potassium into cells
  - o Give 10 units soluble insulin and 25 g glucose IV for treatment of moderate and severe hyperkalaemia. Follow with 10 % glucose infusion at 50 ml/hr for 5 h if pre-treatment blood glucose < 7 mmol/l.
  - o Give nebulised salbutamol (10–20 mg) for moderate and severe hyperkalaemia, as an adjunct to Insulin-glucose therapy.
- Antagonise the effect of hyperkalaemia

SPECIAL CIRCUMSTANCES IN ADULT RESUSCITATION
KEY MESSAGES

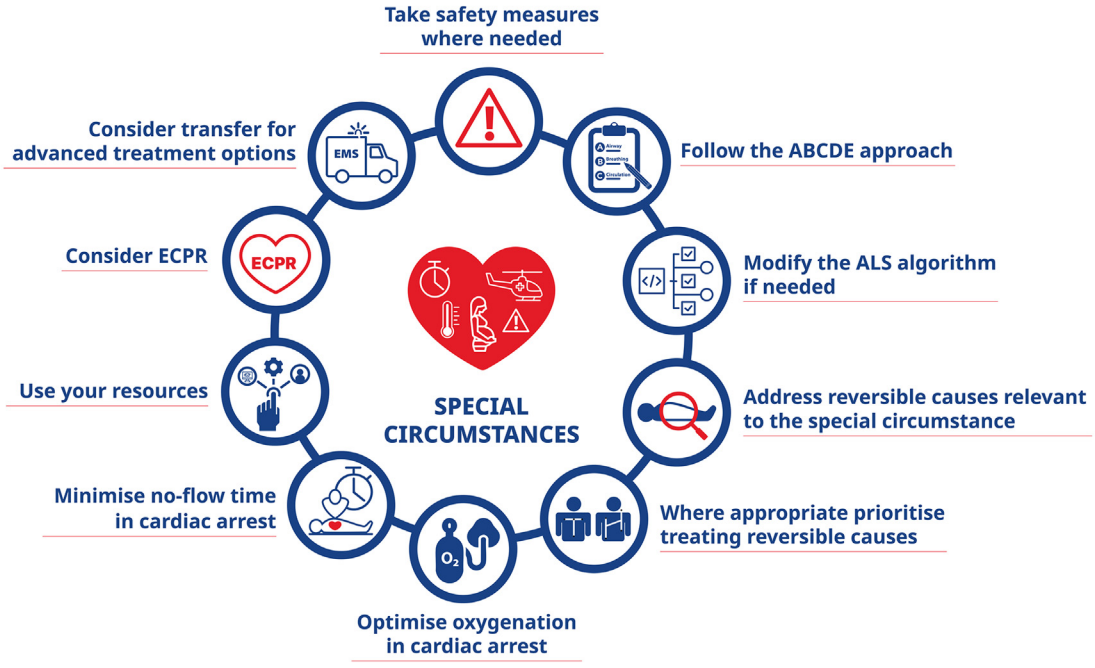


Fig. 1 – Key messages of the ERC Guideline 2025 Special Circumstances in Resuscitation.

- Use IV 10 mL 10 % calcium chloride for patients with severe hyperkalaemia with ECG changes.
- Administer IV 10 mL 10 % calcium chloride and 50 mmol sodium bicarbonate, through separate lines or with flush in between, in the treatment of hyperkalaemic cardiac arrest in all settings of severe hyperkalaemia.

- Remove potassium from the body
  - Give sodium zirconium cyclosilicate 10 g orally.
  - Consider dialysis for patients with refractory severe hyperkalaemia.
- Consider ECPR in accordance with local protocols if initial resuscitation attempt is unsuccessful.

Hypokalaemia

- Treatment is guided by the severity of hypokalaemia and presence of symptoms and/or ECG abnormalities.
- Where appropriate replace potassium and correct magnesium deficit concurrently.
- Give IV 20 mmol potassium chloride over 2–3 min, followed by 10 mmol over 2 min in hypokalaemic cardiac arrest then monitor K^+ level and adjust infusion rate accordingly.

Hyperthermia, malignant hyperthermia and toxin-induced hyperthermia

Hyperthermia

- Measure core temperature to guide treatment.
- Move patient to a cool environment.
- Simple external cooling may involve conductive, convective and evaporative measures (See ERC Guidelines 2025 First Aid).[3]
- With heat syncope and heat exhaustion quick removal to a cool place, simple external cooling and provision of fluids are sufficient
- With heat stroke prioritise active cooling methods that achieve the most rapid cooling rate such as application of ice and cold-water immersion (Fig. 3).

Malignant hyperthermia

QR code. 1 – Malignant hyperthermia algorithm.
Treatment of malignant hyperthermia, modified from (Hopkins et al., 2021)[91] and (Kollman-Camaiora et al., 2017).[109]

- Stop triggering agents immediately. This includes turning off and removing vaporiser and changing the ventilator circuit.
- Give IV 2.5 mg/kg dantrolene as soon as possible.
- Start active cooling.
- Give 100 % oxygen and aim for normocapnia using hyperventilation.
- Change the ventilator. If the ventilator cannot be changed, change charcoal filters

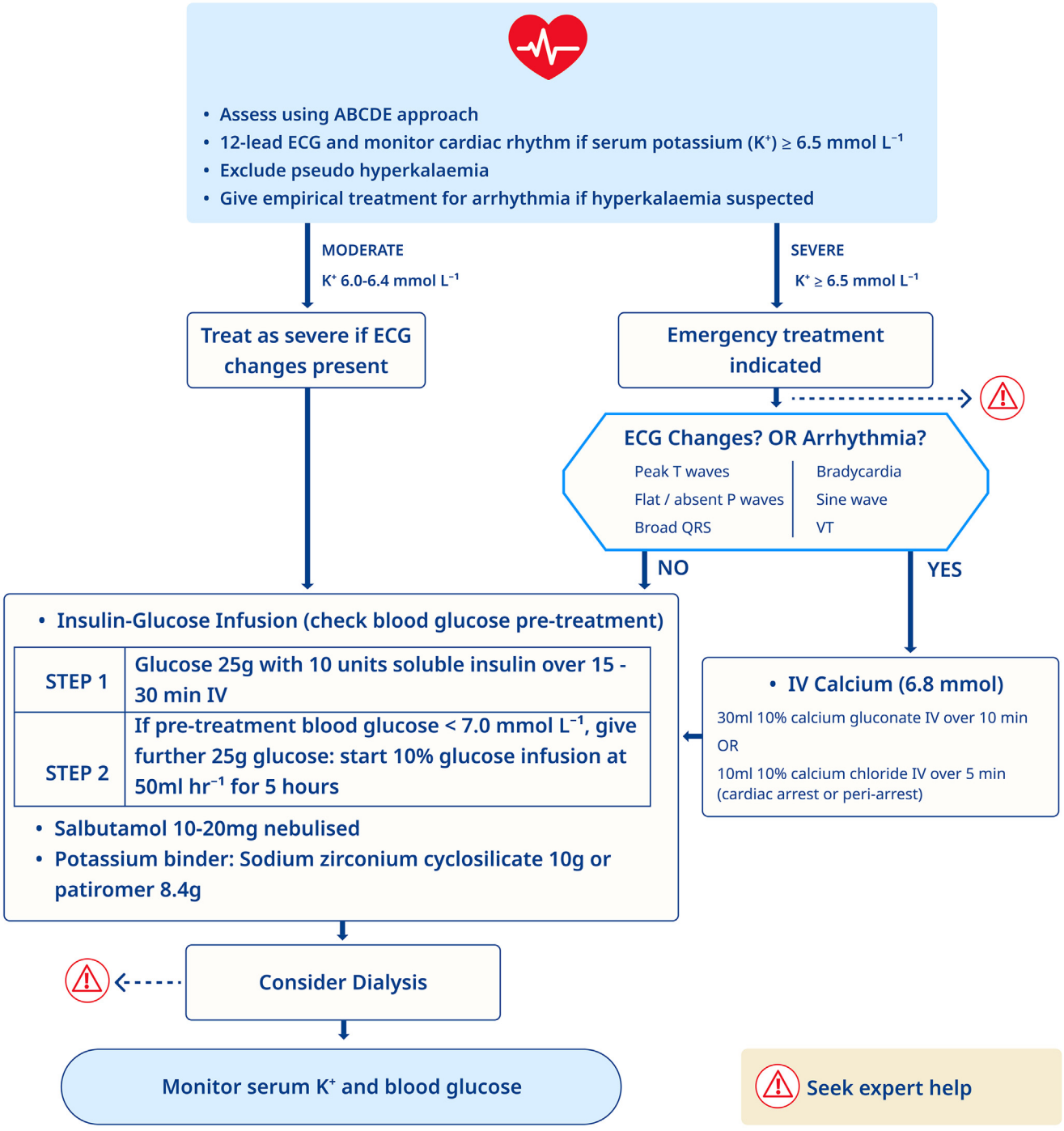


Fig. 2 – Treatment algorithm of hyperkalaemia in adults.
ABCDE – airway breathing circulation disability exposure, ECG – electrocardiography, IV – intravenous, VT – ventricular tachycardia, K – potassium.

- Contact a malignant hyperthermia centre for advice and follow-up.

Toxin-induced hyperthermia

- Minimise exposure and absorption of the toxin.
- Use active cooling techniques. Antipyretics have no benefit as central thermoregulatory mechanisms are affected by toxins.

Accidental hypothermia and avalanche rescue

Accidental hypothermia

- Check vital signs for up to one minute in an unconscious hypothermic patient (Fig. 5).
- Measure core temperature with a low reading thermometer to diagnose accidental hypothermia.
- Use the Swiss Staging System if core temperature cannot be measured.

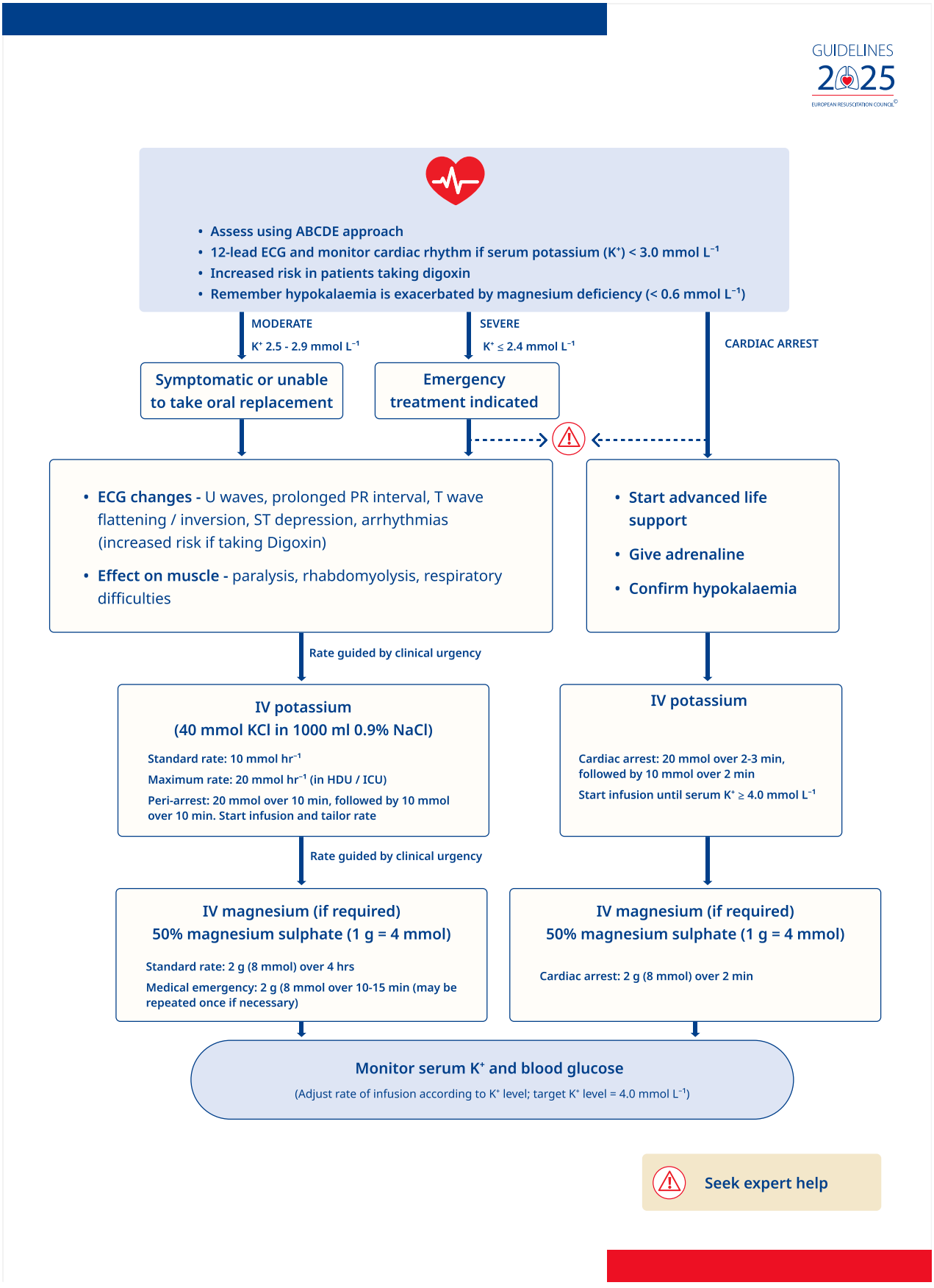


Fig. 3 – Treatment algorithm of hypokalaemia in adults.
ABCDE – airway breathing circulation disability exposure, ECG – electrocardiography, IV – intravenous.

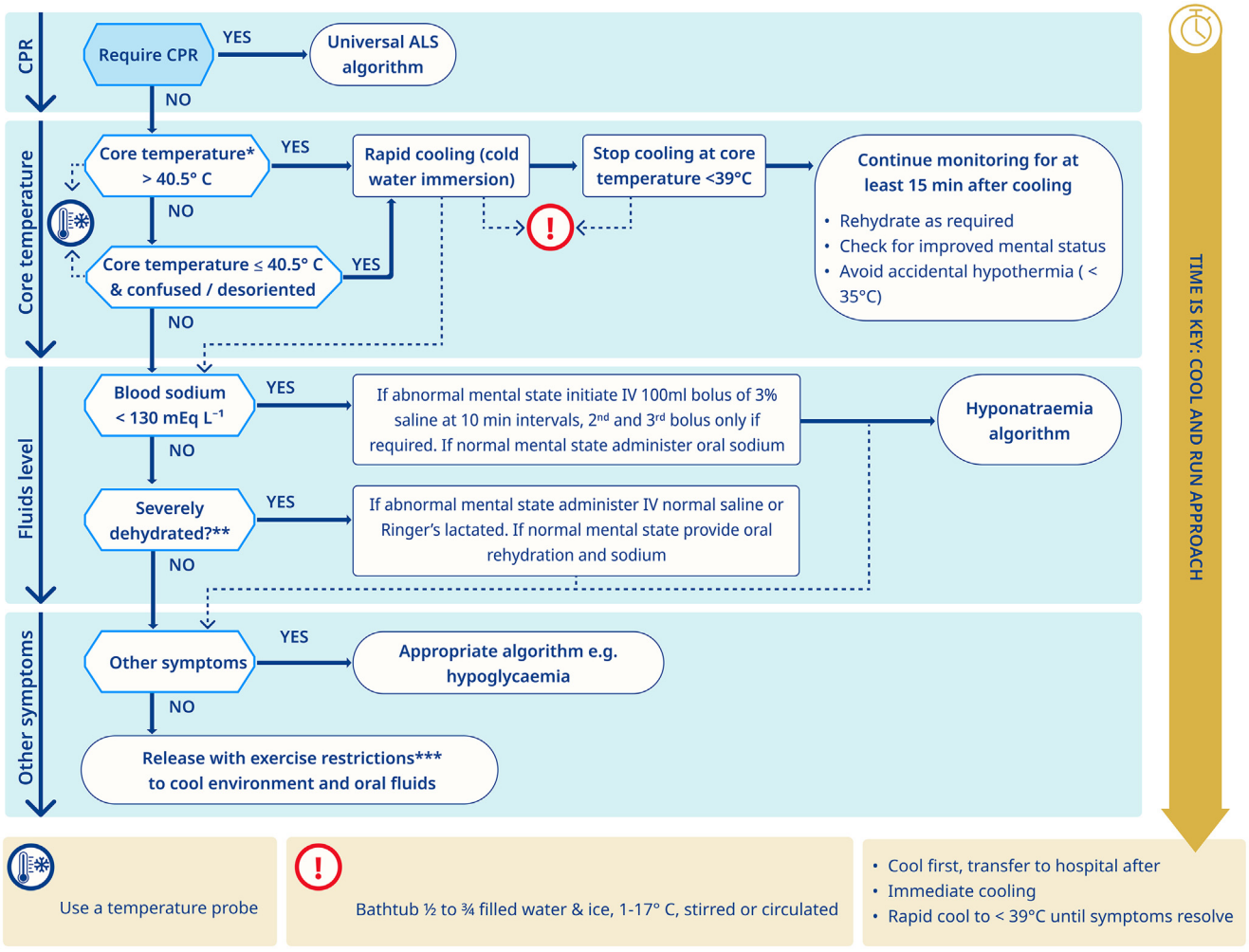


Fig. 4 – Emergency treatment of hyperthermia.
CPR – cardiopulmonary resuscitation, ALS – advanced life support. Footnote: *Core temperature should be measured, e.g. tympanic, rectal, or oesophageal. ** Dry mouth, thirsty, hypotensive. ***Return to activity considerations following a diagnosis of exertional heat illness and exertional head stroke have been published recently elsewhere. [96,99.]

- Transfer hypothermic patients with risk factors for imminent cardiac arrest and those in cardiac arrest directly to an extracorporeal life support (ECPR) centre for rewarming.
- Delay CPR or use intermittent CPR in hypothermic cardiac arrest patients with a core temperature below 28 °C when immediate or continuous CPR is not feasible.
- Delay further defibrillation attempts if ventricular fibrillation (VF) persists after three shocks until core temperature is > 30 °C.
- Below 30 °C adrenaline will accumulate and may have more detrimental than beneficial effects. Give IV 1 mg adrenaline once to facilitate ROSC unless planning imminent initiation of ECPR. Increase administration intervals for adrenaline to 6–10 min if the core temperature is 30–35 °C.
- Consider use of a mechanical CPR device if transport is prolonged, or when there are difficulties with the terrain.
- Base in-hospital prognostication of successful rewarming on the Hypothermia Outcome Prediction after Extracorporeal Life Support (HOPE) score.
- Rewarm hypothermic arrested patients with veno-arterial extracorporeal membrane oxygenation (VA-ECMO).
- Initiate non-extracorporeal life support rewarming if an ECPR centre cannot be reached within a reasonable time (e.g. 6 h).

Avalanche rescue

- Base initiation of CPR in cardiac arrest on core temperature, burial time, and airway patency (Fig. 6).
- Consider proceeding according to the AvaLife algorithm, in multi-burial avalanche accidents with BLS providers only and insufficient numbers of rescuers.

Thrombosis

Pulmonary embolism

- Consider pulmonary embolism in all patients with sudden onset of progressive dyspnoea and absence of known heart or pulmonary disease.
- Obtain 12-lead ECG (exclude acute coronary syndrome, look for right ventricular strain).

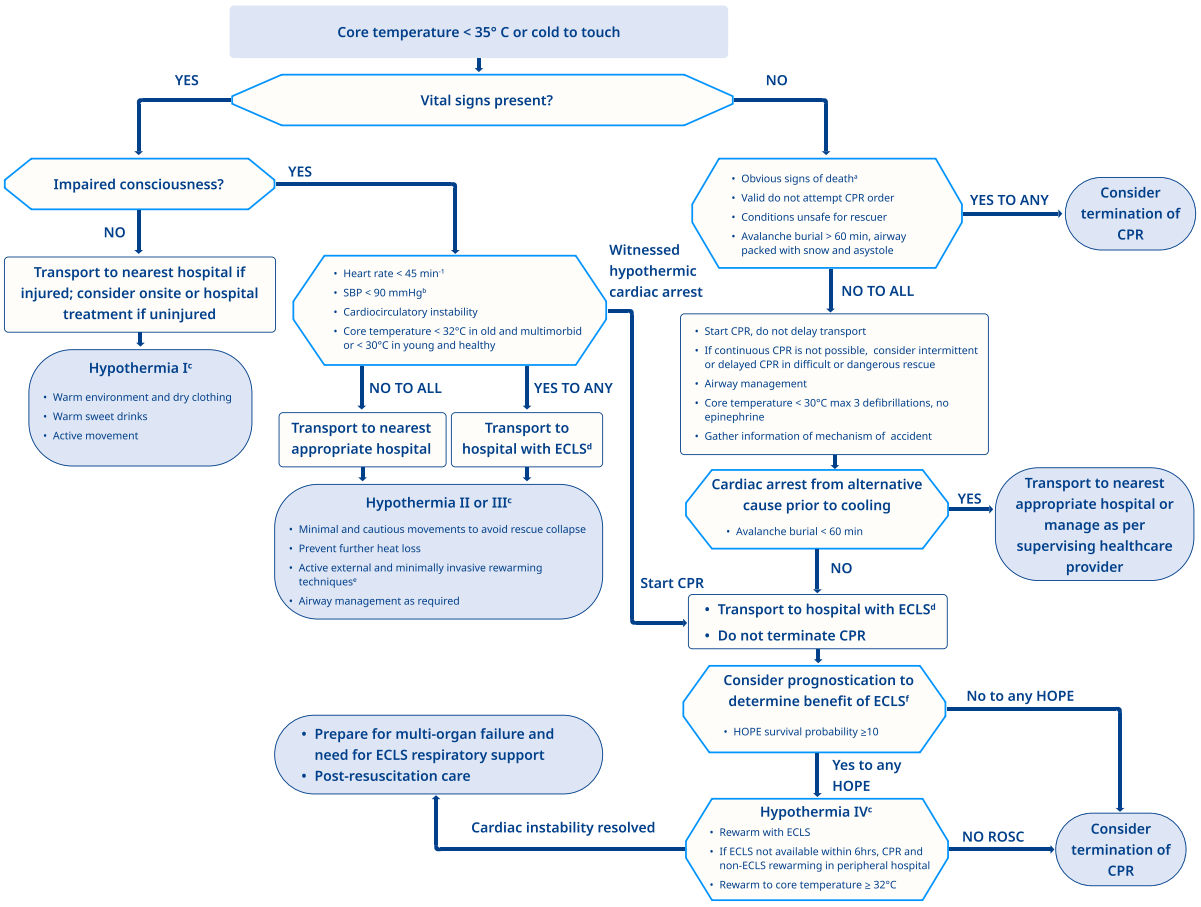


Fig. 5 – Emergency treatment of accidental hypothermia.

[a] Decapitation; truncal transection; whole body decomposed or whole body frozen solid (chest wall not compressible). [b] Systolic blood pressure < 90 mmHg is a reasonable prehospital estimate of cardiocirculatory instability but for in-hospital decisions, the minimum sufficient circulation for a deeply hypothermic patient (e.g., <28 °C) has not been defined. [c] Swiss staging of accidental hypothermia. [d] Direct transport to an ECLS centre is recommended in an arrested hypothermic patient. In remote areas, transport decisions should balance the risk of increased transport time with the potential benefit of treatment in an extra corporal life support centre. Transfer should be commenced if such a centre can be reached within 6 h. [e] Warm environment, chemical, electrical, or forced air heating packs or blankets, and warm IV fluids (38–42 °C). In case of cardiac instability refractory to medical management, consider rewarming with extra corporal life support. [f] If the decision is made to stop at an intermediate hospital to measure serum potassium, a hospital enroute to an extra corporal life support centre should be chosen. The HOPE score [156,158,162] should not be used in children, consider expert consultation instead. ECLS extracorporeal life support, ROSC return of spontaneous circulation, SBP systolic blood pressure.

- Identify haemodynamic instability and high-risk pulmonary embolism.
- Perform bedside echocardiography.
- Initiate anticoagulation therapy (heparin 80 IU/kg IV) during diagnostic process, unless signs of bleeding or absolute contraindications.
- Confirm diagnosis with computed tomographic pulmonary angiography.
- Consider surgical embolectomy or catheter-directed treatment as alternative to rescue fibrinolytic therapy in rapidly deteriorating patients.

Cardiac arrest due to pulmonary embolism.

- Low $ETCO_2$ values (<1.7 kPa/13 mmHg) while performing high quality chest compressions may support a diagnosis of pulmonary embolism, although it is a non-specific sign.
- Use fibrinolytic drugs for cardiac arrest when pulmonary embolism is the suspected cause of cardiac arrest.
- Use fibrinolytic drugs or surgical embolectomy or percutaneous mechanical thrombectomy for cardiac arrest when pulmonary embolism is the known cause of cardiac arrest.
- Consider ECPR as a rescue therapy for selected patients with cardiac arrest when conventional CPR is failing in settings in which it is implemented.

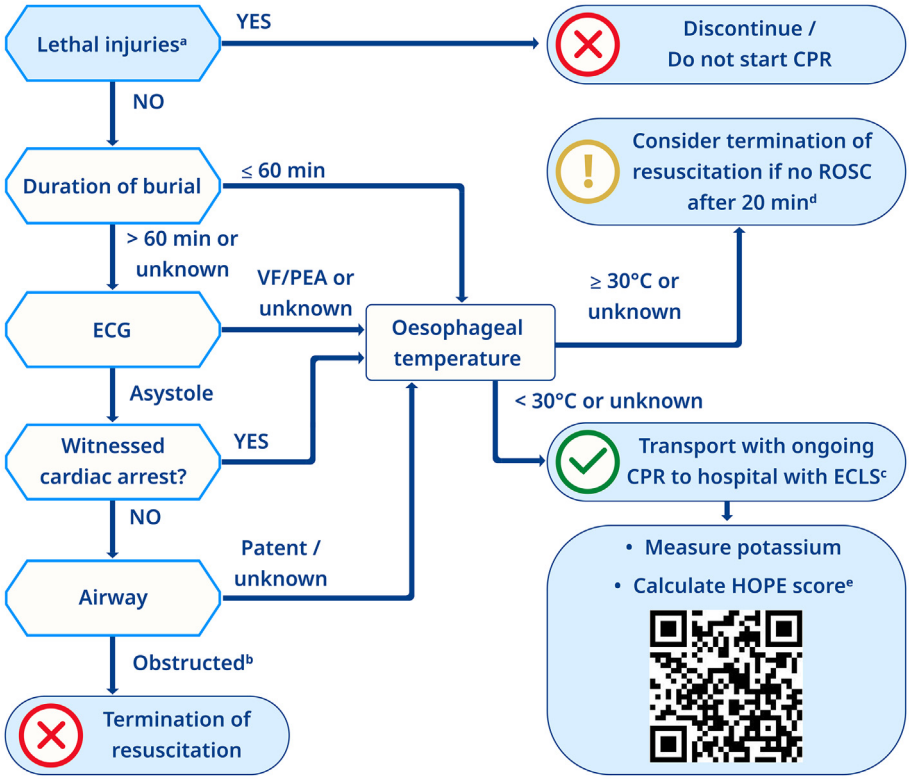


Fig. 6 – Decision-making algorithm for advanced management of critically buried avalanche victims in cardiac arrest.[188]

CPR – cardiopulmonary resuscitation, ROSC – return of spontaneous circulation, ECLS – extracorporeal life support, HOPE – Hypothermia Outcome Prediction after ECLS rewarming for hypothermic arrested patients, ECG – electrocardiography. [a] Decapitation, truncal transection, whole body decomposed. [b] An obstructed or blocked airway requires that both the nose and mouth be completely filled with compact snow or debris. [c] With a deeply hypothermic patient (<28 °C), if rescue is too dangerous consider delayed CPR and if transport is difficult consider intermittent CPR. [d] If core temperature measurement is not available, hypothermic CA may be considered, at the rescuer's discretion, despite a burial duration of < 60 min in a victim with a patent airway and no vital signs when there is a possibility if very rapid cooling (e.g. burial during ascent, low body mass index or small persons, minimally dressed, sweating before burial). [e] In-hospital prognostication of successful rewarming in an avalanche victim should include estimation of the survival probability using the HOPE score. If any doubt exists whether the avalanche victim may have asphyxiated despite critical burial, the HOPE score should be calculated using the NON-ASPHYXIA option. This will reduce the risk of under-treatment. If the HOPE score cannot be determined, the combination of potassium < 7 mmol L^{-1} and a temperature < 30 °C may be used instead to help indicate ECLS rewarming.

- Set-up a multidisciplinary team for making decisions on management of high-risk pulmonary embolism depending on local resources.

Coronary thrombosis

- Enhance health education to recognise symptoms and minimise delays in seeking medical care
- Promote BLS training for likely rescuers of high-risk groups.
- Strengthen regional networks to ensure timely percutaneous coronary intervention (PCI).
- Transfer the patient to a centre with PCI capability and activate existing STEMI networks in case of ST-elevation or suspected ongoing ischaemia.
- In patients with sustained ROSC and ST-elevation on ECG:
  - o Perform immediate coronary angiography (and PCI if required) within 120 min of diagnosis.
  - o Consider fibrinolysis in pre-hospital and non-PCI-capable settings if greater delay is expected.
- In patients with sustained ROSC and no ST-elevation on ECG:
  - o Consider immediate coronary angiography (and PCI if required) if the patient is haemodynamically unstable or shows signs of ongoing ischaemia.
  - o In stable patients without ischaemic signs, emergent cardiac catheterisation laboratory evaluation should not be systematic and can be delayed if there is no estimated high probability of acute coronary occlusion.
  - o Assess for non-coronary-causes if the clinical context suggests an alternative aetiology of the arrest.
  - o Unless on-going resuscitation is considered futile, transfer patients without sustained ROSC with ongoing CPR, to a PCI centre for consideration for angiography or ECPR depending on available resources and team expertise.

Toxic agents

- Ensure your personal safety (Fig. 7), as direct skin contact (e.g., mouth-to-mouth ventilation) might transmit toxic agents.

- Assess all patients in cardiac arrest for potential intoxication.
- Reduce absorption, consider using specific treatment measures as antidotes, decontamination and enhanced elimination.
- Administer antidotes, where available, as soon as possible.
- Be prepared to continue resuscitation for a prolonged period of time, as the toxin concentration may fall as it is metabolised or excreted during extended resuscitation measures.
- Consult regional or national poison centres for information on treatment of the poisoned patient.

Traumatic cardiac arrest (TCA)

- Traumatic cardiac arrest is different from cardiac arrest due to medical causes; this is reflected in the treatment algorithm (Fig. 8).
- The response to traumatic cardiac arrest is time-critical and success depends on a well-established chain of survival, including focused pre-hospital and specialised trauma centre care.
- Early and aggressive management of reversible causes (e.g. haemorrhage control, airway management, chest decompression) is essential for survival.
- Ultrasound aids in identifying the cause of cardiac arrest and guides resuscitative interventions.

Special settings

Cardiac arrest in the catheterisation laboratory

- Promote adequate training of the staff in technical skills and ALS, and consider periodic emergency drills.
- Ensure emergency equipment is readily available and functional.
- Plan elective procedures carefully to minimise potential complications and promote the use of safety checklists.
- Consider echocardiography in case of haemodynamic instability or suspected complication.
- Resuscitate according to the ALS algorithm, BUT modify:
  - Apply 3 consecutive shocks in case of shockable rhythm.
  - Consider external or transvenous pacing for extreme bradycardia.
- Consider, in selected cases depending on clinical context, team expertise and availability:
  - Mechanical CPR, if manual compression is not feasible or safe for the provider.
  - Extracorporeal CPR in selected patients with refractory cardiac arrest, especially if it allows for critical procedures to correct reversible causes.
  - Circulatory support devices, for selected patients in cardiogenic shock after achieving ROSC.

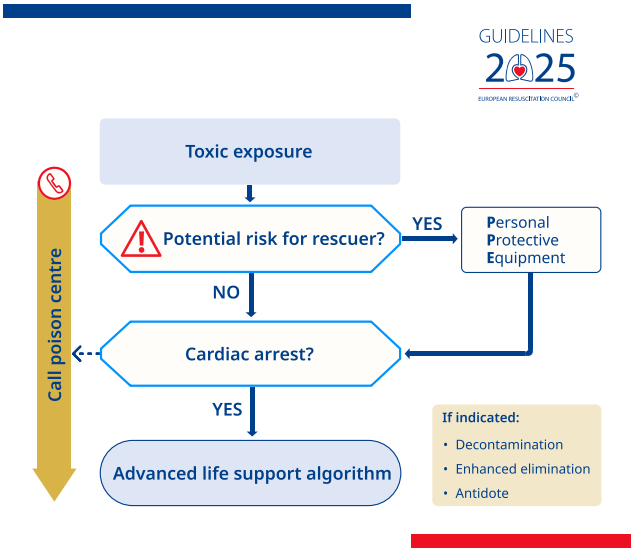


Fig. 7 – Management of toxic exposure.

Drowning

- Rescuers and first responders should prioritise their safety and use the safest rescue technique.
- Bystanders should call for professional help and use rescue techniques with which they feel confident, based on their competencies.
- First responders should use rescue material and flotation devices they are trained to use.
- Spine immobilisation in water should not delay removing the victim from the water when resuscitation is required.
- Start with 5 ventilations using 100 % inspired oxygen when available, continue with standard CPR protocol.
- Airway and ventilation equipment can be used when the provider is trained appropriately.
- Increase ventilation pressure gradually when a high inspiration pressure is needed, in order to avoid stomach inflation.
- Consider scaling up to ECPR if initial resuscitation is unsuccessful, in accordance with local protocols.
- Follow the recommendations for hypothermia.

Cardiac arrest in the operating room (OR)

- Prevent and mitigate the risk of cardiac arrest through preoperative screening and identification of high-risk patients, clear communication with surgeons about potential critical procedures, advanced monitoring and continuous presence of an anaesthesiologist during patient instability.
- Start chest compressions if the systolic blood pressure suddenly decreases below 50 mmHg, in association with fall in $ETCO_2$, despite appropriate interventions.
- Inform the surgeon and the operating room team of the cardiac arrest.
- Initiate high-quality chest compressions and adjust the height of the operating table to improve work efficiency.
- Ensure the airway is secure, review the $ETCO_2$ tracing, and deliver effective ventilation, administering 100 % oxygen. Exclude unrecognised oesophageal intubation.
- Use ultrasound to guide resuscitation addressing the reversible causes.
- Exclude tension pneumothorax.
- Consider early ECPR as therapy for selected patients when conventional CPR is failing.
- Trained healthcare professionals may consider open chest cardiac compression in specific cases as an alternative, if ECPR is unavailable.
- Human factors are crucial to improve survival of intraoperative cardiac arrest – ensure familiarity with equipment, assign strategies and roles during surgical team time-outs and include perioperative cardiac arrest in multidisciplinary and interprofessional team training, in-situ simulation, and ALS courses.

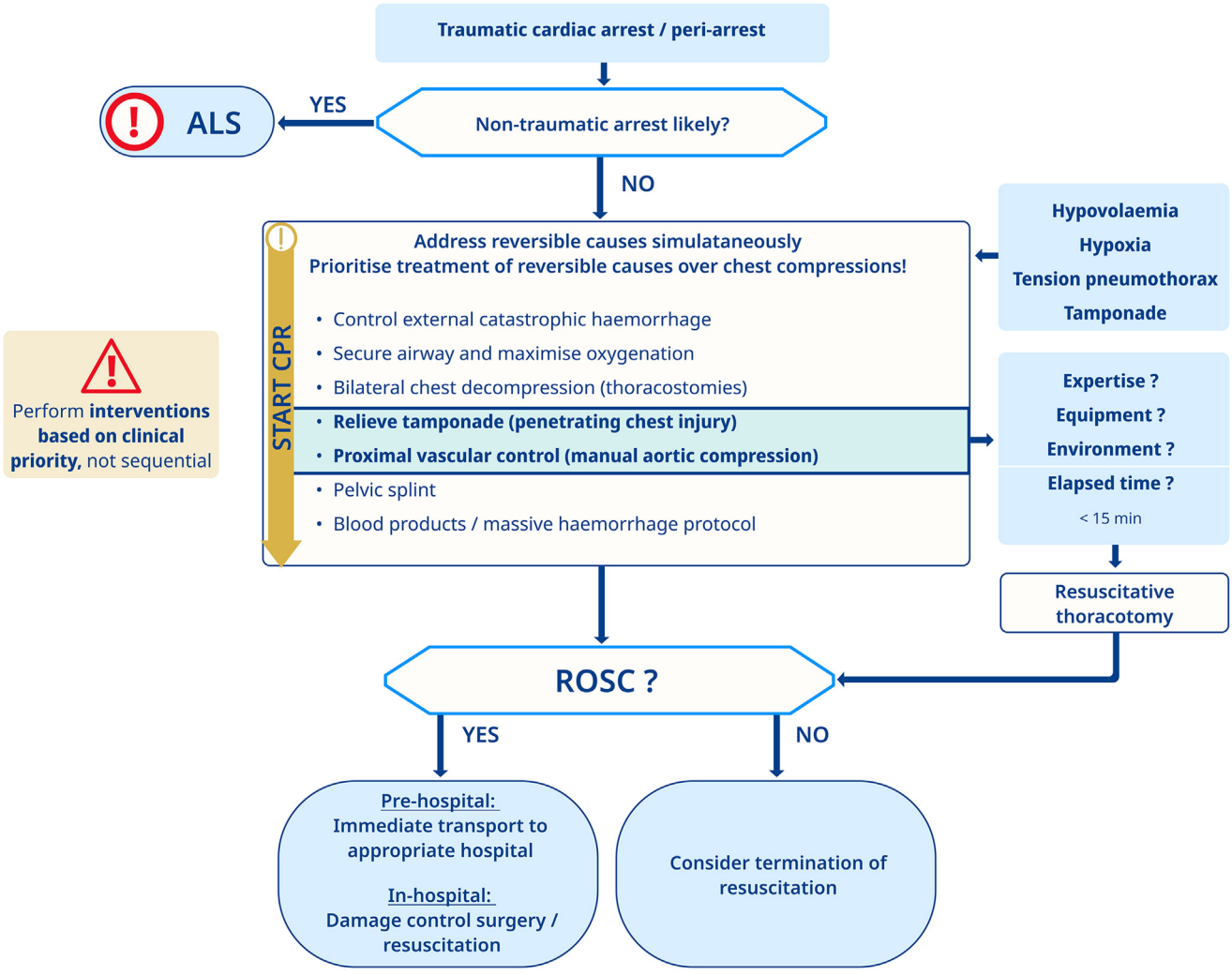


Fig. 8 – Traumatic cardiac arrest algorithm.
ROSC – return of spontaneous circulation, ALS – advanced life support. This algorithm should be used to guide the management of traumatic cardiac arrest (TCA) and peri-arrest trauma patients with impending circulatory collapse. In contrast to the sequential ALS algorithms, it is a framework for context-sensitive decisions on clinically prioritised interventions. The aim is to treat the most urgent, reversible cause based on individualised treatment (e.g. patients with a cardiac tamponade need urgent thoracotomy; patients with pelvic fracture in haemorrhagic shock but with a stable airway may benefit more from immediate application of a pelvic binder and rapid transfer without airway intervention).

Local anaesthetic systemic toxicity

- Stop the local anaesthetic if possible.
- Hyperventilate the patient to increase plasma pH if metabolic acidosis is present.
- Give a lower adrenaline dose ($\leq$1 μg kg^{-1} instead of 1 mg IV bolus)
- Give an initial IV bolus of 20 % lipid emulsion at 1.5 mL kg^{-1} over 1 min, followed by an infusion at 0.25 mL kg^{-1} min^{-1} but do not exceed a maximum cumulative dose of 12 mL kg^{-1} IV 20 % lipid emulsion.
- If ROSC has not been achieved at 5 min, double the rate of lipid infusion and give a maximum of two additional lipid boluses at 5-minute intervals until ROSC has been achieved.
- Consider prolonged resuscitation (>1 h) and ECPR
- Treat seizures by administering benzodiazepines

Cardiac surgery

- Confirm cardiac arrest by clinical signs and pulseless pressure waveforms.
- Consider ultrasound to identify reversible causes.
- Provide up to 3 consecutive shocks in VF/pVT
- Use epicardial pacing at maximum output in asystole or extreme bradycardia
- Perform re-sternotomy up to 10 days post-surgery within 5 min regardless of the patient's location.

- Provide open cardiac compressions once the chest is reopened.
- Reduce IV adrenaline dose (0.05–0.1 mg)
- Consider ECPR for prolonged resuscitation or minimally invasive cases where reopening may be delayed

Left ventricular assist device (LVAD) patients

- Immediately activate specialised teams for unconscious LVAD patients.
- Start CPR while simultaneously attempting to restore device function if multiple rescuers are available.
- Consider delaying CPR for up to 2 min to attempt device restoration if a single rescuer is present.
- Troubleshoot device issues as a priority, following relevant protocols.

Cardiac arrest in sports

- Screening as primary prevention plays an important role, but remains controversial.
- All sports and exercise facilities should undertake a risk assessment which considers the likelihood and consequence of cardiac arrest and put in place mitigation strategies to reduce the risk.
- Gain immediate and safe access to the field of play.
- Awareness programs in sport events have proven to be feasible to raise awareness amongst target groups not yet involved with cardiac arrest.

Emergency medical services

- Healthcare professionals should provide resuscitation at the scene rather than undertake ambulance transport with ongoing resuscitation, unless there is an appropriate indication to justify transport (bridging to in-hospital treatment).
- Consider mechanical CPR for transport with ongoing resuscitation.
- Consider obtaining invasive arterial blood pressure to guide resuscitation and post-resuscitation care already in the prehospital setting if it is feasible.
- EMS systems should use registry and data provided from equipment data (e. g. defibrillators) for debriefing and continuous quality improvement.

Inflight cardiac arrest and microgravity resuscitation

Inflight cardiac arrest

- Healthcare professional help should be sought (in-flight announcement).
- The rescuer should kneel in the leg-space in front of the aisle seats to perform chest compressions if the patient cannot be transferred within a few seconds to an area with adequate floor space (galley).
- Overhead-CPR is a possible option in limited space environments.
- Airway management should be based on the equipment available and the expertise of the rescuer.
- If the planned route leads over an area where no airport can be reached for a longer period of time with high possibility of ROSC during an ongoing resuscitation, consider an early diversion.

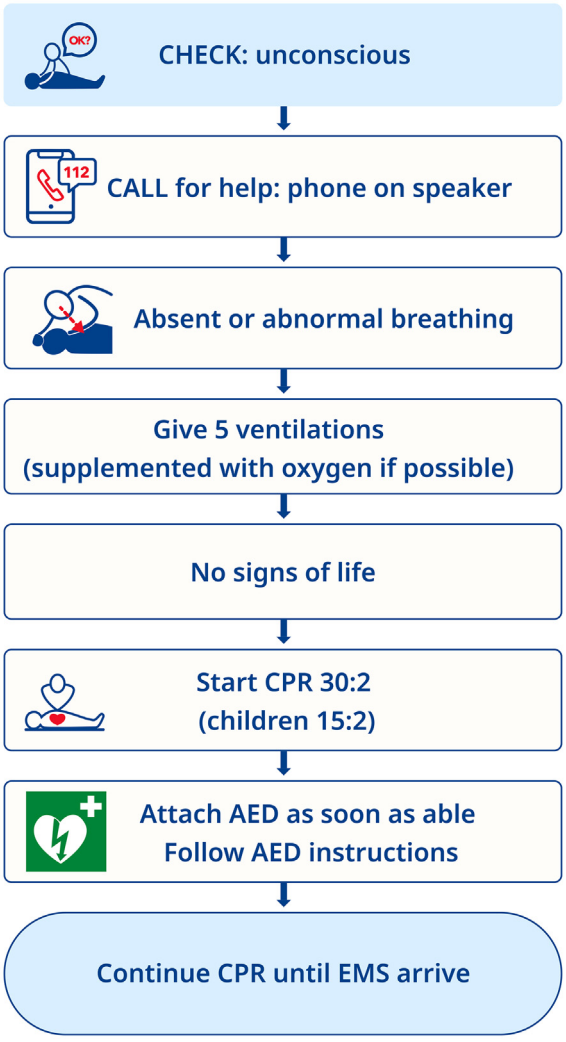


Fig. 9 – CPR after drowning for rescuers with a duty to respond.
CPR – cardiopulmonary resuscitation, EMS – emergency medical services, AED – automatic external defibrillator.

- Consider risks of diversion if ROSC is unlikely and give appropriate recommendations to the flight crew.
- If CPR is terminated (no ROSC) there is no medical need for flight diversion – follow airline policy.

Microgravity resuscitation

- Airway management, defibrillation and IV/IO access are similar to terrestrial ALS, but only once the patient is secured.
- Consider mechanical CPR
- Consult telemedicine support during cardiac arrest in low earth orbit if feasible and manpower allows.
- The crewmember with the highest medical qualification should decide on termination of resuscitation, consulting telemedicine support.

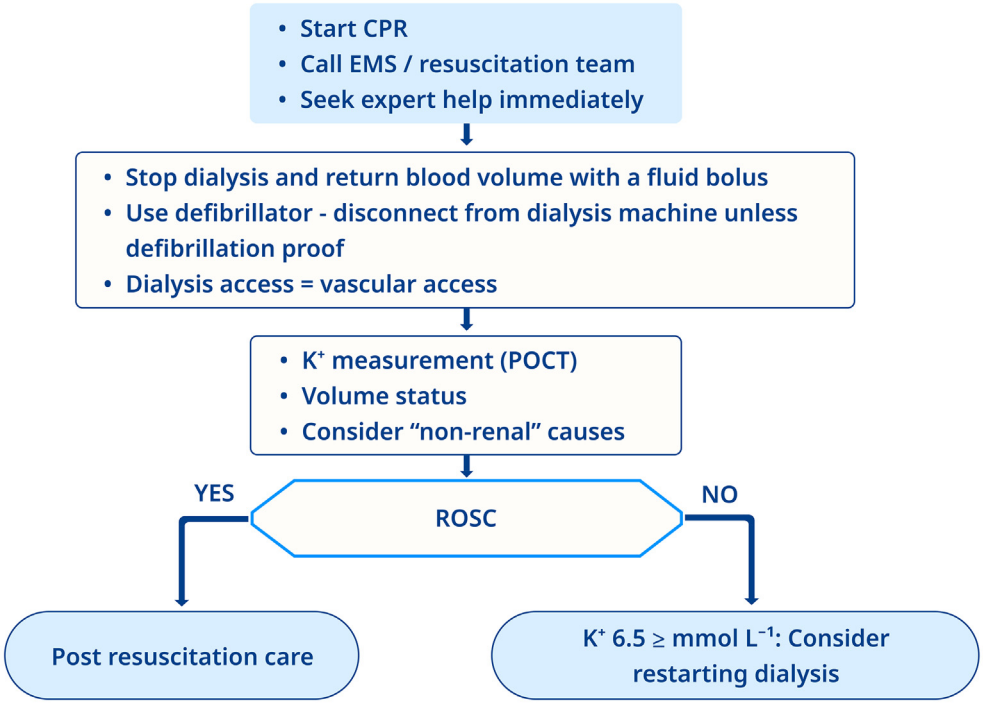


Fig. 10 – Cardiac arrest during dialysis.
Abbreviations: CPR – cardiopulmonary resuscitation; EMS – emergency medical services; K+ – potassium; HD – haemodialysis; ROSC – return of spontaneous circulation; POCT – point of care testing.

Cruise ship

- Use all healthcare resources immediately (personal, equipment).
- Activate helicopter emergency medical service if close to the coastline.
- Consider early telemedicine support.
- Have all equipment needed for ALS available on board.
- In case of insufficient number of health care professionals to treat CA, call for further medical staff via an on-board announcement.

Special patient groups

Asthma and chronic obstructive pulmonary disease

- Treat life-threatening hypoxia with 100 % oxygen.
- Check for evidence of (tension) pneumothorax.
- Provide endotracheal intubation (because of high inflation pressures).
- Consider manual decompression and disconnection from ventilator to manage dynamic hyperinflation.
- Consider ECPR in accordance with local protocols if initial resuscitation efforts are unsuccessful.

Cardiac arrest in haemodialysis patients

- Assign a trained dialysis nurse or technician to operate the dialysis machine.
- Stop dialysis and return the patient's blood volume with a fluid bolus.
- Disconnect from dialysis machine (unless defibrillation-proof) and beware of wet surfaces.
- Leave dialysis access open and use for drug administration.
- Dialysis may be required in the early post resuscitation period.

Resuscitation in obese patients

- Obese patients should receive standard resuscitation treatment – no deviation from standard BLS and ALS is needed.

Resuscitation in patients with pectus excavatum

- Consider reduced chest compression depth of 3–4 cm.
- In the case of a Nuss bar correction, substantially increased force is required to deliver effective chest compressions.
- Consider early implementation of ECPR if chest compressions are ineffective.
- Use anteroposterior pad placement for defibrillation using standard energies.

Cardiac arrest in pregnancy

- Consider pregnancy in any collapsed woman of childbearing age.
- Pregnant and peripartum women can deteriorate to cardiac arrest anywhere and medical facilities and services must be prepared for such events.

- Obstetric-specific early warning systems enable early recognition of deteriorating pregnant patients.
- Relieve aortocaval compression as early as possible and maintain it throughout resuscitation. Manual left uterine displacement in maternal cardiac arrest is suggested due to practicalities.
- Systematically address the 4Hs and 4Ts and seek pregnancy-specific causes of cardiac arrest, the 4Ps: Pre-eclampsia and eclampsia, Puerperal sepsis, Placental and uterine complications and Peripartum cardiomyopathy.
- Resuscitative hysterotomy is a time-sensitive intervention. Preparation to perform the procedure should be undertaken early.
- Resuscitative hysterotomy should be performed as soon as possible at the site of cardiac arrest by a skilled team.
- Post-resuscitation care in pregnant and postpartum women requires a multidisciplinary approach.

The evidence informing the guidelines

Special causes

Management and prevention of cardiac arrest due to anaphylaxis

There is no universally accepted definition of anaphylaxis. It is an acute systemic hypersensitivity reaction, usually rapid in onset and may be fatal if not appropriately managed. Diagnosis of anaphylaxis is clinical.

The estimated incidence of anaphylaxis is 1.5–7.9 per 100.000 persons per year in Europe.[4] The most common triggers of anaphylactic reactions are food, medications and hymenoptera venom.[5–7]

This guidance on anaphylaxis is based on the most recent ILCOR CoSTR,[8] guidelines and updates from the World Allergy Organization Anaphylaxis Committee,[9] European Academy of Allergy and Clinical Immunology,[10] North American Practice Parameter,[11] Australasian Society of Clinical Immunology and Allergy,[12] the findings from the UK National Audit Project (NAP 7) of perioperative anaphylaxis.[13] Most of these recommendations are based on observational data, good practice statements and expert consensus.

Recognition of anaphylaxis

According to the World Allergy Organization Anaphylaxis Committee, anaphylaxis is likely when at least one of the following criteria is fulfilled[9]:

1. Acute onset within minutes to several hours, with simultaneous involvement of the skin, mucosal tissue, or both (e.g. generalised hives, pruritus or flushing, swollen lips, tongue or uvula) and one of the following:
   a. Respiratory compromise (e.g., dyspnoea, wheeze/bronchospasm, stridor, reduced peak expiratory flow, hypoxemia)
   b. Reduced blood pressure or associated symptoms of end-organ dysfunction (e.g., hypotonia, syncope, incontinence)
   c. Severe gastrointestinal symptoms (e.g., severe crampy abdominal pain, repetitive vomiting), especially after exposure to non-food allergens
2. Acute onset of hypotension or bronchospasm or laryngeal involvement after exposure to a known or highly probable allergen for that patient (minutes to several hours), even in the absence of typical skin involvement.

Anaphylaxis can occur without any skin involvement or with skin involvement remote to the site of exposure, and an anaphylactic reaction may initially present only with respiratory or cardiovascular involvement. During general anaesthesia or mechanical ventilation in emergency or intensive care settings, anaphylaxis may clinically manifest through suddenly increased ventilation pressures and prolonged expiration, combined with a decrease in blood pressure, with or without skin and mucosal changes.

Early recognition of symptoms suggesting anaphylactic reaction, should elicit immediate reaction.

The initial approach if suspecting an anaphylactic reaction

Stop or remove the trigger if possible – stop or remove any potential or probable trigger. Do not delay treatment if removing the trigger is not feasible.

Ensure the patient is lying – do not sit or stand the patient up – fatal anaphylaxis has been associated with upright posture or patient sitting/standing up.[14–16] Position patients according to their symptoms and specifically consider:

- Supine position with raised legs, to improve venous return.
- Sitting position with legs stretched if airway or breathing symptoms are present without circulation problems.

Give adrenaline

Administer IM adrenaline as first-line drug for the management of anaphylaxis.[17] Initial IM adrenaline both aims provide haemodynamic support as well as acting to inhibit mast cell degranulation. The preferred site is the lateral mid-thigh,[18] standard dose for adults is 0.5 mg.[10] This should be repeated after 3–5 min, according to clinical response.[19] Auto-injectors or intranasal adrenaline applicators can be used for early self-administration or injection by a rescuer. If symptoms fail to resolve or the patient is in a monitored area e.g. intensive care unit (ICU), operating room (OR), emergency department (ED), IV administration of adrenaline, starting at a dose of 0.1 $\mu g\ kg^{-1}\ min^{-1}$ titrated according to response can be administered by appropriately trained personnel when patients are fully monitored.[20]

In a patient with upper airway obstruction or bronchospasm, consider adding nebulised adrenaline.[10,21] However, systemic absorption of inhaled adrenaline is minimal and should not delay concurrent IM adrenaline administration.[22]

Secure vascular access – give intravenous fluids

Anaphylaxis may result in severe hypovolaemia because of peripheral vasodilation and increased vascular permeability (distributive shock).[23,24]Fluid resuscitation is essential, in addition to the vasoconstrictive effect of adrenaline. Immediately after the first adrenaline dose, ensure adequate vascular access (e.g. wide-bore IV catheter, intraosseous access). Administer crystalloid solution in bolus doses of 10–20 $mL\ kg^{-1}$ and repeat according to the patient's response. Large volumes of fluids might be required to restore haemodynamic stability.

Give oxygen

Provide 15 L min^{-1} 100 % oxygen to every patient with an anaphylactic reaction and titrate to an oxygen saturation targeting 94–98 %.[25]

Other medications to support the circulation

In the case of no response to adrenaline, consider administration of a second vasoactive drug, such as noradrenaline or vasopressin.[10,21]

Role of steroids and antihistamines in the management of anaphylaxis

H1- antihistamines antagonise the pro-inflammatory action of histamine, which can relieve the cutaneous symptoms of histamine release. However, their onset of action is slow, and they should not delay the administration of adrenaline.

Caution: Rapid IV administration of first generation H1-antihistamines might cause or exaggerate hypotension.[26]

Corticosteroid administration to prevent protracted symptoms or biphasic reactions has been based on low-certainty evidence.[27,28] Recent studies indicate increased risk for negative outcomes (second dose of adrenaline, hospitalisation or ICU admission) in patients treated with corticosteroids in the pre-hospital setting.[29,30] Based on experts' opinion, the ERC does not recommend the routine use of corticosteroids in the management of anaphylactic reactions.

Considerations for cardiac arrest in anaphylaxis

In a case-series of perioperative cardiac arrest, 94 % of patients with anaphylactic cardiac arrest had initial pulseless electrical activity.[13]

Expert consensus is to follow the standard ALS protocol, including IV adrenaline administration and correction of relevant reversible causes, in particular hypovolaemia and hypoxia. Consider ECPR in cases of refractory cardiac arrest, specifically in hospitals where this can be implemented.[8]

Hyper/hypokalaemia and other electrolyte disorders

Electrolyte abnormalities are a recognised cause of arrhythmias and cardiac arrest, potassium disorders (hyperkalaemia and hypokalaemia) are most commonly seen in clinical practice and a U-shaped association between serum K^+ and mortality has been shown.[31]

Hyperkalaemia has also been subject to a recent ILCOR review (2025).[32]

Hyperkalaemia – Non-cardiac arrest

Hyperkalaemia occurs in 1–10 % of hospitalised patients.[33–35] In patients with chronic kidney disease (CKD), hyperkalaemia results in a significantly higher risk of in-hospital major adverse cardiovascular events and arrhythmias compared to patients without hyperkalaemia.[36] Dialysis patients are also more prone to severe hyperkalaemia than non-dialysis patients (45.8 % vs 10.3 %) during hospitalisation.[35] In-hospital mortality is significantly higher in patients with hyperkalaemia (18.1 %) compared to those with hypokalaemia (5 %) or normokalaemia (3.9 %).[33] In-hospital mortality is 3.9-fold higher in patients with a serum $K^+ > 6.5$ mmol L^{-1} when compared with normokalaemic patients.[37]

Renal and cardiac disease often co-exist and these patients are at high risk of hyperkalaemia exacerbated by drug therapy (e.g ACE-inhibitors, angiotensin II antagonists and mineralocorticoid receptor antagonists). However, down-titration or stopping these drugs in response to hyperkalaemia is associated with worse patient outcomes.[38–40] There is now a role for potassium binders (sodium zirconium cyclosilicate and patiromer) to provide cardio-renal protective therapy.[41,42]

Hyperkalaemia is evident with a serum potassium (K^+) concentration greater than 5.5 mmol/l, although hyperkalaemia is a continuum, and its severity guides treatment. Hyperkalaemia is classified as 'mild' (K^+ 5.5–5.9 mmol L^{-1}), 'moderate' (K^+ 6.0–6.4 mmol L^{-1}), 'severe' ($K^+ \geq 6.5$ mmol L^{-1}), or 'extreme' ($K^+ \geq 9.0$ mmol L^{-1}).

The risk of hyperkalaemia increases with multiple simultaneous risk factors (e.g. concomitant use of ACE-I and/or mineralcorticoid receptor antagonist (MRA) in the presence of CKD).

Diagnosis of hyperkalaemia

Consider hyperkalaemia in all at risk patients (e.g. renal failure, heart failure, diabetes mellitus, chronic liver disease) with an arrhythmia or cardiac arrest. Limb weakness, flaccid paralysis or paraesthesia may be indicators of severe hyperkalaemia.

Confirm hyperkalaemia using point-of-care testing, as formal laboratory samples will take time.[43–45]

ECG changes may reflect the severity and rate of rise of serum K^+,[46,47] but it may be normal even in severe hyperkalaemia. When the diagnosis of hyperkalaemia can be established based on the ECG, treatment can be initiated before the laboratory result is available.[46] These ECG signs of hyperkalaemia may develop progressively and include (Fig. 11a):

- Tall, peaked (tented) T waves (i.e. T wave larger than R wave in more than one lead);
- First degree heart block (prolonged PR interval > 0.2 s);
- Flattened or absent P waves;
- Widened QRS (>0.12 s);
- Sine wave;
- Ventricular tachycardia;
- Bradycardia;
- Cardiac arrest (PEA, VF/VT, asystole).

In patients with severe hyperkalaemia, arrhythmias or cardiac arrest have been shown to occur in 15 % of patients within 6 h of the presenting ECG.[46] Therefore, delays in treatment may have serious consequences.

Emergency treatment of hyperkalaemia

Treatment is guided by the severity of hyperkalaemia and the presence of ECG changes. Avoid delay in initiating potassium-lowering treatments (i.e. insulin-glucose, salbutamol and sodium zirconium cyclosilicate). Follow a systematic approach as outlined in the hyperkalaemia treatment algorithm (Fig. 2). The treatment of mild hyperkalaemia is not within the scope of this guideline. Systematic reviews of the pharmacological treatment of hyperkalaemia have been conducted both by Cochrane and ILCOR.[32,48,49]

Insulin and glucose. This is the most effective and reliable K^+-lowering therapy which works by shifting K^+ into cells. The conventional dose of soluble insulin (10 units) has been shown to reduce serum K^+ by 0.7–1.4 mmol L^{-1}.[32,50] Studies have suggested a possible dose-dependent effect of insulin[51–55] and a potential correlation between the severity of hyperkalaemia and the degree of K^+-lowering with 10 units insulin.[56] These findings are particularly relevant in the resuscitation setting.

Hypoglycaemia remains a major iatrogenic risk with a reported incidence of up to 28 %.[53,57–62] Reducing the dose of insulin (5 units) did not significantly lower the risk of hypoglycaemia (blood

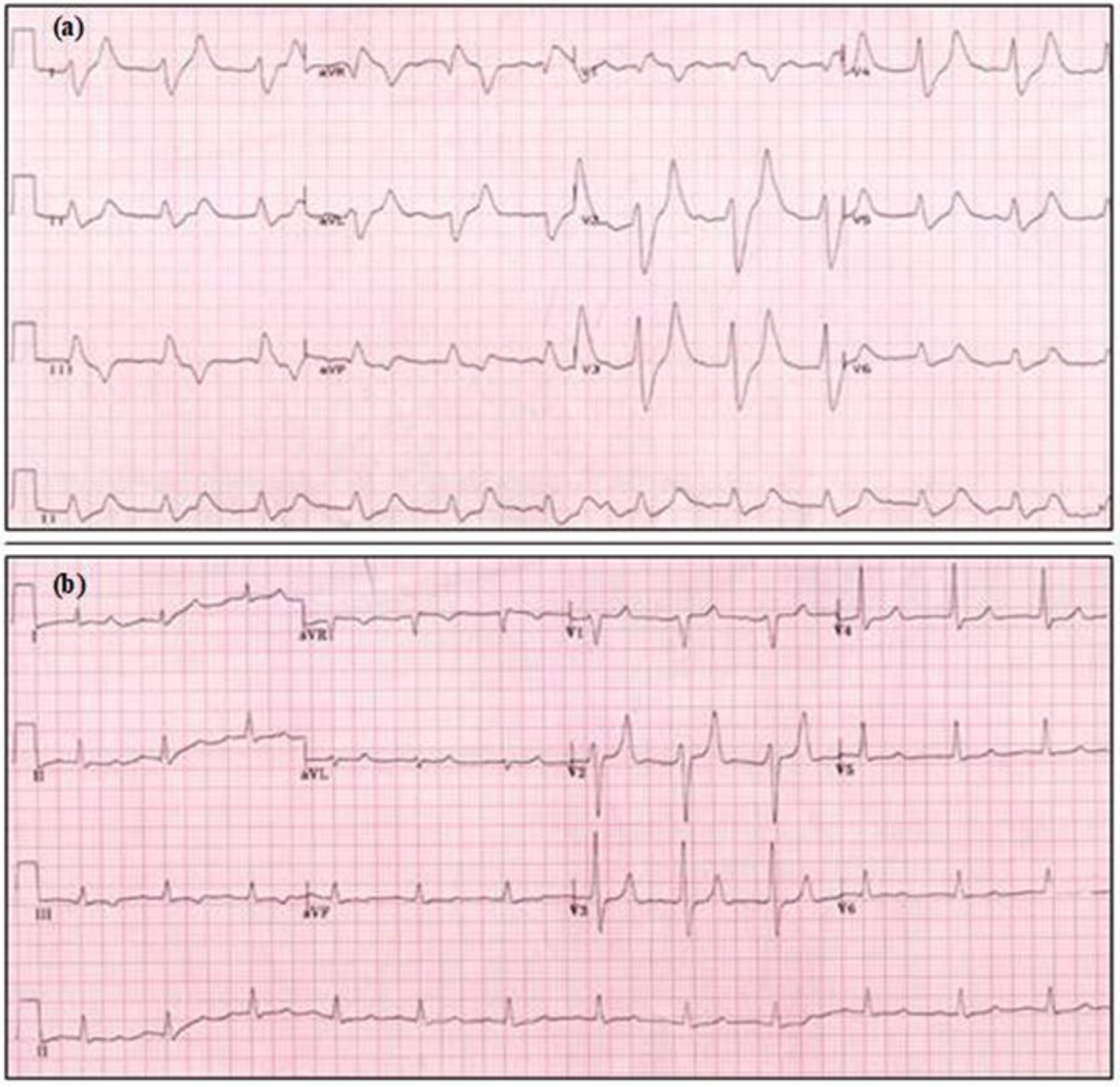


Fig. 11 – Effect of IV calcium on ECG in hyperkalaemia.
ECG on admission (a) and following pre-emptive administration of 20 ml 10 % calcium gluconate IV (b) in a patient who presented with a flaccid paralysis. Response to IV calcium shown with narrowing of QRS complex. Blood gas analyser was unavailable and formal lab result later

glucose < 4 mmol L^{-1}).[51,53,60,61] A scoping review (n= > 15,000) found that the most consistent risk factor for hypoglycaemia is a low pre-treatment blood glucose value.[63] A threshold of < 7 mmol L^{-1} blood glucose has been consistently identifies patients at increased risk of iatrogenic hypoglycaemia.[55,64–67] In one study, administration of 50 g glucose over 4 h resulted in hypoglycaemia in 6.1 % of patients.[59] Based on these collective findings and on evidence that this strategy is effective,[68] a modified protocol which is recommended in the ERC algorithm (Fig. 2) has been developed in order to reduce iatrogenic hypoglycaemia.[50]

Salbutamol. Salbutamol is a beta-2 adrenoceptor agonist and promotes the intracellular shift of K^+. A *meta*-analysis including seven studies administering 10–20 mg inhaled salbutamol demonstrated a reduction in serum K^+ by 0.9 mmol L^{-1} within 120 min.[32] Early studies suggested that salbutamol may be less effective in

patients receiving non-selective beta-blockers and in up to 40 % of patients with end-stage kidney disease.[69,70] On this basis, monotherapy has not been advised. Studies combining insulin-glucose and beta-2 agonists were more effective than either treatment alone.[69,70] The ILCOR review noted a K^+-reduction of 1.2 mmol L^{-1} with combined therapy and supported the use of both drugs.[32] Thus, the ERC recommends simultaneous administration of insulin-glucose and beta-2-agonists for reducing potassium values. Insulin-glucose and salbutamol are effective for 4–6 h, after which rebound hyperkalaemia may occur.

Intravenous calcium salts (calcium chloride or gluconate). Intravenous calcium has been used for decades for the treatment of hyperkalaemia, particularly in the presence of ECG changes, despite lacking clinical evidence. A recent randomised trial suggested harm from the routine use of IV calcium during OHCA; however patients with hyperkalaemia were excluded.[71] In resuscitation practice, the use of IV calcium has been restricted to the treatment of electrolyte disorders (i.e. hyperkalaemia, hypocalcaemia, hypermagnesaemia) and calcium channel-blocker overdose. In clinical practice, the improvement in ECG changes after IV calcium may be seen even before K^+-lowering drugs have taken effect (Fig. 11).

The rationale for the use of IV calcium in hyperkalaemia and hypermagnesaemia is '*antagonism*' of its effect on cardiac and skeletal muscle (i.e. membrane stabilisation), but efficacy may be influenced by the dose and rate of administration. An alternative mechanism has been proposed in an animal study where IV calcium was shown to restore '*conduction*' resulting in improvement of hyperkalaemia-induced ECG changes.[72] In pre-eclampsia, IV calcium ameliorates limb weakness, respiratory depression and cardiac effects induced by iatrogenic hypermagnesaemia.[73]

The recent ILCOR systematic review included only one non-cardiac arrest study of IV calcium in adults and found no evidence to support a clinical effect of IV calcium in hyperkalaemia, although considered the study to have a critical risk of bias.[32]

The Cochrane reviews included no studies evaluating the effect of IV calcium, but suggested that withholding IV calcium in patients with severe hyperkalaemia or ECG changes or both is not advised given potentially life-threatening consequences.[48] There is currently insufficient evidence for or against the use of IV calcium in the treatment of hyperkalaemia, therefore the ERC continues to recommend the administration of IV calcium to patients most at risk of arrhythmias (i.e. severe hyperkalaemia with ECG changes present).

Sodium bicarbonate. The ILCOR review included five studies in adults using variable doses of bicarbonate (50–390 mmol) and found a K^+-lowering of only 0.1 mmol L^{-1} within 60 min.[32] The Cochrane review also concluded that there is no evidence to support the use of sodium bicarbonate in hyperkalaemia.[48,49] Therefore, the ERC recommends against routine use of sodium bicarbonate in the treatment of hyperkalaemia in non-cardiac arrest cases.

Potassium binders. Novel potassium binders were not included in the ILCOR review, but sodium zirconium cyclosilicate (SZC) and Patiromer are well tolerated and have a role in both acute and chronic hyperkalaemia. SZC has a more rapid onset of action (within 1 h) than Patiromer.[74] Within 48 h, SZC lowers serum K^+ by 1.1 mmol/l and shows greater efficacy with higher potassium levels (1.5 mmol/l K^+-reduction in patients with a serum $K^+ > 6.0$ mmol/l).

Indications for dialysis

Dialysis is the most definitive treatment for hyperkalaemia, and the main indications with hyperkalaemia are:

- Severe life-threatening hyperkalaemia with or without ECG changes or arrhythmia;
- Hyperkalaemia resistant to medical treatment;
- End-stage kidney disease;
- Oliguric acute kidney injury (urine output < 400 mL/day);
- Marked tissue breakdown (e.g. rhabdomyolysis).

Following dialysis, rebound hyperkalaemia may also occur.

Pre-hospital setting and hyperkalaemia

The management and identification of patients with hyperkalaemia in the pre-hospital setting can be challenging, because of the limited diagnostic options.

Resuscitation of hyperkalaemic cardiac arrest

Hyperkalaemia is the most common metabolic disturbance associated with cardiac arrest and is potentially reversible, with a reported IHCA incidence of 1 %[75] to 12 %,[76] with PEA as the most common initial arrest rhythm.[77] The ILCOR review included only one study of hyperkalaemia in cardiac arrest (high risk of bias due to resuscitation time). This review describes decreased rates of ROSC with calcium, sodium bicarbonate or both.[32]

A study of hyperkalaemic IHCA ($n = 109$; mean serum K^+ 7.8 mmol L^{-1}) used IV calcium and sodium bicarbonate [76] in a very heterogeneous population and achieved 36.7 % ROSC, but only 12.8 % survived > 24 h and 3.7 % survived to hospital discharge. Given the poor outcome in patients with extreme hyperkalaemia, the authors proposed that dialysis may be an option.

Dialysis is the definitive treatment for hyperkalaemia, but is rarely used in cardiac arrest. A review of case reports of dialysis during CPR demonstrate successful outcomes in patients with a serum K^+ ranging between 8.2–10.2 mmol L^{-1}.[50] All dialysis modalities (with and without ECMO) have been used during CPR, demonstrating that it is technically feasible.[78–81] The mean duration of dialysis to achieve ROSC was 45.4 min (range 15–95 min) and the mean reduction in serum K^+ was 3.2 mmol L^{-1} which would be difficult to achieve with medications alone, particularly during cardiac arrest.[50] The severity of hyperkalaemia appears to be a good indicator of the likelihood of achieving and sustaining ROSC. A protocol for initiation of dialysis during CPR has been reported.[50]

A study assessing the outcome of OHCA following anti-hyperkalaemic medical treatment ($n = 465$; mean K^+ 6.9 mmol L^{-1}, IQR 5.7–8.4 mmol L^{-1}) found no effect on ROSC, despite achieving K^+-lowering (mean K^+ 5.4 mmol L^{-1}, IQR 4.4–6.8 mmol L^{-1}).[82] There is currently insufficient evidence for or against the use of IV calcium in the treatment of hyperkalaemia, therefore the ERC continues to recommend the administration of IV calcium to patients with hyperkalaemic cardiac arrest in all settings.

Hypokalaemia

Hypokalaemia is defined as a serum $K^+ < 3.5$ mmol L^{-1} [mild (K^+ 3.0–3.4 mmol L^{-1}), moderate (K^+ 2.5–2.9 mmol L^{-1}) or severe (K^+ -

< 2.5 mmol L^{-1}or symptomatic].[83] It is usually caused by excessive K^+ loss, transmembrane shift of K^+ into cells, or reduced K^+ intake.[84] Hypokalaemia is associated with higher in-hospital mortality and an increased risk of ventricular arrhythmias. Risks are increased in patients with pre-existing heart disease,[85,86] those treated with digoxin[87] or those undergoing primary percutaneous coronary intervention for ST-elevation myocardial infarction.[88] In acute heart failure, hypokalaemia may be associated with increased short and long-term all-cause mortality after hospital discharge.[89]

Treatment of hypokalaemia

Treatment is guided by the severity of hypokalaemia and presence of symptoms and/or ECG abnormalities, as illustrated in Fig. 3. Slow replacement of potassium is preferable, but in an emergency, rapid IV replacement, preferable via central route is required. The target level is 4 mmol $L^{-1}K^+$.[90] Correction of any concomitant hypomagnesaemia is essential. Concomitant magnesium deficiency is common in patients with hypokalaemia. Repletion of magnesium will facilitate more rapid correction of hypokalaemia.[91] Seek expert advice for potassium replacement in patients with severe renal impairment (see Fig. 3).

Calcium and magnesium disorders

The recognition and treatment of calcium and magnesium disorders is summarised in Table 2.

Hyperthermia and malignant hyperthermia

Hyperthermia results from a body temperature above normal (core temperature 36.5–37.5 °C) because of failed thermoregulation. Extremes of age and multimorbidity are specific risk factors.[92,93]

Table 2 – Calcium and magnesium disorders with associated clinical presentation, ECG manifestations and recommended treatment.

Disorder	Causes	Presentation	ECG	Treatment
Hypercalcaemia Calcium > 2.6 mmol L^{-1}	Primary or tertiary hyperparathyroidism Malignancy Sarcoidosis Medications	Confusion Weakness Abdominal pain Hypotension Arrhythmias Cardiac arrest	Short QT interval Prolonged QRS interval Flat T waves AV block Cardiac arrest	Guided by underlying cause Fluid replacement IV Furosemide 1 mg kg^{-1} IV Hydrocortisone 200–300 mg IV Pamidronate 30–90 mg IV
Hypocalcaemia Calcium < 2.1 mmol L^{-1}	Chronic kidney disease Acute pancreatitis Calcium channel blocker overdose Toxic shock syndrome Rhabdomyolysis Tumour lysis syndrome Massive blood transfusion	Paraesthesia Tetany Seizures AV-block Cardiac arrest	Prolonged QT interval T wave inversion Heart block Cardiac arrest	Bolus: 10–20 mL 10 % Calcium gluconate over 5–10 min Infusion: 100 mL 10 % Calcium gluconate in 1000 mL 0.9 % Saline or 5 % Glucose at 50 mL h^{-1} IVI (monitor Ca^{2+} level and adjust rate) 50 % Magnesium sulphate 4–8 mmol IV (if necessary)
Hypermagnesaemia Magnesium > 1.1 mmol L^{-1}	Renal failure Iatrogenic	Confusion Flaccid paralysis Respiratory depression Hypotension AV-block Cardiac arrest	Prolonged PR and QT intervals T wave peaking AV block Cardiac arrest	Consider treatment when magnesium > 1.75 mmol L^{-1}: 10 % Calcium gluconate (10–30 mL) or 10 % Calcium chloride (5–10 mL) IV repeated if necessary Saline diuresis – 150 mL 0.9 % saline/ hr IV and Furosemide 1 mg/ kg IV Haemodialysis – when renal function impaired or severe symptoms, but risk of causing hypocalcaemia. Ventilatory support if necessary
Hypomagnesaemia Magnesium < 0.6 mmol L^{-1}	GI loss Polyuria Starvation Alcoholism Malabsorption	Tremor Ataxia Nystagmus Seizures Arrhythmias – torsade de pointes Cardiac arrest	Prolonged PR and QT intervals ST-segment depression T-wave inversion Flattened P waves Increased QRS duration Torsades de pointes	Severe or symptomatic: 50 % Magnesium sulphate 2 g (8 mmol) IV over 15 min Torsades de pointes: 50 % magnesium sulphate 2 g (8 mmol) IV over 1–2 min Seizures: 50 % magnesium sulphate 2 g (8 mmol) IV over 10 min

Malignant hyperthermia is a rare pharmacogenetic disorder of skeletal muscle calcium homeostasis characterised by muscle contracture and life-threatening hypermetabolic crisis following exposure of genetically predisposed individuals to halogenated anaesthetics, succinylcholine, or neuroleptics.[94,95] Rarely, malignant hyperthermia can be triggered non-pharmacologically. The most common clinical signs and symptoms include hypercapnia (34 %), sinus tachycardia (25 %), hyperthermia (20 %), masseter spasm (11 %), generalised muscle rigidity (3 %), acidosis, hyperkalaemia and death if left untreated.[96] This section is based on two systematic reviews, five non-systematic reviews, and two scoping reviews the latter being most recently performed on June 15, 2024.[94–101]

Hyperthermia

Environmental-associated hyperthermia (core temperature > 38 °C) can be avoided by acclimatisation, adequate hydration and avoidance of physical activity in hot weather.[92,98,102] The major risk factor is dehydration, which risks progression to heat syncope, heat exhaustion, heat stroke, and finally multiple organ dysfunction and cardiac arrest. Treatment of hyperthermia see Fig. 4 and Table 3. Core temperature should be measured centrally (e.g. tympanic, rectal, oesophageal) to guide treatment.[103]

Malignant hyperthermia

Prevention of malignant hyperthermia is key; it is a genetic illness that if untreated results in death.[97,108,109] Drugs such as 3,4-methyle nedioxymethamphetamine (MDMA, 'ecstasy') and amphetamines may also cause a condition similar to MH and the use of dantrolene may also be therapeutic in these cases.[110] Always consider malignant hyperthermia, with unexplained, unexpected increases in $ETCO_2$, heart rate or temperature. Further information on malignant hyperthermia management (See QR code. 1).[94,111]

Briefly, stop exposure, provide high flow oxygen, give dantrolene until $ETCO_2$ < 45 mmHg (6 kPa) with normal minute ventilation and core temperature < 38.5 °C, cool the patient. If cardiac arrest occurs, follow the universal ALS algorithm and continue to cool the patient. Apply the same cooling techniques as for post-resuscitation care targeted temperature management (see Fig. 5).

It is essential to contact an expert malignant hyperthermia centre for ongoing advice.[97–112] Dantrolene should be stored centrally where anaesthesia is provided, and algorithms for MH management should be readily available (see QR code 1).

Toxin-Induced hyperthermia

Intoxication may present with hyperthermia as an early sign. Risk is higher in people taking psychotropic drugs (for treatment or recreation), sympathomimetics, anticholinergics, salicylates, weight-loss drugs or following ingestion of wild mushrooms.

Carry out an initial ABCDE approach after applying appropriate personal protective equipment (PPE) as in all cases of unknown toxic agents. Specific symptoms and the patient's history may help to identify the suspected substance, even before toxicology results are available. For most poison-induced hyperthermia cases, prompt symptomatic treatment is key. Active cooling and targeted strategies for specific symptoms: benzodiazepines to reduce agitation and tremor, dantrolene for muscle contraction and rigidity, and measures to reduce toxin concentrations (See Table 4).

Accidental hypothermia and avalanche rescue

Accidental hypothermia is defined as a decrease in core temperature < 35 °C, during which vital signs and consciousness fade and finally disappear.[150] However, vital signs may be minimal but still be present with temperatures < 24 °C.

In hypothermic patients with spontaneous circulation, key interventions are insulation, and hospital triage followed by transfer and rewarming. In hypothermic patients with cardiac arrest, key interventions are continuous CPR and extracorporeal life support rewarming. These measures may result in good neurological outcome even with prolonged no-flow or low-flow (i.e. CPR) times, if hypothermia (e.g. < 30 °C) ensued before cardiac arrest. A scoping review up to February 13th 2025 found three systematic reviews for this recommendation,[151–153] but also included other relevant articles.[150,154–161]

Prevention from cardiac arrest

Primary accidental hypothermia is induced by exposure to cold, while secondary accidental hypothermia is triggered by illness and other external causes. Primary hypothermia is common in outdoor activities (mainly athletes and lost persons) and urban environments (e.g. homeless and intoxicated persons), while the incidence of secondary hypothermia is increasing among old and multimorbid persons in the indoor environment.[154,157]

Measuring the core temperature with a low reading thermometer is the gold standard for diagnosis of hypothermia[157]:

- tympanic in spontaneously breathing patients and
- oesophageal in patients having a tracheal tube or supraglottic airway in situ.[159]

If the core temperature cannot be measured, temperature should be assessed according to the level of consciousness with the Revised Swiss Staging System.[156] (Table 5 and Fig. 12).

- In the Revised Swiss System, "Alert" corresponds to a GCS score of 15; "Verbal" corresponds to a GCS score of 9–14, including confused patients; "Painful" and "Unconscious" correspond to a GCS score < 9. While shivering is not used as a stage-defining sign in the Revised Swiss System, its presence usually means that the temperature is > 30 °C, a temperature at which hypothermic cardiac arrest is unlikely to occur.
- No apparent respiration, no apparent palpable carotid or femoral pulse, no measurable blood pressure – check for signs of life (pulse and, especially, respiration) for up to 1 min.
- The transition of colours between stages represents the overlap of patients within groups. The estimated risk of cardiac arrest is based on accidental hypothermia being the only cause of the clinical findings (Fig. 12). If other conditions impair consciousness, such as asphyxia, intoxication, high altitude cerebral oedema or trauma, the Revised Swiss System may falsely predict a higher risk of cardiac arrest due to hypothermia. Caution should be taken if a patient remains "alert" or "verbal" showing signs of haemodynamic or respiratory instability such as bradycardia, bradypnea, or hypotension because this may suggest transition to a stage with higher risk of cardiac arrest.

Hypothermic patients should be protected from the cold environment through minimal exposure and insulation and be transferred as fast as possible to the next appropriate hospital for rewarming. While not harmful, active rewarming is impractical during brief transport

Table 3 – Treatment of hyperthermia.

Degree of hyperthermia	Symptoms	Treatment
Mild – Heat syncope	Transient loss of consciousness and fast return to normal neurologic baseline.	Remove patient to a cool environment, passive cooling, resting and administration of oral isotonic or hypertonic fluids (the latter only if $Na^+ \leq 130$ mmol L^{-1}).
Moderate – Heat exhaustion	Intense thirst, weakness, discomfort, anxiety, dizziness, syncope. Caused by mild to moderate hyperthermia (>40 °C) due to exposure to high environmental heat or excessive exercise.	Additionally, lie patient flat and administer isotonic IV fluids. Simple external cooling measures are usually not required but may involve conductive (e.g. cold floor, ice sheets; commercial ice packs to hands, feet and cheeks), convective (cold water immersion, cold shower) and evaporative measures (spraying cold water, fanning bare skin).
Severe – Heat stroke	Triad of severe hyperthermia (core temperature > 40 °C), neurological symptoms and recent passive environmental exposure (classic or passive heat stroke) or excessive exercise (exertional heat stroke). Symptoms include central nervous system dysregulation (e.g. altered mental state, seizure, coma), tachycardia, tachypnoea and arterial hypotension. [92]Mortality is approximately 10 %, and when combined with hypotension approaches 33 %.[98] The outcome worsens if the core temperature is sustained at > 40.5 °C.	Rapidly cool the patient to < 39 °C, preferably < 38.5–38.0 °C as quickly as possible. [98] Prioritise active cooling methods over passive cooling – a cooling rate $\geq$ 0.155 °C min^{-1} is recommended[104]. It is important to account for the time between symptom onset and the provision of care when selecting a cooling method, reaching the target temperature within 30 min of onset of heat stroke should be the goal [104]. For exertional heatstroke, a cooling rate faster than 0.10°C min^{-1} is safe and desirable. Ice or cold-water immersion (from neck down) or full body conductive cooling should be used, cooling rates of 0.2–0.35°C min^{-1} can be achieved.[98,639] Cold water immersion should be continued until the symptoms have resolved or for a reasonable amount of time, e.g. 15 min, because benefit outweighs risk (weak recommendation, very low certainty evidence).[105] if cold water immersion is not available, a combination of simple cooling techniques may be used, including conductive, convective and evaporative measures, although there are no comparative studies to guide the best option.[105] A systematic review concluded that water immersion (1–26 °C water) lowers body temperature faster and more effectively compared to passive cooling (low to very low certainty of evidence). Misting and fanning cooling techniques are marginally faster than passive cooling, and cold showers (20.8 °C) cool faster than passive cooling.[105] IV isotonic or hypertonic fluids should be administered (if $Na^+ \leq$130 mmol L^{-1}, for example up to 3 × 100 mL 3 % NaCl at 10 min intervals).[106] Additional electrolyte replacement with isotonic fluids should be considered and substantial amounts of fluids may be required. Follow the ABCDE approach in any patient with deteriorating vital signs. Critically ill patients will require aggressive and extended treatment in an intensive care unit.[92,107] There may be a requirement for advanced cooling techniques including external or internal devices used for targeted temperature management. There are no specific medications lowering core temperature.

Treatment is progressive in accordance with the degree of hyperthermia.

periods (e.g., less than 1 h).[153] Hypothermic patients with prehospital cardiac instability (i.e. heart rate < 45/min, systolic blood pressure < 90 mmHg, ventricular arrhythmia, core temperature < 30 °C) should be rewarmed in-hospital using minimally invasive techniques with timely consultation with an ECMO centre being essential.[156,161]

Management of cardiac arrest

The lowest published temperature from which successful resuscitation and rewarming has been achieved is currently 11.8°C[155] for accidental hypothermia and 4.0 °C for induced hypothermia.[162] A systematic review reported only five patients (28–75 years of age) who had arrested at a body core temperature > 28 °C, suggesting that cardiac arrest caused by primary hypothermia at $\geq$ 28 °C is possible, but unlikely.[151] Some patients may still have minimal vital signs at a core temperature < 24 °C.[163]

Check for signs of life for one minute – not only by clinical examination but also using ECG and ultrasound.[164]

In hypothermic cardiac arrest, outcome relevant information should be collected to estimate the survival probability from hypothermic cardiac arrest with the HOPE (Hypothermia Outcome Prediction after ECLS rewarming for hypothermic arrested patients) –score.[158,160,165]

The prognosis of patients with primary hypothermic cardiac arrest can be excellent,[157] while in cases of secondary hypothermia outcome is more influenced by co-morbidity.[166] Hypothermic patients

Table 4 – Toxins inducing hyperthermia.

Category	Substance	Mechanism	Symptoms	Diagnostic testing	Specific Management
Antipsychotics[113–117]	Risperidone, Arapiprazole, Haloperidol, Olanzapine, Quetiapine, Clozapine, Blonanserine	Dopamine antagonism/acute withdrawal of dopamine agonists → neuroleptic malignant syndrome (NMS)	Hyperthermia, muscle rigidity, tremor, autonomic dysfunction, altered mental status	Blood testing for antipsychotics	Benzodiazepines against agitation. Bromocriptine for hypodopaminergic state. Dantrolene as muscle relaxant
Antidepressants[118–122]	Lithium, MAOI, SSRI, SNRI, TCA	Serotonin syndrome	Hyperthermia, flushing, shivering, akathisia, agitation, mydriasis, autonomic dysfunction	Blood testing for antidepressants, serum lithium level	Benzodiazepines against agitation. Consider Chloropromazine. Consider sodium bicarbonate for TCA
Recreative/Party Drugs[123–137]	MDMA (Ecstasy), LSD	Central catecholamine release and reuptake inhibition in the CNS, hypermetabolic condition with skeletal muscle stimulation, tachycardia and vasoconstriction	Hyperthermia, euphoria, hallucinations, agitation, shivering, mydriasis, nausea	Urine screening (MDMA, LSD)	Benzodiazepines for agitation. Dantrolene for hyperthermia. Consider carvedilol for MDMA
	Methamphetamine		Hyperthermia, hallucinations, tremor, agitation, mydriasis Autonomic dysfunction	Urine or blood screening for amphetamines	Ammonium chloride for excretion (urine acidifier). Activated charcoal to reduce absorption
	Cocaine	Nonselective dopamine, serotonin, noradrenaline reuptake inhibitor. CNS stimulation, sympathetic system activation. Direct sodium channel blockade. Coronary vasoconstriction	Hyperthermia, hallucinations, tremors, agitation, mydriasis, autonomic dysfunction, arrythmias, chest pain	Urine and blood screening	Consider sodium bicarbonate for broad complex tachycardia or cardiac arrest, avoid β-blockers
Anticholinergics[138–142]	Atropine, scopolamine, plant alkaloids (belladonna, brugmansia, amanita)	Blockade of muscarinic receptors. Anticholinergic hyperthermic syndrome	Hyperthermia. tachycardia, sweating Inhibiton, dry skin & mucus membranes, flushing, mydriasis, altered mental status	Urine and serum screening	Benzodiazepines and central acting cholinesterase inhibitors against agitation. Activated charcoal within 1st hour (time window may be extended as anticholineregics reduce gastrointestinal motility)
Sympathomimetics[143–145]	Ephedrine, pseudoephedrine	Sympathetic system activation Increased metabolic rate and peripheral vasoconstriction	Hyperthermia, tachycardia, hypertension, arrythmias, muscle twitching, nausea, mydriasis, urinary retention	Urine screening, serum toxicology testing for pseudoephedrine/ ephedrine	Benzodiazepines against agitation
Salicylates[146,147]	Aspirin, methyl salicylate	Uncoupling of oxidative phosphorylation leading to increased heat production.	Mild hyperthermia, nausea, tachypnea, confusion, tinnitus	Serum salicylate levels	Urine alkalization with $NaHCO_3$. Prevent hypoglycemia. Consider dialysis for drug excretion and cooling
Miscellaneous[148,149]	Dinitrophenol (DNP)	Uncoupling of oxidative phosphorylation leading to increased heat production	Hyperthermia, sweating, flushing, agitation, tachycardia & tachypnea, fatigue	Serum toxicology testing for DNP	Consider dantrolene

CNS denotes central nervous system, LSD denotes lysergic acid diethylamide, MAOI – Monoaminoxidase inhibitor, MDMA – 3,4-Methylenedioxymethamphetamine, SNRI – Serotonin and norepinephrine reuptake inhibitor, SSRI – Selective serotonin reuptake inhibitor, TCA – Tricyclic antidepressant.

in witnessed and unwitnessed cardiac arrest have good chances of neurological recovery if hypothermia developed before hypoxia and cardiac arrest, and if the chain of survival functioned well.[151,152,166] Hypothermia diminishes the oxygen demand of the body (6–7 % per 1 °C cooling) and thereby protects the most oxygen dependent organs of the body (brain and heart) against hypoxic damage.[167] A systematic review of witnessed hypothermic cardiac arrest patients ($n = 214$) reported a survival to hospital-discharge rate of 73 %, with 89 % of survivors having a favourable neurologic outcome. A systematic review of unwitnessed hypothermic cardiac arrest patients ($n = 221$) reported a survival rate of 27 %, with 83 % of survivors having a favourable neurological outcome. Of note, the first rhythm was asystole in 48 % of these survivors.[152]

Hypothermic cardiac arrest patients should receive continuous CPR until circulation has been re-established. Chest compression and ventilation rate should follow the standard ALS algorithm as for normothermic patients. Efforts should also focus on maintaining normoxia during resuscitation.

Hypothermic cardiac arrest is often refractory to defibrillation and adrenaline. Defibrillation attempts have been successful in patients with a core temperature > 24 °C, however, ROSC tends to be unstable with lower temperature.[168] The hypothermic heart may be unresponsive to cardioactive drugs, attempted electrical pacing and defibrillation. If ventricular fibrillation or pulseless ventricular tachycardia persist after three shocks, it is reasonable to delay further attempts until the core temperature is > 30 °C.

Medication metabolism is slowed, leading to potentially toxic plasma concentrations, therefore, medications should be administered cautiously. The evidence for the efficacy of medication in severe hypothermia is limited and based mainly on animal studies. In severe hypothermic cardiac arrest, the effectiveness of amiodarone is reduced.[169] Adrenaline may be effective in increasing coronary perfusion pressure, but not survival.[170,171] Adrenaline

Table 5 – Swiss staging of accidental hypothermia.[157]

Stage	Clinical Findings	Core temperature (°C) (if available)
Hypothermia I (mild)	Conscious*	35–32 °C
Hypothermia II (moderate)	Impaired consciousness*	<32–28 °C
Hypothermia III (severe)	Unconscious*; vital signs present	<28 °C
Hypothermia IV (severe)	Apparent death; Vital signs absent	Variable**

* Consciousness may be impaired by comorbid illness (e.g. trauma, central nervous system pathology, toxic ingestion) or medications (e.g. sedatives, muscle relaxants, opioids) independent of core temperature.

** The risk of cardiac arrest increases < 30 °C, older and sicker patients. Alternative causes should be considered. Some patients still have vital signs < 24 °C.

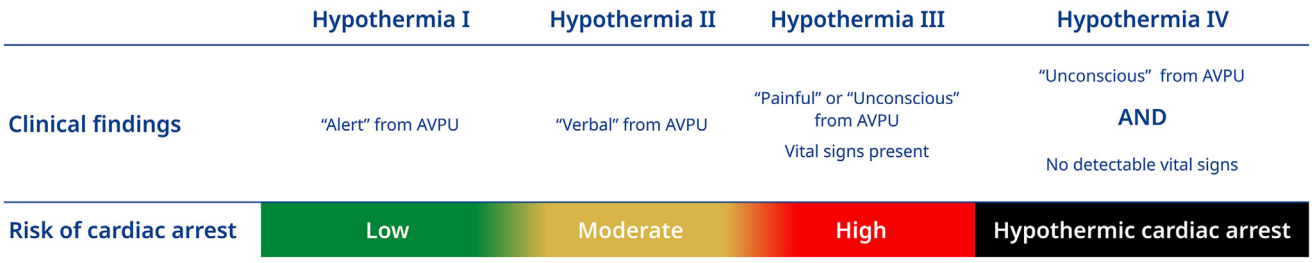


Fig. 12 – Revised Swiss System for staging of accidental hypothermia.[156]
AVPU – alert verbal pain unresponsive.

may induce myocardial injury and impaired neurologic recovery; it is reasonable to withhold adrenaline and other CPR drugs until the patient has been warmed to a core temperature ≥ 30 °C. If access to extracorporeal life support is delayed, since shorter CPR duration might be associated with better outcome, it may be reasonable to administer 1 mg of adrenaline even at lower core temperature in an attempt to achieve ROSC.[172] Once 30 °C has been reached, the intervals between drug doses should be doubled when compared with those during normothermia (i.e. adrenaline every 6–10 min). Once normothermia is achieved (≥35 °C), use standard drug protocols.

If possible, transfer arrested hypothermic patients (or those at risk of arrest), directly to a hospital able to provide extracorporeal life support. If prolonged transport is required or the terrain is difficult, mechanical CPR is suggested. In hypothermic arrested patients with a body temperature < 28 °C delayed CPR may be used when CPR is too dangerous, and intermittent CPR can be used when continuous CPR is not possible, for example because of technically difficult rescue (Fig. 13).[173]

Establish extracorporeal life support only in cardiac arrest or deteriorating patients (e.g. decreasing blood pressure, increasing acidosis). Primary ECLS may be considered in patients with $ETCO_2$ < 10 mmHg (1.3 kPa) or a systolic blood pressure ≤ 60 mmHg.[174] An unwitnessed cardiac arrest with asystole as first rhythm is not a contraindication for ECLS rewarming.[152] Rewarming should preferably be performed with VA-ECMO rather than cardiopulmonary bypass.[175,176] If ECLS is not available within 6 h, non-extracorporeal life support rewarming may be used.[177,178]

In-hospital prognostication of successful rewarming should be based on the HOPE score.[158,160] The 5A score is a screening tool for predicting in-hospital mortality among elderly patients with accidental hypothermia with or without cardiac arrest which may also guide treatment options.[179,180] In hypothermic arrested patients, criteria for ECLS rewarming should not be based on guidelines for normothermic cardiac arrest.[181] This may result in potentially life-saving treatment being withheld in patients with a potential for good neurological outcome.[176]

Emergency medical services and hospitals should install structured protocols to improve prehospital triage, transport and treatment, as well as in-hospital management of hypothermic patients.

Avalanche rescue

The chances of surviving avalanche burial is steadily improving, due to collaborative efforts to improve avalanche search and rescue, and subsequent medical interventions.[182] Most avalanche victims die from asphyxia, fewer from trauma or hypothermia. In cases of unwitnessed cardiac arrest presenting in asystole, avalanche victims have a poor chance of survival, even if guidelines are followed.[183–185]

Several factors improve the likelihood of good outcome from avalanche burial. These include non-critical burial (i.e. head and chest out of the snow), superficial burial, burial for a short time, burial dur-

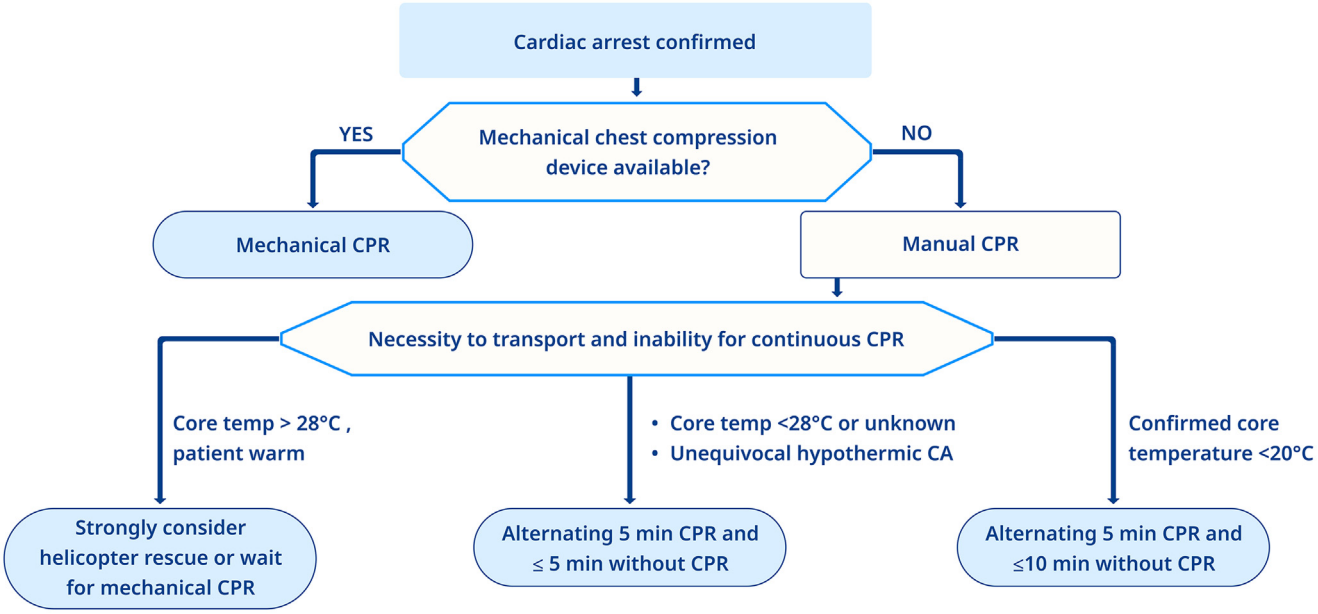


Fig. 13 – Decision making in hypothermic cardiac arrest.
CPR – cardiopulmonary resuscitation. Delayed and intermittent CPR in hypothermic patients when continuous CPR is not possible during dangerous or difficult rescue.[170]

ing daylight hours, the presence of an air pocket (i.e. open airways in addition to any space in the snow in front of nose and mouth), retrieval before cardiac arrest, witnessed cardiac arrest and ROSC in the first few minutes of CPR.[182–184,186,187] The International Commission for Mountain Emergency Medicine performed a scoping review and published guidelines for the management of victims buried in avalanches (Fig. 14).[188]

The AvaLife algorithm should be used in multiple burial scenarios with too few rescuers on site. In this triage situation, AvaLife enables identification of the i) buried subjects who should be excavated first (cut-off < 1.5 m of burial depth) and ii) who should be resuscitated and for how long.[189] AvaLife has been specifically developed for BLS provider.

The quality of CPR can be compromised by several factors, including the confined space of the burial site, chest compressions on snow, hypobaric hypoxia on mountains leading to faster exhaustion of rescuers, and long and difficult extrication and transport of victims. Mechanical chest compression devices can be helpful in technically difficult and prolonged rescues.[190–192]

Thrombosis

Pulmonary embolism

Cardiac arrest from acute pulmonary embolism (PE) is the most serious clinical presentation of venous thromboembolism, in most cases originating from a deep venous thrombosis (DVT).[193] The reported incidence of cardiac arrest caused by PE is 2–7 % of all OHCAs,[194,195] and 5–6 % of all in-hospital cardiac arrests,[75,196] but it is likely to be underestimated. Overall survival is low, even if invasive treatment or ECPR is used.[195,197,198] Specific treatments for cardiac arrest resulting from PE include administration of fibrinolytics, surgical embolectomy and percutaneous mechanical thrombectomy.

The 2020 ILCOR systematic review explored the influence of specific treatments (e.g. fibrinolytics, or any other) yielding favourable outcomes.[199] The 2019 ILCOR summary statement reviewed the use ECPR for cardiac arrest in adults,[200] while the 2022 ILCOR summary statement updated evidence on sensitivity and specificity of POCUS for specific pathophysiological states, including PE, and reviewed four small additional observational studies on cardiac arrest from PE which were published since the previous review. No additional evidence was found to change the management.[201] Additional evidence was identified from the European Society of Cardiology (ESC) guideline on pulmonary embolism.[193]

These ESC Guidelines define 'confirmed pulmonary embolism' as a probability of pulmonary embolism high enough to indicate the need for specific treatment.[193] Clinical history, assessment, capnography, and echocardiography (if available) can assist in the diagnosis of acute pulmonary embolism during CPR. Cardiac arrest commonly presents as PEA.[197] Constant low $ETCO_2$ readings (below 1.7 kPa (13 mmHg)) while performing high-quality chest compressions may support a diagnosis of pulmonary embolism, although it is a non-specific sign.[202,203] If a 12-lead ECG can be obtained before cardiac arrest, changes indicative of right ventricular strain may be helpful for decision making.

Common symptoms preceding cardiac arrest are described in Table 6.

Acute pulmonary embolism can cause right ventricular pressure overload and dysfunction, POCUS might be helpful for detection, (Table 6). but no individual echocardiographic parameter provides fast and reliable information on right ventricle size or function. Signs of right ventricular overload or dysfunction may also be caused by other cardiac or pulmonary diseases.[204]

Initial treatment (Fig. 15)

All patients with a sudden onset of progressive dyspnoea, especially in patients without pre-existing cardiac or pulmonary disease are suspicious for pulmonary embolism. Hypoxaemia is usually reversed with administration of oxygen, while, in some patients, correction of

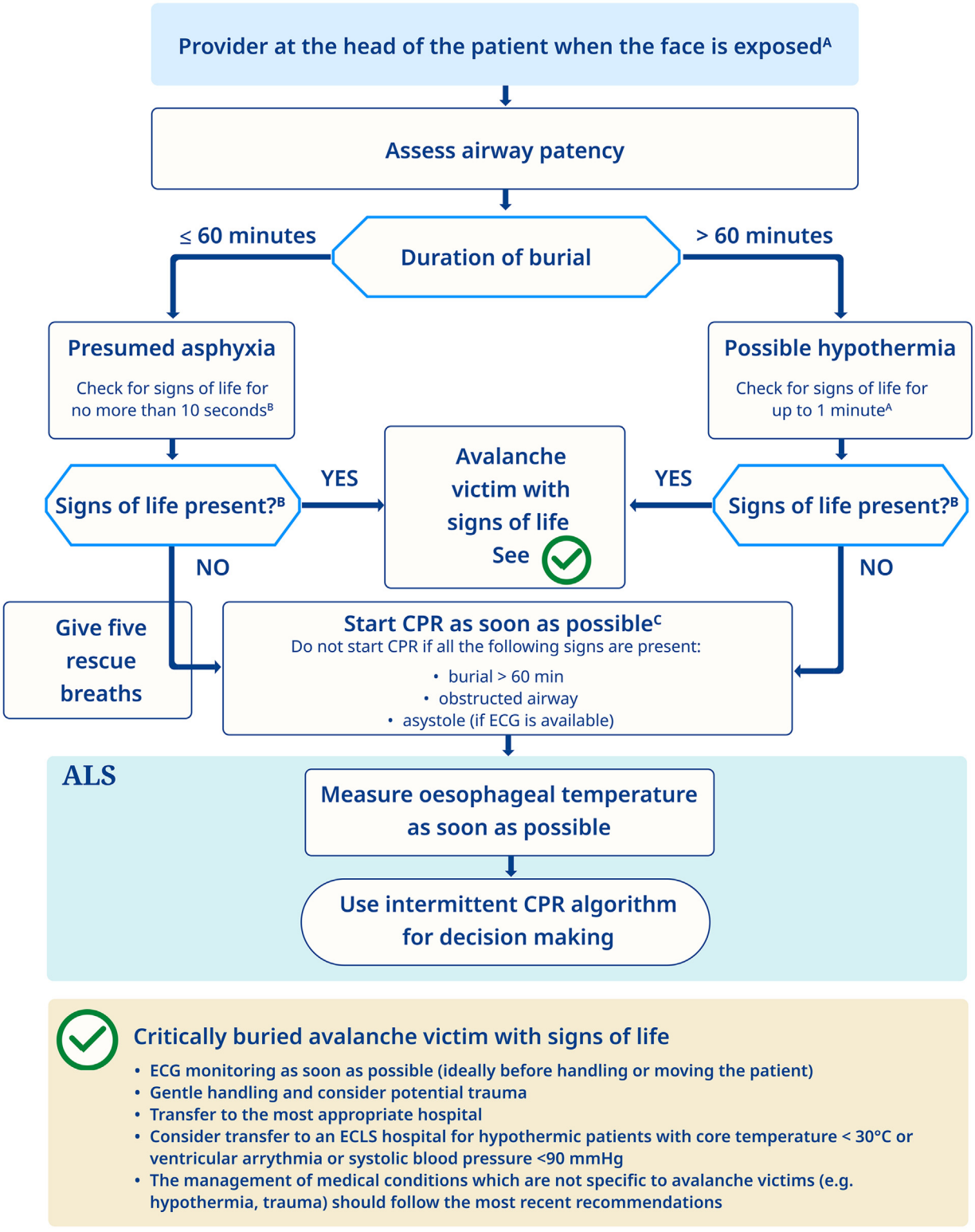


Fig. 14 – Initial management of critically buried avalanche victim.[188]

CPR – cardiopulmonary resuscitation, ECG – electrocardiography, ECLS – extracorporeal life support. Figure legend. [A] Assess for lethal injuries: decapitation; truncal transection; whole body decomposed. If present, do not start CPR. [B] Signs of life include any of the following: A, V or P from AVPU (alert, responsive to verbal stimuli, responsive to pain, unresponsive) or Glasgow Coma Scale > 3, any visible movement, respirations, or a palpable carotid or femoral pulse (for experienced ALS providers). [C] Standard compression / ventilation rates. Drug dose and defibrillation depending on core temperature or, if not available, burial duration. If ventricular fibrillation persists after three shocks, delay further attempts until the core temperature is > 30 °C.

hypoxaemia will not be possible without simultaneous pulmonary reperfusion.[193]

High-risk pulmonary embolism is suspected with shock or persistent arterial hypotension and is immediately life-threatening. Leave hypotensive patients lying flat if breathing allows, to prevent further progression of hypotension and cardiac arrest. Acute right ventricular failure is the leading cause of death in patients with high-risk pulmonary embolism. Aggressive volume expansion is of no benefit and may even worsen right ventricular function. However, cautious volume loading ($\leq$ 500 mL over 15–30 min) may increase cardiac output, and the use of vasopressors and/or inotropes is frequently beneficial.[193]

IV anticoagulation should be initiated while awaiting the results of diagnostic tests. Unfractionated heparin is recommended for patients with shock and hypotension, and for whom primary reperfusion is considered. Thrombolytic treatment of acute pulmonary embolism restores pulmonary perfusion more rapidly than anticoagulation with heparin alone.[206]

Modifications to ALS

Fibrinolysis. If pulmonary embolism is the suspected cause of cardiac arrest, fibrinolytic drugs should be administered, based on evidence from an ILCOR CoSTR.[201] There is insufficient evidence to recommend optimal drug and dosing strategy for fibrinolysis during CPR. ROSC and survival were observed after recombinant tissue type plasminogen activator (alteplase, bolus 50 mg IV with or without additional 50 mg after 30 min, or 0.6–1.0 mg/kg IV – max. 100 mg).[197,207,208] When thrombolytic drugs have been administered, continue CPR for at least 60–90 min.[195,209,210] Based on expert opinion, thrombolysis or surgical embolectomy should be considered for pregnant women with high-risk pulmonary embolism and PE causing cardiac arrest.[193]

Table 6 – Non-specific patient characteristics observed with higher incidence in OHCA caused by pulmonary embolism compared with other causes[193,198,205].

Symptoms preceding cardiac arrest
Sudden onset of dyspnoea
Pleuritic or substernal chest pain
Cough
Haemoptysis
Syncope (otherwise unexplained and/or repeated collapses)
Signs of DVT (unilateral low extremity swelling)
Signs of right ventricular strain on 12-lead ECG (if obtained before cardiac arrest) • Inversion of T waves in leads V1–V4 • QR pattern in V1 • S1 Q3 T3 pattern (i.e. a prominent S wave in lead I, a Q wave and inverted T wave in lead III) • Incomplete or complete right bundle-branch block
Assessment during resuscitation
Female biological sex
Lower age
EMS witnessed cardiac arrest
PEA as first observed rhythm
Low $ETCO_2$ readings during high quality CPR (<1.7 kPa/13 mmHg)
Presence of right heart dilation with poor filling of the left heart, D sign (straightening of interventricular septum) and/or intracardiac thrombi (intra-arrest POCUS)

Surgical embolectomy or percutaneous mechanical thrombectomy. Successful surgical embolectomy and percutaneous mechanical thrombectomy have been reported in cardiac arrest patients and are recommended if PE is the known cause of cardiac arrest, and the specialised skills are available.[211–213] Treatment decisions should be made by a highly experienced interdisciplinary team, involving a thoracic surgeon or interventional cardiologist.[193,214]

Extracorporeal CPR. Some observational studies suggest the use of ECPR if cardiac arrest is associated with pulmonary embolism[198,215] ECPR maintains circulation and gas exchange. Time to ECPR correlates with neurological outcome.[216] Consider ECPR as a rescue therapy for selected patients with cardiac arrest when conventional CPR is failing in settings in which it can be implemented.[201] It is recommended that adequate ECPR flow is established within 60 min of the onset of cardiac arrest. [217] Favourable neurological outcomes in patients with pulmonary embolism undergoing ECPR is inferior to outcomes related to other aetiology.[198,218] Despite the extremely high mortality rate of patients with cardiac arrest refractory to standard ALS, ECPR is also an option to increase the pool of organ donors.[198]

Coronary thrombosis

Coronary artery disease (CAD) remains the leading cause of OHCA in adults, either due to ventricular arrhythmias triggered by acute myocardial ischaemia, or those arising from the fibrotic arrhythmogenic substrate in patients with previous myocardial infarction.[219,220] While CAD prevalence increases with age, it is also the most common cause of cardiac death in adults aged 35 to 50 years.[221,222]

A recent systematic review and *meta*-analysis reported significant CAD in 75 % of OHCA cases,[223] ranging from 88 % in patients with initial shockable rhythm and ST-elevation on ECG, to 54 % in non-shockable cases without ST-elevation. Culprit lesions were identified in nearly 60 %, more often in patients with shockable rhythm and ST-elevation, while acute coronary occlusion was found in around 40 %, with a higher prevalence in patients with ST-elevation. Among those with refractory cardiac arrest, 75 % had significant CAD and 70 % had a culprit lesion, often involving the left main coronary artery.

Prevention strategies for CAD as a cause of OHCA should comprise promoting healthy lifestyles in asymptomatic individuals, as well as addressing modifiable risk factors of atherosclerosis in patients with known disease, most effectively through cardiac rehabilitation.[224,225]

Health education should target time reduction from symptom onset (i.e. chest pain) to seeking medical help, in order to enable early diagnosis and treatment. Behaviour change techniques (action planning, information about health consequences, signs and symptoms and instruction on what to do) might be helpful for this particular purpose.[226]

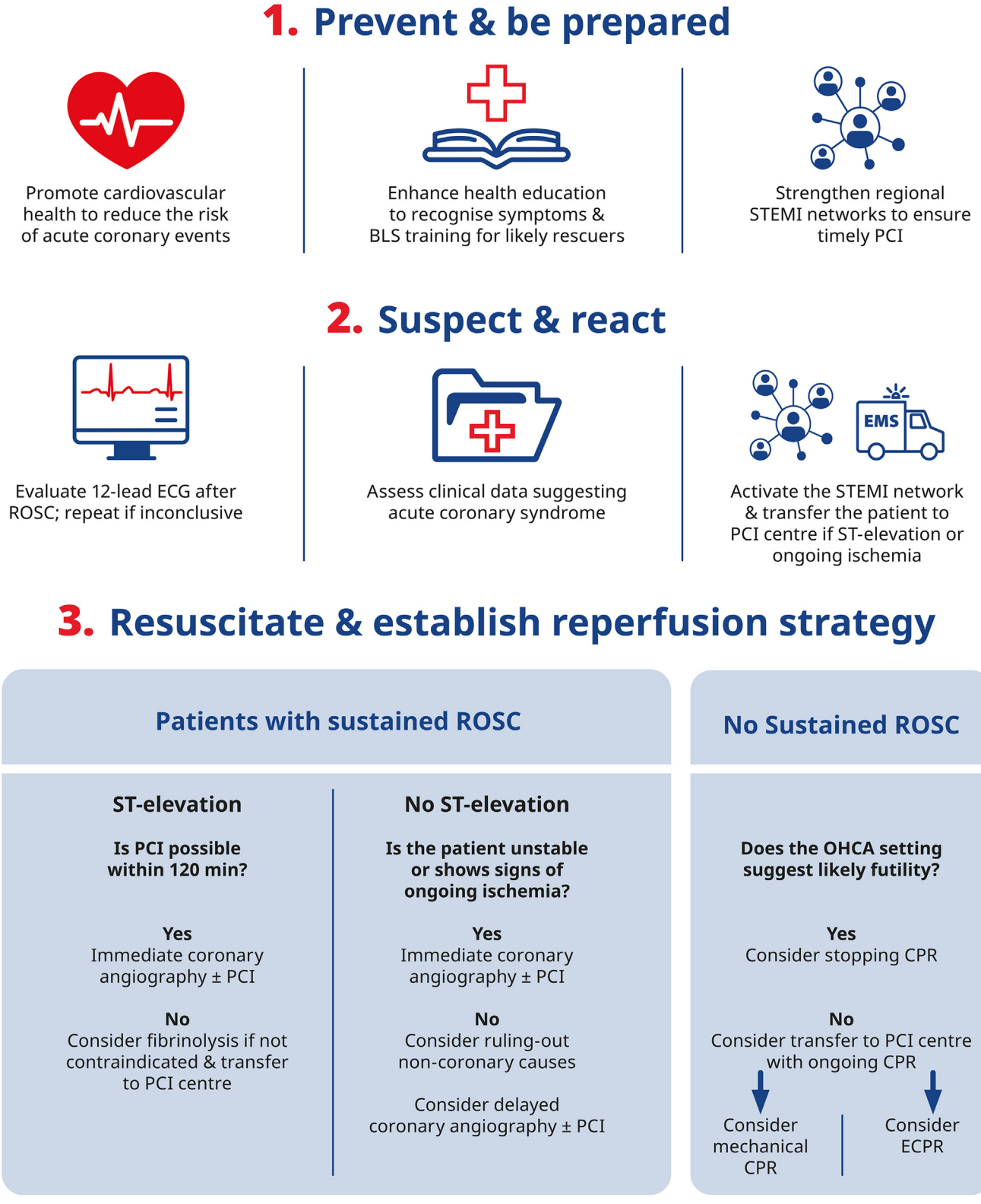


Fig. 15 – Coronary thrombosis algorithm.

BLS – basic life support, STEMI – ST elevation myocardial infarct, PCI – percutaneous coronary intervention, ECG – electrocardiography, OHCA – out-of-hospital cardiac arrest, ROSC – return of spontaneous circulationg.

An updated 2022 ILCOR CoSTR concluded that BLS training consistently improved BLS skills, knowledge, and increased confidence to perform CPR. Thus, BLS training for likely bystanders of high-risk populations is recommended and should be actively promoted by healthcare professionals.[201]

Along with initiatives raising public awareness, healthcare systems should establish regional STEMI networks to ensure equal and timely access to percutaneous coronary intervention (PCI).[225] A recent systematic review and *meta*-analysis found that such networks may reduce STEMI case-fatality by 35 % and long-term mortality by 27 %.[227] Integration of the emergency transport system was a critical factor for success.

Detect features suggesting coronary thrombosis and activate STEMI network

A 12-lead electrocardiogram (ECG) should be obtained and evaluated after ROSC to identify possible ischaemic features. Additional ECGs may help decision-making, as defibrillation and the time elapsed from ROSC to ECG acquisition may affect findings, with a higher percentage of false-positive for STEMI if the ECG is performed $\leq$ 8 min from ROSC.[228] ST elevation remains the most sensitive and specific sign of coronary artery occlusion; however, its absence does not completely exclude the condition.[229] Other ECG patterns —such as bundle branch block or diffuse ST-depression with concurrent ST-segment elevation in aVR and/or V1— may suggest coronary occlusion and should be considered if the clinical context is compatible.[225] Additionally, non-cardiac conditions, such as subarachnoid haemorrhage, can also cause ST-changes,[230] highlighting the importance of clinical correlation.

A comprehensive approach integrating ECG findings and clinical information suggesting a possible coronary cause —such as a history of CAD, chest pain before arrest, or an initial shockable rhythm—[231] is recommended. Once clinical suspicion is established, the STEMI network should be promptly activated to ensure early transfer to a centre with PCI capability.

Resuscitate according to ALS algorithm & establish reperfusion strategy

Patients with ROSC and ST-elevation. OHCA resuscitation should follow the standard ALS protocol (see ALS chapter). Conscious patients with persistent ST-elevation (or equivalent) after ROSC should undergo immediate coronary angiography and PCI within 120 min of diagnosis, as per standard STEMI management. If significant delays are expected, pre-hospital fibrinolysis may be considered unless CPR was prolonged or traumatic or there are other contraindications, followed by immediate transfer to PCI centre. [225] Comatose patients with ST-elevation after ROSC have significantly worse prognosis, and no RCTs have directly compared early versus delayed angiography in this group. However, since early angiography is the standard of care for STEMI and no evidence suggests otherwise, both the ILCOR [232] and the European Society of Cardiology[225] recommend the same approach for these patients.

Pharmacological therapy should align with STEMI protocols for non-arrest patients.[225] In patients targeted for a primary PCI strategy, aspirin is recommended and early administration of a P2Y12 inhibitor (ticagrelor or prasugrel over clopidogrel, or IV cangrelor if oral intake is not possible) may be considered. Unfractioned heparin (IV) is the preferred anticoagulant, with enoxaparin (SC) or bivalirudin (IV) as alternatives.

Patients with ROSC and no ST-elevation. While previous observational studies suggested a potential benefit of early coronary angiography in resuscitated patients without ST-elevation on ECG,[233,234] recent RCTs have not confirmed this. A 2021 ILCOR systematic review and *meta*-analysis[235] compared routine early (2–6 h) versus delayed (within 24 h) coronary angiography in unconscious adult patients with ROSC after OHCA. This included data from the Direct or Subacute Coronary angiography in Out-of-hospital Cardiac Arrest-DISCO trial ($n = 79$),[236] Coronary Angiography After Cardiac Arrest Trial-COACT ($n = 552$)[237] and Randomized Pilot Clinical Trial of Early Coronary Angiography-PEARL ($n = 99$)[238] – the latter being underpowered. No survival or neurological benefit was found for early versus delayed angiography in patients without ST-elevation. In 2022, an updated ILCOR CoSTR[232] added the results of the Angiography after Out-of-Hospital Cardiac Arrest without ST–Segment Elevation-TOMAHAWK ($n = 554$) trial,[239] which also found no advantage of a routine early approach. Accordingly, the Task Force deemed both early and delayed angiography reasonable in patients without ST-elevation after ROSC (weak recommendation, low-certainty evidence).[232] Two latter RCTs, Emergency vs Delayed Coronary Angiogram in Survivors of Out-of-Hospital Cardiac Arrest-EMERGE ($n = 279$)[240] and Coronary angiography in Out-of-hospital cardiac arrest Patients without ST-segment Elevation-COUPE ($n = 66$)[241] have reinforced these findings, despite variations in study protocols and outcome definitions, as well as limited statistical power.

Importantly, patients with shock, electrical instability, or signs of ongoing ischaemia were excluded or allowed to cross over to the emergency arm. Thus, current evidence does not support routine early over delayed angiography in stable patients without ST-elevation on the post-ROSC ECG. However, individual decisions should consider the patient's haemodynamic status and signs of ongoing ischaemia. Also, ruling out non-coronary causes is recommended if the clinical context suggests a potential alternative aetiology for the arrest.

Pharmacological treatment should generally follow the recommendations for non-ST-elevation acute coronary syndrome if suspected.[225] Aspirin is recommended, but routine early use of P2Y12 inhibitors is discouraged if early angiography is planned. Unfractioned heparin (IV) and fondaparinux (SC) are the preferred anticoagulants for the early and delayed angiography strategies, respectively. However, if there are concerns about other non-coronary causes for the arrest, withholding antiplatelet and anticoagulant therapies until further evaluation is reasonable.

Patients without sustained ROSC. Mechanical CPR and, ultimately, ECPR might be the only therapeutic option for refractory OHCA. The first has not proved consistent superiority over manual CPR, but it may facilitate delivering high-quality chest compression during transportation or while performing coronary angiography.[242] Studies addressing ECPR in this setting have reported conflicting results. An updated ILCOR systematic review compared ECPR with manual or mechanical CPR for refractory OHCA, assessing survival and neurological outcomes.[8,243] This included two single-centre RCTs: the ARREST ($n = 30$) trial was terminated early because of superiority in the ECPR arm for primary outcome (survival to hospital discharge). Interpretation of included studies was difficulted due to different study designs and inconsistent findings.[244,245] A multicentre

RCT found no difference in 30-day survival with favourable neurological outcomes.[246] Given these inconclusive findings but considering the potential risk–benefit balance in this poor-prognosis scenario, ECPR may be considered as a rescue therapy for selected OHCA patients when conventional CPR fails to achieve ROSC, provided it can be implemented.[243]

Toxic agents

Intoxication is one of the eight reversible causes of cardiac arrest. Thus, all patients with cardiac arrest should be screened for signs of intoxication, especially in suspicious cases, unexpected cardiac arrests or in cases with more than one casualty. If intoxication is likely, resuscitation teams should avoid contamination by first donning appropriate personal protective equipment (PPE). Direct skin contact or mouth to mouth ventilation might transmit toxic agents and should therefore be avoided (See Fig. 7). The therapeutic strategy of intoxication consists of the three pillars:

- Decontamination
- Enhanced elimination
- Administration of antidotes

Helpful online databases on poison centres and toxins can be found in the QR codes 2 and 3). The patient's temperature should be measured because hypo- or hyperthermia may occur during drug overdose, as mentioned earlier. The 2021 ERC guidelines provide a detailed overview about intoxication.[99] These updated recommendations are based on recent scientific evidence, systematic reviews, and expert consensus. A separate subchapter addresses local anaesthetic systemic toxicity.

QR code. 2 – World directory of poisons centres – provided by the World Health Organization.

QR code. 3 – PubChem – world's largest collection of freely accessible chemical information – provided by the National Library of Medicine.

Intoxication with opioids

An ILCOR systematic review found heterogenous results on the benefit of opioid-specific advanced life support-level therapies for cardiac arrest.[247] Existing evidence is not sufficient to recommend administration of an opioid-antagonist (e.g. naloxone) for cardiac arrest caused by opioid poisoning.

Intoxication with cardiac glycoside

A narrative review on treatment of patients with haemodynamic instability caused by cardiac glycoside poisoning found an improved haemodynamic status and survival after administration of digoxin immune-Fab fragments. Favourable outcomes were seen in patients receiving magnesium, cardioversion, or cardiac pacing.[248]

ECPR

ECPR seems to be associated with increased survival in intoxicated patients in refractory cardiogenic shock or cardiac arrest.[249]

Traumatic cardiac arrest

Traumatic cardiac arrest is associated with a very high mortality and good neurological outcome is reported in less than 50 % of those who survive. The response to traumatic cardiac arrest is time-critical and success depends on a well-established chain of survival, including advanced prehospital and specialised trauma centre care. Immediate resuscitative efforts in traumatic cardiac arrest focus on simultaneous treatment of reversible causes, which takes priority over chest compressions. Evidence is based on nine systematic reviews and evidence updates and consensus from the expert group.[250–258]

In Europe, traumatic cardiac arrest accounts for 4 % of all cardiac arrests occurring in the pre-hospital setting.[259] Registry data for survival range from 0 %[260] to 37 %.[261] A recent systematic review[255] of traumatic cardiac arrest identified 36 studies, and a total of 51,722 patients, reporting an overall mortality rate of 96.2 %, with 43.5 % of survivors achieving a favourable neurological outcome. The presence of a physician at the prehospital scene was associated with improved outcomes (6.1 % vs 2.4 % survival and 57.0 % vs 38.0 % favourable neurological outcome, with or without physician respectively). Another systematic review confirmed these findings.[253]

Factors relevant for prognostication are listed in Table 7.

Withholding resuscitation

The American College of Surgeons and the National Association of EMS Physicians recommend withholding resuscitation in situations where death is inevitable or established and in trauma patients presenting with apnoea, pulselessness and without organised ECG activity.[271] However, neurologically intact survivors initially presenting in this state have been reported. [272] The ERC based on expert consensus recommends the following approach:

Consider withholding resuscitation in traumatic cardiac arrest in any of the following conditions:

- no signs of life within the preceding 15 min.
- massive trauma incompatible with survival (e.g. decapitation, extensive cardiac destruction, massive head injury with loss of brain tissue).

We suggest termination of resuscitative efforts if there is:

- no ROSC within 20 min after reversible causes have been addressed.
- no detectable ultrasonographic cardiac activity in PEA 20 min after reversible causes have been addressed.

Preventable deaths

For a diagnosis of TCA, there must be plausible signs of traumatic injury or, at least, a mechanism of injury consistent with trauma. In the absence of an identifiable mechanism or visible signs of injury, the standard ALS algorithm should be followed instead. The use of ultrasound supports findings in this context, aiding in differentiating *peri*-arrest from TCA, identifying reversible causes, and guiding resuscitative efforts accordingly.[273]

A considerable proportion of trauma-related deaths can be attributed to management errors. In an urban German population, the

Table 7 – Prognostication in traumatic cardiac arrest.[254,262–270.]

–	+
Age	Emergency surgery
Female	Major trauma centre care
Increased ISS	Shockable ECG rhythm
Head injury	Reactive pupils
Shock on admission	Respiratory activity
Need for blood transfusion	Spontaneous eye or extremity movements
CPR in the emergency department	Organised ECG rhythm
Children	Shorter CPR duration
	Reduced prehospital time
	Penetrating chest injury
	Witnessed arrest
	Cardiac motion in ultrasound

prevalence of potentially preventable prehospital deaths from trauma was reported as 15.1 %,[274] whereas in an urban U.S. population, this figure was higher at 29 %.[275] In Australia, the rate of potentially preventable trauma deaths was found to be 20 %.[276] Throughout these studies, exsanguination was identified as a leading cause of preventable death. Taking these data into account, the ERC recommends participation in an accredited trauma management training program for those involved in the care of trauma patients. Ideally such a training format reflects the standard team approach provided in the European systems.[277]

The reversible causes associated with TCA are uncontrolled haemorrhage (48 %); tension pneumothorax (13 %); asphyxia (13 %); and cardiac tamponade (10 %). The presenting rhythms found in traumatic cardiac arrest are usually PEA or asystole, depending on the time interval between circulatory arrest and the first ECG recording; PEA (66 %); asystole (30 %); VF (4 %).[278] The key pathophysiological mechanisms leading to traumatic cardiac arrest are listed in Table 8:

As these mechanisms progress beyond a critical threshold, irreversible circulatory failure ensues:

- Progressive bradycardia and hypotension (caused by severe hypoxia and acidosis)
- PEA with minimal cardiac activity on ultrasound (Pseudo-PEA) refers to a state where the heart exhibits weak contractile activity on ultrasound but fails to generate an effective pulse or circulation.[266]
- PEA without with no cardiac activity detectable on ultrasound. The mortality of this condition approaches 100 %.
- Asystole → The final stage of cardiac arrest, with no electrical or mechanical activity.

Effectiveness of chest compressions

In cases of cardiac arrest due to hypovolaemia, cardiac tamponade, or tension pneumothorax, the effectiveness of chest compressions is uncertain. Their impact likely depends on ventricular filling, which is compromised in these conditions, and in *peri*-arrest states (pseudo-PEA), chest compressions may even reduce the remaining cardiac output by further decreasing venous return.[279–281] Therefore, chest compressions must not delay immediate treatment of reversible causes.

Following resuscitative thoracotomy, open cardiac compressions might be beneficial. Patients sustaining traumatic cardiac arrest within the first six hours of hospital admission may benefit from open

Table 8 – Major causes of traumatic cardiac arrest and their pathophysiology.

Cause	Mechanism	Impact on Circulation
Hypovolaemic shock	Severe blood loss → inadequate preload & cardiac output	Decrease in right ventricular filling → hypotension, decrease in cardiac output → tissue hypoperfusion including coronary perfusion, → tissue hypoxia → metabolic acidosis, shock, ECG typically PEA, followed by asystole
Tension pneumothorax	Increased intrathoracic pressure → impaired venous return	
Cardiac tamponade	Pericardial blood accumulation → restricted ventricular filling	
Hypoxia/asphyxia	Airway compromise, lung injury, or Brain Impact Apnoea	Progressive hypoxaemia → bradycardia → PEA → asystole
Metabolic acidosis (contributing factor)	Ischaemia from prolonged hypoxia & hypoperfusion	Cardiac dysfunction, reduced contractility
Neurogenic shock (contributing factor)	Loss of sympathetic tone	Aggravates other shock states, worsening hypotension

cardiac compression instead of closed chest compressions; in one retrospective trial, open cardiac compressions in traumatic cardiac arrest were associated with a higher long-term survival both in penetrating and blunt trauma. However, the study does not address the management of reversible causes.[282]

Providers without the training to manage reversible causes should follow the standard ALS algorithm and prioritise rapid transport under ALS or BLS, depending on system capability. Those with the necessary expertise should make case-by-case decisions based on available resources, likely reversible causes, and regional guidelines.

The role of inotropes and vasopressors

Although adrenaline may increase the rates of ROSC with medical cardiac arrest,[283] the role of inotropes and vasopressors in traumatic cardiac arrest (TCA) is unclear.[284] They may serve as a temporary bridge until reversible causes are addressed. Their use may also be considered in late-stage shock with cardiac dysfunction or mixed shock states such as trauma with a neurogenic component. The primary aim in traumatic cardiac arrest is to identify and treat any reversible cause which should take preference over inotrope/vasopressor therapy.

Pre-hospital care

The TCA algorithm (Fig. 8) applies not only to patients in traumatic cardiac arrest but also to *peri*-arrest trauma patients who present with signs of impending circulatory collapse. In both scenarios, the response must be immediate, targeted, and adapted to the capabilities of the prehospital system. The choice between a "stay and treat" strategy versus "scoop and run" or "treat-as-you-go" depends less on geography and more on the available skill set, equipment, and system infrastructure. In highly trained systems with extended capabilities, life-saving interventions may be feasible on scene. In others, immediate transfer may be the best chance for survival, provided that basic haemorrhage control and oxygenation are ensured during transport. Regardless of the system configuration, prolonged prehospital time must be avoided.[273] Early pre-alerting of the Major Trauma Centre (MTC) is essential. In cases of ongoing haemorrhage or severe physiological compromise, the patient should be declared "Code Red" (or equivalent), enabling the hospital to activate the massive transfusion protocol, mobilise the trauma team, and ensure immediate access to surgical care upon arrival.

The recently published practice guidelines of the Royal College of Surgeons of Edinburgh on traumatic cardiac arrest provide a comprehensive overview of prehospital management.[285]

In-hospital care

Successful treatment of traumatic cardiac arrest requires a highly coordinated, team-based approach, where all life-saving interventions are carried out in parallel rather than sequentially, based on the clinical priorities dictated by the patient's presentation. The focus is on rapid identification and treatment of all potentially reversible causes to maximise the chances of survival. A prospective observational study in patients with exsanguinating injuries and systolic blood pressure < 90 mmHg showed lower 30-day mortality (17.5 % vs. 72.0 %, $p < 0.001$) when prioritising circulation (CAB approach) over tracheal intubation (ABC approach), thus enabling for resuscitative bleeding control before ventilation.[286] Fig. 8 illustrates the traumatic cardiac (peri-)arrest algorithm, which is based on the universal ALS algorithm but integrates trauma-specific modifications to accommodate the unique challenges of traumatic cardiac arrest management. A multidisciplinary team approach, including trauma surgeons, emergency physicians, anaesthetists, radiologists, intensivists and nursing staff, is essential to ensure that each critical intervention is initiated without delay, according to the patient's immediate needs.

Treatment of the reversible causes in traumatic cardiac arrest

Hypovolaemia. The treatment of severe hypovolaemia has several components. The main principle is to achieve immediate haemostasis. Temporary haemorrhage control can be lifesaving.[273] Compressible external haemorrhage can be treated with elevation (of a bleeding limb), direct or indirect pressure, pressure dressings, tourniquets and topical haemostatic agents.[273,287] Non-compressible haemorrhage is more difficult to address and splints (pelvic splint), blood products, IV fluids and tranexamic acid can be used while transferring the patient for surgical haemorrhage control.[288]

Immediate aortic occlusion is recommended as a last resort measure in patients with exsanguinating and uncontrollable infradiaphragmatic torso haemorrhage. This can be achieved through resuscitative thoracotomy and cross-clamping (or manual compression) of the descending aorta or resuscitative endovascular balloon occlusion of the aorta (REBOA). There is no evidence for one technique being superior to the other.[289] Both are highly specialised interventions, appropriate expertise and equipment. A recent UK REBOA study[290] in traumatic shock revealed a possible increase in mortality. The ERC does not recommend the use of REBOA outside of clinical trials.

In hypovolaemic traumatic cardiac arrest, immediate restoration of the circulating blood volume with blood products is mandatory. Prehospital transfusion of fresh plasma and packed red blood cells may improve survival, especially in cases with prolonged prehospital time.[291,292] Recent evidence suggests additional benefit from whole blood transfusion.[258,293]

Hypoxia. In traumatic cardiac arrest, hypoxaemia can be caused by airway obstruction, traumatic asphyxia or impact brain apnoea.[294] Impact brain apnoea is an underestimated cause of morbidity and mortality in trauma, but not necessarily associated with an unsurvivable brain injury.[295] Data from the National Trauma Audit and Research Network database in UK reported a 15 % survival rate with 90 % favourable outcome among traumatic cardiac arrest patients with brain impact apnoea.[296] Brain impact apnoea may aggravate the course of traumatic brain injury and can lead to asphyxiation if left untreated. Effective airway management and ventilation with oxygen can prevent and reverse hypoxic cardiac arrest. In a recent national Dutch study, 52 % of traumatic cardiac arrest were attributed to traumatic brain injury-related apnoea.[297]

Controlled ventilation in circulatory compromised patients is associated with major risks because of the increase in intrathoracic pressure[298,299] that may lead to further decreased cardiac output caused by:

- Impeded venous return to the heart, particularly in severe hypovolaemia.
- Reduced diastolic filling, particularly in cardiac tamponade
- Conversion of pneumothorax into a tension pneumothorax
- Increase in blood loss from venous bleeding sites

Minimising intrathoracic pressure using low tidal volumes and minimal PEEP may help optimise cardiac preload. Ventilation should

be monitored with capnography and adjusted to achieve normocapnia.[265,300,301]

Tension pneumothorax. Tension pneumothorax is a reversible cause of cardiac arrest and must be excluded in traumatic cardiac arrest. It may lead to cardiac arrest by obstructing venous return through mediastinal shift and impairing effective gas exchange. Positive pressure ventilation can convert a simple pneumothorax into a tension pneumothorax.[302] The prevalence of tension pneumothorax is approximately 0.5 % in all major trauma patients treated in the prehospital setting and 13 % of those develop traumatic cardiac arrest.[278] Diagnosis of tension pneumothorax in a patient with cardiac arrest or haemodynamic instability must be based on clinical examination or POCUS. The symptoms include haemodynamic compromise (hypotension or cardiac arrest) in conjunction with signs suggestive of a pneumothorax (preceding respiratory distress, hypoxia, absent unilateral breath sounds on auscultation, subcutaneous emphysema and mediastinal shift with tracheal deviation and jugular venous distention).[302] The presentation of a tension pneumothorax is not always classical, but when it is suspected in the presence of cardiac arrest or severe hypotension, chest decompression by open thoracostomy should be carried out immediately. To decompress the chest in traumatic cardiac arrest, perform bilateral thoracostomies in the 4th intercostal space at the midaxillary line, allowing extension to a clamshell thoracotomy if required. Needle thoracocentesis should be attempted if the provider is not competent to perform a thoracostomy, or if the necessary surgical instruments are not immediately available.[303–306]

Cardiac tamponade and resuscitative thoracotomy. Cardiac tamponade is a frequent cause of cardiac arrest in penetrating chest trauma. Those with the clinical ability, competence, and equipment to perform it, can restore circulation with immediate resuscitative thoracotomy via a clamshell or left anterolateral incision.[307,308] A systematic review on needle pericardiocentesis in traumatic cardiac tamponade concluded that there remains a limited role for this method in non-trauma centres where definitive surgical management is not immediately available.[309]

While resuscitative thoracotomy is often performed for the relief of cardiac tamponade, it is not exclusively indicated for this condition. Resuscitative thoracotomy is also applicable for direct haemorrhage control, aortic cross-clamping, and open cardiac compressions.[282]

A recent systematic review and *meta*-analysis examined resuscitative thoracotomy in civilian thoracic trauma, analysing 49 studies across both pre-hospital and emergency department settings.[251] The study found that timing is critical, as performing pre-hospital resuscitative thoracotomy more than five minutes after arrival at the scene was associated with increased neurological complications, while a delay of more than ten minutes from the initial encounter to resuscitative thoracotomy was linked to higher mortality rates. Patients with an Injury Severity Score of 25 or higher and those without signs of life also had poorer outcomes. Overall, mortality was higher in pre-hospital resuscitative thoracotomy (93.5 %) compared to ED-resuscitative thoracotomy (81.8 %) ($P = 0.02$). Among emergency department-resuscitative thoracotomy cases, blunt trauma patients had significantly higher mortality (92.8 %) compared with penetrating trauma patients (78.7 %) ($P < 0.001$). In summary, emergency resuscitative thoracotomy is a high-risk intervention, with better survival rates in the hospital, and timely intervention within 5–10 min is crucial for improving outcomes. Blunt trauma patients have poorer survival prospects compared with those with penetrating injuries.

The prerequisites for a successful resuscitative thoracotomy can be summarized as the 'four E rule':

- Expertise: teams that perform resuscitative thoracotomy must be led by a highly trained and competent healthcare practitioner. These teams must operate under a robust governance framework.
- Equipment: adequate equipment to carry out resuscitative thoracotomy and to deal with the intrathoracic findings is mandatory.
- Environment: ideally resuscitative thoracotomy should be carried out in an operating room. Resuscitative thoracotomy should not be carried out if there is inadequate physical access to the patient, or if the receiving hospital is not easy to reach.
- Elapsed time: the time from loss of vital signs to commencing a resuscitative thoracotomy should not be longer than 15 min

If any of the four criteria is not met, resuscitative thoracotomy is futile and exposes the team to unnecessary risks.[310] A retrospective cohort study found that prehospital resuscitative thoracotomy for traumatic cardiac arrest was associated with 3.8 % of patients surviving with favourable neurological outcome, all presenting with cardiac tamponade following penetrating trauma, and none of the patients with exsanguination or other pathology surviving with favourable neurological outcome. There were no survivors beyond 15 min of traumatic cardiac arrest for cardiac tamponade and 5 min after exsanguination-induced cardiac arrest.[311]

Post resuscitation care after traumatic cardiac arrest

As with all aetiologies of cardiac arrest, optimising cardiac output is essential for restoring oxygenation and meeting the metabolic demands of post-arrest physiology. This includes fluid resuscitation and vasopressor support as needed to maintain adequate tissue perfusion and oxygen delivery. Early whole-body CT scanning can help identify major injuries and guide initial management following ROSC by detecting life-threatening conditions such as ongoing haemorrhage, pneumothorax, or cardiac tamponade, which may require immediate intervention.

The principle of damage control resuscitation is advocated for uncontrolled haemorrhage in trauma. Damage control resuscitation integrates permissive hypotension, haemostatic resuscitation, and damage control surgery. Evidence supports a conservative IV fluid approach, maintaining blood pressure at a level no more than is necessary to sustain a radial pulse, until surgical haemostasis is achieved. However, caution is needed in traumatic brain injury, where raised intracranial pressure may necessitate a higher blood pressure to achieve sufficient cerebral perfusion pressure. The duration of hypotensive resuscitation should not exceed 60 min, as the risk of irreversible organ damage then outweighs its benefits.[312–314]

Temperature management is crucial, as hypothermia exacerbates coagulopathy, acidosis, and haemodynamic instability (the 'lethal triad'). To prevent further deterioration, active warming strategies, including fluid warming, external warming devices, and maintaining an optimal resuscitation environment, should be implemented early.

Coagulation management is a key component of resuscitation, as trauma-induced coagulopathy can worsen haemorrhage and organ dysfunction. Strategies include early administration of blood products

(e.g., plasma, platelets, fibrinogen or whole blood), tranexamic acid, and point-of-care coagulation monitoring to guide targeted haemostatic therapy.

Special settings

Cardiac arrest in the catheterisation laboratory

The occurrence and outcomes of cardiac arrest in the cardiac catheterisation laboratory ('cath lab') vary depending on the setting, patient profile and type of intervention performed. Cases range from routine elective procedures to the emergent treatment of critically ill patients with cardiac ischaemia, shock, or life-threatening arrhythmias. Additionally, structural heart interventions, often targeting elderly and high-risk patients, are becoming increasingly prevalent and complex. Causes of cardiac arrest among others in this setting include severe ischaemia, tamponade, arrythmias, vascular perforation/dissection, or anaphylaxis.

A recent ILCOR scoping review[315] estimated the overall incidence of cardiac arrest in the catheterisation lab as 0.2 % to 0.5 % across all procedures.[316,317] For PCI, the incidence is slightly higher (0.8–2 %),[318–320] and for ST-elevation myocardial infarction higher still (STEMI – 1.9 % to 5.5 %), primarily with an initial rhythm of ventricular fibrillation.[321–325]

Overall initial survival rates range from 67 % to 77 % at the event time[316,317,326] and between 38 % to 56 % at hospital discharge.[317,326] For PCI and STEMI, survival to discharge is higher (82–100 %).[321,322,325]

Prevent and be prepared

Adequate Education is essential to ensuring the best cardiac arrest outcomes in the catheterisation lab. Staff should be trained in advanced life support and prepared to quickly recognise and manage procedure-specific risks and complications, including pacing, pericardiocentesis, initiation of ventricular assist devices, or ECPR. Emergency equipment should be functional and readily available (See Fig. 16).

Studies support periodic simulation emergency drills to enhance technical and non-technical skills in the catheterisation lab.[327] Training in non-technical skills has the potential to minimize errors in this setting.[328] Careful risk–benefit assessment and planning for elective procedures are advised to minimise complications. The use of safety checklists has been reported as effective in reducing human errors and has resulted in fewer complications.[329]

Detect and react

Patient's monitored vital parameters including ECG must be checked regularly to detect early complications. Echocardiography should be readily accessible in case of haemodynamic instability or suspected complication (e.g. cardiac tamponade). Transoesophageal echocardiography (TOE), often used for monitoring structural heart interventions in the catheterisation lab, may facilitate early detection of complications with higher quality images and precision.[330]

Cardiac arrest in the catheterisation lab should prompt an immediate call for help and activation of the resuscitation team.[316] While catheterisation lab staff must promptly initiate CPR, additional support is needed to sustain CPR while addressing reversible causes. Depending on the suspected underlying complication or cause of arrest, the cardiac surgery team should also be alerted. Importantly, as highlighted by the Joint British Societies' guideline on management of cardiac arrest in the catheterisation lab,[331] all emergency team members should don lead aprons before entering, since fluoroscopy may often be necessary. Ensure that an adequate supply of lead aprons, protection for eyes and thyroid is readily available in advance.

Resuscitate and treat possible causes

Cardiac arrest in the catheterisation lab should be generally managed according to the ERC Guidelines 2025 ALS,[164] with some modifications. In the presence of monitored VF/pVT, immediate defibrillation with up to three stacked shocks if a shockable rhythm persists is recommended before starting chest compressions. This approach aligns with the recommendations for witnessed arrests in monitored patients with a shockable rhythm when a defibrillator is readily available. In case of PEA/ asystole, CPR should be initiated and adrenaline injected. However, extreme bradycardia may be treated with external or transvenous temporary pacing, especially if it arises from atrio-ventricular block complicating certain procedures, such as transaortic valve implant, tricuspid valve interventions or catheter ablation. During cardiac arrest, invasive procedures to correct reversible causes (such as PCI, pericardiocentesis, or mechanical support device initiation) might be needed during on-going CPR or immediately after ROSC.[331]

Point of care ultrasound (POCUS)

ILCOR reviewed the diagnostic accuracy of POCUS in detecting reversible causes of cardiac arrest in different scenarios, concluding that POCUS evaluation may be considered during cardiac arrest in the catheterisation lab if performed by experienced personnel without interrupting CPR, especially when a specific reversible cause is clinically suspected.[332] In patients already undergoing TOE at the time of cardiac arrest, maintaining the TOE probe in place could be considered if the airway is secured, since TOE may offer additional feedback and assist in guiding ECPR or mechanical support device placement if performed by a skilled operator, without interfering with chest compression. However, the use of these tools should not compromise adherence to the ALS protocol.

Mechanical CPR

An ILCOR systematic review evaluated the impact of mechanical chest compression devices compared with manual compression on cardiac arrest outcomes,[242] and found evidence against the routine use of automated mechanical chest compressions to replace manual compressions for in-hospital cardiac arrest. However, mechanical CPR was considered a reasonable alternative when high-quality manual compressions may compromise the safety of the provider or interfere with critical procedures, such as those performed in the catheterisation lab. Additionally, the ILCOR scoping review on cardiac arrest in the catheterisation lab[315] described outcomes of cardiac arrest in the catheterisation lab following the use of mechanical CPR, mainly during PCI or cannulation for mechanical circulatory support or extracorporeal CPR. The mixed cohorts included in the remaining studies and the inconsistent outcome reporting made interpretation difficult, so the overall results in this setting are uncertain. Until new evidence is produced, mechanical CPR may be used in the catheterisation lab following the ILCOR CoSTR considerations discussed above.[242] Importantly, if used,

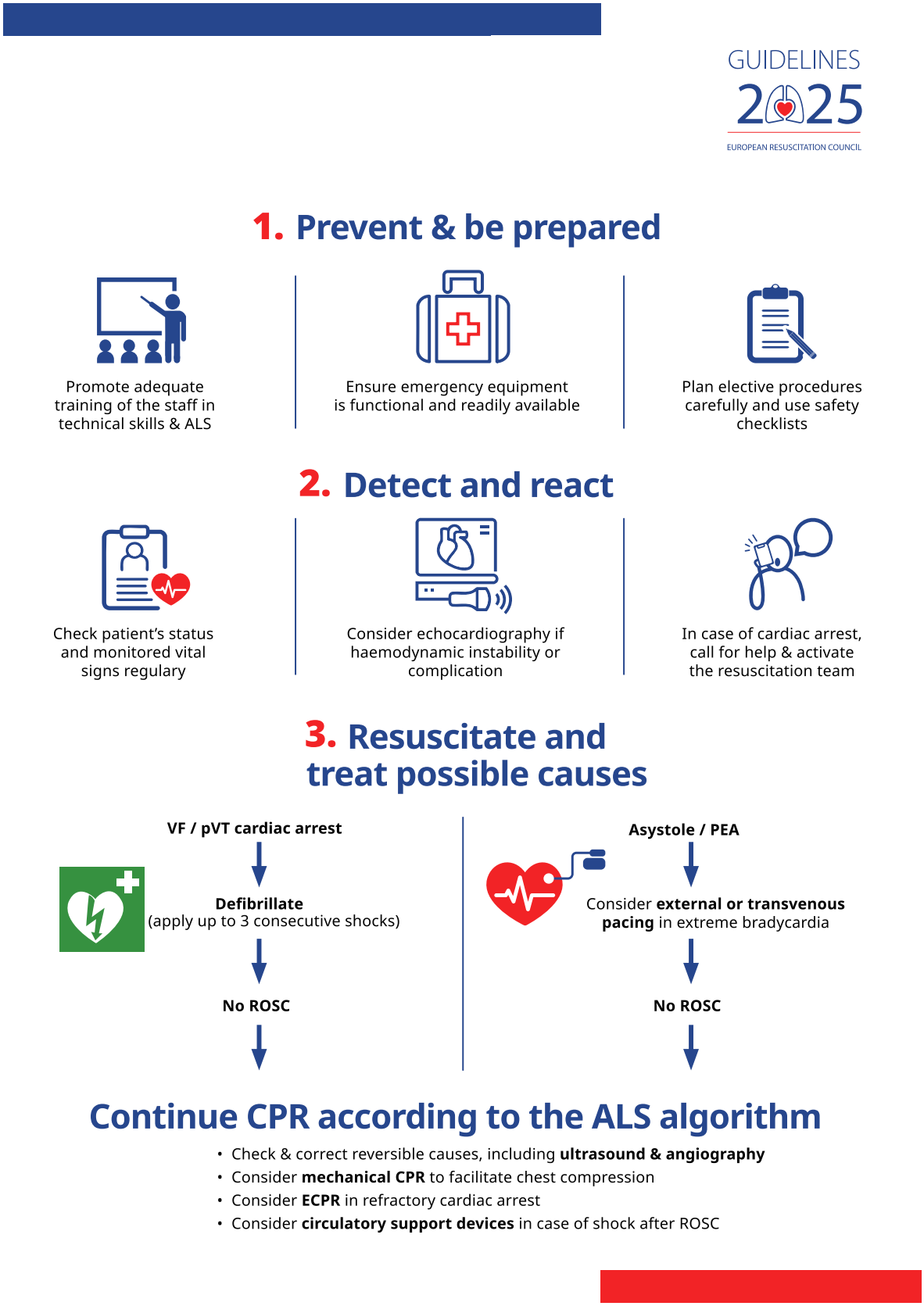


Fig. 16 – Treatment of cardiac arrest in catheterisation laboratory.
ALS – advanced life support, VF – ventricular fibrillation, pVT – pulseless ventricular tachycardia, ROSC – return of spontaneous circulation, PEA – pulseless electrical activity, POCUS –point of care ultrasound.

pauses during device placement should be minimized, and correct positioning ensured to avoid visceral injuries.

Extracorporeal CPR

The use of veno-arterial extracorporeal membrane oxygenation (VA-ECMO) to support refractory cardiac arrest patients (ECPR) was recently updated by ILCOR.[243] In the in-hospital setting, ECPR was considered as a rescue therapy for selected patients with refractory cardiac arrest if implementation is feasible. A recent ILCOR scoping review[315] covered the use of ECPR in the catheterisation lab. Most evidence derived from the Extracorporeal Life Support Organization registry with 39 % survival to hospital discharge.[333] Despite its potential advantages in sustaining resuscitation while addressing reversible causes, evidence is limited due to study heterogeneity and high risk of bias. Nevertheless, considering the risk–benefit ratio, ECPR may be considered for selected cardiac arrest patients in the catheterisation lab based on clinical circumstances, available resources and experience. ECPR facilitates performing diagnostic or therapeutic procedures, including coronary angiography/angioplasty, pulmonary embolectomy or cardiac surgery.

Mechanical circulatory support

A variety of temporary devices can be used in the catheterisation lab to assist cardiac pumping function, offering different levels of haemodynamic support for severe heart failure or during high-risk procedures. Common examples include the intra-aortic balloon pump, Impella®, TandemHeart® or VA-ECMO.

The use of mechanical circulatory support devices for cardiogenic shock after ROSC in any setting was addressed by ILCOR.[334] This showed no survival benefit at different follow-up points when comparing early routine device use with standard care. However, most evidence derived from cardiogenic shock patients rather than those specifically resuscitated from cardiac arrest. In summary, mechanical circulatory support in patients with cardiogenic shock after ROSC in the catheterisation lab may be considered in selected cases. Individualised decisions should consider the clinical picture, device availability and team expertise. When used, close monitoring for complications is recommended to ensure prompt management.

Intracoronary adrenaline

The recent ILCOR scoping review on cardiac arrest in the catheterisation lab included a comparison of intracoronary adrenaline with either peripheral intravenous or central venous administration.[334] Adrenaline via central intravenous and intracoronary routes was associated with higher rates of ROSC, survival to hospital discharge, and survival with good neurological outcomes compared with peripheral intravenous administration. However, intracoronary administration was associated with an increased risk of stent thrombosis. Despite these promising findings, current evidence is insufficient to recommend routine intracoronary administration of adrenaline during cardiac arrest in the catheterisation lab.

Drowning

Once the World Health Organization recognised accidental drowning as a serious public health problem—especially in low-resource settings—annual global deaths from drowning decreased from 370,000 in 2000 to 300,000 in 2021[335]. This decline might be attributed to legislation and regulations (e.g., pool fencing and mandatory lifejacket use),[336] as well as effective preventive measures (e.g., day-care centres for children and water safety training).[337] Fatal drownings are associated with several risk factors: 1) sex: males account for up to six times more drownings than females; 2) age: although in Europe drowning is the fourth leading cause of death in children aged 5–14 years, those older than 50 years of age have the highest incidence; 3) location: inland waterways represent a significant risk location; 4) circumstances such as alcohol consumption and migrant status increase the likelihood of drowning. The WHO statistics do not include fatalities from drowning caused by suicide (the most frequent cause of drowning death in several European countries), transport accidents, or natural disasters such as floods.[338–340] Most fatal drownings never reach the health system because rescue or retrieval often occurs too late for medical intervention.[341]

Recommendations are based on a scoping review in 2021 and a systematic review in 2023.[342,343] There are no RCTs. Most recommendations are good practice statements or expert opinions based on indirect evidence and are in line with the position statements from the Medical Commission of the International Lifesaving Federation.[344]

Drowning is defined as 'the process of experiencing respiratory impairment from submersion or immersion in liquid'.[345] Immersion is a situation in which the person stays in a liquid with the airway above the liquid surface, while submersion refers to the state in which the airway remains submerged. When respiratory impairment progresses during submersion, the heart slows down and finally stops due to prolonged hypoxia, and only resuscitation can prevent the drowning mechanism to become fatal.[346,347] Submersion time is the most robust and independent prognostic factor.[348] The Adult BLS CoSTR 2020 recommends submersion time as the sole indicator guiding prognosis and decisions regarding clinical management and search and rescue operations.[349] Less than 5–10 min of submersion is associated with a better prognosis.[348–350]

The extent of lung damage depends on the amount and degree of pollution of the aspirated water.[346] Salinity is of no proven predictive value.[348,349,351]

The autonomic conflict, caused by simultaneous stimulation of the sympathetic and parasympathetic autonomic nervous system may explain the genesis of cardiac arrhythmias in circumstances with cold water immersion and breath-holding.[352] In drowning, low water temperature may exert a protective effect by reducing brain metabolism.[346,348,349] However, this phenomenon is exceedingly rare and is most likely in small individuals who cool quickly in water below 6 °C.[353] Submersion longer than 60 min with good neurological outcomes has been reported,[354] particularly in children immersed in cold water, preceding the submersion.[354,355] These reports suggest that if water temperature is above 6 °C, survival or successful resuscitation becomes extremely unlikely after about 30 min of submersion, whereas in water at or below 6 °C, this threshold may extend to around 90 min.[354]

Water rescue

Water rescue is needed to prevent drowning, to interrupt drowning, and to provide immediate life-saving intervention. Many untrained people have died while attempting a rescue.[356] Rescuers should never deliberately place themselves in danger. For this reason, it is strongly recommended that bystanders, especially those who are

unable to swim, do not enter deep water. Instead, they should rely on indirect rescue methods, such as using public rescue equipment, throwing any available flotation device or reaching out with a long object, while seeking professional assistance. First responders with rescue training have the competencies to select and apply the appropriate rescue technique, rescue material and flotation devices where possible.[357] Rescue material and flotation devices also reduce the rescue time.[357]

Physical fatigue is a limiting factor when CPR is required, especially after water rescue.[358,359] If possible, a person not involved in the rescue should perform CPR.[357] Spinal injuries are uncommon after drowning.[360] Spinal stabilisation should not delay assessment of vital signs or resuscitation. If resuscitation is not needed and clear signs of a cervical spine injury are present, it is recommended that at least three people carry out spinal motion restriction during extrication from water, preferably with at least one of them specifically trained in the procedure.[361] If the required people are unavailable, the extrication should not be postponed any further. In every situation of a spinal injury in water, emergency medical services should be alerted immediately.

Cardiac arrest caused by drowning

Evidence showed better prognosis when drowned persons are ventilated when initiating CPR.[362–364] For this reason, in-water ventilation and on-board resuscitation are gaining acceptance within the lifesaving community, as these techniques are feasible with training.[342,362,365–367]. In practice, some circumstances do not allow this. For example, due to lack of training, absence of flotation equipment or the conditions of the water. Then, it is more practical to wait until the victim is onshore.

Onshore, first responders and EMS should follow the ABC approach.[362,365] CPR should start with 5 ventilations. If the person remains unconscious without normal breathing, continue with standard CPR (Fig. 9). Starting CPR with compression is only advised if the rescuer is unwilling to provide ventilations.[368]

For simplicity, untrained bystanders should start with chest compressions whilst trained first aid providers should consider ventilations, since the time to ventilation is critical in restoring cardiac arrest in drowned victims. In isolated respiratory arrest, ventilations can prevent cardiac arrest (see Fig. 10).

In drowning, an initial shockable rhythm is present in less than 10 % of cases because of the cardiac response to hypoxia. Although victims removed from the water might be in cardiac arrest due to cardiac cause, for example because of arrhythmias caused by autonomic conflict[352] or the presence of cardiovascular disease,[369] CPR should not be delayed by AED application.

Oxygen should be provided early because drowning is a respiratory event. However, a recent study showed that it is difficult to provide evidence of the impact of oxygen on prognosis.[370] Airway management should be based on the competencies and training of the first responder or EMS.[365] Tracheal intubation compared with supraglottic airway devices was associated with higher ROSC, but not associated with survival or favourable neurological outcome at one month.[371]

Impact of hypothermia

Most drowned victims are hypothermic (core body temperature < 35 °C), which affects diagnosis, treatment and prognosis.[346,348,372,373] In general, guidelines for accidental hypothermia can also be applied to hypothermic drowned victims, including the one-minute vital sign check, accurately measuring core temperature, the alternative treatment regarding defibrillation, use of medication when body temperature is below 30 °C, and access to extracorporeal life support rewarming.[372] Hypothermia reflects a longer submersion time, resulting in poorer neurological outcome and survival. However, when drowning occurs in cold water, generally considered below 6 °C, and notably after a period of immersion, associated hypothermia may exert a neuroprotective effect.[374]

The Adult BLS CoSTR 2020 suggests not using water temperature when making prognostic decisions[349] and no specific guidelines exist to indicate precisely when to move from rescue to recovery—a stance that also acknowledges the exclusion of rare favourable outcomes in icy water. This is partly due to the wide variety of drowning scenarios regarding submersion time, water temperature, available resources, or environmental hazards. Some agencies or countries have local or national protocols. In the absence of definitive guidance, it is crucial that those on scene reach a consensus on the point at which further medical intervention is deemed futile.[374]

Cardiac arrest in the operating room (OR)

Cardiac arrest in the operating room is a rare event with an incidence of about 3/10,000 anaesthetics,[375–377] with a higher incidence in low-resource settings,[378] in older-frailer patients, and in newborns and infants.[379,380] Overall survival rate is > 50 %.[381] Strong predictors of intraoperative cardiac arrest are higher scores in the American Society of Anesthesiologists (ASA) physical status, sepsis, urgent or emergency case, complexity of the case, anaesthetic technique and age.[381] The leading causes are complications during cardiac surgery, major haemorrhage, bradyarrhythmias and septic shock.[378,381]

Specifics of intraoperative cardiac arrest and its treatment

Mostly, gradual physiological deterioration leads to intraoperative cardiac arrest.[382] Cardiac arrest treatment in the OR follows the general ALS algorithm. However, several modifications intended to identify reversible causes are required. Key interventions include immediately calling for help, informing the surgical and anaesthesia team, and ensuring the presence of sufficiently skilled people.

High-risk surgical patients are often monitored with invasive blood pressure pre-arrest. Recent proposals suggest starting chest compression if systolic blood pressure stays below 50 mmHg despite interventions to treat the underlying cause.[375,383,384] Sudden fall in $ETCO_2$ in such cases is a strong indicator for cardiac arrest. Adjust the position and the height of the operating table or trolley to optimise delivery of high-quality chest compressions.

Low initial end-tidal capnography values ($ETCO_2$ < 2.7 kPa or 20 mmHg) are linked to inadequate chest compression quality, indicating the need for improvement and possibly suggesting rescuer fatigue.[385–387] For pre-arrest patients (SBP < 50 mmHg), initial incremental boluses of 50–100 μg adrenaline intravenously have been proposed, rather than the standard 1 mg bolus. In pre-arrest patients, higher adrenaline doses may induce severe hypertension or tachyarrhythmias. If a low-dose adrenaline bolus fails, the standard 1 mg of intravenous adrenaline should be given.[375,388]

In circumstances where the probability of cardiac arrest is high, a defibrillator should be readily available in standby mode and self-adhesive defibrillation electrodes should be applied before induction of anaesthesia. Safe defibrillation should be performed immediately in case of a shockable rhythm. Ensure adequate venous access, pre-

pare resuscitation drugs and fluids, establish advanced airway management (if not already undertaken) and use a mechanical ventilator delivering 100 % oxygen as soon as possible.[389] Current data suggest that mechanical ventilation yields a similar PaO_2 to that of manual ventilation with a self-inflating bag.[390–393] If there is a qualified sonographer able to perform ultrasound (transthoracic/transoesophageal) with minimum interruptions to chest compressions, they should be summoned to aid diagnosis.[389]

Chest compression is optimally performed in the supine position, but in case of a cardiac arrest in prone position with an advanced airway in place, follow the ILCOR Good Practice Statement to initiate CPR in prone position.[394,395] Consider simultaneous left lateral decubitus and head-down positioning in cases of massive air embolism[396–398] if it does not affect chest compression quality.

Identification of reversible causes should be prioritised and treated appropriately:

- If arrest is caused by significant blood loss, chest compressions are effective only if the circulating volume is replaced simultaneously and haemorrhage control (e.g. surgery, endoscopy, endovascular techniques) is initiated immediately.[389]
- In cases of severe subdiaphragmatic exsanguination, resuscitative endovascular balloon occlusion of the aorta (REBOA) may be considered in an attempt to slow intravascular volume depletion. However, there is limited evidence on improved survival and further studies are required to elucidate the potential benefit.[389,399,400]
- ECPR should be considered in cases where conventional CPR fails or when prolonged resuscitation is required.
- Open cardiac compressions should be performed only by trained healthcare professionals in cases of intraoperative cardiac arrest or as part of resuscitative thoracotomy for trauma patients.
- If arrest occurs during laparoscopic or robotic surgery, consider releasing any pneumoperitoneum and deflate the abdomen to enhance venous return during CPR; during thoracoscopy, stop CO_2 insufflation and rule out contralateral pneumothorax.
- For other reversible causes, consult the specific subchapters of these guidelines.

Human factors in intraoperative cardiac arrest. As in every resuscitation event, a designated team leader should direct and coordinate the resuscitation team and their assistants, focusing on high-quality chest compressions and ventilations, minimising no-flow times, addressing reversible causes simultaneously, and preventing focus on low-priority distracting tasks. Surgery must be stopped unless it addresses a reversible cause of cardiac arrest. There may be a need to cover the surgical field to enable access to the patient and to perform resuscitation tasks.

Successful management of intraoperative cardiac arrest requires not only individual technical skills and a well-organised team response, but also an institutional safety culture embedded in everyday practice through continuous education, training and multidisciplinary cooperation.[8,401,402] Institutional protocols for responding to potential arrest situations (e.g. massive transfusion protocols) and checklists will help to optimise the response to cardiac arrest in the operating room environment.[8,403]

There is no evidence to support the use of hypothermic temperature control after adult intraoperative cardiac arrest.[404] Therefore, post-arrest temperature control should follow local post-resuscitation protocols.

Local anaesthetic systemic toxicity

Cardiac arrest is a rare complication of local anaesthetic overdose, which is often caused by inadvertent intravascular injection. Direct action of local anaesthetics on the sodium channels of cardiac myocytes causes cardiovascular collapse, usually within 1–5 min, but onset was reported from 30 sec to 60 min.[405,406] Early symptoms are *peri*-oral numbness, metallic taste, dizziness, tinnitus and blurred vision followed by substantial hypotension, dysrhythmias, and generalised seizures. The emergency diagnosis is often based on exclusion of other causes.[407,408] Seizure management involves administering benzodiazepines in incremental doses (e.g. IV lorazepam 0.1 mg kg^{-1} IV, midazolam 0.05–0.1 mg kg^{-1} IV), followed by stepwise doses of propofol or pentothal (up to induction doses) if needed. Attention should be given to securing the airway and maintaining ventilation while preventing cardiovascular collapse during sedative drug administration (especially propofol). Intravenous lipid therapy is recommended as rescue therapy to treat cardiovascular collapse and cardiac arrest although its use is based on very low-certainty evidence,[131,408–410] but without documented harm.[411] A 20 % lipid emulsion (at least 4 bags of 250 mL) should be available if large doses of local anaesthetics are used (e.g. operating rooms, labour wards, emergency department).[409,412] During cardiac arrest, after an initial 20 % lipid emulsion IV bolus (1.5 mL/kg IV over 1 min), an infusion should be started (0.25 mL kg^{-1} min IV). If ROSC is not achieved in 5 min, the infusion rate should be doubled with two additional boluses at 5-minute intervals.[409,412] A maximum cumulative dose of 12 mL kg^{-1} IV 20 % lipid emulsion is recommended to avoid fat overload.[411] It is suggested that adrenaline IV be given at a lower dose ($\leq$1 μg kg^{-1}) in local anaesthetic intoxication because its arrhythmogenic and acidotic effects may impede sustained ROSC – this has been shown in animal studies.[409,413–416]

QR code. 4 – Cardiac arrest due to local anaesthetic toxicity management.

Further information on cardiac arrest due to local anaesthetic toxicity can be found at the QR code. 4.

Cardiac surgery

The incidence of cardiac arrest following cardiac surgery is 2–5 %, with higher survival rates (around 50 %) that are higher than other causes.[417–421] This is largely due to early detection of, and the high incidence of, reversible causes. Common causes of cardiac arrest in this setting include arrhythmias causing VF, accounting for up to 50 % of cases, followed by cardiac tamponade and major bleeding, which often presents as PEA.

Evidence-based recommendations for the management of cardiac arrest following cardiac surgery derive from the European Association for Cardio-Thoracic Surgery,[422,423] the Society of Thoracic Surgeons expert consensus document for the resuscitation of patients who arrest after cardiac surgery,[424] the British Societies

Guidelines,[425] and the ILCOR CoSTR for the Management of Implantable Left Ventricle Assist Devices recipients.[426]

Ensure adequate initial and refresher training of staff in resuscitation technical skills, ALS and teamwork through simulated cardiac surgery scenarios, including training to perform an emergency resternotomy. Teamwork, including human factors such as situational awareness and communications skills, should be included in the training and acquired through practice in simulated scenarios. Roles should be previously allocated to staff in every setting to ensure effective coordination of resuscitation efforts.[427]

Emergency equipment should include small resternotomy sets containing only the essential elements to open the chest, be standardised, adequately marked, readily available where patients with recently performed interventions are recovering and periodically checked.[423,424]

Safety checklists reduce complications and mortality in non-cardiac surgery and should be implemented for the management of cardiac arrest in these settings.[428]

Detect cardiac arrest and activate cardiac arrest protocol. Early signs of deterioration can be identified in the monitored post-operative patient after careful examination. Hypotension is a common sign of several post-operative complications (Table 9).[429–431] Echocardiography should be performed in case of haemodynamic instability; consider transoesophageal echocardiography for more precise diagnosis.[432,433] Continuous ECG monitoring enables early identification of arrhythmias; supraventricular tachycardias are the most frequent in this setting.[434]

Cardiac arrest can be detected by checking ECG rhythm, clinical examination and review of vital signs, including pressure waveforms (arterial, central venous and pulmonary artery pressures, and pulse oximetry) and $ETCO_2$.[423,424]

Resuscitate and treat possible causes in cardiac surgery

Key modifications to the standard ALS algorithm include immediate correction of reversible causes and, if this is not successful, emergent resternotomy.[423,424].

Resuscitate and treat possible causes:

- Start resuscitation according to ALS but with modification:
- VF/ pVT: Apply up to 3 consecutive shocks (<1 min).
- Asystole/ extreme bradycardia: Apply early pacing – maximum output (<1 min).
- PEA: Correct potentially reversible causes. If paced rhythm, transiently turn off pacing to exclude VF.

No ROSC:

- Initiate chest compression and ventilation.
- Consider POCUS/ TOE.
- Perform early resternotomy (<5 min).
- Consider circulatory support devices and ECPR (Fig. 17).

In patients with VF/pVT, defibrillation of up to three stacked shocks are prioritised within a maximum time of 60 s.[435,436] If these fail, immediate resternotomy and internal defibrillation are advised.[436] In case of asystole or extreme bradycardia, attempt epicardial pacing (DDD mode at 80 to 100 beats/min and at maximum output voltages) or transcutaneous pacing should be attempted for one minute before initiating chest compressions. PEA should trigger immediate external chest compressions, searching for reversible causes and preparing for early resternotomy. In the presence of a pulseless stimulated rhythm, pause the pacing to exclude underlying VF and, if indicated, perform defibrillation.[423,424]

If ROSC is not achieved following defibrillation or pacing, or in case of PEA, initiate compressions and ventilations should be initiated while preparing for emergency resternotomy. Perform external compressions at 100–120 beats/min, aiming to reach a systolic blood pressure > 60 mmHg; failure to attain this value despite adequate

Table 9 – Common causes of patient deterioration after cardiac surgery and management.

• Haemorrhage • 'Medical' bleeding: post-operative coagulopathy • 'Surgical' bleeding: operative trauma	• Correct hypothermia and hypotension, avoid haemodilution • Consider blood product transfusion and use of haemostatic agents, guided by haematological tests • Check chest drains to identify active bleeding and perform echocardiography to exclude cardiac tamponade; consider early re-operation if suspected
• Low cardiac output state • Inadequate preload • Excessive afterload • Decreased ventricular contractility • Diastolic dysfunction	• Perform echocardiography to assess ventricular function • Ensure adequate ventricular filling • Correct systemic vasoconstriction • Maintain atrioventricular coordination • Correct metabolic disturbances and hypocalcaemia • Consider inotropic or mechanical circulatory support
Graft or valve failure	• Check for ECG abnormalities • Perform echocardiography • Consider percutaneous intervention or re-operation
Arrhythmias	• Correct electrolytic disturbances • Consider antiarrhythmic, electrical cardioversion or pacing
Vasodilation • Rewarming • Analgesics / sedatives • Sepsis • Anaphylaxis • Adrenal insufficiency • Vasoplegic syndrome	• Correct specific underlying causes • Consider haemodynamic-guided IV fluid therapy • Consider vasopressor support

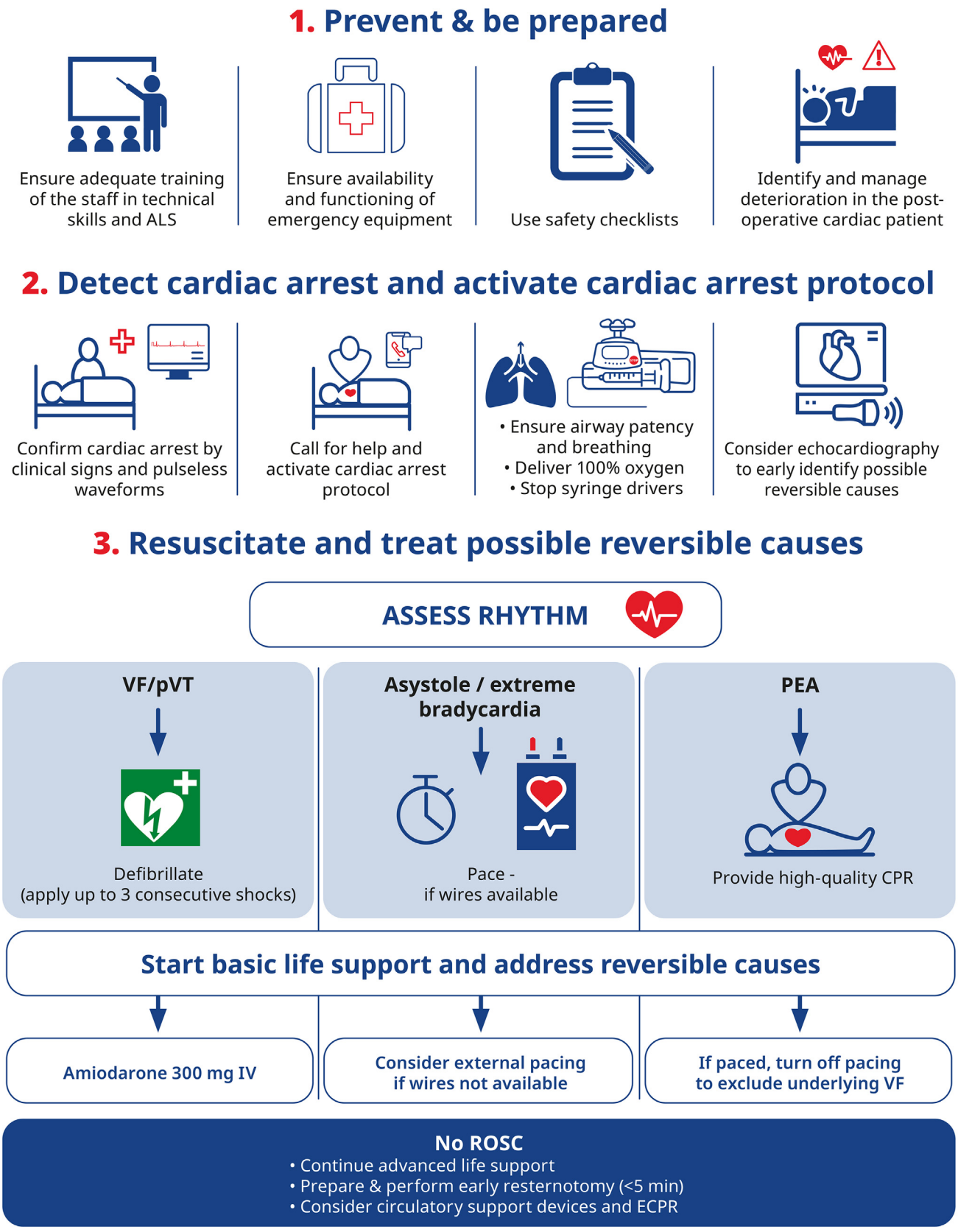


Fig. 17 – Post-cardiac surgery cardiac arrest algorithm.
ALS – advanced life support, VF – ventricular fibrillation, pVT – pulseless ventricular tachycardia, ROSC – return of spontaneous circulation, PEA – pulseless electrical activity, IV – intravenous.

performance may indicate tamponade or severe haemorrhage, requiring emergency resternotomy.[423,424] Compared with external compressions, internal cardiac compression provides better coronary and systemic perfusion pressure, which may justify chest reopening.[437,438] Airway management in this setting follows the usual indications for ALS.

In mechanically ventilated patients check the position and patency of the tracheal tube, increase inspiratory oxygen to 100 % and remove positive end-expiratory pressure. If a tension pneumothorax is suspected, emergency decompression is necessary.[423,424]

Medications during resuscitation. As a general principle, stop all infusions other than those needed for resuscitation. Amiodarone (300 mg) or lidocaine (100 mg) may be administered intravenously after three failed shocks to treat VF/ pVT.[424,439]. Injecting adrenaline (1 mg) shortly after cardiac surgery is controversial. The European Association of Cardio-Thoracic Surgery and Society of Thoracic Surgeons discourage the routine use of adrenaline based on the concern that intense hypertension induced by adrenaline may cause bleeding or disruption of surgical anastomoses after ROSC[423,424,439], although lower doses (50–100 mcg boluses) may be considered in *peri*-arrest situations based on expert consensus.[375,388,424,429,437]

POCUS and Transoesophageal echocardiography. In a *peri*-arrest patient following cardiac surgery, consider transthoracic POCUS, although it may give limited views of the posterior cardiac chambers and any surrounding posterior cardiac tamponade. Transoesophageal echocardiography (TOE) is a preferable alternative, giving clearer 360° views to include posterior cardiac structures, and enables uninterrupted chest compressions. The presence of cardiac tamponade, intrathoracic haemorrhage, pleural effusions, hypovolemia,

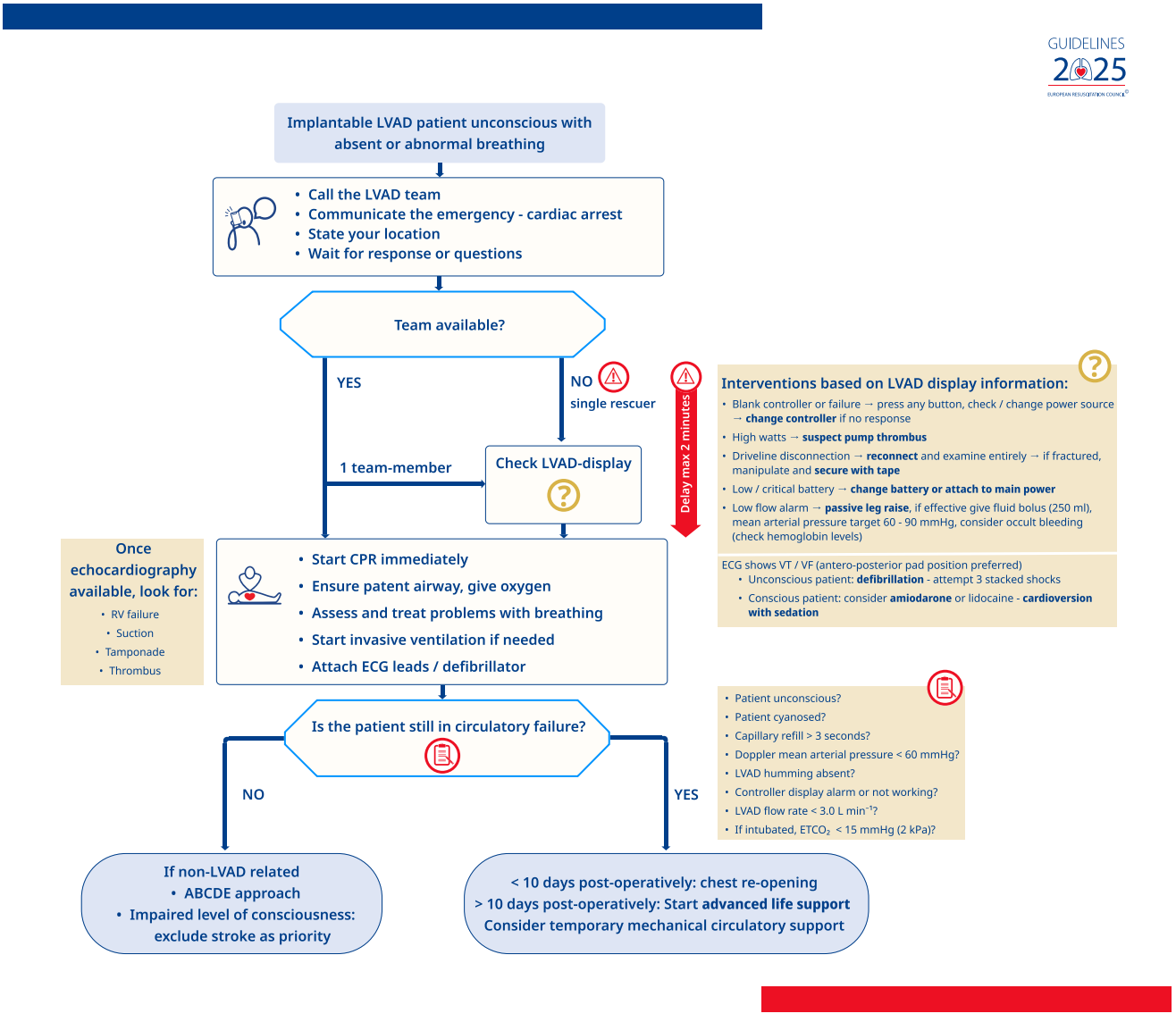


Fig. 18 – Left ventricular assist device ALS algorithm.
LVAD – left ventricular assist device, ALS – advanced life support, VT – ventricular tachycardia, VF – ventricular fibrillation, ECG – electrocardiography.

dynamic left ventricular outflow tract obstruction and aortic dissection can generally be identified using TOE.[432,433,440–447] TOE can evaluate the effectiveness of chest compressions by real-time imaging of the emptying and filling of compressed cardiac chambers, potentially leading to repositioning of hands for chest compressions.[448,449]

Early resternotomy

Refractory cardiac arrest requires resternotomy within 5 min, in order to perform open cardiac compressions compressions, release any tamponade and correct underlying causes. This is a safe procedure in the ICU,[450] leading to higher survival rates, especially if performed with minimal delay and in the presence of surgically repairable problem on reopening.[451] Resternotomy should be attempted as part of the resuscitation protocol of cardiac patients until at least day 10 post-operatively.[424]

Circulatory support devices

Intra-aortic balloon pump. In patients supported by intra-aortic balloon pump who present in cardiac arrest, the device may contribute to improving coronary and brain perfusion if coordinated with cardiac compression (1:1 ratio, with maximal amplification).[452] The ECG trigger of the balloon is not reliable during resuscitation and should be switched to pressure trigger mode, or to internal mode at 100 beats/min if cardiac compressions is interrupted for a significant interval.

Extracorporeal CPR. ECPR may be considered if resternotomy fails to revert cardiac arrest or as an initial approach, alternative to resternotomy, for patients undergoing minimally invasive cardiac surgery or those who arrest > 10 days after initial sternotomy.[424] However, there is limited data addressing this specific scenario, since most studies relate to cardiogenic shock or paediatric populations.[453]

Left ventricular assist devices. Mechanical circulatory support devices, especially left ventricular assist devices (LVAD) are being increasingly used as a bridge to heart transplantation or recovery in advanced heart failure patients. Patients with these devices often lack traditional clinical signs such as a pulse, even when haemodynamically stable and therefore assessment of the circulatory state using palpation, non-invasive blood pressure measurement and pulse oximetry may be difficult. Recognition of cardiac arrest is based on the absence of responsiveness and breathing. When performed, conventional CPR is recommended. The risk of device dislodgement during CPR appears minimal.[425,426]

The ERC recommendations are based on the ILCOR 2025 CoSTR and the British Societies guidelines 2025[425,426] on the management of emergencies in implantable LVAD recipients in transplant centres (Fig. 18).

- Immediate activation of specialised teams for unconscious LVAD patients.
- Start CPR while simultaneously attempting to restore the device if multiple rescuers are available. Consider delaying CPR for up to 2 min to attempt device restoration if a single rescuer is present.
- Troubleshoot device issues as a priority, following relevant protocols:
  - Low Flow Alarms: Check for volume responsiveness with leg raise technique. If the alarm resolves and hypovolaemia is confirmed, proceed with fluid resuscitation. Check haemoglobin values as soon as possible to evaluate the context of hypovolaemia, haemorrhage or dehydration. In cases of low flow resulting from high blood pressure, manage afterload with antihypertensives.
  - Pump Thrombosis: Administer anticoagulation or consider mechanical circulatory support like ECMO.
  - Electrical Failure: Ensure connection to a power source and integrity of powerlines. Replace the batteries or the controller.
  - Arrhythmias: Defibrillation or cardioversion should be performed if required, ensuring adequate sedation if the patient is still conscious. A functioning LVAD may provide sufficient brain perfusion even in fibrillating hearts.
- Simultaneously (if second responder available) address Airway, Breathing, Cardiac (Monitor/Defibrillator).
- Determine the adequacy of circulation. Evaluate the patient for MAP > 60 mmHg, absence of cyanosis, and presence of an audible LVAD hum. Echocardiography and invasive monitoring may be required for precise assessment. In cases of inadequate circulation, consider temporary mechanical support or corrective surgery. If the device:
  - Is working well and patient not in circulatory failure: Perform a complete ABCDE assessment
  - Is still not working or patient is in circulatory failure: Start CPR and
    - consider chest reopening if < 10 days from implantation
    - deliver standard ALS, addressing 4H & 4 T.

Cardiac arrest in sports

The absolute risk of experiencing of cardiac arrest during physical exercise is small.[454] The incidence of cardiac death associated with sport or exercise in the general population is reported between 0.46 and 6.8 per 100,000 person-years.[455–458] Large population-based studies of cardiac arrest in athletes from the USA and Europe indicate regional differences in the underlying causes of death.[459,460] About a third survived; most cases occurred during non-elite competitive or recreational sports, and bystander CPR was performed in 75 %. In patients aged $\leq$ 35 years, premature coronary artery disease and sudden arrhythmic death syndrome predominated, followed by myocarditis. In athletes aged $\geq$ 35 years, coronary artery disease predominated.[461] The likelihood of sport-related cardiac arrest is highest for males aged between 40 and 60 and with pre-existing cardiomyopathy. In 22 % of cases no pathology was found and survival was better with early resuscitation, use of AED, and presence of professional staff.[462] Highest incidences are reported for football players during competition and for running and gym exercise during non-competition.[463]

Cardiac arrest during sport or exercise requires rapid recognition and effective treatment if the affected individual is to survive. Improved survival of cardiac arrest during sport is attributed to witnessed events, prompt resuscitation and availability of an AED.[455,464] This evidence supports the importance of planning, adhering and implementing standard BLS in event-prone sport events.

For those athletes who have a shockable cardiac rhythm during cardiac arrest, a minimum of three shocks should be delivered on the field of play if the shockable rhythm persists.

The medical team should consider moving the athlete in cardiac arrest to a designated rendezvous point, in the safest and most effi-

cient way. If that is not possible, CPR should be continued on the field.[465] These plans should be rehearsed regularly.

Unlike in professional sports, recreational athletes, supporters and fans may be less aware of the risk of cardiac arrest, highlighting the importance of awareness programs. Initiatives such as the ERC–UEFA cooperation in 2024 during the European championships demonstrate how strategic collaborations between sports and health organisations can raise awareness and improve outcomes.[466] Once an athlete is successfully resuscitated, thorough cardiological assessment and follow-up are vital before considering a return to sport.[467]

Prevention

There is no consensus between the major organisations on preventative measures. The International Olympic Committee recommend cardiac screening for athletes. The European Society of Cardiology recommends 12-lead ECG as a screening tool for all young athletes,[467] but the AHA and American College of Cardiology conclude that there is insufficient evidence to support this as a screening measure.[468,469] Processes applied often follow economic views rather than a health care perspective. Primary prevention includes a targeted history and a physical examination, and the addition of a 12-lead ECG to at least prevent some unnecessary deaths, but this may still overlook several important conditions associated with cardiac arrest including high-risk anomalous coronary origins, aortopathies and adrenergically-mediated arrhythmias. Beyond an ECG, there are insufficient data to support additional routine testing.[470]

For older participants in sports and exercise, a medical evaluation of their individual risk should include the current level of physical activity, their known cardiovascular, metabolic, or renal diseases, the presence of the signs or symptoms suggestive of cardiovascular disease and the desired or anticipated exercise intensity.[471] In this context, screening approaches should be adapted to the specific characteristics and risk profile of the target population.[467,470]

Commotio cordis

Commotio cordis is a rare but potentially fatal cause of cardiac arrest, triggered by a blunt, non-penetrating impact to the precordium, typically occurring within a 20-millisecond window during the rising phase of the T wave, inducing VF.[472,473] It has historically been cited as a leading cause of cardiac arrest in young athletes, particularly in sports involving high-velocity projectiles such as baseball, lacrosse, and hockey[474,475]. In football, commotio cordis has been reported in 9 % of cardiac arrests in players $\leq$ 35 years old, with 79 % of cases caused by a ball impact to the chest.[462]

Survival rates are approximately 66 % in 2008–2023.[474] Witnessed CA, early recognition, immediate CPR initiation, and rapid defibrillation with an AED remain the most important factors for survival[474–477] Survival rates are 40 % when resuscitation occurs within 3 min, but drop to just 5 % when delayed beyond this window.[475,476]

Protective gear, such as chest protectors in lacrosse has been introduced in attempt to prevent commotio cordis, but recent studies suggest that they do not reduce the risk of VF in critical impacts.[478,479]

Emergency medical services (EMS) and transportation

EMS play a crucial role in the chain of survival by providing timely, high-quality care to patients experiencing life-threatening emergencies, including cardiac arrest. This chapter provides evidence-based recommendations for resuscitation practices in the context of EMS (including specialised medical transport services) and transportation.

EMS collect valuable data that can support continuous quality improvement and provide feedback to healthcare providers involved in CPR.[480] However, validity of data should be assessed before use.[481,482] Feedback systems have a positive effect on the quality of care and medical personnel are willing to receive feedback.[483,484] A recent systematic review showed improvements in documentation, protocol adherence, and small effects on cardiac arrest performance, clinical decision-making, ambulance times, and survival rates.[485]

Resuscitation during transport

CPR quality is reduced if performed during transportation, affecting correct hand position, chest compressions rate and depth, pauses, and overall CPR quality.[201,486] Only a few indications justify ongoing resuscitation during transport (advanced interventions not available in the prehospital setting as outlined in this chapter). Whenever possible, mechanical CPR should be implemented to mitigate the risk to both patient and rescuer.

Arterial line in the prehospital setting

Invasive blood pressure measurement in OHCA patients in a HEMS situation is feasible,[383,487–491] and can help prehospital teams to guide resuscitation and post-resuscitation care,[383,487,489,492] specifically in haemodynamically unstable patients.[493,494]

Resuscitation by two-member ALS crews

Teams larger than two ALS members improve CPR quality and efficiency in rhythm recognition, adrenaline administration, and intubation.[495] No significant no-flow fraction differences were found between two-, three-, and four-member teams.[495] Two-paramedic teams were slower and more error-prone than paramedic-emergency medical technician teams.[495] The evidence is not robust enough to support formal recommendations for education, protocols, or equipment regarding ALS provided by two HCPs. However, studies suggest that pre-filled syringes and automation-assisted protocols might improve team performance.[495]

Inflight cardiac arrest and microgravity resuscitation

Inflight cardiac arrest

Although air travel is safe in general, physiological changes during air travel, passenger demographics, pre-existing medical conditions and the number of passengers aboard larger aircraft and long distance flights raise the probability of in-flight emergencies.[496,497] A *meta*-analysis reported an incidence 0.09 cardiac arrest events per million passengers.[498] Not all airlines are equipped with an AED and ALS equipment.[499–501]

Medical professional help should be sought via in-flight announcement. The rescuer should kneel in the leg-space in front of the aisle seats to perform chest compressions if the patient cannot be transferred within a few seconds to an area with adequate floor space (e.g. galley). Overhead-CPR is a possible option in limited space environments. Airway management should be based on the equipment available and the expertise of the rescuer. If the flight plan is over open water, with high possibility of ROSC during an ongoing resuscitation, consider an early diversion. If ROSC is unlikely (pre-existing conditions, absence of an AED), the expected time for diver-

sion and landing would be too long to improve the prognosis reasonably.

Microgravity resuscitation. CPR is challenging even for trained professionals on earth, and spaceflight adds further complications due to microgravity, confined space, and limited resources. With the rise of commercial missions by private companies, clear guidelines are essential for managing medical emergencies in both long-duration and short-term space missions.

Recommendations exist from the German Society of Aerospace Medicine and the European Society of Aerospace Medicine Space Medicine Group.[502] However, a recent simulation study[503] using underwater methods to approximate microgravity found that all commonly recommended CPR techniques[504] (including the Reverse-Bear Hug, Schmitz Hinkelbein, Cologne, and Evetts-Russomano) resulted in rates below 5 % of effective chest compressions. In the absence of data from real space environment, it is not possible to endorse any particular CPR method.

The ERC key recommendations are summarised here

- Airway management, defibrillation and IV/IO access are similar to terrestrial ALS, but only once the patient is secured.
- Consider mechanical CPR
- Consult telemedicine support during cardiac arrest in low earth orbit if feasible and manpower allows.
- The crewmember with the highest medical qualification should decide on termination of resuscitation, consulting telemedicine support.

Cruise ships

There is limited evidence about treatment of OHCA on cruise ships. The ERC guidelines recommend adhering to standard BLS and ALS protocols. Outcome from cardiac arrest on cruise ships is expected to be worse, compared with the general population, because access to healthcare facilities is more complicated, on-board resources are limited, and transfers can be prolonged.[505] A medical first-responder team should be available 24/7. All equipment necessary for ALS should be available onboard and readily accessible. An AED should be onboard and requested immediately. Where there are too few numbers of crew health care professionals, an onboard announcement should be made to call for further medical professional help. In most cruise ships telemedicine is available, and it should be used as early as possible.[506] Qualified medical air transportation is an option to cover long distances to medical facilities.

Special patient groups

Asthma and chronic obstructive pulmonary disease

Evidence based recommendations for the management of acute life-threatening asthma are based on the British Thoracic Society, Scottish Intercollegiate Guidelines Network[507] and the Global Initiative for Asthma Strategy 2021,[508] while for chronic obstructive lung disease (COPD) recommendations are based on those of the Global initiative for chronic obstructive lung disease.[509] A recent ILCOR Evidence Update[8] did not reveal any new data on management of cardiac arrest in asthma patients beyond the 2021 ERC guidelines.

Patients with an exacerbation of obstructive lung disease (asthma/ COPD) are at high risk for cardiac arrest.

For COPD, the Global initiative for chronic obstructive lung disease guidelines recommend that supplemental oxygen is titrated to achieve a target saturation of 88–92 %, with frequent monitoring of blood gases to ensure adequate oxygenation without carbon dioxide retention. Pharmacological therapy comprises inhaled short-acting beta-2 agonists with or without short-acting anticholinergics (with repeated dosing as required), systemic corticosteroids and, in case a bacterial infection is suspected, antibiotics. Non-invasive ventilation is recommended in the presence of respiratory acidosis ($PaCO_2 > 6$ kPa/45 mmHg and arterial pH $\leq$ 7.35); severe dyspnoea with clinical signs of fatigue or increased work of breathing. Escalation to invasive ventilation may be necessary if NIV fails, if the patient cannot tolerate NIV, or there are factors such as agitation, reduced consciousness, high aspiration risk, cardiovascular instability, or life-threatening hypoxia. However, be alert to the higher risk of life-threatening hypotension after emergency intubation and mechanical ventilation in patients with raised arterial CO_2 and obstructive lung disease.[510,511] In selected unconscious cases with severe hypoxemia, veno-venous ECMO may be an option to prevent hypoxic cardiac arrest.[512,513]

Treatment of cardiac arrest caused by obstructive lung disease

Cardiac arrest in patients with obstructive lung disease may be caused by hypoxia, hypovolaemia, toxic agents (arrhythmias caused by stimulant drugs e.g. beta-adrenergic agonists, aminophylline), electrolyte disturbance (hypokalaemia), tension pneumothorax and/or the effects of gas trapping leading to reduced venous return and hypotension.[514–519] Cardiac arrest in obstructive lung disease is usually associated with a non-shockable rhythm and poor survival rates.[520,521]

Because of extremely elevated inflation pressure during severe asthma attacks there is a significant risk of gastric inflation and aspiration with simultaneous hypoventilation of the lungs when attempting to ventilate a severe asthmatic patient with bag valve mask devices. The trachea should be intubated as soon as possible during cardiac arrest caused by asthma, by someone who is trained and competent to do so.

Tension pneumothorax may develop because of high airway pressure, which, if left untreated, may cause cardiac arrest. Check for signs of tension pneumothorax and treat accordingly.[522,523] Disconnect from positive pressure ventilation if air-trapping and hyperinflation occurs and apply pressure to manually reduce the hyperinflation. Some case reports have described ROSC in patients with air trapping when the tracheal tube was disconnected from the breathing system.[524–530] If dynamic hyperinflation of the lungs is suspected during CPR, compression of the chest while temporarily disconnecting the tracheal tube may relieve air trapping.[524,527,529] Although this procedure is supported by limited evidence, it is unlikely to be harmful in an otherwise desperate situation.

Ventilating the lungs with a slower respiratory rate of 8–10 breaths per minute and sufficient tidal volume to cause the chest to rise during CPR should minimise dynamic hyperinflation of the lungs (air trapping).[528] In mechanically ventilated patients with severe asthma, increasing the expiratory time (achieved by reducing the respiratory rate and changing inspiration to expiration time ratio) provides only moderate gains in terms of reduced gas trapping when a minute volume of less than 10 L min^{-1} is used.[531]

No studies evaluating the use of IV fluids for cardiac arrest caused by obstructive lung disease were identified. Consider giving intravenous fluids to patients with obstructive lung disease, particularly those with an acute exacerbation of asthma, because they be dehydrated as a result of reduced oral intake and/or increased insen-

sible losses. Give fluids cautiously to prevent potential adverse effects.[532]

ECPR has been used successfully in patients with life threatening asthma.[513,533] Consistent with the ERC Guidelines 2025 ALS, ECPR may be considered if conventional therapies fail and there is immediate access to this treatment.

Cardiac arrest in haemodialysis patients

Chronic kidney disease is a global health problem affecting 1 in 10 people worldwide[534] and the WHO projects it will become the 5th most prevalent chronic condition by 2040.[535]

Risk factors for cardiac arrest in dialysis patients are summarised in Table 10. Fluid and electrolyte disturbances are common, with the highest risk period being just before the first dialysis session of the week, i.e. on Mondays or Tuesdays.[536–540] The risk period extends over the 12 h after start of treatment. This suggests that the non-physiological rapid removal of toxins, fluid and electrolytes, most pronounced during the first session of the week, accounts for the high risk period.[541,542] Clinically significant arrhythmias are also more common on dialysis compared with non-dialysis days.[543]

Out-of-hospital cardiac arrest in haemodialysis patients

Cardiac arrest accounts for 47.1 % of deaths in HD patients, occurring 20 times more frequently in dialysis patients compared with the general population.[544–546] Within a dialysis centre, the odds of VF was found to be 5-fold greater in patients during dialysis and 14-fold greater in patients who arrest after dialysis compared with events occurring before dialysis.[537] In a cohort of dialysis patients with a wearable cardioverter defibrillator, VT/VF was the initial rhythm in 78.6 %, with most occurring during dialysis.[547]

Table 11 was reproduced with permission from UK Kidney Association Hyperkalaemia Guideline in adults.[50]

A three-fold increase in odds to hospital discharge with favourable neurological outcome has been shown when CPR is initiated by dialysis staff rather than awaiting the arrival of emergency services.[546] Following cardiac arrest, 24 % of haemodialysis patients survived to hospital discharge and 15 % still were still alive at 1 year following cardiac arrest.[537] The poor outcome in one report may reflect the low rate of bystander CPR and AED use.[548,549]

Table 10 – Risk factors for cardiac arrest in haemodialysis patients.

1. Hyperkalaemia
2. Excessive fluid shifts during dialysis
3. The 3-day inter-dialytic interval – 'weekend break'
   - in-centre dialysis is delivered 3 days per week (Mon / Wed / Fri or Tue / Thu / Sat)
   - highest risk period is just prior to the first session of the week (i.e. Monday or Tuesday) as K+ level peak and fluid accumulates
   - risk extends for 12 h after initiation of dialysis on the first session of the week after rapid fluid and electrolyte shifts from peak levels
4. Low potassium dialysate fluid (1 mmol L^{-1})
5. History of heart disease
6. QT-prolonging medications
7. Non-compliance with diet and / or dialysis regimen

In-hospital cardiac arrest in haemodialysis patients

The incidence of in-hospital cardiac arrest (IHCA) in patients receiving haemodialysis (HD) is approximately 20 times higher than in the general population (6.3 % vs. 0.3 %), with dialysis patients accounting for 17 % of all IHCA cases. The incidence of cardiac arrest specifically in dialysis clinics ranges from 3.4 to 7.8 per 100,000 dialysis sessions. Most events are witnessed, with 70–80 % occurring during treatment.[537–539,550] Multiple studies in HD patients demonstrate ROSC in 44–72 %[551–553] and survival to hospital discharge ranges from 22-31 %.[551–555] Duration of CPR and older age were predictors of a poor outcome.[555] The 'Get With The Guidelines-Resuscitation' registry shows comparable neurological outcomes in HD patients compared with non-dialysis patients (17 % vs 16 %, $p = 0.07$).[551] These findings suggest that outcomes for HD patients are no worse than other patients dispelling the perception of futility.[556] Nevertheless, a large national registry of IHCA found that dialysis patients had lower overall resuscitation quality compared with case-matched non-dialysis patients.[551] Shortfalls in resuscitation practice in dialysis patients include a delay in initiation of CPR[546] and failure to achieve timely first defibrillation for a shockable rhythm.[536,546,551]

Modifications to cardiopulmonary resuscitation in haemodialysis patients

Start resuscitation by following the standard ALS algorithm. Assign a trained dialysis nurse to operate the HD machine (Fig. 10). Stop the HD machine and return blood volume to the patient with a fluid bolus. If the HD machine is not defibrillation-proof disconnect it from the patient in accordance with the International Electrotechnical Committee (IEC) standards. Keep the dialysis access open so that it can be used for drug administration The Kidney Disease Outcomes Initiative guideline on the management of cardiovascular disease in dialysis patients recommends that all dialysis units should have on-site capability for external defibrillation.[557] Most are equipped with AEDs,[546,558] but manual defibrillators may also be used by trained staff. Dialysis clinics are predominantly nurse-led units. Staff training and confidence may influence the rate of nurse-led defibrillation. When dialysis staff apply the AED before arrival of paramedics, there is a greater proportion of shockable primary arrest rhythms.[537,546] Given the higher chance of survival with shockable rhythm, avoid delays in defibrillation. All of the reversible causes (4 Hs and 4 Ts) apply to dialysis patients. Electrolyte imbalances and fluid shifts during dialysis are common causes of cardiac arrest. Consider hyperkalaemia if cardiac arrest occurs pre or early in the dialysis session. For management of hyperkalaemic cardiac arrest, refer to

Table 11 – Cardiac arrest during dialysis in outpatient clinics.
Reproduced with permission from UK Kidney Association Hyperkalaemia Guideline in adults.

Study	N=	Before HD	During HD	After HD
Karnik 2001[538]	400	7 %	81 %	12 %
La France 2006[539]	38	8 %	78 %	14 %
Davis 2008[537]	110	10 %	70 %	20 %

Section *Hyperkalaemia*. Consider hypokalaemia if cardiac arrest occurs mid-late or immediately post dialysis.

Dialysis may be required in the early post-resuscitation period, guided by fluid status and serum biochemistry. Patient transfer to an intensive care unit with dialysis facilities is essential.

Prevention of cardiac arrest in dialysis patients

Avoiding hyperkalaemia and volume overload requires patient adherence and careful dialysis prescription, but may reduce the risk of cardiac arrest.[538,559,560] The use of potassium binders on non-dialysis days to facilitate use of a higher dialysate potassium content (3 mmol) can reduce the occurrence of clinically significant arrhythmias (bradycardia, ventricular tachycardia, and/or asystole).[561] The higher frequency of cardiac arrest during dialysis and the equivalent survival in dialysis patients compared with non-dialysis patients may reflect a higher likelihood of a reversible cause (i.e. electrolyte or fluid disturbance).[551] The highest risk period is the 'weekend break.' It is conceivable that removing this inter-dialytic gap with short, frequent (4–5 per week) dialysis sessions may reduce risk of cardiac death, but this is only achievable with home haemodialysis.

Resuscitation in obese patients

Obesity is defined by WHO as a body mass index exceeding 30 kg m^{-2}.[562] Obesity can increase cardiovascular morbidity and mortality directly and indirectly.[563] Given the global increase in obesity, an ILCOR scoping review assessed the evidence for cardiac arrest treatment and outcomes in obese patients.[564] In adults, the effect of obesity on neurological outcome, survival to hospital discharge, longer term survival (months to years), and ROSC was variable. Few studies reported resuscitation quality indicators, and no studies reported adjustments to resuscitation techniques, or provider outcomes. Current evidence indicates that it is reasonable to use standard resuscitation protocols.

Delivery of effective CPR may be challenging in obese patients.[564] Rescuer fatigue may make it advisable to change the rescuer performing chest compressions more often than every two minutes. The use of mechanical chest compression devices might be considered although body dimensions and slope of the anterior chest wall limit usability of most devices in very obese patients. Obesity is associated with difficult mask ventilation and might pose difficulties with airway management.[565,566] Experienced providers should secure a patent airway (supraglottic airway devices or tracheal intubation) early to minimise the period of bag-mask ventilation. Although mortality seems to be higher in obese patients than normal-weighted patients receiving ECPR, it should not be withheld in obese patients.[567]

Resuscitation in patients with pectus excavatum

This chest wall deformation (sometimes associated with congenital heart disease) reduces available space for heart and lungs with direct pressure to these organs and increases the risk of cardiac arrest.[568] The heart is often displaced leftward, which can complicate effective chest compressions. Reports suggest reduced chest compression depth (3–4 cm) to minimise the risk of organ injury in the presence of reduced anteroposterior thoracic diameter.[569,570]

Surgically placed corrective "Nuss bars" complicate CPR, as they require significantly increased force to deliver proper chest compression depth.[571] Rescuer fatigue and organ damage (liver lacerations specifically) are to be considered when mechanical chest compressions are delivered.[572] Defibrillation in the presence of a Nuss bar may divert electrical current flow through the low resistance metallic bar when defibrillation pads are placed anterolaterally.[573]

Based on very indirect data from case reports, anatomical and simulation studies reporting cardiac arrest in patients with pectus excavatum, the following deviations from the standard algorithm might be considered:

- During CPR, consider a lower chest compression depth of 3–4 cm, because the reduced anteroposterior thoracic diameter limits the effective compression depth achievable and increases the risk of direct trauma to the heart, lungs and great vessels.
- In case of a Nuss bar correction, substantially increased force is required to deliver effective chest compressions because increased chest wall rigidity, potentially accelerating rescuer fatigue.
- Use mechanical chest compressions with caution.
- If chest compressions are ineffective consider early implementation of ECPR to ensure sufficient organ perfusion.
- Use anteroposterior pad placement for defibrillation using standard energies to ensure optimal current flow through the myocardium, despite the presence of the metallic Nuss Bar.[574]

Cardiac arrest in pregnancy

Maternal cardiac arrest refers to cardiac arrest that occurs at any stage in pregnancy or within six weeks after birth. Maternal mortality remains high, with an estimated 287,000 cases globally in 2020 – equivalent to one death every two minutes. The majority occur in low- and middle-income countries. A significant proportion of maternal cardiac arrests occur outside maternity units. Pregnancy is not always immediately apparent, particularly in its early stages. However, considering pregnancy in reproductive-age patients is essential for identifying reversible causes such as concealed ectopic bleeding and modifiable factors such as aortocaval compression after 20 weeks' gestation.[575]

These Guidelines has been informed by an ILCOR scoping review[334] and international guidelines.[575–583] Most guidance is based on observational data, expert opinion and physiological principles. This update introduces a new process for management of maternal cardiac arrest along with key figures and tables to support clinical application.

US data reveal that 32 % of obstetric patients experiencing cardiac arrest have no history of a pre-existing disorder, 36.1 % had respiratory insufficiency while 33.3 % had hypotension as the most common antecedent conditions. Pulseless electrical activity is the most common rhythm.[584] While there are limited data on precise causes of maternal cardiac arrest, MBRRACE-UK reports causes of maternal mortality from 2020 to 2022 to be thromboembolism (16 %), COVID-19 (14 %), cardiac disease (13 %), mental health conditions (11 %), sepsis (9 %), epilepsy and stroke (9 %), obstetric bleeding (7 %), early pregnancy disorders (5 %), cancer (3 %), and pre-eclampsia (3 %). Risk factors included Black and Asian ethnicity, social deprivation, maternal age > 35, and obesity.[575] In contrast, global data from low- and middle-income countries identified haemorrhage (27.1 %), hypertensive disorders (14 %), and sepsis (10.7 %) as the leading direct causes of maternal deaths.[585]

The UK Obstetric Surveillance System identified 66 cases of cardiac arrest in pregnancy in a three year period with a survival rate of 58 %, poor outcomes linked to OHCA, and delays in resuscitative hysterotomy.[586] The UK NAP7 survey reported an incidence of perioperative

cardiac arrest in obstetric patients of 7.9 per 100,000 anaesthetic encounters and a survival rate of 82 %, with haemorrhage, high neuraxial block, and bradyarrhythmias as the leading causes.[587]

Prevention of maternal cardiac arrest

Maternal cardiac arrest is usually preventable, though in certain causes, such as amniotic fluid embolism, arrest may occur before intervention.[588] Approach any deteriorating pregnant or peripartum patient following the ABCDE approach. There is evidence to suggest that implementing an obstetric-specific early warning system enables early recognition of deteriorating pregnant patients; however, uptake across Europe is low.[589–593] Early involvement of an obstetrician, along with simultaneous activation of maternal and neonatal resuscitation teams, is essential.

Aortocaval compression

Aortocaval compression (i.e., compression of the inferior vena cava and the aorta by the gravid uterus) usually manifests by the 20th week of gestation. This may significantly reduce venous return and subsequently cardiac output in the supine position.[594,595] In healthy pregnant patients with preserved intrinsic compensatory mechanisms, the effects of aortocaval compression may be absent or minimal.[596] However, in critically ill or hypotensive patients, aortocaval compression may precipitate cardiac arrest and limit the effectiveness of cardiopulmonary resuscitation.

Aortocaval compression may be relieved by manual left uterine displacement or left lateral tilt (Fig. 19), though supporting data are derived from non-cardiac arrest and simulation studies. ILCOR conducted a scoping review on this topic and found insufficient evidence to recommend either method over the other during CPR in pregnant patients.[8] Magnetic resonance imaging suggests that a left lateral tilt of approximately 30° is needed to partially relieve inferior vena cava compression. This may be achieved by applying lateral tilt on an operating table or by placing wedges under the right hip for patients on a conventional bed.[597–599] However, wedges are rarely available, and simulation and animal studies have questioned the effectiveness of chest compressions in the left lateral position.[600,601]

Accordingly, the ERC suggests performing manual left uterine displacement in maternal cardiac arrest. It can be achieved by placing one or both hands below the uterus, on the patient's right side, and pushing upwards and to the left, or if standing on the patient's left, reaching across to cup the uterus from below and lifting upward and leftward (Fig. 19).[602,603]

Definitive relief of aortocaval compression may be achieved only by resuscitative hysterotomy (sometimes known as "perimortem Caesarean section").

Resuscitative hysterotomy

Resuscitative hysterotomy should be performed by a skilled team at the site of cardiac arrest to achieve ROSC by relieving aortocaval compression.[604] Previous guidelines recommended starting the procedure at 4 min and completing uterine evacuation by 5 min.[605] The maternal cardiac arrest supplement to the ALS algorithm (Table 12) shifts the focus to preparing for resuscitative hysterotomy, highlighting the time-sensitive nature of the intervention.

- The ILCOR review found insufficient evidence to support a specific time for initiating resuscitative hysterotomy.
- Time-sensitive resuscitative hysterotomy depends on clearly designated team competences, rapid system activation, and equipment readiness, all requiring training and rehearsal.[606,607]
- If arrest results from hypotension despite optimal resuscitation, it is suggested that resuscitative hysterotomy be performed as soon as possible.
- The procedure should not be considered futile beyond 5 min, however, the benefit declines steadily the longer emptying the uterus is delayed.[586,608]
- In exceptional cases, ECPR may be initiated immediately, with uterine evacuation postponed due to anticoagulation-related bleeding risks.[609,610]
- In the prehospital setting, the procedure requires adequate access to the patient and a trained clinician, otherwise prioritise time-critical transport to hospital

While fixed timing for resuscitative hysterotomy is de-emphasised, early intervention remains paramount to maximise the chance of return of spontaneous circulation and reduce the risk of hypoxic brain injury.

Extracorporeal life support

A retrospective analysis of peripartum patients requiring ECPR from the International Registry of Extracorporeal Life Support Organization, identified 280 patients,[611] with 70 % survival. Survival rates were higher when extracorporeal membranous oxygenation (ECMO) was initiated prior to cardiac arrest.

If available, early ECMO can be considered by the multidisciplinary team in pregnant patients with signs of impending circulatory collapse.

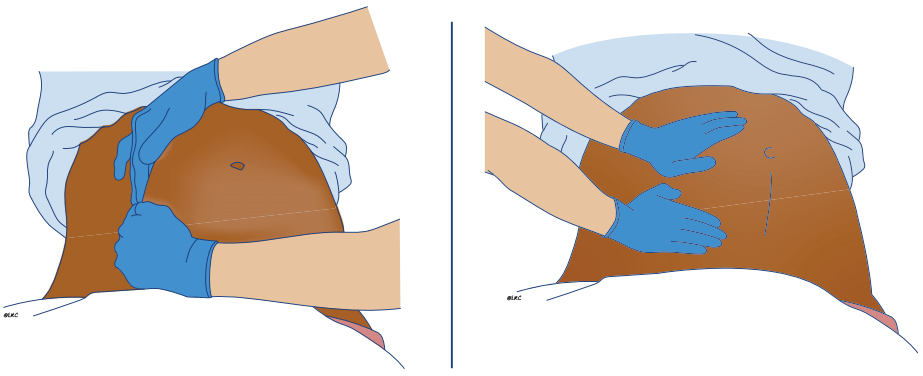


Fig. 19 – Manual left uterine displacement manoeuvre.

Table 12 – Modifications to advanced life support in obstetric patients.

ALS during pregnancy	Rationale
Detection of cardiac arrest: unconscious + abnormal breathing = suspected cardiac arrest	*No change*
Call for help – "maternal arrest team"	Consider pregnancy in any collapsed woman of childbearing age. Call maternal cardiac arrest team (including an obstetrician and neonatologist)
Manual (left) uterine displacement throughout	Relieve aortocaval compression to improve cardiac output as early as possible and maintain it throughout resuscitation. Establish manual left uterine displacement when two or more team members are available—one performing manual left uterine displacement, the other performing CPR. (Fig. 19)
Chest compression quality parameters and ventilation-compression-ratio	*No change*
Airway management	Aspiration and failed intubation risk are both increased. Use a stepwise approach (bag-mask, tracheal tube or supraglottic airway if tracheal intubation fails), according to rescuer skills. Try to achieve a ramped position. Intubation should be performed by an experienced person. Equipment considerations: - Short-handled laryngoscope for large breasts - Video laryngoscope as standard for intubation - Smaller tracheal tube with guidance
Defibrillation – Shock energy	*No change*
Pad position	No change: ensure defibrillation pads are placed beneath, not over, enlarged breast tissue
Fetal monitoring	Remove internal & external fetal monitors before defibrillation
Identify common and reversible causes	See Table 13 on 4Hs, 4Ts and 4Ps
Medications	
Vascular access early	Consider IV/IO access above the diaphragm if possible .
Dosage and time of adrenaline, amiodarone and lidocaine	*No change*
Calcium chloride	10 ml IV calcium chloride 10 %: for Mg overdose, low calcium or hyperkalaemia
Magnesium	2 g IV: for polymorphic VT 4 g IV: for eclampsia
Tranexamic acid	1 g IV: for haemorrhage
Resuscitative Hysterotomy (Perimortem Caesarean section)	In patients > 20 weeks' gestation or fundus above umbilicus. Resuscitative hysterotomy is a time-sensitive intervention. Preparation to perform should be undertaken early. Resuscitative hysterotomy should be performed as soon as possible at the site of cardiac arrest by a skilled team.
Post-resuscitation care	Stabilise mother to stabilise fetus and prepare for major obstetric haemorrhage.

Relieve aortocaval compression. Aortocaval compression should be relieved as early as possible and maintained throughout resuscitation (Fig. 19).

Chest compressions. Currently, there is no strong evidence to support modifying hand position for chest compressions during pregnancy. A magnetic resonance imaging study of cardiac remodelling

in the third trimester of pregnancy showed an increase in left ventricular mass but no cephalad displacement.[612] However, a subsequent transthoracic echocardiography study of left ventricular position during the third trimester demonstrated that it is located approximately 6 cm cranial to the distal tip of the xiphoid process.[613]

With regard to mechanical chest compression devices, there is insufficient evidence to make a recommendation for or against their use, though in certain scenarios, practical alternatives are unavailable – for example, during extrication or transport in the prehospital setting.[614]

Airway management. Pregnancy increases the risk of aspiration of gastric contents and difficult intubation.[615–617] Manage the airway as directed by the ERC Guidelines 2025 ALS (bag-mask, tracheal tube or supraglottic airway if tracheal intubation fails) according to skills of the HCP. Early tracheal intubation facilitates oxygenation and ventilation, while protecting against aspiration, but it is considered an expert skill and should be performed in accordance with current obstetric-anaesthesia guidelines.[617]

Defibrillation. When using anterolateral positioning, ensure defibrillation pads are placed beneath, not over, enlarged breast tissue. Defibrillation energy levels are the same as those for non-pregnant adults.[618] To avoid burns, external fetal monitoring should be removed before defibrillation.

Medications. Medications used in the resuscitation of pregnant women are the same as for the general adult population. While there is limited evidence, intravenous or intraosseous access should be established above the level of the diaphragm whenever possible, based on physiological considerations.[619]

Reversible causes. The 4Hs and 4Ts are important considerations in all cardiac arrests, including during pregnancy, and may prompt pregnancy-specific diagnoses such as hypovolaemia from a ruptured ectopic pregnancy or pulmonary embolism, the latter being more common in pregnant and postpartum women (Table 13). However, there are also pregnancy-specific causes of cardiac arrest, which are now introduced as the 4Ps:

Pre-eclampsia and eclampsia: Follow established guidelines for management.[620] Initiate immediate treatment for severe hypertension, defined as $\geq$ 160/110 mmHg. In severe cases give 4 g IV magnesium sulphate over 5 to 15 min to treat and prevent eclampsia, followed by 1 g/h over 24 h.[620] Consider pulmonary oedema and treat accordingly. Magnesium toxicity from treatment overdose may cause cardiac arrest (see Table 14).

Puerperal sepsis: In suspected puerperal sepsis, take blood cultures, give early broad-spectrum antibiotics, and consider obstetric sources such as chorioamnionitis, retained products, endometritis, or surgical site infection that may require intervention.

Placental and uterine complications: Examples include placental abruption, placenta praevia or accreta, uterine atony, rupture, inversion, and amniotic fluid embolism. Seek clinical signs of overt or occult haemorrhage (vaginal or intra-abdominal). Examine the abdomen for peritonism and free fluid (use ultrasound if available), assess for hypovolaemia, check haemoglobin concentration and assess clotting function. Request blood products, alert the obstetric team, and prepare for urgent surgical intervention. The management of amniotic fluid embolism is supportive: maintain oxygenation, treat haemorrhage with blood products, correct disseminated intravascular coagulation (DIC), and immediately involve obstetric, anaesthetic and critical care teams.

Peripartum cardiomyopathy: Treat as acute heart failure. Consider intravenous diuretics, vasodilators (e.g. nitrates), and inotropes if indicated. Avoid fluid overload. Seek early echocardiography and cardiology input.

Table 13 – Potentially reversible causes of cardiac arrest in obstetric patients: 4Hs,4Ts,4Ps.

Potentially reversible causes in pregnancy	Obstetric-specific considerations
Hypoxia	- high risk of aspiration - high risk of difficult airway - reduced lung capacity - higher oxygen demand
Hypovolaemia	- aortocaval compression - haemorrhage (e.g., ectopic pregnancy and other pregnancy-related causes below, DIC) - distributive (e.g., high regional block, anaphylaxis)
Hypo-/hyperkalaemia, other electrolyte disorders	- also consider magnesium levels
Hypo-/hyperthermia	
Thrombosis (coronary and pulmonary)	- high risk for pulmonary embolism - myocardial infarction - coronary and aortic dissection - (amniotic fluid embolism)
Tamponade (cardiac)	
Tension pneumothorax	- nitrous oxide in pre-existing pneumothorax
Toxic agents (poisoning)	- local anaesthetic and other perioperative drugs
Pre-eclampsia and eclampsia	- Follow guidelines - Consider pulmonary oedema - Magnesium overdose may cause cardiac arrest
Puerperal sepsis	- take blood cultures and give early broad-spectrum antibiotics - Chorioamnionitis, retained products, endometritis, - Surgical site infection
Placental and uterine complications	- Placental abruption, placenta praevia, placenta accreta, uterine atony, uterine rupture, uterine inversion, amniotic fluid embolism)
Peripartum cardiomyopathy	- Treat as acute heart failure. - Early echocardiography - Consult cardiology experts

Table 14 – Suggested pre-prepared equipment to perform Resuscitative Hysterotomy.We suggest as a minimum a scalpel and 3 cord clamps to be available in all resuscitation carts.

For staff	- Sterile gloves (non-latex) - Gowns - Masks
For mother	- Skin preparation solution - 3 scalpels (1: incision, 2: umbilical cord, 3: backup) - Dissection scissors - Laparotomy sponges - 4 haemostat clamps - Retractor - Gauze (ideally haemostatic)
For baby	- 3 cord clamps - Hat, 4 towels, heated incubator - Equipment to resuscitate the neonate

Cardiovascular disease

Percutaneous coronary intervention is the preferred reperfusion strategy for STEMI in pregnancy.[582] Consider thrombolysis if timely PCI is unavailable. A review of 200 cases of thrombolysis for massive pulmonary embolism in pregnancy reported maternal mortality rate of 1 % supporting its safe use in pregnancy when clinically indicated.[621] Point-of-care ultrasound is invaluable in cases where it is unclear if the cause of arrest is due to concealed bleeding or thromboembolism.[575]

Haemorrhage

This is a leading cause of maternal morbidity and mortality.[622] Life-threatening haemorrhage can occur both antenatally and postnatally. Ensure that a massive/major obstetric haemorrhage protocol is available in all units, and that it is reviewed regularly and rehearsed in collaboration with all team members including transfusion services and portering staff.[623]

Management includes:

- Immediate involvement of obstetric, anaesthetic, and critical care teams who should follow existing guidelines for the management of major obstetric haemorrhage.[623,624]
- Activation of the major obstetric haemorrhage protocol, with prompt blood transfusion and correction of coagulopathy.
- Administration of tranexamic acid 1 g IV in cases of suspected bleeding.[625–628]

Maternal considerations for post resuscitation care

Post resuscitation care in pregnancy aligns with standard adult management, with some important additional considerations. Hypothermic temperature control has been reported in isolated cases during early pregnancy, with fetal heart rate monitoring in place. There was no evidence of harm and maternal and neonatal outcomes were favourable.[629,630] The continued focus should be to resuscitate the mother. Once the mother is stabilised, fetal resuscitation will also be optimised. This includes treating maternal pathology, optimising maternal physiology, and ensuring necessary investigations and imaging. Preparation for major obstetric haemorrhage in anticipation of ROSC is essential following resuscitative hysterotomy or thrombolysis, as well as for other maternal cardiac arrest causes such as amniotic fluid embolism.

Maternal critical illness requires a multidisciplinary approach making it essential to involve all relevant specialties, including obstetrics, anaesthesia, critical care and neonatology.[631]

The psychological impact of adverse maternal outcomes should be acknowledged, with support offered to the patient, their family, and the staff involved in their care.

Preparation for cardiac arrest in pregnancy

Gaps in preparedness, including equipment availability and multidisciplinary coordination, remain widespread and may hinder advanced life support in pregnancy, including time-sensitive resuscitative hysterotomy and neonatal resuscitation.[593]

Pregnant and peripartum women can deteriorate to cardiac arrest anywhere and medical facilities and services must be prepared for such events. There should be[632–638]:

- Plans and equipment in place for resuscitation of both the pregnant woman and newborn (see Table 14).
- Early involvement of obstetric, anaesthetic, critical care, and neonatal teams.
- Regular multidisciplinary training in obstetric emergencies, using simulated resuscitation scenarios.
- Review and debriefing following clinical events to support learning and team performance

Collaborator

We would like to thank Ryan Aird, cardiac arrest survivor, Member of SCAUK (Sudden Cardiac Arrest UK) for his comments and input while developing these ERC Guidelines 2025 Special Circumstances in Resuscitation.

Disclosures

Declarations of competing interests for all ERC Guidelines authors are displayed in a COI table which can be found online at https://doi.org/10.1016/j.resuscitation.2025.110753.

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Practice Guideline

European Resuscitation Council and European Society of Intensive Care Medicine Guidelines 2025 Post-Resuscitation Care ☆

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Abstract

The European Resuscitation Council (ERC) and the European Society of Intensive Care Medicine (ESICM) have collaborated to produce these post-resuscitation care guidelines for adults, which are based on the International Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations (CoSTR) pubished by the International Liaison Committee on Resuscitation (ILCOR). The topics covered include the post-cardiac arrest syndrome, diagnosis of cause of cardiac arrest, control of oxygenation and ventilation, coronary reperfusion, haemodynamic monitoring and management, control of seizures, temperature control, general intensive care management, prognostication, long-term outcome, rehabilitation, and organ donation. The post-resuscitation care of children is described in the ERC Guidelines 2025 Paediatric Life Support.

Keywords: Post-cardiac arrest syndrome, Cardiac arrest, Acute coronary syndrome, Coma, Temperature, Prognosis, Rehabilitation, Tissue and organ procurement

Abbreviations: ACNS, American Clinical Neurophysiology Society, ACS, Acute coronary syndrome, ADC, Apparent diffusion coefficient, AF, Atrial fibrillation, AHA, American Heart Association, AKI, Acute kidney injury, ALS, Advanced Life Support, AMI, Acute myocardial infarction, ARDS, Acute respiratory distress syndrome, ATP, Adenosine triphosphate, BIS, Bi-spectral index, BOX, Blood Pressure and Oxygenation Targets after OHCA, BS, Burst suppression, CAC, Cardiac arrest centre, CAD, obstructive coronary artery disease, CAG, Coronary angiography, CBF, Cerebral blood flow, COSCA, Core Outcome Set for Cardiac Arrest, CoSTR, Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations, CPC, Cerebral Performance Category, CPR, Cardiopulmonary resuscitation, CR, Corneal reflex, CT, Computed tomography, DBD, Organ donation after brain death, DCD, Donation after Circulatory Determination of Death, DVT, Deep venous thrombosis, DWI, Diffusion-weighted imaging, ECG, Electrocardiogram, ECPR, Extracorporeal cardiopulmonary resuscitation, EEG, Electroencephalogram, FPR, False positive rate, FSS, Fatigue Severity Scale, GFAP, Glial fibrillary acidic protein, GRADE, Grading of Recommendations Assessment, Development, and Evaluation, GWR, Grey white matter ratio, HADS, Hospital Anxiety and Depression Scale, HIBI, Hypoxic ischaemic brain injury, ICD, Implantable cardioverter defibrillator, ICP, Intracranial pressure, ICU, Intensive care unit, ILCOR, International Liaison Committee on Resuscitation, LBBB, Left bundle branch block, LMWH, Low molecular weight heparin, MAP, Mean arterial pressure, MCS, Mechanical circulatory support, MRI, Magnetic resonance imaging, NSE, Neuron specific enolase, OHCA, Out-of-hospital cardiac arrest, PCAS, Post-cardiac arrest syndrome, PCI, Percutaneous coronary intervention, PLR, Pupillary light reflex, PPCI, Primary percutaneous coronary intervention, RASS, Richmond Agitation Sedation Scale, ROC, Receiver operating characteristic, ROSC, Return of spontaneous circulation, SBP, Systolic blood pressure, SCA, Sudden cardiac arrest, SCD, Sudden cardiac death, SGA, Supraglottic airway, SSEP, Somatosensory evoked potential, STEMI, ST elevation myocardial infarction, TBI, Traumatic brain injury, TCD, Transcranial Doppler, VF, Ventricular fibrillation, VT, Ventricular tachycardia, WLST, Withdrawal of life-sustaining treatment

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Introduction and scope

In 2015, the European Resuscitation Council (ERC) and the European Society of Intensive Care Medicine (ESICM) collaborated to produce their first combined post-resuscitation care guidelines, which were co-published in *Resuscitation* and *Intensive Care Medicine*.[1,2] These 2025 guidelines represent the third collaboration between the ERC and ESICM and reflect the science published since the previous guidelines were issued in 2021.[3,4] The topics covered include the post-cardiac arrest syndrome, control of oxygenation and ventilation, haemodynamic targets, coronary reperfusion, temperature control, control of seizures, prognostication, long-term outcome and rehabilitation. Key messages from these guidelines are summarised in Fig. 1. A summary of the main changes from the 2021 ERC-ESICM Postresuscitation care guidelines is set out in Table 1.

Methods

The international consensus on cardiopulmonary resuscitation science evidence review process

The International Liaison Committee on Resuscitation (ILCOR, https://www.ilcor.org) includes representatives from the American Heart Association (AHA), the European Resuscitation Council (ERC), the Heart and Stroke Foundation of Canada (HSFC), the Australian and New Zealand Committee on Resuscitation (ANZCOR), the Resuscitation Council of Southern Africa (RCSA), the Inter-American Heart Foundation (IAHF), the Resuscitation Council of Asia (RCA), and the Indian Resuscitation Council Federation (IRCF). From 2000 to 2015, researchers from the ILCOR member councils evaluated resuscitation science in 5-yearly cycles. After the publication of the 2015 International Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations (CoSTR),[5] ILCOR committed to a continuous evidence-evaluation process, with topics prioritised for review by the task forces and with the CoSTR updates published annually. For the 2025 CoSTR, the six ILCOR task forces performed three types of evidence evaluation: the systematic review, the scoping review, and the evidence update.[6,7] Only systematic reviews (these used the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) methodology) could result in new or modified treatment recommendations.[8] The data analysis from each systematic review was presented to the task force, and the task force drafted the summary CoSTR. Each treatment recommendation indicated the strength of the recommendation and the certainty of the evidence. Draft 2025 CoSTRs were posted on the ILCOR website (ilcor.org) for a 2-week comment period, after which final wording of science statements and treatment recommendations were completed by the task forces and published in *Resuscitation* and *Circulation* as the 2025 CoSTR.[6,7]

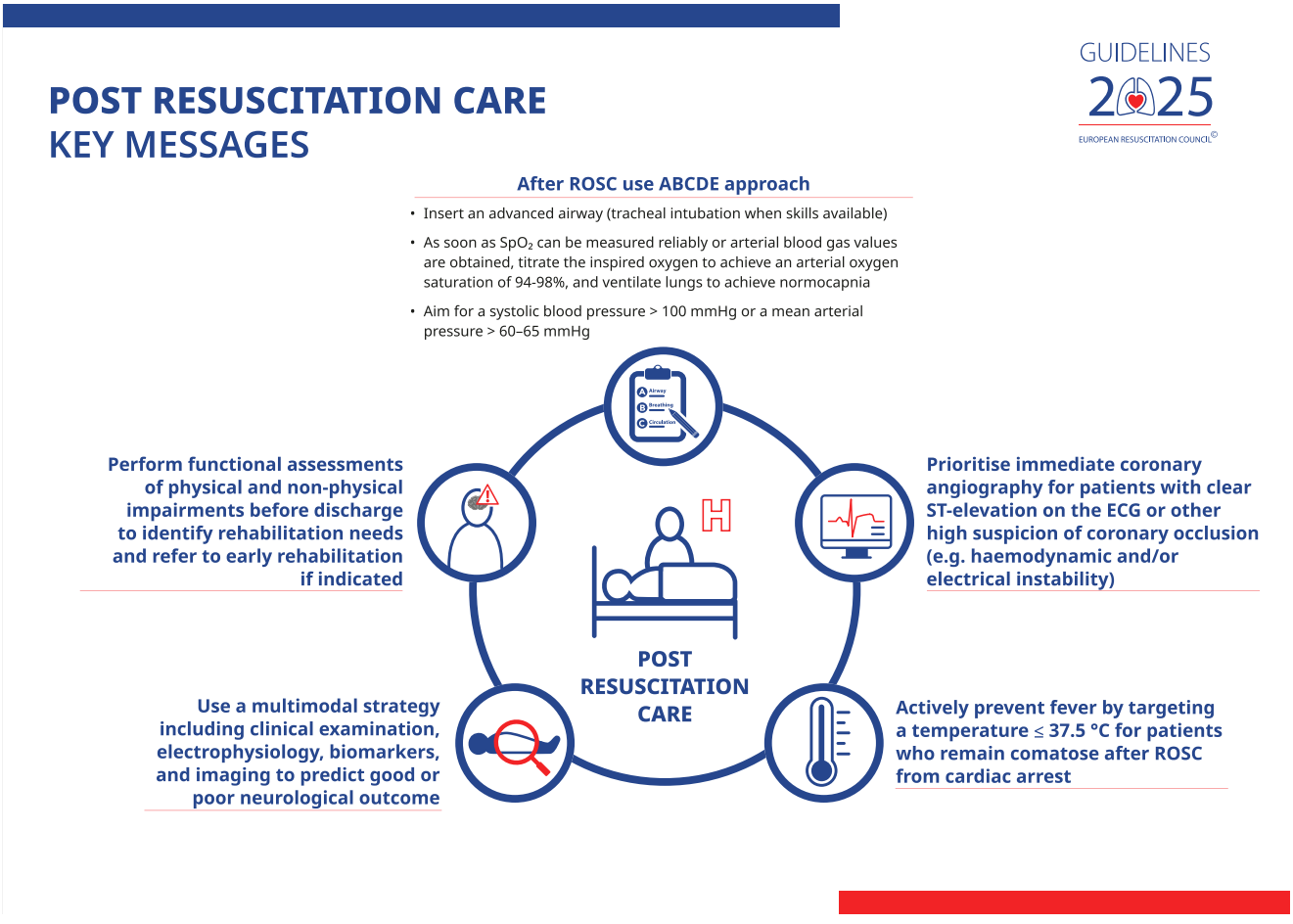


Fig. 1 – Key messages from post-resuscitation care guidelines.

The European Resuscitation Council (ERC) and European Society for Intensive Care Medicine (ESICM) process for developing post-resuscitation care guidelines

Fourteen individuals were selected for the ERC-ESICM Post-Resuscitation Care Writing Group based on their expertise, ERC and ESICM representation, and diversity (gender, physician, non-physician, survivor, seniority (senior and mid-career), and geography (Northern and Southern Europe)).

These ERC-ESICM guidelines on post-resuscitation care for adults are based mainly on the advanced life support section of the 2025 CoSTR document and represent consensus among the writing group, which included representatives from the ERC and

Table 1 – Comparison of ERC-ESICM Post-Resuscitation Care Guidelines (2021 vs 2025).

Topic	2021 Guidelines	2025 Guidelines
Diagnosis of Cause and Complications of Cardiac Arrest	Suggested coronary angiography first in patients with myocardial ischemia. CT brain and chest scan were considered if coronary angiography did not find causative lesions.	Coronary angiography remains first if ST-elevation is present; otherwise, whole-body CT scan (including head, neck, chest, abdomen, pelvis, and CT pulmonary angiography) takes priority.
Airway and Oxygenation Management	Recommendation to start with 100 % oxygen immediately after ROSC, then titrate to 94–98 % SpO_2 or PaO_2 10–13 kPa (75–100 mmHg).	Maintains recommendation and adds explicit guidance highlighting inaccuracies in pulse oximetry in patients with darker skin tones.
Ventilation Management	Recommended normocapnia ($PaCO_2$ 4.7–6.0 kPa (35–45 mmHg)).	Maintains recommendation with additional caution in patients with hypothermia, noting risk of hypocapnia.
Coronary Reperfusion Strategy	Immediate coronary angiography strongly considered in OHCA without ST-elevation if high likelihood of coronary occlusion.	Suggests delaying cardiac catheterisation if clinical context does not clearly indicate a high likelihood of acute coronary occlusion in OHCA patients without ST-elevation.
Hemodynamic Management	Emphasised targeting MAP >65 mmHg guided by adequate urine output and lactate normalization.	Specifies MAP target of >60–65 mmHg.
Post-ROSC arrhythmias	Not included in any detail	Section added on recurrent and refractory arrhythmias post-ROSC
Seizure Management	Recommended EEG monitoring.	Explicitly states patients with myoclonus but benign EEG backgrounds should undergo wake-up trials days after arrest.
Temperature Management	Recommended targeted temperature management at 32–36 °C for at least 24 h and fever avoidance (>37.7 °C) for at least 72 h post-ROSC.	Preferred terminology is temperature control. Recommends actively preventing fever $\leq$37.5 °C for at least 72 h post-ROSC.
General Intensive Care Management	Recommended prophylactic stress ulcer prophylaxis and thromboembolism prophylaxis.	Maintains previous recommendations. Emphasises using short-acting sedatives to facilitate neurological assessment, discourages routine neuromuscular blocking drugs unless severe acute respiratory distress syndrome.
Neurological Prognostication	Emphasised multimodal neurological assessment at $\geq$72 h.	Maintains recommendation with specified indicators of favourable neurological outcome and suggested timing for brain CT and SSEP recording added to the algorithm.
Rehabilitation and Follow-up	Recommended functional assessment before discharge and follow-up within 3 months post discharge including screening of cognitive, emotional problems and fatigue. Brain injury and cardiac rehabilitation when indicated.	Maintains recommendations and adds structured guidance on rehabilitation in the ICU including early mobilisation, delirium management, ICU diaries, and to address physical limitations during follow-up. Stronger focus on the involvement of co-survivors.
Organ Donation	Recommended considering organ donation post-resuscitation.	Maintains recommendation and adds recommendations for cardiac arrest registries to report organ donation activities.
Investigating Unexplained Cardiac Arrest	Not included.	New recommendations for comprehensive diagnostic work-up (including genetic testing, cardiac MRI, sodium channel blocker tests, exercise testing) and emphasises long-term follow-up.

the ESICM.[9] Where treatment recommendations are provided by ILCOR, these have been adopted by the ERC and ESICM. In the absence of an ILCOR recommendation or good practice statement, ERC-ESICM guidance was based on review and discussion of the evidence by the working group until consensus was achieved, and more direct language is used. The writing group chairs ensured that everyone on the working group had the opportunity to present and debate their views and ensured that discussions were open and constructive. All discussions took place during 14 videoconferences that were held between April 2024 and March 2025. Consensus was achieved by all 14 writing group members on all the treatment recommendations using an open process.

These guidelines were drafted and agreed upon by the Post-Resuscitation Care Writing Group members and the Guidelines Steering Committee before being posted on the ERC website for public comment from May 5th to May 30th, 2025. The opportunity to comment on the guidelines was advertised through social media (Facebook and *X*, formerly known as Twitter) and the ERC network, comprising 33 national resuscitation councils. A total of 61 individuals submitted 69 comments, resulting in 10 changes to the final version. The guidelines were presented to and approved by the ERC General Assembly on 12th June 2025.

Concise guidelines for clinical practice

This section includes only a summary of the main recommendations. The evidence underpinning each recommendation is detailed in the section on 'evidence informing the guidelines'.

Immediate post-resuscitation care

- Post-resuscitation care is started immediately after sustained return of spontaneous circulation (ROSC), regardless of location (Fig. 2).

Diagnosis of cause and complications of cardiac arrest

- Prioritise immediate coronary angiography for patients with clear ST-elevation on the ECG or other high suspicion of coronary occlusion (e.g. haemodynamic and/or electrical instability). Perform a head-to-pelvis CT scan (including CT pulmonary angiography) if coronary angiography fails to identify causative lesions.
- If there are signs or symptoms pre-arrest suggesting a non-coronary cause (e.g. headache, seizures or neurological deficits, shortness of breath or documented hypoxaemia in patients with known respiratory disease, abdominal pain), perform a dual phase whole body tomography (CT) scan (including head, neck, chest, abdomen, pelvis, and CT pulmonary angiography) before or after coronary angiography if indicated.

Airway and breathing

Airway management after return of spontaneous circulation

- Airway and ventilation support should continue after ROSC is achieved.
- Patients who have had a brief period of cardiac arrest and an immediate return of normal cerebral function and are breathing normally, may not require airway or ventilatory support but should be given supplemental oxygen via a facemask if their arterial blood oxygen saturation is less than 94 %.
- Patients who remain comatose following ROSC, or who have another clinical indication for sedation and mechanical ventilation, should have their trachea intubated if this has not been done already during CPR.
- Tracheal intubation (with or without drugs) should be performed only by experienced operators who have a high success rate.
- Correct placement of the tracheal tube must be confirmed with waveform capnography.
- In the absence of personnel experienced in tracheal intubation, it is reasonable to retain or insert a supraglottic airway (SGA) or maintain the airway with basic techniques until personnel skilled in drug-assisted tracheal intubation are available.
- Post ROSC patients may require drug assisted tracheal intubation – the same level of care should be provided as for any other critically ill patient with a physiologically or anatomically challenging airway in terms of skills of the provider, monitoring, and choice of drugs for induction, and maintenance of sedation

Control of oxygenation

- Immediately after ROSC, use 100 % (or the maximum available) inspired oxygen until the arterial oxygen saturation (SpO_2) can be measured and titrated reliably with pulse oximetry or the partial pressure of arterial oxygen (PaO_2) can be measured.
- As soon as SpO_2 can be measured reliably or arterial blood gas values are obtained, titrate the inspired oxygen to achieve an arterial oxygen saturation of 94–98 % or arterial partial pressure of oxygen (PaO_2) of 10–13 kPa (75–100 mmHg). Be aware that pulse oximetry can overestimate the true oxygen saturation in people with darker skin tones, and low-flow states will cause low signal quality.
- Avoid hypoxaemia (PaO_2 < 8 kPa or 60 mmHg) following ROSC.
- Avoid hyperoxaemia following ROSC.

Control of ventilation

- Obtain arterial blood gases and monitor end tidal CO_2 in mechanically ventilated patients.
- Target normocapnia – a partial pressure of carbon dioxide of 4.7–6.0 kPa (or approximately 35–45 mmHg) in adults with ROSC after cardiac arrest.
- In patients with accidental hypothermia or treated with hypothermia monitor $PaCO_2$ frequently as hypocapnia may occur.
- In hypothermic patients use consistently either temperature or non-temperature corrected blood gas values.
- Use a lung protective ventilation strategy aiming for a tidal volume of 6–8 mL kg^{-1} ideal body weight.

Circulation

Coronary reperfusion

- Emergent cardiac catheterisation laboratory evaluation (and primary percutaneous coronary intervention (PPCI) if required) should be performed in adult patients with ROSC after cardiac arrest of suspected cardiac origin with persistent ST-elevation on the electrocardiogram (ECG).
- In patients with ROSC after out-of-hospital cardiac arrest (OHCA) without ST-elevation on the ECG, cardiac catheterisation laboratory evaluation should be delayed unless the clinical context suggests a high likelihood of acute coronary occlusion.

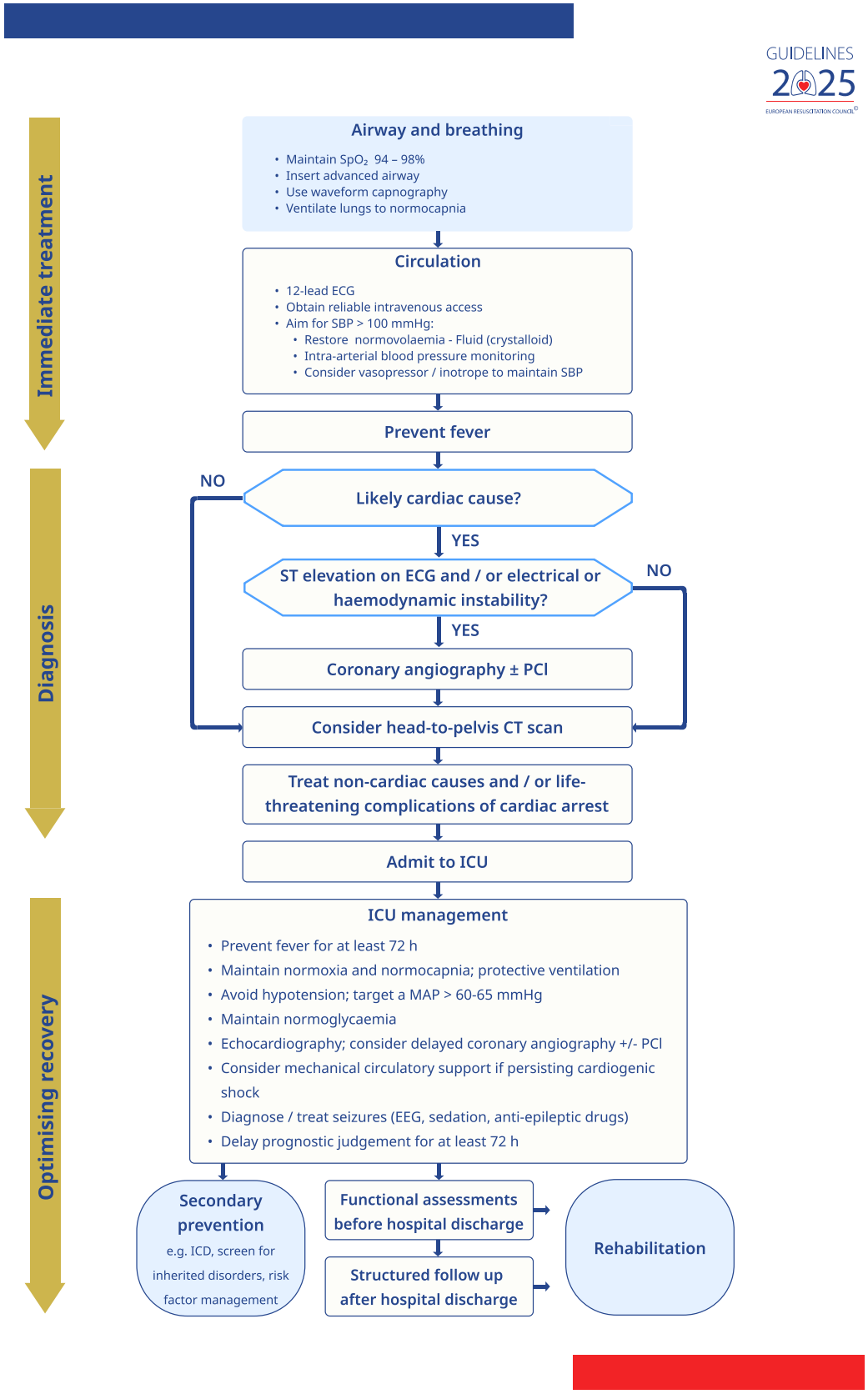


Fig. 2 – Post-resuscitation care for unconscious patients.

Abbreviations: PCI percutaneous coronary intervention; ICU intensive care unit; EEG electroencephalogram; ICD implantable cardioverter defibrillator.

Haemodynamic monitoring and management

- All patients should be monitored with an arterial line for continuous blood pressure measurements, and it is reasonable to monitor cardiac output in haemodynamically unstable patients.
- Perform echocardiograpy as soon as possible in all patients to detect any underlying cardiac pathology and quantify the degree of myocardial dysfunction.
- Avoid hypotension and target a mean arterial pressure (MAP) >60–65 mmHg after cardiac arrest (Fig. 3).
- Maintain perfusion with fluids, noradrenaline and/or dobutamine, depending on individual patient need for intravascular volume, vasoconstriction or inotropy.
- Do not give steroids routinely after cardiac arrest.
- Avoid hypokalaemia and hyperkalaemia, which are associated with ventricular arrhythmias.
- In select patient populations (e.g. Glasgow Coma Scale score ≥8 on hospital arrival, with ST-elevation myocardial infarction (STEMI) and <10 min cardiac arrest) consider mechanical circulatory support (such as intra-aortic balloon pump, left-ventricular assist device or veno-arterial extracorporeal membrane oxygenation) for persisting cardiogenic shock from left ventricular failure if treatment with fluid resuscitation, inotropes, and vasoactive drugs is insufficient. Left-ventricular assist devices or veno-arterial extracorporeal membrane oxygenation should also be considered in haemodynamically unstable patients with acute coronary syndromes (ACS) and recurrent ventricular tachycardia (VT) or ventricular fibrillation (VF) despite optimal therapy.

Post-ROSC arrhythmias

- In patients with arrhythmia immediately after ROSC, follow the ERC Guidelines 2025 Adult Advanced Life Support for peri-arrest arrhythmia.
- In patients with arrhythmia after ROSC, treat any potential underlying causes, such as coronary occlusion or electrolyte disorders.
- In patients with no arrhythmia after ROSC, do not routinely give anti-arrhythmic drug prophylaxis.

Disability (optimising neurological recovery)

Control of seizures

- Use electroencephalography (EEG) to diagnose electrographic seizures in patients with clinical convulsions and to monitor treatment effects.

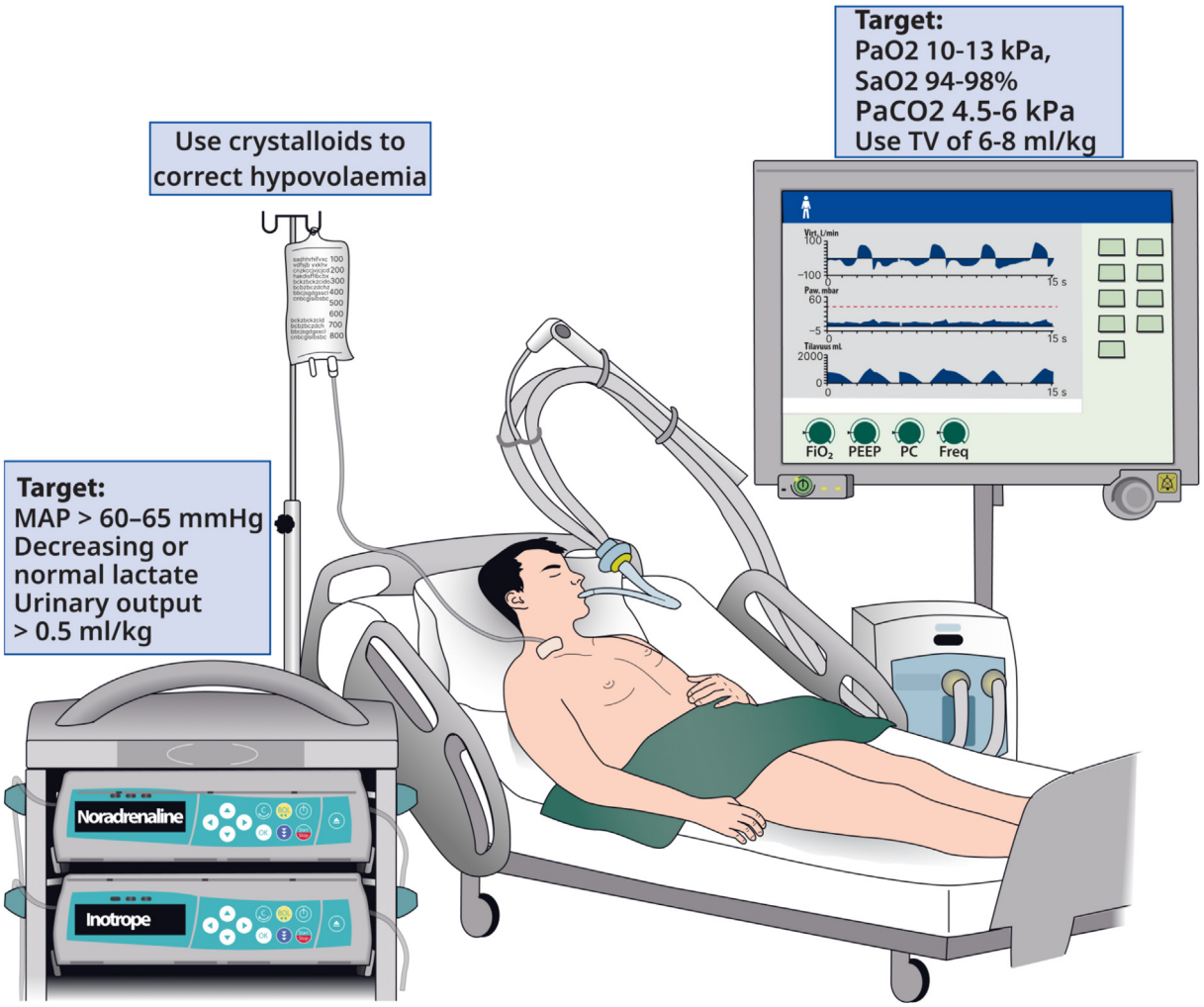


Fig. 3 – Haemodynamic and ventilation targets for the comatose post-cardiac arrest patient.
Abbreviations MAP mean arterial pressure; TV tidal volume.

- Use levetiracetam or sodium valproate as first-line antiepileptic drugs in addition to sedative drugs to treat seizures after cardiac arrest.
- Do not use seizure prophylaxis in post-cardiac arrest patients.
- Attempt a wake-up trial in patients with myoclonus and benign EEG background (days after arrest).

Temperature control

- Actively prevent fever by targeting a temperature $\leq$37.5 °C for patients who remain comatose after ROSC from cardiac arrest.
- Comatose patients with mild hypothermia (32–36 °C) after ROSC should not be actively warmed to achieve normothermia.
- We recommend against the routine use of prehospital cooling with rapid infusion of large volumes of cold intravenous fluid immediately after ROSC.
- Use surface or endovascular temperature control techniques when temperature control is used in comatose patients after ROSC.
- When a cooling device is used, we suggest using a temperature control device that includes a feedback system based on continuous temperature monitoring to maintain the target temperature.
- Prevent active fever for 36 to 72 h in post-cardiac arrest patients who remain comatose.

Other therapies to improve neurological outcome

- There is insufficient evidence to recommend the use of any specific neuroprotective drug for comatose survivors of cardiac arrest.

General intensive care management

- Do not use prophylactic antibiotics routinely in patients following ROSC. However, it is reasonable to have a low threshold for giving antibiotics when there is any clinical suspicion of pneumonia.
- Use short-acting sedative agents and daily sedation holds when treating post-cardiac arrest patients receiving mechanical ventilation – this may enable earlier clinical examination that is less confounded by sedation when assessing neurological recovery.
- We do not recommend systematic use of neuromuscular blocking drugs in comatose post-cardiac arrest patients.
- In patients with critical hypoxaemia and ARDS following cardiac arrest, the use of a neuromuscular blocker may be considered.
- Patients should be nursed 30° head-up.
- It is reasonable to start gastric feeding at low rates (trophic feeding) and increase as tolerated.
- Given the high incidence of upper gastrointestinal ulceration in post-cardiac arrest patients and the use of anticoagulant and antiplatelet drugs both pre and post arrest, use stress ulcer prophylaxis in post-cardiac arrest patients, especially in those with coagulopathy.
- Anticoagulation of post-cardiac arrest patients should be individualised and be based on general ICU recommendations.
- Use standard glucose management protocols for adults with ROSC after cardiac arrest.

Predicting neurological outcome

General guidelines

- In patients who are comatose after resuscitation from cardiac arrest, neurological prognostication should be performed using clinical examination, electrophysiology, biomarkers, and imaging, to both inform the patient's relatives and to help clinicians target treatments based on the patient's chances of achieving a neurologically meaningful recovery (Fig. 4).
- No single predictor is 100 % accurate. Use multimodal neuroprognostication strategies.
- When predicting poor neurological outcome, a high specificity and precision are desirable, to avoid falsely pessimistic predictions. When predicting good outcome, the aim is to identify those patients with a better potential for recovery. Since the consequence of a false prediction in this setting is less severe, the predictive performance of the test is not as critical. Both predicting good and poor outcome are essential to reduce prognostic uncertainty.
- The clinical neurological examination is central to prognostication. To avoid falsely pessimistic predictions, clinicians should exclude potential residual effects of sedatives and other drugs that may confound the test results.
- Index tests for neurological prognostication are aimed at assessing the severity of hypoxic-ischaemic brain injury. Neurological prognosis is one of several aspects to consider in discussions about an individual's potential for recovery.

Clinical examination

- Perform a daily neurological examination in patients who are unconscious after cardiac arrest.
- Clinical examination is prone to interference from sedatives, opioids or muscle relaxants. Potential confounding from residual sedation should always be considered and excluded.
- Consider neurological prognostication in patients who are not awake and obeying commands (Glasgow coma scale motor score <6) at 72 h or later after ROSC
- In unconscious patients at 72 h or later after ROSC, the following tests may predict a poor neurological outcome:
  - The bilateral absence of the pupillary light reflex.
  - The bilateral absence of corneal reflex
  - The presence of myoclonus within 96 h and, in particular, status myoclonus within 72 h.
- We also suggest recording the EEG in the presence of myoclonic jerks to detect any associated epileptiform activity or to identify EEG signs, such as background reactivity or continuity, suggesting a potential for neurological recovery.

Neurophysiology

- Perform EEG from day 1 after ROSC to predict outcome and detect seizure activity in comatose patients. Routine EEG or continuous EEG monitoring may be used.
- Suppressed background with or without periodic discharges and burst suppression on EEG ('highly malignant' patterns) are accurate indicators of a poor prognosis. We suggest using these EEG patterns after 24 h from ROSC.
- The bilateral absence of somatosensory evoked cortical N20 potentials indicates poor prognosis after cardiac arrest.
- Always consider the EEG and somatosensory evoked potentials (SSEPs) results in the context of clinical examination findings and other tests. Always consider using a neuromuscular blocking drug when performing SSEPs.

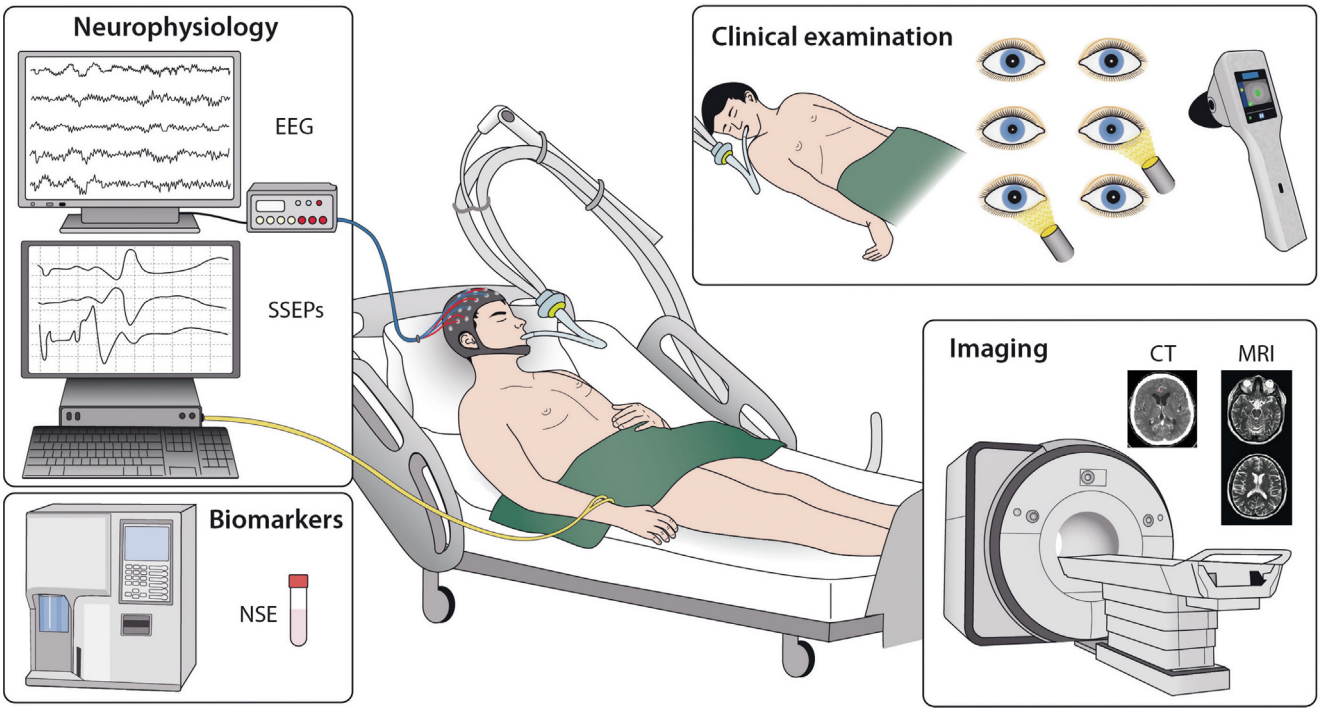


Fig. 4 – Multiple modalities used for the prediction of neurological outcome in the comatose post-cardiac arrest patient.

Abbreviations: EEG electroencephalogram; SSEPs somatosensory evoked potentials; NSE neuron specific enolase; CT computed tomography; MRI magnetic resonance imaging.

Biomarkers

- Use serial measurements of neuron-specific enolase (NSE) to predict outcome after cardiac arrest. Increasing values between 24 and 48 h or 72 h in combination with high values at 48 and 72 h indicate a poor prognosis.
- We do not recommend using neurofilament light chain for predicting outcome after cardiac arrest, because of the absence of consistent thresholds for predicting poor outcome with high specificity, and because the evidence to date is mostly based on assays for research use only.

Imaging

- Use brain imaging studies to predict poor neurological outcome after cardiac arrest. Ensure that the images are evaluated by someone with specific experience in these studies.
- Where specialist neuroradiology expertise is unavailable, consider telemedicine consultation for brain imaging interpretation.
- Use presence of generalised brain oedema, manifested by a marked reduction of the grey matter/white matter ratio on brain CT, or extensive diffusion restriction on brain MRI to predict poor neurological outcome after cardiac arrest.
- Repeat the brain CT if the patient is unconscious at the time of prognostication (72 h–96 h after ROSC) and the first brain CT does not show signs of HIBI.

Multimodal prognostication

- Once major confounders have been excluded, start the prognostication assessment with an accurate clinical examination (Fig. 5).
- In an unconscious patient at $\geq$72 h from ROSC, in the absence of confounders, poor outcome is likely when two or more of the following predictors are present: no pupillary and corneal reflexes at $\geq$72 h, bilaterally absent N20 somatosensory evoked potential (SSEP) wave at $\geq$24 h, highly malignant EEG at >24 h, neuron specific enolase (NSE) >60 $\mu g\ L^{-1}$ at 48 h and/or 72 h, status myoclonus $\leq$72 h, or a diffuse and extensive anoxic injury on brain CT/MRI. Most of these signs can be recorded before 72 h from ROSC; however, conclusions on prognosis will be made only at the time of clinical prognostic assessment at $\geq$72 h.

Withdrawal of life-sustaining treatment

- Separate discussions around withdrawal of life-sustaining treatment and the assessment of prognosis for neurological recovery; withdrawal of life-sustaining treatment decisions should consider aspects other than brain injury such as age, co-morbidity, general organ function and the patients' preferences.
- Allocate sufficient time for communication around the level-of-treatment decision within the team and with the relatives.
- After a decision on withdrawal of life-sustaining treatment, use a structured approach to shift from curative to end-of-life palliative care and consider organ donation.

Rehabilitation and follow-up after cardiac arrest

- Implement early mobilisation, delirium management and ICU diaries during hospitalisation
- Provide information for patients and co-survivors
- Perform functional assessments of physical and non-physical impairments before discharge to identify rehabilitation needs and refer to early rehabilitation if indicated.
- Provide cardiac rehabilitation as indicated by the cause of the cardiac arrest.

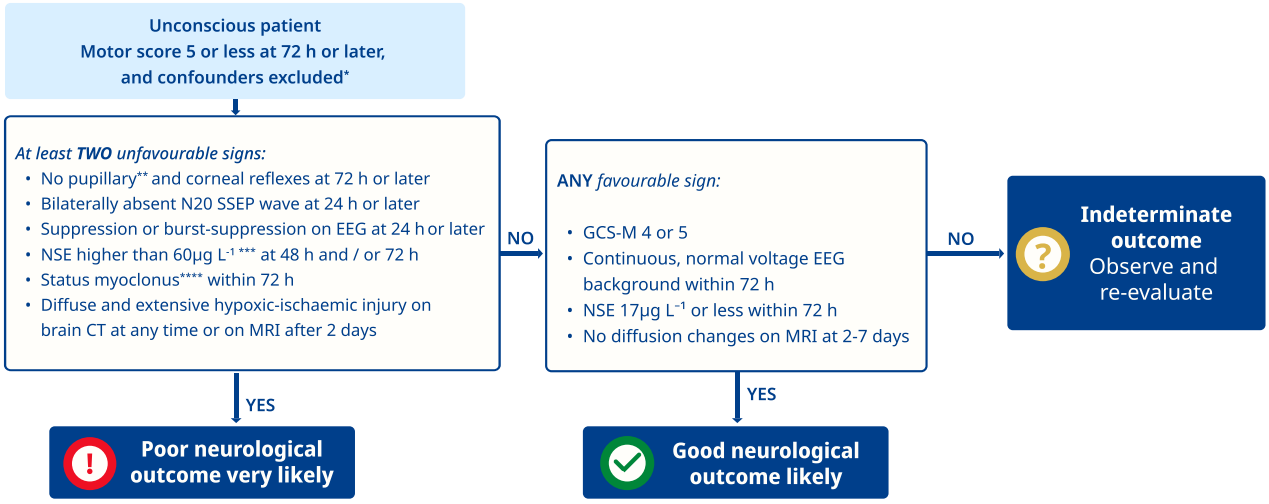


Fig. 5 – Algorithm for neurological prognostication in patients who are comatose after cardiac arrest. This algorithm is designed specifically for predicting neurological prognosis and does not account for extracerebral factors that may influence patient outcomes.

Abbreviations – CT: computed tomography; EEG: electroencephalography; GCS-M: Glasgow Coma Scale Motor score; MRI: magnetic resonance imaging; NSE: neuron-specific enolase; SSEP: short-latency somatosensory evoked potentials. NOTES. * Major confounders may include analgo-sedation, neuromuscular blockade, hypothermia, severe hypotension, hypoglycemia, sepsis, and metabolic and respiratory derangements. ** Use a pupillometer, when available, to determine if the pupillary light reflex is absent. ***Perform serial NSE samples at 24, 48, and 72 h after ROSC to detect NSE trends and minimise confounding from occasional haemolysis. Increasing NSE values between 24–48 h or 24/48 h and 72 h further support a likely poor outcome. ****Defined as continuous and generalised myoclonus persisting for 30 min or more.

- Organise a follow-up of cardiac arrest survivors within three months after hospital discharge; screening for cognitive, physical, emotional problems, fatigue, and impact on life roles.
- Invite co-survivors to the follow-up; ask about emotional problems and impact on life roles.
- Undertake specialist referral and further rehabilitation as indicated.

Organ donation

- We recommend that all patients who have restoration of circulation after CPR and who subsequently progress to death be evaluated for organ donation.
- In comatose ventilated patients who do not fulfil neurological criteria for death, if a decision to start end-of-life care and withdrawal of life support is made, organ donation should be considered for when circulatory arrest occurs.
- All decisions concerning organ donation must follow local legal and ethical requirements.
- Cardiac arrest registries should report if organ donation after initial resuscitation from cardiac arrest occurred.

Investigating unexplained cardiac arrest

- Diagnostic testing of patients with unexplained cardiac arrest includes blood sample collection for toxicology and genetic testing, data retrieval from cardiac implantable electronic devices and wearable monitors, repeated 12-lead ECG and continuous cardiac monitoring, cardiac MRI, sodium channel blocker tests, and exercise testing.
- A confirmed diagnosis of a heritable condition should prompt targeted genetic testing.
- Long-term follow-up of unexplained cardiac arrest patients is recommended because of the high risk of recurrence of arrhythmia.

Cardiac arrest centres

- Adult patients with non-traumatic OHCA should be considered for transport to a cardiac arrest centre for post-resuscitation care, whenever possible, according to local protocols.
- Health care networks should establish local protocols to develop and maintain a cardiac arrest network.

Evidence informing the guidelines

Post-cardiac arrest syndrome

In the post-resuscitation phase, several pathophysiological mechanisms contribute to primary ischaemic and secondary reperfusion injury.[10] The cessation of cerebral blood flow (CBF) in the no-flow phase prevents aerobic metabolism, resulting in the rapid depletion of adenosine triphosphate (ATP), failure of energy-dependent Na^+/K^+ ion exchange pumps, accumulation of intracellular calcium, and cessation of neuronal activity.[11]

Following the return of spontaneous circulation (ROSC) and restoration of CBF, reperfusion of the ischemic cerebrovascular bed causes further accumulation of intracellular calcium as a result of glutamate release, and activation of proteases and phospholipases. This causes cellular energy failure and further neuronal damage.[12] The inflammatory and coagulative cascades are activated in the post cardiac arrest syndrome, resulting in the release of cytokines which further amplify the inflammatory response and contribute to multiorgan failure.[13] In the post cardiac arrest phase, secondary brain injury may be caused by haemodynamic instability (in particular hypotension from vasodilation), derangements in arterial blood gases (hypo/hyperoxaemia, hypo/hypercapnia), hypo/hyper glycaemia, fever, with consequent altered CBF autoregulation, seizures, cerebral oedema.

The severity of the post-cardiac arrest syndrome is associated with the duration of no flow and low flow.[14] Any primary hypoxic-ischemic brain injury (HIBI) can be exacerbated directly by secondary ischaemia–reperfusion of the brain and indirectly by the extracerebral complications of generalised ischaemia–reperfusion such as respiratory failure, haemodynamic instability and multiorgan failure.[15,16]

A scientific statement by the ILCOR categorised HIBI into four distinct but overlapping phases: ischemic depolarization, reperfusion repolarization, dysregulation, and recovery and repair.[17] This document aimed also to explore the reasons of failure in translating preclinical data to clinical practice suggesting the presence of important limitations of the experimental models, but also the heterogeneity of the patients included and their post resuscitation care, suggesting a more tailored approach and the selection of specific patients which could benefit of specific treatments.

Post-resuscitation care management aims to mitigate the severity of HIBI [18] which is the most common cause of in hospital death.[17] A wide variety of drugs have been studied for their ability to improve the functional outcome of comatose cardiac arrest survivors, but to date, none has convincingly shown therapeutic benefit.[19] Withdrawal of life-sustaining treatment (WLST) following multimodal neurological prognostication of a poor outcome accounts for most of the later deaths.[20]

Diagnosis of cause and complications of cardiac arrest

Cardiac causes, particularly ischaemic heart disease, are the most common cause of OHCA in the general adult population.[21] However, about one third of these events are due to extracardiac causes that can be identified by transthoracic echocardiography and early CT imaging, sometimes making specific therapeutic intervention possible.[22,23] Extra-cardiac causes are diverse and include acute respiratory disease, massive pulmonary embolism, intracranial haemorrhage, thromboembolic stroke and aortic dissection. Neurological causes of OHCA are relatively rare, but they are strongly associated with an unfavourable neurological outcome, making early brain imaging valuable for the management of these patients.[24,25]

An early dual-phase contrast-enhanced CT—with a pulmonary-arterial and venous protocol – also helps to identify traumatic complications related to CPR (such as liver and spleen lacerations or perforation of digestive tract). Many cardiac arrest patients present with resuscitation-related injuries, most commonly thoracic complications such as rib fractures, pulmonary contusion or pneumothorax, but sometimes also pelvic or abdominal complications.[26,27]

The ERC and ESICM guidelines 2021 suggested that CT brain and CT pulmonary angiogram should be considered in post-cardiac arrest patients when there is no evidence of cardiac causes.[3] Recently, several observational studies have shown that this strategy enables diagnosis or identification of a complication in 5 to 22 % of cases.[28–31] In a prospective pre-/post-analysis, a standard-of-care strategy (i.e., CT scan at the discretion of the treating physician) was compared with a strategy of a systematic whole-body CT scan within 6 h of hospital arrival.[28] The systematic strategy identified the cause of CA more frequently than the standard of care strategy (92 vs 75 %, $p < 0.001$), with a significantly shorter time to diagnosis (3 h vs 14 h, $p < 0.0001$) and without an increase in the rate of complications attributable to the systematic CT-scan, such as contrast-associated renal dysfunction or transport complications (e.g. accidental extubation or line dislodgement).

In comatose post-cardiac arrest patients without ST-elevation on the ECG, and no overt signs of cardiac cause, perform an immediate whole-body CT scan to identify treatable causes (like pulmonary embolism or haemorrhage) before deciding on coronary angiography. Prioritise immediate coronary angiography for patients with clear ST-elevation MI on the ECG or other high suspicion of coronary occlusion (e.g. haemodynamic and/or electrical instability).[32]

Airway and breathing

Airway management after return of spontaneous circulation

Patients can have their trachea intubated before, during or following cardiac arrest depending on the setting or particular circumstances.[33] Following most cardiac arrests tracheal intubation will occur during resuscitation or if the patient remains comatose after ROSC.[34]

Tracheal intubation following ROSC in comatose patients will facilitate post-resuscitation care that includes controlled oxygenation and ventilation, protection of the lungs from aspiration of stomach contents, and interventions to control of seizures, temperature, and brain injury – see below for further details.

Post ROSC patients are haemodynamically unstable and, depending on their level of consciousness, may require drug assisted tracheal intubation. The same level of care should be provided as for any other critically ill patient with a physiologically or anatomically challenging airway in terms of skills of the provider, monitoring, and choice of drugs for induction, and maintenance of sedation.[35–38] There are no recommendations for a specific drug combination,[39] but use of a low dose of a sedative with the aim of avoiding profound hypotension, an analgesic and a rapid onset neuromuscular blocking drug is probably optimal. Successful tracheal intubation and ventilation must be confirmed by the presence of a sustained end-tidal carbon dioxide waveform on waveform capnography.[40]

Control of oxygenation

These guidelines are informed by the ILCOR systematic review on oxygenation and ventilation targets after cardiac arrest which identi-

fied 15 studies from 12 RCTs.[9,41] The ILCOR treatment recommendations in relation to oxygenation have been adopted by ERC/ESICM:

- We recommend the use of 100 % inspired oxygen until the arterial oxygen saturation or the partial pressure of arterial oxygen can be measured reliably in adults with ROSC after cardiac arrest in the pre-hospital setting (strong recommendation, moderate certainty evidence) and in-hospital setting (strong recommendation, low certainty evidence).
- We recommend avoiding hypoxemia in adults with ROSC after cardiac arrest in any setting (strong recommendation, very low certainty evidence).
- We suggest avoiding hyperoxemia in adults with ROSC after cardiac arrest in any setting (weak recommendation, low certainty evidence).
- Following reliable measurement of arterial oxygen values, we suggest targeting an oxygen saturation of 94–98 % or a partial pressure of arterial oxygen of 75–100 mm Hg (approximately 10–13 kPa) in adults with ROSC after cardiac arrest in any setting (good practice statement).
- When relying on pulse oximetry, health care professionals should be aware of the increased risk of inaccuracy that may conceal hypoxemia in patients with darker skin pigmentation (good practice statement).

This guidance is based on aiming for 'normal' values of oxygenation (normoxia) given that there is evidence of harm from hypoxaemia and potential for harm from hyperoxaemia.[42] Randomised trials in the prehospital[43] and hospital settings,[44] which compared an oxygen saturation of 90–94 % with 98–100 % and a PaO_2 of 68–75 mmHg (9–10 kPa) with 98–113 mmHg (13–15 kPa) did not identify an optimal arterial oxygen saturation or partial pressure of oxygen but support normoxaemia being safe and hence the recommendations for an oxygen saturation of 94–98 % or a PaO_2 target of 75–100 mm Hg (10–13 kPa). The results of the largest RCT in the prehospital setting found there were more desaturation events in the lower target group (90–94 %) compared with 98–100 % and suggest that early titration to a lower oxygen target is harmful.[43] There is also general consensus that hypoxaemia is harmful and interventions to mitigate this risk such as the use of a high inspired oxygen until blood oxygen values can be reliably measured with a pulse oximeter or blood gases are therefore recommended. A large RCT compared a peripheral oxygen saturation target of 90 % with usual care among 16,500 mechanically ventilated patients.[45] In a prespecified subgroup of 1502 patients with hypoxic-ischaemic brain injury there was no difference in 90-day mortality (odds ratio 0.94; 95 % CI 0.76 to 1.17). Another large RCT of oxygen targets in critically-ill patients also includes a predefined subgroup of patients admitted to intensive care after cardiac arrest.[46] There is also a large study looking specifically at early restricted oxygen therapy after cardiac arrest.[47] A recent secondary analysis of the Targeted Temperature Management-2 (TTM2) trial showed an association between early severe hyperoxaemia (PaO_2 > 245 mmHg [~33 kPa]) following intensive care admission and a poor functional outcome in patients with OHCA.[48,49]

Avoiding hyperoxemia is based on very low-to-moderate certainty evidence that shows either harm or no benefit (in RCTs) from hyperoxaemia. The relationship between arterial oxygen values and mortality in critically ill patients is depicted by a U-shaped curve[50] but most RCTs evaluating the impact of hyperoxaemia have studied oxygen values on the flat central part of the curve thus missing the more extreme values that have been associated with increased mortality.[51]

Recent evidence shows that pulse oximeters may overestimate true oxygen saturation in people with darker skin tones.[52] In most post-cardiac arrest patients, controlled oxygenation will require tracheal intubation and mechanical ventilation for at least 24–72 h. The exception being the completely conscious patient with a patent airway who should be treated with an oxygen mask or non-invasive ventilation targeting a peripheral oxygen saturation (SpO_2) of 94–98 %.

Control of ventilation

These guidelines are informed by the same ILCOR systematic reviews noted in the section on oxygenation. Three RCTs addressed control of ventilation.[9,41] After ROSC, blood carbon dioxide values ($PaCO_2$) are commonly increased because of intra-arrest hypoventilation and poor tissue perfusion,[53] causing a mixed respiratory acidosis and metabolic acidosis.[54] Carbon dioxide is a well-known regulator of blood vessel tone and cerebral blood flow.[55] Increased $PaCO_2$ (hypercapnia) increases cerebral blood flow, cerebral blood volume and intracerebral pressure. Hypocapnia causes vasoconstriction that may decrease blood flow and cause cerebral ischaemia.[56]

The evidence for a specific $PaCO_2$ target after ROSC is inconsistent and RCTs have not shown any benefit for any specific target. The largest RCT found no differences in outcomes from targeting normocapnia (35 to 45 mmHg) or mild hypercapnia (50–55 mmHg).[57] Several studies show that end-tidal CO_2 values on waveform capnography do not closely match $PaCO_2$ values and this makes targeting specific $PaCO_2$ targets difficult when arterial blood gas measurement is not feasible. In hypothermic patients $PaCO_2$ management including measurement is particularly challenging and these patients are prone to hypocapnia.[58,59] There is currently no evidence to support a particular strategy for measuring $PaCO_2$ during hypothermia, we have therefore recommended using a consistent approach with either temperature or non-temperature correction according to local protocols.[60]

The main method for controlling $PaCO_2$ in a mechanically ventilated patient is by adjusting the minute volume by changing the ventilation frequency or tidal volume. In general, limiting the tidal volume and using a lung protective ventilation strategy is the standard of care, especially in patients with acute respiratory distress syndrome (ARDS).[61–63] Acute respiratory distress syndrome is not uncommon in cardiac arrest patients and is associated with worse outcomes.[62,64,65] Low lung compliance predicts poor functional outcome in OHCA patients.[66] Although ventilation with lower tidal volumes is not standard practice in neurointensive care,[67] an analysis of 1848 patients recruited to the TTM2 trial showed that they were ventilated with a median tidal volume of 7 mL kg^{-1} predicted body weight.[68]

The recommendation for tidal volume is based on current guidance for lung protective ventilation in the ICU[69] and limited observational data from post-cardiac arrest patients.[70] One observational study suggests that using a tidal volume of 6–8 mL kg^{-1} to ventilate the lungs of out-of-hospital cardiac arrest patients in the ICU may be associated with improved outcome.[70] This study also showed that by using higher ventilation frequency normocapnia may be achieved.[70] In contrast, another observational study showed no association between tidal volume and neurological outcome after in-hospital cardiac arrest.[71] In studies of patients with brain injury after trauma or

stroke, protective ventilation (tidal volume < 8 mL kg^{-1} and PEEP $\geq$ 5 cm H_2O) is not associated with lower mortality or a lower incidence of ARDS, but is associated with improved oxygenation and is generally considered safe.[72] Patients should be nursed 30° head-up to decrease the risk of aspiration pneumonia[73] – this may also decrease intracranial pressure (ICP).

Circulation

Coronary reperfusion

Among the many causes of OHCA, acute coronary syndrome remains the most common cause in adults who survive to ICU admission with sustained ROSC.[21,74] Immediate coronary reperfusion using a strategy of primary PCI of the culprit coronary lesion has been used for more than 30 years. This invasive strategy is supported by many observational studies that reported a significant association between early PCI with survival and favourable neurological outcome after OHCA. While the benefit of early PCI for OHCA caused by a recent coronary occlusion is generally accepted, the main challenge is to identify the best candidates for coronary angiography among all resuscitated patients.

Percutaneous coronary intervention following ROSC with ST-elevation. In patients with ST segment elevation or left bundle branch block on the post-ROSC electrocardiogram (ECG), more than 80 % will have an acute coronary lesion.[75] A systematic review completed for the 2021 ILCOR CoSTR identified five observational studies.[76] An ILCOR evidence update in 2025 identified no additional studies involving participants with ST-elevation. Unadjusted data from the five observational studies indicated benefit at various time points for survival and survival with favourable neurological outcome; however, none of these studies confirmed such benefit when reporting adjusted data.[76] Nevertheless, given the strong evidence for benefit of early PCI for STEMI (without cardiac arrest), the ERC-ESICM treatment recommendation from 2021 was to recommend that emergent cardiac catheterisation laboratory evaluation (and immediate PCI if required) should be performed in adult patients with ROSC after cardiac arrest of suspected cardiac origin with ST-elevation on the ECG.[3] ST segment elevation on a 12-lead ECG recorded immediately after ROSC is often transient; thus, a prehospital ECG showing post-ROSC ST segment elevation should be repeated on arrival in hospital.[77–79] The 2023 European Society of Cardiology (ESC) guidelines for the management of acute coronary syndromes also state that 'a primary PCI strategy is recommended in patients with resuscitated cardiac arrest and an ECG with persistent ST-segment elevation (or equivalents as defined in the ESC Guidelines).[32]

Percutaneous coronary intervention following ROSC without ST-elevation. In OHCA patients without ST-segment elevation, several large observational series have shown that the absence of ST-segment elevation does not completely exclude the presence of a recent coronary occlusion.[80,81] However, the proportion of patients with recent acute coronary occlusion is small and several studies have shown a lack of benefit with systematic early coronary angiography in this population. Large, randomised trials (COACT, TOMAHAWK) have shown that immediate routine early coronary angiography is not superior to a delayed invasive strategy in OHCA with an initial shockable rhythm and without ST-segment elevation or equivalent and without cardiogenic shock.[82–84] Smaller trials (EMERGE, PEARL, and COUPE) have also reached the same conclusion,[85–87] and a meta-analysis of these five RCTs confirmed the absence of benefit in the general population and in the different subgroups (age, initial cardiac rhythm, history of coronary artery disease, presumed ischemic event as the cause of arrest, time to ROSC).[88] The 2025 ILCOR treatment recommendation is unchanged from 2020 and states: 'when early coronary angiography is considered for comatose post-arrest patients without ST elevation, we suggest that either an early or delayed approach for angiography is reasonable (weak recommendation, low-certainty evidence)'.[9] The 2023 ESC guidelines for the management of acute coronary syndromes in patients without persistent ST-segment elevation favour a delayed approach and state that 'routine immediate angiography after resuscitated cardiac arrest is not recommended in haemodynamically stable patients without persistent ST-segment elevation (or equivalents)'.[32] Delaying coronary angiography may buy time for initial management in ICU, enabling early initiation of post-resuscitation care and prognostication. This 'wait and see' management may also avoid performing coronary angiography in patients with the lowest probability of an acute coronary lesion.

When an ischaemic cause is considered likely, a similar approach as for patients with STEMI should be followed. The decision for early coronary angiography should be based on careful assessment of the patients for the presence of haemodynamic or electrical instability and ongoing myocardial ischaemia, taking into account multiple factors including previous medical history, prearrest warning symptoms, initial cardiac rhythm for cardiac arrest, ECG pattern post ROSC, and echocardiography, as well as preexisting comorbidities.

Brain injury caused by cardiac arrest should be considered in the decision. Ideally, coronary interventions would be undertaken only in those patients without permanent severe neurological injury. Patients with irreversible hypoxic–ischaemic brain injury are unlikely to benefit from PCI, even if a culprit coronary lesion is successfully treated.[89] Risk scores have been proposed for the early prediction of neurological outcome after OHCA;[90,91] however, the absence of a universally acceptable prognostic tool in the first hours after ROSC makes it difficult to identify such patients with high sensitivity and specificity prehospital or at the time of hospital admission.

Haemodynamic monitoring and management

Haemodynamic monitoring. Post-resuscitation myocardial dysfunction and low cardiac index may occur in up to 60 % of post-cardiac arrest patients[92,93] and may be even more common in patients with an acute myocardial infarction (AMI) as the cause of the arrest.[94] Early echocardiography can identify underlying cardiac pathology, quantify the degree of myocardial dysfunction and help guide haemodynamic management. Serial echocardiography or invasive monitoring with a pulmonary artery catheter quantifies myocardial dysfunction and indicates trends.[95–97] Impaired cardiac function is most common during the first 24–48 h, after which it gradually resolves.[92,93] Whether low cardiac output (or index) is associated with poor outcome is currently unclear. A sub-study of the TTM2 trial showed that low cardiac index may not be associated with outcome if lactate clearance is maintained.[98] These findings were independent of target temperature. In a substudy of the Blood Pressure and Oxygenation Targets After OHCA (BOX) trial, in a multivariable analysis, a low cardiac index at admission was not associated with increased mortality.[99] Both non-invasive and invasive monitoring with echocardiography, arterial lines and measurement of cardiac

output are commonly used in intensive care and it is reasonable to use these to guide treatment in cardiac arrest patients.'

Haemodynamic management. Mean arterial pressure and cerebral perfusion. Guidelines on post-cardiac arrest care published in 2021 recommended targeting a mean arterial pressure (MAP) higher than 65 mmHg during the first 72 h.[3] This was based mainly on observational data and three pilot trials.[100–102] A systematic review completed in 2023 and adoloped by ILCOR in 2024 included four studies with more than 1000 patients and compared a standard MAP target of higher 60–65 mmHg with targets higher than 71 mmHg.[103] The studies did not mandate the use of any specific drug or protocol to achieve the set targets, but noradrenaline was the most commonly used vasopressor. A higher MAP target was not associated with higher survival, better functional outcome or lower rates of acute kidney injury, but was also not associated with significant risks such as recurrent cardiac arrest or cardiac arrhythmias. ILCOR made a treatment recommendation to target a MAP higher than 60–65 mmHg but noted that the evidence is weak and that no studies have compared a MAP of 60–65 mmHg with lower MAP targets. In making these recommendations, ILCOR also noted that many observational studies have documented higher mortality rates in patients with MAP values below 60–65 mmHg. Furthermore, a MAP target of higher than 65 mmHg is common in many other critically ill patients, such as those with septic shock.

A recent scientific statement from the American Heart Association and the Neurocritical Care Society recommends targeting a MAP higher than 80 mmHg in post-cardiac arrest patients. This was based mainly on the physiological rationale that cerebral blood flow is inadequate after cardiac arrest. If the ICP is elevated, cerebral perfusion pressure is likely to be compromised by a MAP of 60–65 mmHg, as MAP is one of the primary determinants of cerebral blood flow (CBF).[104] Although a high MAP is generally required in non-anoxic brain-injured patients because of cerebral swelling and increased intracranial pressure (ICP),[105] few data on ICP values are available in cardiac arrest survivors. In many post-cardiac arrest patients, CBF autoregulation is impaired or the lower limit is right-shifted.[106,107] This means that at lower MAP values, in some patients CBF may be MAP-dependent with an increased risk of cerebral hypoperfusion (i.e. hypotension) or hyperaemia and intracranial hypertension (i.e. hypertension).

The use of cerebral oxygen saturation or ICP monitoring to determine the presence of autoregulation and to determine an optimal MAP may enable a more individualised approach.[108] In a retrospective study, the estimated optimal MAP (i.e. MAP target at which the autoregulation is more effective) was 85 mmHg in post-cardiac arrest patients with preserved autoregulation and 100 mmHg when the autoregulation was impaired.[106] Another small observational study calculated a median optimal MAP of 89 mmHg in the same setting.[109] However, there are no prospective studies evaluating whether an autoregulation-driven MAP target may influence neurological injury and/or outcome. A more recent study has shown that after cardiac arrest, in particular in cases of non-cardiac origin, episodes of elevated ICP and/or brain hypoxia are frequent, and a higher MAP is necessary to improve brain oxygenation.[109] Preliminary evidence based on measurement of brain tissue oxygenation ($PbtO_2$) has shown that in resuscitated comatose patients, impairment of oxygen diffusion to the brain may cause persisting brain hypoxia despite optimisation of oxygen delivery to the brain.[110] The implementation and the safety of these invasive monitoring tools in cardiac arrest patients need to be further evaluated. While these are all observational findings, they indicate optimal MAP targets may need to be individualised and support further research into identification of optimal MAP targets for individual cardiac arrest survivors receiving intensive care.

In the post-cardiac arrest patient, transcranial Doppler (TCD) can give information about cerebral haemodynamics and, in the future, may have a role in optimising haemodynamics in these patients.[111] Changes in cerebral blood flow can be seen using TCD and this may be a target for treatment.[112–114] However, the technique and interpretation of the images are operator-dependent and require an acoustic window in the patient's skull. Moreover, cerebral haemodynamics are continuously changing, and serial measurements are possible only intermittently; the monitoring is labour-intensive. To date, no study has utilised any of these approaches to modify MAP targets in individual patients. In general, based on the evidence summarised by ILCOR[41] including the recent systematic review including more than 1000 patients,[103] the ERC/ESICM suggests avoiding hypotension and targeting a MAP > 60–65 mmHg after cardiac arrest. A higher MAP target might be appropriate in selected patients, particularly in patients with chronic hypertension and in those with persistent and documented peripheral hypoperfusion despite a MAP between 60 and 65 mmHg (e.g., oliguria, persistent high lactate value).

Heart rate. Tachycardia was associated with poor outcome in one retrospective study.[115] During hypothermic temperature control, the normal physiological response is bradycardia. In animal models, this has been shown to reduce the diastolic dysfunction that is usually present early after cardiac arrest.[116] Bradycardia was previously considered to be a side effect of hypothermia, especially below a rate of 40 min^{-1}; however, bradycardia is associated with a good outcome.[117,118] Similar association between bradycardia and improved long-term outcome has been shown in patients not treated with hypothermic temperature control.[119] However, there are few studies on the association between heart rate and outcome conducted in patients treated with normothermia or with avoidance of fever only. Although bradycardia generally reduces cardiac output, this is well tolerated in this post-arrest setting. ERC/ESICM recommends that bradycardia (heart rate < 30–40 min^{-1}) be left untreated provided there are no signs of hypoperfusion (i.e. increasing lactate, reduced urinary output, etc.).

Fluid resuscitation, vasoactive and inotropic drugs. There is little evidence suggesting that the strategy for fluid therapy in post-cardiac arrest patients should differ from that for any other intensive care unit patients. In the initial phases, many of the patients are in cardiogenic shock, but over the next hours to days, the inflammatory response that accompanies the post-cardiac arrest syndrome may result in a distributive shock with accompanying hypovolaemia.[120] In less controlled prehospital environments, the rapid infusion of large volumes of cold fluid immediately after the return of spontaneous circulation is harmful.[121] Patients who are hypovolaemic (based on clinical judgement and echocardiography) will benefit from judicious fluid administration using crystalloids (either balanced solutions or sodium chloride 0.9 %). A systematic review and meta-analysis suggested that the estimated effect of using balanced crystalloids compared with sodium chloride 0.9 % in critically ill adults

ranges from a 9 % relative reduction to a 1 % relative increase in the risk of death; thus, there is a high probability that using balanced crystalloids may reduce mortality.[122] However, for patients with traumatic brain injury, the effect estimate ranged from a 2 % relative reduction to a 60 % relative increase in risk of death.[122] Recent ESICM guidelines suggest using balanced crystalloids rather than sodium chloride 0.9 % for volume expansion in adult critically ill patients;[123] however, in keeping with the findings of the systematic review,[122] these ESICM guidelines also suggest using sodium chloride 0.9 % rather than balanced crystalloids for volume expansion in adult critically ill patients with traumatic brain injury. No studies compared outcomes for balanced crystalloid versus sodium chloride 0.9 % in post-cardiac arrest patients.

The adequacy of haemodynamic optimisation, which includes the use of intravenous fluids, may be judged by improvements in blood pressure, adequate urinary output (>0.5 ml/kg/h), and decreasing lactate values. Several studies have documented that acute kidney injury (AKI) is common in patients after cardiac arrest with an incidence ranging from 34 to 52 %.[124–128] Most cases of AKI are mild, but in a sub-study of the BOX trial, 77/759 (10.1 %) patients required continuous kidney replacement therapy.[125] A lower mean arterial pressure (<70 mmHg) after cardiac arrest is associated with a higher incidence of AKI[129], but there is no evidence suggesting that more liberal fluid management would decrease the prevalence of AKI.[130] Recent randomised controlled trials evaluating mean arterial blood pressure targets in post-cardiac arrest care have implemented fluid therapy with meticulous monitoring. The ERC/ESICM suggests the use of controlled and carefully supervised fluid administration, including measurement of filling pressures and cardiac output in selected patients (e.g., those with myocardial dysfunction), which may help optimise clinical outcomes.[131,132] Assessment of fluid responsiveness may help to guide fluid therapy and is well-established practice in the care of critically ill patients.[133,134]

The ILCOR Advanced Life Support Task Force has concluded that 'there is insufficient evidence to recommend a specific vasopressor to treat low blood pressure in patients after cardiac arrest'.[9] A recent ILCOR systematic review identified only one small randomised controlled trial that included 40 patients who experienced non-traumatic cardiac arrest and had a post-ROSC mean arterial pressure (MAP) below 65 mmHg. These patients were randomised to receive either noradrenaline or adrenaline. The study reported identical 30-day mortality rates of 90 % in both groups.[135] Observational studies comparing adrenaline and noradrenaline have yielded inconsistent results. [136–139] While some studies associate adrenaline use with higher hospital mortality, increased rates of cardiac re-arrest, and worse neurological outcomes,[136–138] other research has not demonstrated significant differences in survival to hospital discharge, favourable neurological outcomes, or cardiac rearrest rates.[139] Observational data suggest that the combination of dopamine with either noradrenaline or adrenaline may be associated with higher mortality or an increased risk of poor neurological outcomes compared with dopamine monotherapy.[131,140] These findings should be interpreted with caution. Despite adjustments for confounding variables, residual confounding remains a significant limitation. The results are particularly prone to confounding by indication because adrenaline and vasopressor combinations are often reserved for the most critically ill and unstable patients. In the out-of-hospital settings, adrenaline tends to be more readily available than noradrenaline and is more likely to be used in the peri-arrest conditions.

Indirect evidence is available from studies conducted on patients with cardiogenic shock and acute myocardial infarction. In one study involving 57 patients randomised to receive either noradrenaline or adrenaline as the first-line vasopressor, the trial was prematurely discontinued because refractory shock was more common in the adrenaline-treated group.[141] Another study, which included 280 critically ill patients with hypotension, found no significant differences in clinical outcomes between the noradrenaline and adrenaline groups. However, there were more treatment withdrawals in the adrenaline group.[142] In an RCT comparing dopamine with noradrenaline in the treatment of shock, among those in cardiogenic shock, dopamine was associated with an increased rate of death at 28 days ($P = 0.03$).[143]

Despite the scarcity of high-certainty evidence, noradrenaline is considered a reasonable first-line vasopressor for managing hypotension in patients following cardiac arrest.[144] It is the most commonly used first-line vasopressor in cases of distributive shock and is generally well-tolerated in post-ROSC cardiac arrest patients. Randomised trials evaluating the use of noradrenaline to achieve higher MAP targets in comatose post-ROSC patients reported no clinically significant arrhythmias requiring urgent intervention or repeated shocks, even when higher doses of noradrenaline were administered compared with lower MAP groups.[100,101,132] Noradrenaline is recommended as the first-line vasopressor for managing hypotensive complications in post-ROSC cardiac arrest patients, such as cardiogenic shock due to acute heart failure, acute coronary syndromes, and sepsis.[145–148] However, in settings where noradrenaline is not available (e.g., pre-hospital), the use of adrenaline as an infusion or as small boluses may be an accepted approach. If central venous access has not been established, a dilute solution of noradrenaline (e.g., 8–40 μg/mL) can be safely infused through a peripheral intravenous cannula.[149,150]

Echocardiography is the primary bedside imaging modality for diagnosing and monitoring acute cardiovascular conditions. It is non-invasive, rapid, and provides accurate assessments of cardiac morphology and hemodynamics. Echocardiography is also valuable in guiding therapeutic procedures and can be repeated as needed, making it essential in emergency care. In shock patients, it aids in differential diagnosis by identifying both cardiac and non-cardiac causes, distinguishing various forms of cardiogenic shock, and guiding appropriate therapy.[151]

Post-resuscitation myocardial dysfunction (as confirmed by echocardiography and/or hemodynamic investigations) frequently requires inotropic support. Experimental evidence highlights dobutamine as the most established treatment in this context;[152] however, in the BOX trial, the higher doses of noradrenaline received by the high MAP target group were associated with a higher cardiac index than the lower MAP group.[153] In patients with cardiogenic shock, dobutamine is used to mitigate peripheral vasoconstriction and decrease afterload. However, its inotropic benefits are often limited in such scenarios. According to the ESC guidelines for managing cardiogenic shock, inotropic agents should be considered for patients with a systolic blood pressure below 90 mmHg and signs of hypoperfusion who do not respond to standard treatments, such as fluid resuscitation, to improve peripheral perfusion and preserve end-organ function.[147] In post-cardiac arrest patients, the systemic inflammatory response syndrome is a frequent complication, often resulting in vasoplegia and severe vasodilation.[93] In these situations, inotropic support should be initiated only after mean arterial pressure

has been optimised using fluids and vasopressors. The NEUROPROTECT trial investigated the use of dobutamine to enhance cardiac index in patients within the higher MAP target group.[100] While this approach did not decrease neurological injury, it also did not worsen myocardial injury. Similarly, the BOX trial used dopamine at a maximum dose of 10 μg/kg/min alongside fluid resuscitation and noradrenaline infusion to achieve the desired MAP.[132]

Steroids. A recent ILCOR evidence update on the use of steroids in post-cardiac arrest patients included three RCTs that evaluated the role of steroids in comatose survivors of in-hospital cardiac arrest.[154–157] The first RCT demonstrated improved survival to hospital discharge when methylprednisolone, vasopressin, and adrenaline were administered during cardiac arrest, compared with adrenaline and placebo alone, followed by hydrocortisone post-ROSC for patients in shock (19 % vs. 4 %; RR 4.87; 95 % CI 1.17–13.79).[156] The second RCT showed improved survival to hospital discharge with favourable neurological outcomes when methylprednisolone, vasopressin, and adrenaline were administered during cardiac arrest, combined with hydrocortisone post-ROSC, compared with adrenaline and placebo alone (13.9 % vs. 5.1 %; RR 2.94; 95 % CI 1.16–6.50).[155] In contrast, the third RCT, which restricted the use of steroids to the post-resuscitation phase, found no benefit from steroid administration after ROSC.[157] A systematic review and individual patient data meta-analysis pooled data from these studies (n = 869 patients).[158] While the analysis showed higher rates of ROSC with steroid use, it found no significant difference in survival to discharge or survival to discharge with favourable neurological outcomes. Data from one RCT showed no differences in health-related quality of life at 90 days, as measured by the EQ-5D-5L visual analogue scale and health utility index.[157]

Following the ILCOR meta-analysis, a new RCT—the CORTICA trial—compared low-dose steroids with placebo in patients with in-hospital cardiac arrest.[159] The trial included 184 patients and reported no significant differences in predefined outcomes, including haemodynamics, end-organ failure-free days, risk of poor in-hospital or functional outcomes, and adverse events.

Based on the combined evidence from the three RCTs in the meta-analysis, ILCOR made a weak recommendation against the routine use of vasopressin and corticosteroids in conjunction with standard care for adult in-hospital cardiac arrest.[154] This recommendation reflects the low confidence in the effect estimates for critical outcomes (low to moderate certainty of evidence). The neutral findings of the CORTICA trial,[159] which showed no significant benefit of low-dose steroids, further supports the ERC/ESICM recommendation against the the routine use of vasopressin and corticosteroids.

Three ongoing RCTs are anticipated to provide additional evidence for the use of vasopressin and steroids in patients experiencing in-hospital cardiac arrest (VAST-A, NCT05139849). For patients with out-of-hospital cardiac arrest, the ongoing HYVAPRESS (NCT04591990) trial is investigating the effect of steroids and vasopressin, and the DANOCHA (NCT05895838) trial is evaluating the effect of steroids.

Potassium. Hyperkalaemia occurs frequently immediately after cardiac arrest – data from 4 RCTs indicate that almost 20 % of patients admitted to ICU after cardiac arrest had hyperkalemia.[160] However, the release of endogenous catecholamines, along with the correction of metabolic and respiratory acidosis, promotes the intracellular movement of potassium, which may lead to hypokalaemia. Post-cardiac arrest hyperkalaemia is associated with poorer clinical outcomes.[160,161]

Based on observational data, ILCOR suggests that intravenous insulin combined with glucose can be used in cases where cardiac arrest is suspected to be caused by acute hyperkalaemia (weak recommendation, with very low certainty of evidence).[9,162] In such patients, ILCOR concluded that there is insufficient evidence to support or oppose the use of intravenous sodium bicarbonate or calcium (weak recommendation, very low certainty of evidence).

Hypokalaemia and hyperkalaemia may increase the risk of ventricular arrhythmias.[163] Observational studies suggest maintaining serum potassium values between 4.0 and 4.5 mmol/L through potassium supplementation, which is recommended as a best practice.[164]

Mechanical circulatory support. Managing post-ROSC patients with refractory shock that persists despite fluid resuscitation and vasoactive drugs presents a significant clinical challenge. In such cases, mechanical circulatory support (MCS – such as intra-aortic balloon pump, left-ventricular assist device or arterio-venous extra corporal membrane oxygenation) might be considered the next therapeutic step.[147]

A pooled analysis of up to 14 randomised trials[9] showed no significant difference in survival outcomes (ranging from 30 days to 1 year) between the early routine use of temporary MCS devices and standard care in patients with cardiogenic shock, regardless of whether a cardiac arrest had occurred.[165–178] For patients who experienced cardiac arrest, the evidence was mostly indirect, being based on randomised trials involving cardiogenic shock patients, many of whom had experienced cardiac arrest.

While the overall findings do not support the routine use of MCS devices, certain subgroups may benefit. An individual data meta-analysis of nine RCTs evaluating temporary MCS in infarct-related cardiogenic shock showed that the use of MCS devices in these patients did not lower 6-month mortality, regardless of the device type, and was associated with increased major bleeding and vascular complications.[179] However, in the subgroup of patients with cardiogenic shock and ST-elevation who were not at risk of hypoxic brain injury, MCS use led to a reduction in mortality. Therefore, MCS should be reserved for select patient populations, such as patients with a Glasgow Coma Scale score $\geq$8 on hospital arrival, with ST-elevation myocardial infarction (STEMI) and a short duration of cardiac arrest (<10 min). For patients at high risk of brain injury, the potential benefits of these devices may be diminished.

Given the current evidence, making definitive recommendations for selecting post-ROSC cardiogenic shock patients for MCS is challenging. Based on the findings, ILCOR made a weak recommendation against the routine use of these devices in cardiogenic shock patients following cardiac arrest and ROSC, citing low certainty of evidence.[9] However, MCS may be considered for carefully selected patients in appropriate settings where the devices can be effectively used (weak recommendation, low certainty of evidence). When these devices are used, it is advised to closely monitor for potential adverse events and complications to ensure timely identification and management (good practice statement).[9] The ERC/ESICM has adopted these ILCOR recommendations.

Post-ROSC arrhythmias

Recurrent arrhythmias following ROSC pose significant clinical challenges, impacting both short-term management and long-term prognosis in cardiac arrest survivors.[180] Myocardial ischemia and post-

arrest myocardial dysfunction are the primary causes of electrical instability. However, other contributing factors in the acute phase include electrolyte imbalances, elevated catecholamine values, the use of vasopressors and inotropes, as well as pre-existing structural heart disease or channelopathies.[136] Arrhythmias may range from isolated extrasystoles and short runs of supraventricular and ventricular tachycardia to life-threatening tachyarrhythmias and bradyarrhythmias.[180]

Comprehensive information on the management of these arrhythmias, both immediately before and after cardiac arrest, in accordance with guidelines from relevant scientific associations, is provided in the ERC Guidelines 2025 Adult Advanced Life Support (ALS).[181] In a post hoc analysis of a prospective randomised trial, the cumulative incidence of atrial fibrillation was reported to be 15 % on the first day and 11 % on the second day following OHCA.[182] Atrial fibrillation was independently associated with increased mortality, predominantly driven by cardiovascular complications and multiple organ failure, highlighting a vulnerable subset of patients requiring close monitoring. Data from a multicentre database encompassing 9295 patients revealed that a new diagnosis of atrial fibrillation within the first two weeks post-ROSC was strongly associated with elevated risks of stroke and mortality.[183] However, the optimal management strategy to improve outcomes in such cases remains unclear.

Recurrence of ventricular arrhythmias is common during the ICU stay of cardiac arrest survivors. In a retrospective study involving consecutive OHCA patients with VF or pulseless VT as initial rhythms, obstructive coronary artery disease, and successful primary PCI, early recurrence of ventricular arrhythmias was documented in more than 9.8 % of cases, primarily within the first 24 h.[184] Furthermore, in a post hoc analysis of a randomised trial of hypothermic temperature control, VF/VT occurred in 16.2 % of patients between days 1 and 3, with no significant differences observed between core temperatures of 33 °C and 36 °C.[185] The recurrence of life-threatening ventricular arrhythmias after ROSC may signal unrecognised underlying causes of cardiac arrest, such as hypoxaemia, hypovolemia, hypothermia, hypo/hyperkalaemia, acidaemia, toxins, cardiac tamponade, tension pneumothorax, coronary thrombosis, or pulmonary embolism.[186] Prompt recognition and treatment of these conditions are crucial to preventing recurrent cardiac arrest.[186]

Refractory arrhythmias often result from a complex interplay between myocardial substrate abnormalities (e.g., arrhythmia syndromes or myocardial scarring from structural heart disease), arrhythmia triggers, and autonomic imbalance. This necessitates a stepwise approach to management, including assessing the arrhythmia's severity, identifying triggers, evaluating the cardiac substrate, determining the hemodynamic impact, and risk-stratifying the patient.[187]

Medical management should proceed according to ALS guidelines for refractory arrhythmias. In some cases of electrical storm, measures such as sedation, stellate ganglion blockade, mechanical circulatory support, or urgent catheter ablation should be considered if initial interventions fail to resolve or prevent arrhythmias.[188] During the first hours and days, the benefit of prophylactic antiarrhythmic treatment has not been established. Antiarrhythmic medications should be reserved for the control recurrent ventricular arrhythmias. Long-term management for many of these patients involves the implantation of an implantable cardioverter-defibrillator (ICD).[189]

Implantable cardioverter defibrillators

An implantable cardioverter defibrillator (ICD) is a device designed to manage and treat certain life-threatening arrhythmias. The European Society of Cardiology has established guidelines specifying the indications for ICD therapy.[189] Indications for ICD implantation can be classified into two categories: primary prevention and secondary prevention. Primary prevention applies to patients who have not yet experienced a life-threatening arrhythmia but are at high risk of developing one. This group includes individuals with cardiomyopathies, inherited arrhythmic syndromes, congenital heart disease, or primary arrhythmias occurring in structurally normal hearts.[190,191] Secondary prevention is intended for patients who have already survived a serious arrhythmic event and remain at high risk of recurrence.

Careful patient selection is crucial to identify those most likely to benefit from ICD implantation, especially individuals whose survival may be prolonged by preventing sudden cardiac death caused by arrhythmias.

For post-resuscitation patients, ICDs are often necessary for secondary prevention. A meta-analysis[192] of three major early ICD trials comparing ICD therapy with medical treatment for secondary prevention of sudden cardiac death documented a 28 % reduction in mortality (HR 0.72; 95 % CI 0.6–0.87; P = 0.0006).[193–195] This benefit was primarily attributed to a significant decrease in arrhythmic deaths (HR 0.5; 95 % CI 0.37–0.67; P < 0.0001) among ICD-treated patients.

The ESC currently recommends ICD implantation in patients with documented ventricular fibrillation (VF) or hemodynamically unstable ventricular tachycardia (VT) where reversible causes have been excluded.[189] For adult patients with a secondary prevention ICD indication but who are temporarily not candidates for ICD implantation, the ESC recommends consideration of a wearable cardioverter defibrillator (an external defibrillator).[109,189,196]

Disability (optimising neurological recovery)

Control of seizures

Some of the evidence informing these Guidelines is set out in a systematic review that informed the 2024 ILCOR CoSTR summary.[41] The 2024 ILCOR updated treatment recommendations have been adopted by ERC/ESICM:

- We suggest against the use of prophylactic antiseizure medication in post–cardiac arrest adults (weak recommendation, very low–certainty evidence).
- We suggest treatment of clinically apparent and EEG seizures in post–cardiac arrest adults (good practice statement).
- We suggest treatment of rhythmic and periodic EEG patterns that are on the ictal-interictal continuum in comatose post–cardiac arrest adults (weak recommendation, low-certainty evidence).

The EEG is an important tool to detect corresponding electrographic seizure activity in a patient with observed clinical convulsions and to monitor treatment effects. Shivering is a common seizure mimic during hypothermic temperature control. Active treatment of status epilepticus usually necessitates repeated routine EEGs or continuous EEG-monitoring. The relative benefit of continuous EEG compared with routine EEG has not been shown. Continuous EEG monitoring is labour intensive and likely to add significant cost to patient care. The net cost-effectiveness of this approach is controversial and may depend substantially on the setting.[197,198]

Based on expert opinion, we suggest recording a routine EEG from day one after cardiac arrest. Further recordings or establishment of a continuous EEG can be performed based on clinical needs, such as prognostication or the treatment of seizures.

Seizures are reported in 20–30 % of cardiac arrest patients in the ICU and are usually a sign of a severe hypoxic-ischaemic brain injury. A seizure may be characterised by prominent motor activity (convulsions or myoclonus), or it may only be detected by an EEG recording (electrographic seizures). Focal or generalised tonic-clonic seizures also occur after cardiac arrest, and it is not uncommon that an individual patient has several seizure subtypes.[199]. Standardised criteria for possible and definite electrographic seizure activity have been published.[200]

Myoclonus is sudden, brief, shock-like involuntary muscle contractions and is by far the most common type of clinical seizure in post-arrest patients.[199,201] It is often generalised but may be focal (periodic eye-opening, swallowing, diaphragmatic contractions, etc) or multi-focal.[202] It typically develops during the first 1–2 days after the arrest and is often transient during the first days-week. It is associated with a poor prognosis[203] but some patients survive with a good outcome.[204,205] Most post-hypoxic myoclonus has a cortical origin [206] and the EEG shows time-locked discharges or burst-suppression in a substantial proportion of patients.[204]

Lance-Adams syndrome is a less frequent form of myoclonus, usually developing in a patient who has regained consciousness.[207,208] It is more common after hypoxic cardiac arrest and mainly affects the limbs, where it is induced by purposeful actions or sensory stimulation. It may be disabling and often becomes chronic.[205,209] Generalised myoclonus in combination with epileptiform discharges may be early signs of Lance-Adams syndrome. In such cases, aggressive treatment with high doses of sedatives and anti-epileptic drugs may confound the clinical examination and lead to overly pessimistic prognostication.

Studies using continuous EEG monitoring reveal that electrographic epileptiform (rhythmic and periodic) activity and clinical convulsions are equally common and that there is a substantial overlap.[210] In patients with seizures, clinical examination may be confounded by the concomitant effects of brain injury, metabolic factors and sedation, making possible clinical correlates and effects of seizure treatment harder to evaluate. Definitions of electrographic status epilepticus have been published by the American Clinical Neurophysiology Society (ACNS).[200] The timing of EEG or sedative drugs can affect the likelihood of detecting ictal-interictal patterns on the EEG..

Seizures may increase the cerebral metabolic rate and have the potential to exacerbate brain injury caused by cardiac arrest: treat seizures with levetiracetam and/or sodium valproate or a combination. Consider possible drug interactions. After the first event, start maintenance therapy. Consider increased dose of propofol or benzodiazepines to suppress myoclonus and electrographic seizures. Thiopental or phenobarbital may be considered in selected patients. Clonazepam may suppress myoclonus but may cause sedation.

Sedative drugs have potent seizure-suppressing effects and are recommended as third-line treatment of status epilepticus. Propofol and benzodiazepines are used routinely during the first days after cardiac arrest while the patient is mechanically ventilated. Depending on the dosing, these drugs will suppress clinical myoclonus and epileptiform activity in the EEG.[211,212] The seizures may be unmasked during sedation holds.

Treatment of detected clinical seizures has not been studied in an RCT.[41] However, in one multi-centre RCT, patients were treated with antiepileptic drugs and sedative agents in a stepwise goal-directed manner to suppress abundant rhythmic and periodic activity detected in the EEG.[213] The outcome was equally poor in most (90 %) patients in both intervention and control group.

In several case series, 4–44 % of patients with post-anoxic status epilepticus had a good outcome.[214–217] These patients were usually treated with multiple anti-epileptic drugs and had a delayed awakening, often beyond 1–2 weeks. Whether antiseizure medications or prolongation of intensive care contributed to good outcome in these patients cannot be confirmed in these case series.

There is limited evidence that conventional antiseizure drugs (mainly valproate and levetiracetam) suppress epileptic activity in the EEG of post cardiac arrest patients.[218] These drugs are known to suppress myoclonus of other origins.[219] Phenytoin and the prodrug fosphenytoin are still used for the treatment of status epilepticus. In post-cardiac arrest patients, however, their negative inotropic and vasodilating effects make them less suitable.[220]

There is currently no evidence supporting prophylactic treatment with antiepileptic drugs in the post-arrest setting. Previous studies on the effects of bolus-doses of thiopental[221] and diazepam/magnesium[222] after resuscitation showed no benefit in terms of survival or neurological function but these studies were designed to investigate neuroprotection, not seizure suppression.

Since post-anoxic seizures and status epilepticus are manifestations of hypoxic-ischaemic brain injury, an assessment of the prognosis and potential for an eventual good outcome are central components of a treatment strategy. The EEG-background pattern is important but may sometimes be difficult to assess if there are concomitant abundant discharges. A continuous, normal voltage and reactive EEG background are benign features whereas a burst-suppression pattern or a suppressed background without reactivity are features related to worse prognosis.[204,217] Early onset (<24 h) of electrographic seizures, before the recovery of a continuous background is associated with worse prognosis.[223–225] In these patients, the EEG is often affected by the ongoing treatment. It is therefore suggested that additional information is obtained on the severity of brain injury from methods not significantly affected by sedative drugs, such as somatosensory evoked potentials, serum NSE and neuroradiological investigations (preferably MRI).

Treatment with sedatives and conventional antiepileptic drugs in high doses may delay awakening, prolong the need for mechanical ventilation, and increase critical care length of stay.[226] The preferable approach is to treat the patient holistically instead of focusing purely on the EEG.

Temperature control

A comprehensive systematic review of temperature control in comatose post–cardiac arrest patients was conducted by the ALS Task Force of ILCOR in 2021[227] and updated in 2023.[41,228] The systematic review covered six aspects of temperature management: (1) use of hypothermic temperature control, (2) timing, (3) specific temperature, (4) duration of temperature control, (5) method of temperature control, and (6) rate of rewarming. Only controlled trials were included in these reviews. The 2021 and 2023 systematic reviews identified 38 trials.

The term targeted temperature management was updated by the ALS Task Force and the following definitions have been adopted:

- Hypothermic temperature control – active temperature control with the target temperature below the normal range
- Normothermic temperature control – active temperature control with the target temperature in the normal range
- Fever prevention temperature control – monitoring temperature and actively preventing and treating temperature above the normal range
- No temperature control – no protocolised active temperature control strategy

Comparisons in the systematic reviews included temperature control versus no temperature control, timing of temperature control, specific temperature targets, durations of temperature control, methods of temperature control, and rates of rewarming. Overall, there was no difference between hypothermic temperature control and normothermic temperature control or between other specific temperatures studied or different durations or methods of temperature control.

The ILCOR ALS Task Force made the following treatment recommendations and good practice statements, and these have been adopted unchanged for these 2025 ERC–ESICM Guidelines.

- We suggest actively preventing fever by targeting a temperature $\leq$37.5 °C for patients who remain comatose after ROSC from cardiac arrest (weak recommendation, low-certainty evidence).
- Whether subpopulations of cardiac arrest patients may benefit from targeting hypothermia at 32 °C to 34 °C remains uncertain.
- Comatose patients with mild hypothermia after ROSC should not be actively warmed to achieve normothermia (good practice statement).
- We recommend against the routine use of prehospital cooling with rapid infusion of large volumes of cold intravenous fluid immediately after ROSC (strong recommendation, moderate-certainty evidence).
- We suggest surface or endovascular temperature control techniques when temperature control is used in comatose patients after ROSC (weak recommendation, low-certainty evidence).
- When a cooling device is used, we suggest using a temperature control device that includes a feedback system based on continuous temperature monitoring to maintain the target temperature (good practice statement).
- We suggest active prevention of fever for 36 to 72 h in post-cardiac arrest patients who remain comatose (good practice statement).

Hypothermia compared with normothermia or prevention of fever. Although the ILCOR systematic reviews found no difference in overall outcomes between patients treated with hypothermia and normothermia or fever prevention the authors of a Cochrane systematic review concluded that hypothermic temperature control may improve neurological outcomes after cardiac arrest.[229] The conflicting results of these systematic reviews have been reflected in differing opinions on whether there is a role for hypothermic temperature control in comatose post-cardiac arrest patients.[230,231] Differences in opinion led the ILCOR ALS Task Force to suggest that there may be subpopulations that might benefit from hypothermic temperature control. A single trial suggested benefit in those with a nonshockable initial rhythm;[232] however, a recent individual patient meta-analysis of this trial and the TTM-2 trial participants with an initial non-shockable rhythm concluded that hypothermic temperature control did not improve survival or functional outcome.[233]

Many animal models have suggested a benefit for hypothermic temperature control after resuscitation from cardiac arrest but in these cases target temperature has generally been achieved in less than 1 h.[234] The failure to translate these findings into positive outcomes in clinical trials may reflect the 5–6 h generally taken to achieve target temperature in the clinical setting.[17] Transnasal cooling can be started before ROSC and may enable target temperature to be achieved more rapidly. The impact of this intervention on neurological recovery after out-of-hospital cardiac arrest with a shockable rhythm is being studied in a randomised controlled trial in multiple European centres.[235] Rapid cooling can also be achieved using total liquid ventilation – a pilot study is evaluating this intervention in resuscitated cardiac arrest patients.[236]

Extracorporeal cardiopulmonary resuscitation (ECPR) may enable more rapid cooling and achievement of target temperature. There are no randomised controlled trials evaluating hypothermic temperature control in patients receiving ECPR; despite this, many centres have adopted hypothermic temperature targets in these patients.

Prehospital cooling. There is no evidence that any method of prehospital cooling improves outcomes. One study indicates that rapid infusion of large amounts of cold fluid immediately after achieving ROSC in the prehospital setting is harmful.[121]

Temperature control devices. Fever control with or without a device is currently being evaluated in the STEPCARE Trial (https://stepcare.org). Until the results of this trial are known, it is considered good practice to monitor temperature continually and use a feedback-controlled system whenever a temperature control device is used to maintain a stable temperature. Two systematic reviews conflict on whether surface or endovascular cooling is preferable. One showed that intravascular cooling is associated with improved neurological outcome,[237] while the other found no association with survival or neurological outcomes.[238] A systematic review and network meta-analysis focusing on temperature feedback during hypothermic temperature control included 14 studies (4062 patients) and concluded that intravascular temperature control had the highest probability of being beneficial.[239] This has been confirmed in a recent post-hoc analysis of the TTM-2 trial.[240,241] In a randomised clinical trial of fever prevention in patients with acute vascular brain injury, use of an automated surface temperature management device did not improve functional outcome in comparison with standardised tiered fever treatment for a temperature $\geq$ 38 °C.[242]

Duration of temperature control. Three trials have investigated the impact of duration of temperature control on outcome. One trial showed no difference between 24 and 48 h of hypothermia,[243] another found no difference between 12 to 24 and 36 h of hypothermia,[244] and a third compared temperature control for 36 h versus 72 h and also found no difference in outcomes.[245] Based on these data, the ILCOR ALS Task Force was unable to reach consensus on a treatment recommendation on duration of temperature control or fever prevention. The good practice statement includes a range of duration (36 to 72 h) that is supported by the few data and by expert opinion.

Other therapies to improve neurological outcome

Many therapies have shown encouraging neuroprotective effects in experimental models. However, there are many limitations to animal models and the positive results of these preclinical clinical studies have failed to translate into clinical practice.[17] The ILCOR ALS Task Force adoloped a published systematic review on drug therapy for comatose survivors of cardiac arrest.[9,19] The adoloped ILCOR systematic review included 44 RCTs (5640 patients),[135,155–157,159,213,221,222,246–280] which were grouped into 3 themes: supportive drug therapy (5 studies), neuroprotective agent (18 studies), and anti-inflammatory/antioxidant (16 studies). The supportive therapies included antiplatelet drugs, sedation, and neuromuscular blockade, and none of these resulted in a difference in mortality at 30 days or hospital discharge.[248,262,263,266,274] The neuroprotective therapies that were investigated included thiopental,[221] amantadine,[251] nimodipine,[258,273] lidoflazine,[249] inhaled xenon,[261] nitric oxide,[253] hydrogen,[276] exenatide (glucagon-like peptide-1 agonist),[279] epoetin alfa,[250] sodium nitrite,[253] magnesium,[277] MLC901 (nine herbal components),[269] and penehyclidine hydrochloride.[278] None of these studies documented significant effects on functional outcome and there were increased rates of serious adverse events in the intervention arms of the studies of thiopental (hypotension), lidoflazine (hypotension), and epoetin alfa (thrombosis).[221,249,250] Anti-inflammatory and antioxidant therapies investigated included steroids,[157,159,268] vasopressin in conjunction with steroids,[155] thiamine,[247,254,270] coenzyme Q10,[252,259,281] vitamin C,[271] tocilizumab (interleukin-6 inhibitor),[265] iloprost,[264] urinastatin (neutrophil elastase inhibitor),[257] and the traditional Chinese medicine Shenfu.[280] None of these therapies reduced 30-day mortality.

Medical gases, noble gases and gaseous molecules have also been evaluated at neuroprotectants. The combination of xenon and induced mild hypothermia, which is beneficial and superior to induced mild hypothermia alone in experimental settings,[282] has been studied in several clinical trials without convincing effects.[246,283] Volatile anaesthetics have demonstrated positive effects on cardiac and cerebral recovery in experimental settings[284] and clinical feasibility studies,[285,286] but outcome data are scarce and uncertain.[287–289]

The 2025 ILCOR treatment recommendation in respect of neuroprotective therapies after cardiac arrest is that there is insufficient evidence to recommend the use of any specific drug therapy for comatose survivors of cardiac arrest (weak recommendation, low- to very low–certainty evidence),[9] and the ERC/ESICM supports this.

General intensive care management

Most of the guidelines for the general ICU management of post-cardiac arrest patients are based on expert opinion. Most aspects of post-cardiac arrest care follow general ICU practices. Some differences and nuances are inherent. Few aspects of general intensive care have been studied separately in the cardiac arrest population, but cardiac arrest patients have been included in trials on general intensive care practices. Specific features of the post cardiac arrest patients include the risk of brain injury and need to apply neurocritical care principles, the high occurrence of myocardial dysfunction, the use of anticoagulants and anti-platelet drugs and the high risk of aspiration pneumonitis among others. The typical length of stay in cardiac arrest patients will vary from three days to several weeks because of differences in time to awakening.[290] This will influence certain aspects of care such as the initiation of and management of nutrition.

Prophylactic antibiotics

Many post-cardiac arrest patients are at high risk of developing aspiration and ventilator-associated pneumonia[291,292] and in some centres it is routine practice to give prophylactic antibiotics to all comatose post-cardiac arrest patients.[268] An RCT examining the prophylactic use of antibiotics in OHCA patients showed a decrease in ventilator-associated pneumonia but did not find any other differences in other clinical outcomes.[256] A systematic review underpins an ILCOR treatment recommendation which suggests against the use of prophylactic antibiotics in patients following ROSC (weak recommendation, low certainty of evidence), and this is supported by the ERC/ESICM.[62,293] Despite this recommendation, it is reasonable to have a low threshold for giving antibiotics when there is any clinical suspicion of pneumonia.

Sedation and analgesia

Many post-cardiac arrest patients will require sedation and pain management, particularly those who are treated with active temperature control.[294] During hypothermic temperature control, shivering is common – this can be managed with opioids and sedation. The role of sedation in patients not treated with hypothermic temperature control remains controversial, and practice varies from deep to light sedation targets. While we await the results from the ongoing Sedation, TEmperature, and Pressure after Cardiac Arrest and REsuscitation (STEPCARE) trial comparing a deep sedation target with minimal sedation,[295] it is reasonable to treat pain, discomfort and shivering in patients not treated with hypothermic temperature control. It is best practice to monitor the level of sedation with a tool such as the Richmond Agitation Sedation Scale (RASS).[296]

One RCT has compared the use of propofol and fentanyl with midazolam and fentanyl.[248] In a trial of 59 patients, the use of propofol and remifentanil resulted in shorter time to awakening but was associated with more frequent need of noradrenaline[248] Similar findings have been shown in observational studies[297] Volatile anaesthetics have been proposed as alternative sedatives because they are cleared more rapidly. A systematic review and meta-analysis including three observational studies compared volatile anaesthetics with conventional sedatives in post-cardiac arrest patients.[287] Those patients sedated with volatile anaesthetics received a shorter duration of mechanical ventilation, but there was no difference in any other outcomes. In a recent propensity-matched control study, sedation of post-cardiac arrest patients with isoflurane was associated with a reduced incidence of delirium and shorter duration of mechanical ventilation compared with those given intravenous sedation.[289] However, results of a recent trial on 687 adults with ARDS, in most cases due to COVID-19, showed that inhaled sedation with sevoflurane resulted in fewer ventilator-free days at day 28 and higher 90-day mortality (53 % vs. 44 %; relative risk 1.31 [95 % confidence intervals 1.05 – 1.62]) than sedation with propofol Moreover, patients randomised to inhaled sedation with sevoflurane had higher rates of acute kidney injury.[298] We suggest using short-acting intravenous sedative agents and daily sedation holds when treating post-cardiac arrest patients receiving mechanical ventilation – this may enable earlier clinical examination that is less confounded by sedation when assessing neurological recovery.

Neuromuscular blocking drugs

A systematic review and meta-analysis of the use of neuromuscular blockers in post-cardiac arrest patients included 12 studies (three RCTs and nine observational studies) and over 11,000 patients.[299] The use of prophylactic (continuous) neuromuscular blockade was associated with a reduced mortality rate compared with patients managed without neuromuscular blocking drugs (OR 0.74; 95 % CI 0.64–0.86; $p < 0.0001$). There was no difference in outcomes between those managed with continuous neuromuscular blocking drugs and those managed with bolus doses. There are major limitations to this systematic review: most of the included studies were retrospective and therefore potentially confounded; observational studies were combined with RCTs; most of the patients in these studies are likely to have been treated with hypothermic temperature control and any beneficial effects of neuromuscular blocking drugs may not be seen in patients treated with normothermic temperature control. In patients with ARDS and critical hypoxaemia, an RCT[300] and a meta-analysis[301] have shown reduced mortality with the use of neuromuscular blockers, but a more recent RCT showed no survival benefit.[302] Thus, in patients with critical hypoxaemia and ARDS following cardiac arrest, the use of a neuromuscular blocker may be considered, given some evidence for their use in ARDS. Short-term use of neuromuscular blockade may be considered in other specific situations such as when performing neurophysiological testing, if shivering occurs during temperature control and in patients with severe myoclonus unresponsive to other measures. In other patients (without ARDS), ERC/ESICM does not recommend systematic use of neuromuscular blocking drugs.

Nutrition

Patients require a nasogastric tube to decompress any abdominal distension. There are no RCTs evaluating nutrition in post-cardiac arrest patients, but 5 observational studies have indicated that enteral feeding is tolerated after OHCA.[303–307] In observational studies, early enteral nutrition (started in less than 48 h from cardiac arrest) appears to be safe and associated with a higher proportion of patients with a good 3-month neurological outcome,[304] improved survival,[305] and a lower 7-day bacteraemia rate.[306] In contrast, in another observational study among patients treated with extracorporeal CPR and hypothermia, delayed enteral nutrition (>48 h) was associated with improved neurologically favourable survival compared with early enteral feeding.[307] It is reasonable to start gastric feeding at low rates (trophic feeding) and increase as tolerated. Low-calorie, low-protein intake during the acute phase of illness or haemodynamical instability is associated with fewer complications compared with standard intakes of energy and protein.[308]

Gastric ulcer prophylaxis

Routine use of ulcer prophylaxis in intensive care patients does not decrease mortality.[309,310] However, a meta-analysis showed that in high-risk patients, the use of ulcer prophylaxis decreased gastrointestinal bleeding[311] and a recent randomised trial in 4821 patients undergoing invasive mechanical ventilation showed a significant reduction in the risk of clinically significant upper gastrointestinal bleeding with pantoprazole 40 mg daily compared with placebo. The incidence of ventilator-associated pneumonia or Clostridium difficile infection was similar in the two study groups.[312] There has been no subgroup study of post-cardiac arrest patients. In one observational retrospective study, non-occlusive mesenteric ischaemia occurred in 2.5–6 % of patients admitted to a cardiac arrest centre.[313] However, in a prospective study, among 214 post-cardiac arrest patients who were still intubated after 2–4 days and systematically underwent upper gastrointestinal endoscopy 121 (57 %) had an upper gastrointestinal ischaemic lesion and these were severe (ulceration or necrosis) in half the cases.[314] Given the high incidence of upper gastrointestinal ulceration in post-cardiac arrest patients and the use of anticoagulant and antiplatelet drugs both pre and post arrest,[315] we suggest the use of stress ulcer prophylaxis in post-cardiac arrest patients, especially in those with coagulopathy.[316]

Anticoagulation

Unless patients receive anticoagulation because of a myocardial infarction or ischaemia, deep venous thrombosis (DVT) prophylaxis is recommended in critically ill patients.[317,318] A systematic review that included 13 RCTs and 9619 critically ill patients showed that low molecular weight heparin (LMWH) reduced the rate of DVT compared with unfractionated heparin.[319] The use of antiplatelet drugs does not prevent DVTs.[320] Out-of-hospital cardiac arrest patients are at risk for developing DVTs, especially if treated with hypothermic temperature control.[321] Deep venous thrombosis may be more common in those treated with an invasive temperature control device, likely related to catheter placement in the femoral vein.[322] No specific evidence exists on DVT prophylaxis in cardiac arrest patients. Thus, treatment should be individualised and be based on general ICU recommendations.[317]

Glucose control

Hyperglycaemia is common after OHCA.[161] Hyperglycaemia is best managed with continuous infusion of insulin. An evidence update on glucose control after resuscitation found no new studies that examined active glucose management in the post-cardiac arrest period, and the 2014 ILCOR treatment recommendation remains valid and supported by the ERC/ESICM: we suggest no modification of standard glucose management protocols for adults with ROSC after cardiac arrest (weak recommendation, moderate-quality evidence).[9]

The 2024 Guidelines of the American Diabetes Association recommend a target glucose range of 7.8–10.0 mmol L^{-1} (140–180 mg dL^{-1}) for most critically ill patients.[323] The American Diabetes Association also recommends that more stringent goals, such as 6.1–7.8 mmol/L (110–140 mg/dL), may be appropriate for selected patients, as long as this can be achieved without significant hypoglycaemia. However, very tight glucose control does not appear to convey benefit[324] and may be associated with hypoglycaemia (<4.0 mmol L^{-1} (<70 mg dL^{-1})),[325] which is harmful in critically ill patients.[326] In general, glucose-containing solutions are not recommended in patients with brain injury,[327] but they may be needed to treat hypoglycaemia.[326]

Predicting neurological outcome

About two-thirds of in-hospital deaths in patients who are admitted to an intensive care unit in a coma following resuscitation from OHCA are caused by hypoxic-ischaemic brain injury (HIBI).[328,329] In a minority of cases, these deaths occur as a direct consequence of HIBI, which results in an irreversible loss of all brain function, i.e., brain death.[330] However, most neurological deaths following cardiac arrest result from active withdrawal of life-sustaining treatment (WLST) in patients where the severity of HIBI indicates that survival with a poor neurological outcome is very likely.[331,332] Accurate

prognostication is therefore essential to avoid an inappropriate withdrawal of life-sustaining treatment in patients who still have a chance of a neurologically meaningful recovery and to avoid futile treatment in patients with a severe and irreversible brain injury.

Outcome measures in neuroprognostication studies

Neurological outcome after cardiac arrest is commonly reported as good or poor and is measured by ordinal hierarchical functional outcome scales, where a poor functional outcome refers to a patient being either dead or having a dependency in basic activities of daily living. Neurological outcome after cardiac arrest is most commonly reported using Cerebral Performance Categories (CPC).[333] The CPC is expressed on a five-point scale: CPC 1 (no or minimal neurological disability); CPC 2 (minor neurological disability); CPC 3 (severe neurological disability); CPC 4 (persistent vegetative state); and CPC 5 (death). Although the CPC is the most commonly used scale, the preferred measure for functional outcome in cardiac arrest is the modified Rankin Score (mRS), which ranges from 0 (no symptoms) to 6 (dead).[334] In 2018, a statement from ILCOR[335] suggested using mRS rather than CPC for measuring functional recovery after cardiac arrest, because mRS is more suitable than CPC for discriminating between mild and moderate disability[336,337] and may have better interrater reliability.[338] However, for both of these scales interrater reliability is generally acceptable in the separation of good and poor outcome.

For both clarity and statistical purposes in studies on neuroprognostication after cardiac arrest the outcome is dichotomised as 'good' or 'poor'. However, there is no universal consensus on what represents a poor functional outcome. Up to 2006, most neuroprognostication studies reported CPC 4 or 5 (vegetative state or death) as a poor outcome, and CPC from 1 to 3 (from absent to severe neurological disability) as a good outcome, while after that date an increasing number of studies included CPC 3 (severe neurological disability) among poor neurological outcomes.[339] In a 2020 systematic review, among 94 total studies on neurological prognostication after cardiac arrest, 90 (96 %) defined a poor neurological outcome as CPC 3–5, while only four defined poor outcome as CPC 4–5.[340]

In prognostic accuracy studies, a predictor (index test) is evaluated for its ability to predict an outcome. When test results are expressed in binary format (i.e., positive vs. negative), accuracy is measured using sensitivity and specificity, which indicate the test's ability to identify individuals who will develop or will not develop the target condition, respectively. Sensitivity is the fraction of subjects who will develop the target condition and have a positive test result. For this reason, sensitivity is also known as the true positive rate. A highly sensitive test will be positive in most of the patients who will develop the target condition. Specificity is the fraction of subjects who will not develop the target condition and have a negative test result. For this reason, specificity is also known as the true negative rate. A very specific test will be negative in most of the patients who will not develop the target condition. Importantly, the remaining patients who will not develop the target condition will, by definition, have a *positive* test result. These are the false positives, and their fraction of the total patients who will not develop the condition is the false positive rate. Specificity and false positive rate complement each other: Specificity = 1 – False Positive Rate.

Since most neuroprognostic tests predict poor functional outcome, having a very high specificity (i.e., a very low rate of falsely pessimistic predictions) is desirable. Ideally, an index test should be 100 % specific, i.e., its false positive rate should be zero. There is no universal consensus on how low the false positive rate of an index test should be for neuroprognostication after cardiac arrest. In a survey of 640 healthcare providers, the majority (51 %) considered an acceptable false positive rate for withdrawing life-sustaining treatment from patients who might otherwise recover to be $\leq$0.1 %.[341] Along with the absolute specificity value, the precision of its estimate is essential. A very specific test predicting poor outcome is of little clinical use when its precision is low (i.e., when the confidence intervals [CI] around the point estimate of its specificity are wide), because this indicates a high degree of uncertainty around the estimated specificity. In the 2014 ERC-ESICM Advisory Statement on neuroprognostication after cardiac arrest, the single most robust predictors were identified as those in which the upper boundary of the 95 % confidence interval of the false positive rate was below 5 %.[332] To increase the safety of neuroprognostication, from 2021, ERC and ESICM have recommended using a combination of at least two concordant unfavourable predictors for predicting poor neurological outcome in patients who are comatose after cardiac arrest. In two multicentre validation studies of the 2021 ERC-ESICM neuroprognostication strategy, one conducted mostly in Central and Nothern Europe[342] and the second conducted in South Korea where withdrawal of life-sustaining treatment was not practised,[343] the ERC-ESICM neuroprognostication algorithm predicted poor outcome with 0 % false positive rate and 95 % confidence intervals of 0–1.2 % and 0–3.4 %, respectively.

For some neuroprognostic tests used after cardiac arrest, such as blood values of biomarkers of neurological injury or the grey matter to white matter density ratio on brain CT, the results are expressed as continuous variables. In this case, sensitivity and specificity will depend on the value of the variable that is chosen as a threshold to separate positive from negative test results, and the values of sensitivity and specificity that are obtained by varying the positivity threshold across all its possible values are expressed by a receiver operating characteristic (ROC) curve. The problem with dichotomising continuous predictive variables to obtain a binary test result is the difficulty in finding a consistent threshold for 100 % specificity. Very high test results can be caused by outliers, which can distort the data and reduce test sensitivity.

Main sources of bias in neuroprognostication

One of the major biases in neuroprognostication after cardiac arrest is self-fulfilling prophecy. This occurs when the treating team is aware of the result of the prognostic test and uses it for decisions that affect the patient's outcome, e.g., withdrawal of life-sustaining treatment (WLST). This leads to an overestimation of test performance and potentially to an inappropriate WLST. In a 2013 systematic review on neuroprognostication after cardiac arrest, 64/73 (88 %) studies were at risk of self-fulfilling prophecy bias.[344,345]

Ideally, the index tests should be investigated blindly to avoid self-fulfilling prophecy bias. However, this is difficult to achieve in practice. Concealing clinical examination results from the treating team is almost impossible, while concealing EEG or brain imaging results would be unethical, since they may reveal the presence of potentially treatable complications (e.g., seizures or intracranial hypertension, respectively). Nevertheless, some predictors, such as biomarkers, have been evaluated blindly.[346–348] A special condition limiting the risk of self-fulfilling prophecy bias is the absence of

an active WLST policy. This has been described in some studies conducted in countries or communities where treatment limitations are not accepted due to cultural, legal or religious reasons.[349,350]

Other strategies to reduce the risk of falsely pessimistic predictions include avoiding confounding from treatments (e.g., sedatives or other drugs) affecting the results of some predictors, such as clinical examination or EEG; avoiding basing decisions on life-sustaining treatments on the results of a single index test, but instead using a multimodal approach (see Fig. 5 – Multimodal prognostication algorithm); and always interpreting the results of the index tests within the clinical context.

A specific source of bias in neuroprognostic studies after cardiac arrest is the presence of a time lag between the recording of the index test, which is usually done very early after the arrest, and the assessment of the target condition, i.e., neurological outcome. Since recovery from hypoxic-ischaemic brain injury following cardiac arrest requires time, the minimum recommended timing for its assessment is 30 days or later from the event or neurological discharge.[335] However, further neurological recovery can occur later. Consequently, an early prediction of outcome, which is confirmed by CPC or mRS measured at hospital discharge, may occasionally prove false when the outcome is reassessed later.[351] For that reason, guidelines suggest reassessing neurological outcome at three or six months after the event.[352] Most studies in the systematic review informing these guidelines report neurological outcomes at least six months after cardiac arrest.[340]

Another bias, which is partly related to the time delay between index test assessment and outcome, is the interference from extracerebral causes of death after cardiac arrest. These include cardiovascular instability, which is the second most common cause of in-hospital death after cardiac arrest,[329] and multiple organ failure due to global ischaemia–reperfusion injury.[128,353] Although the incidence of these complications is maximal early after arrest, death from extracerebral organ failure may occur after neurological recovery.[290] The prevalence of death after awakening was 16 % in the ICU in a single-centre study,[354] and 4.2 % during hospital stay in a multicentre European study including 4646 patients.[355] In that study, death occurred at a median time of 9 (3–18) days after awakening, and it was more common after IHCA than after OHCA.

The present guidelines apply only to neurological prognostication. Besides hypoxic-ischaemic brain injury, other, albeit less common, causes of death in resuscitated comatose patients include cardiovascular instability,[329] and multiple organ failure.[128,353] These factors may result in treatment limitations independently from the patient's neurological status or cause non-neurological death even after the neurological recovery has occurred.[352,355,356] In clinical practice, a comprehensive prognostic approach in resuscitated comatose patients should inevitably consider the role of extracerebral factors as well as patient characteristics such as age, comorbidities, and functional status.

Multimodal prognostication

We recommend that neuroprognostication always be undertaken using a multimodal approach because no single test has sufficient specificity to eliminate false positives (strong recommendation, very low-certainty evidence).

Clinical examination

These guidelines are supported by evidence from a systematic review on prognostication and 2025 ILCOR CoSTRs.[62,340] The relevant treatment recommendations in the 2025 ILCOR CoSTR are:

- We suggest using pupillary light reflex at 72 h or later after ROSC for predicting neurological outcome of adults who are comatose after cardiac arrest (weak recommendation, very-low-certainty evidence).
- We suggest using bilateral absence of corneal reflex at 72 h or later after ROSC for predicting poor neurological outcome in adults who are comatose after cardiac arrest (weak recommendation, very low-certainty evidence).
- We suggest using the presence of myoclonus or status myoclonus within 7 days after ROSC, in combination with other tests, for predicting poor neurological outcome in adults who are comatose after cardiac arrest (weak recommendation, very low-certainty evidence). We also suggest recording EEG in the presence of myoclonic jerks to detect any associated epileptiform activity (weak recommendation, very low-certainty evidence)

Ocular reflexes. Ocular reflexes currently used for neurological prognostication after cardiac arrest include pupillary and corneal reflexes. The pupillary light reflex comprises a temporary reduction of pupil size induced by a light stimulus. Standard pupillary light reflex is evaluated visually and elicited generally using a penlight. In recent years, a quantitative evaluation of pupillary light reflex using portable pupillometers has become available in the ICU. A bilaterally absent standard pupillary light reflex has low specificity for predicting poor outcome in the first hours after ROSC, but its accuracy progressively increases, and it achieves 0 % false positive rate 100 % specificity after 96 h from ROSC with 20–25 % sensitivity.[340] This is presumably due to the process of brain recovery after anoxic-ischaemic injury, but it may be due partly to interference from sedatives used in the early post-resuscitation phase to maintain temperature control. Standard pupillary light reflex is inexpensive and easy to use, but it is subjective and prone to interrater variability.[357]

Quantitative evaluation of pupillary light reflex (automated pupillometry) provides an objective and quantifiable measurement of the pupillary response. The most common pupillometry measures are the percentage reduction of pupillary size, generally indicated as q-pupillary light reflex[358] and the neurological pupil index.[358–360] The neurological pupil index is calculated from several dynamic parameters of the pupillary response (including constriction and dilation velocity, size, and percentage size reduction after stimulation) using a proprietary algorithm. A neurological pupil index value ≥ 3 is considered normal. Limited evidence showed that, unlike standard (visual) pupillary light reflex, neurological pupil index can predict unfavourable outcome with no false positive results from 24 h or less to 72 h from ROSC.[340] In one study, this was because of the pupillometer's ability to detect a response even when the pupil size was minimal, presumably due to sedation.[361] Pupillometry results are expressed as a continuous measure, and the threshold for a 0 % false positive rate varied among studies. In three studies in a recent evidence review, this neurological pupil index threshold varied between <2.0 and 3.14.[358–360] Another limitation of automated pupillometry is its cost.

The corneal reflex is elicited by touching the cornea's outer margin (limbus) with a cotton wisp. Alternatively, an air or water squirt can be used to minimise the risk of corneal abrasion.[362] An eye blink represents the corresponding response. In patients who are comatose after cardiac arrest, an absent corneal reflex predicts poor neurological outcome after 72 h from ROSC with 0 % false positive rate (95 % confidence interval 0–3.4 %) and 25–40 % sensitivity in most studies.[340] Like pupillary light reflex, corneal reflex is prone to inter-

ference from sedation. In addition, it may be affected by muscle relaxants. A 2020 survey revealed that the modalities used to assess the corneal reflex in comatose patients are inconsistent.[363]

Motor response. An absent or extensor motor response to pain (motor component [M] 1 or 2 of the Glasgow Coma Score) is associated with poor neurological outcome after cardiac arrest.[340] However, its specificity is low, rarely achieving 100 %, even after 96 h from ROSC. Like corneal reflex, the motor response is based on striate muscle contraction, which can be affected by muscle relaxants.

Myoclonus and status myoclonus. Myoclonus consists of sudden, brief, involuntary jerks caused by muscular contractions or inhibitions. Their distribution can be focal, multifocal, or generalised.[364] The presence of myoclonus within 96 h from ROSC in patients who are comatose after cardiac arrest is associated with poor neurological outcome in most cases.[340,365,366] However, a false positive rate of up to 22 % has been described.[367] Most prognostication studies did not provide a definition or description of myoclonus. As mentioned above, in some patients with favourable outcome, myoclonus may persist after recovery of consciousness in a chronic form of action myoclonus (i.e., triggered by spontaneous movements) known as Lance-Adams syndrome.[205,368]

Clinical myoclonus can inconsistently be associated with electrographic seizures; therefore, EEG recording can be helpful. Some studies have identified specific EEG features associated with benign myoclonus, such as a reactive[201,207] and/or continuous EEG background.[201,204] The presence of diffuse and continuous myoclonic jerks is usually described as status myoclonus. However, a consensus definition of status myoclonus is lacking. The 2014 ERC-ESICM Advisory Statement on neurological prognostication after cardiac arrest suggested that in comatose survivors of cardiac arrest, status myoclonus should be defined as a continuous and generalised myoclonus persisting for 30 min or more.[332] Evidence from two studies that did not distinguish electrographic features of status myoclonus[340] showed that status myoclonus within 24 h[369] or seven days from ROSC[199,369] is almost invariably associated with poor neurological outcome (specificity 99–100 %).

The advantages of predictors based on clinical examination include minimal equipment and costs (except pupillometry) and availability at the bedside. Their major limitations include interference from sedatives, opioids, and – except for the pupillary light reflex – from muscle relaxants. In addition, their assessment is prone to subjectivity. Automated assessment, such as pupillometry for the pupillary light reflex, may at least address these limitations. Finally, clinical examination results cannot be concealed from the treating team, potentially causing a self-fulfilling prophecy bias.

Neurophysiology

These guidelines are supported by evidence derived from a systematic review on prognostication and the subsequent updates incorporated in the 2025 ILCOR CoSTRs.[9,340] The relevant ILCOR treatment recommendations (which have been adopted by the ERC/ESICM) are:

- We suggest using a bilaterally absent N20 wave of somatosensory evoked potential (SSEP) at $\geq$ 24 h from ROSC in combination with other indices to predict poor outcome in adult patients who are comatose after cardiac arrest (weak recommendation, very low-certainty evidence).
- We suggest against using the absence of EEG background reactivity alone to predict poor outcome in adult patients who are comatose after cardiac arrest (weak recommendation, very low-certainty evidence).
- We suggest using suppression or burst-suppression on EEG to predict poor outcome in adult patients who are comatose and who are off sedation after cardiac arrest (weak recommendation, very low-certainty evidence).

Electroencephalography (EEG). Electroencephalography (EEG) is one of the most widely used and studied methods to assess brain function and prognosis after cardiac arrest.[370] EEG is also essential for diagnosing and treating seizures. The main aspects of assessing EEG for neuroprognostication are background activity, superimposed discharges, and reactivity. The EEG background continuity is most important for prognosis and is commonly categorised as continuous, discontinuous, burst suppression (50–99 % suppression periods), or suppression (>99 % activity with <10 μV amplitude).[371] A standardised terminology for critical care EEG has been proposed by the American Clinical Neurophysiology Society (ACNS).[200]

Immediately after a cardiac arrest, the EEG background is suppressed in many patients, but it returns to a continuous normal voltage EEG within the first 24 h in most patients who ultimately achieve a good outcome.[372,373] The time for this restitution is correlated with the outcome.[371,374] The EEG background is often discontinuous and of low frequency on its first appearance.[372,375] Sedative drugs affect background continuity and have the potential to induce discontinuous or burst-suppression background in a dose-dependent manner.[376,377]

Background patterns

Suppression

A suppressed (<10 μV) or low-voltage (<20 μV) background, based on the American Clinical Neurophysiology Society terminology,[200] is relatively common during the first day after a cardiac arrest in patients who later recover (Fig. 6).[349,372,373] However, 24 h after ROSC, a suppressed EEG background <10 μV is a reliable sign of a poor prognosis, with a false positive rate of 0.4 % (95 % confidence interval 0.04–1.46 %),[378–383] although two false-positive predictions by this pattern 48–72 h after cardiac arrest were reported in a total of 1351 patients included in the systematic review informing these guidelines [340]. There was moderate interrater agreement for suppressed background among senior neurophysiologists.[380,384]

Burst suppression. According to the American Clinical Neurophysiology Society terminology, burst suppression is defined as 50–99 % of the recording consisting of suppression alternating with bursts. The terminology does not specify any amplitude criteria for the bursts, but these may be further defined as 'highly epileptiform bursts' based on their appearance.[200] 'The presence of 'identical bursts' (either the first 0.5 s of each burst or each stereotyped cluster of $\geq$2 bursts appear visually similar in >90 % of bursts) portends a poor prognosis in post-anoxic coma.[385] A substantial portion of patients with burst suppression during the first 24 h and occasional patients with burst suppression-pattern after 24 h still have a good outcome, which is possibly related to sedation use.[351,372,378–380,386–388]



Fig. 6 – EEG patterns with high specificity for poor neurological outcome at 24 h or later after ROSC.
A. Suppressed EEG background. Based on the American Clinical Neurophysiology Society (ACNS) 2021 terminology,[200] this is defined as a very low-voltage background with more than 99 % of the activity having an amplitude below 10 μV. B. Suppressed EEG background with periodic discharges. C. Burst-suppression with identical bursts. Burst-suppression is defined as 50–99 % of the recording consisting of suppression alternating with bursts. When either the first 0.5 s of each burst or each stereotyped cluster of ≥2 bursts appear visually similar in > 90 % of bursts, these bursts are defined as identical. D. Burst-suppression with heterogeneous bursts (variable burst appearance).

American Clinical Neurophysiology Society-defined suppression and burst-suppression are highly specific for predicting poor outcome after cardiac arrest, especially when these patterns are recorded after 24 h from ROSC.[378,379,389,390] However, in a large substudy of the multicentre TTM2 trial including 845 patients, the specificity of these 'highly malignant' patterns assessed locally at each participating centre was only 93 %, suggesting a possible suboptimal implementation.[391] Limited evidence shows that suppression with periodic discharges and burst-suppression with identical bursts are more specific and less time-dependent than suppression and heterogeneous burst-suppression [392–396] There is substantial interrater agreement among experienced neurophysiologists for burst-suppression.[380]

Reactivity

EEG reactivity is a measurable change in amplitude or frequency upon external stimulation (auditory and pain). The interrater agreement for assessing EEG reactivity varied from slight to almost perfect.[380,397] A proposal for international consensus on reactivity testing exists.[398] The prognostic performance of this feature varied substantially between studies.[340,399] The absence of EEG reactivity during the first 24 h after cardiac arrest predicts poor outcome with high sensitivity but low specificity (41.7–87.5 %).[388,400–402] After 24 h, the sensitivity of absent reactivity remains high, but the specificity varied from 50 % to 100 %.[378,380,386,388,401–405] In a recent substudy on 821 comatose patients from the multicentre TTM2 trial, the absence of reactivity on EEG at 24 h to 14 days from ROSC predicted poor neurological outcome at 6 months with 79 [76–82]% sensitivity but only 60 [55–66]% specificity.[391]

Superimposed patterns

Periodic discharges. A 'periodic' pattern is a waveform that occurs repeatedly, with a quantifiable interval between discharges. If no such interval exists, the pattern is termed 'rhythmic'.[200] Periodic discharges may be superimposed on various backgrounds and are related to a worse prognosis. Generalised periodic discharges are a sign of a poor

prognosis with limited specificity.[378,379,382,386] Generally, the background on which periodic discharges appear is more closely related to neurological outcome.[371] Periodic discharges on a continuous and reactive EEG background should not be considered as an indicator of a poor outcome.[204]

Sporadic epileptiform discharges. 'Sporadic epileptiform discharges' describes sharp waves or spikes resembling those seen in patients with epilepsy but without the regularity of a periodic pattern. The frequency by which they appear may vary extensively from 'rare' (<1/h) to 'abundant' (≥1/10 s), bordering on periodic discharges. While their appearance is related to a worse outcome, their specificity to predict poor outcome ranges from 66.7 to 100 %,[340] and reports on the potentially important frequency or number of discharges were lacking in studies.[349,380,382,383] Presence of sporadic epileptiform discharges is *not* a reliable indicator of a poor neurological prognosis.

Electrographic seizures and electrographic status epilepticus. The American Clinical Neurophysiology Society defines 'unequivocal seizures' as epileptiform discharges >2.5 Hz for ≥10 s or any pattern with definite evolution lasting ≥10 s.[200] This definition was inconsistently used in studies. Seizures had a low sensitivity but high specificity for a poor outcome regardless of timing.[378,380,382,386,406]

The term 'electrographic status epilepticus' defines an electrographic seizure for ≥10 continuous minutes or for a total duration of ≥20 % of any 60-min period of recording. This definition has been included for the first time in the 2021 update of the American Clinical Neurophysiology Society terminology, and none of the currently available prognostic studies has incorporated it yet. Some studies based their definition of electrographic status epilepticus on the American Clinical Neurophysiology Society classification of unequivocal seizures extending ≥30 min but also included epileptiform discharges ≥1 Hz,[215,374] and in one study ≥0.5 Hz as electrographic status epilepticus.[407] Other studies had an unclear definition of electrographic status epilepticus.[351,386,387,401] The proportion of patients classified with electrographic status epilepticus varied considerably between studies, possibly reflecting differences in definitions. One study showed that electrographic status epilepticus evolves from high-frequency discharges early after onset to progressively slower frequencies during the following days and weeks.[210] While electrographic status epilepticus is associated with hypoxic-ischaemic brain injury after cardiac arrest, it is not as specific and consistent as suppression and burst-suppression.[214,215,217] This is likely partly due to its inconsistent definition in the available literature. As with periodic discharges, it is important to consider whether the EEG background is continuous and reactivity is present, both of which are favourable features.[215,217] Due to the lack of a standardised classification, we recommend avoiding the term 'status epilepticus' for assessments of prognosis and instead classify the EEG background and superimposed discharges, as well as unequivocal seizures, according to the standardised terminology of the American Clinical Neurophysiology Society.[200]

Quantitative EEG indices

Automated assessment of quantitative EEG features such as the burst-suppression amplitude ratio and reactivity has been tested in individual studies.[408,409] Combinations of quantitative EEG features include the Bispectral index (BIS) and the Cerebral Recovery Index.[410] The threshold value and specificity for BIS to predict poor outcome varied widely between studies.[411–413] Automated EEG assessments may decrease subjectivity. Prospective multi-centre studies are needed to assess their prognostic performance after cardiac arrest.

Evoked potentials

Somatosensory evoked potentials (SSEPs). When performing SSEPs, the median nerve is electrically stimulated and the ascending signals are recorded from the peripheral plexus brachialis, cervical level, subcortical level and the sensory cortex (N20-potential) (Fig. 7a). SSEPs may be depressed by barbiturate coma but are preserved with other sedative drugs such as propofol and midazolam.[414] A bilateral absence of the short-latency N20-potentials over the sensory cortex (Fig. 7b) is a reliable sign of a poor prognosis after cardiac arrest with high specificity both within 48 h (99.7; 85 % confidence interval 98.2–100.0 %) and at 48–96 h (99.8; 95 % confidence interval 99.0–100.0) after cardiac arrest.[198,223,351,361,383,387,400,402,403,409,415–426] with a sensitivity ranging between 37.7 % (95 % confidence interval 34.4–41.1 %) and 45.2 % (95 % confidence interval 40.8–49.7 %). Occasional false-positive predictions were reported.[427] The interrater reliability for interpretation of SSEPs was moderate to good.[428,429] The recording quality is critical, and noise from muscle activity is an important limiting factor that neuromuscular blocking drugs may eliminate.[414,428]

Recent studies have shown that very low cortical SSEP amplitudes predict poor outcome with similar specificity as absent N20 potential.[430–434] In most studies, the N20 amplitude threshold for 100 % specificity was < 0.5 μV. However, because of the documented variability in thresholds and SSEP montages across studies and the potential interference from sedation, low N20 amplitude is not yet recommended for predicting poor outcome after cardiac arrest.[435]

Biomarkers

These guidelines are supported by evidence derived from a systematic review on prognostication and the 2025 ILCOR CoSTRs.[340] The relevant 2025 ILCOR treatment recommendations (which have been adopted by the ERC/ESICM) are:

- We suggest using neuron-specific enolase (NSE) within 72 h after ROSC, in combination with other tests, for predicting neurological outcome of adults who are comatose after cardiac arrest (weak recommendation, very-low-certainty evidence).
- We suggest against using S-100B protein for predicting neurological outcome of adults who are comatose after cardiac arrest (weak recommendation, low-certainty evidence).
- We suggest against using serum levels of glial fibrillary acidic protein (GFAP), serum tau protein, or neurofilament light chain (NfL) for predicting poor neurological outcome of adults who are comatose after cardiac arrest (weak recommendation, very low-certainty evidence).

Protein biomarkers released following injury to neurons and glial cells may be measured in blood and are likely to correlate with the extent of brain injury and neurological outcome. Neuron-specific biomarkers include NSE, NfL, and tau protein, while S100B and glial fibrillary acidic protein originate from astrocytes. Neuron-specific enolase has been recommended for assessment of brain injury and to help prognosticate outcome after cardiac arrest since 2015.[2] Several reports on novel biomarker candidates have been

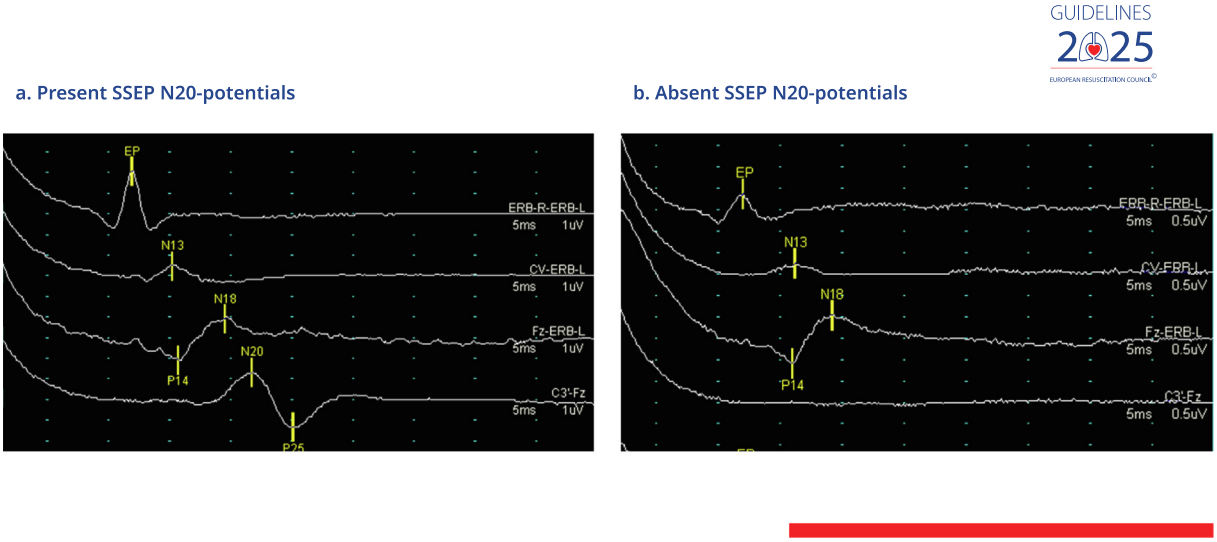


Fig. 7 – Short-latency somatosensory evoked potentials (SSEP) in a patient with preserved SSEP cortical activity (a) and in a patient with severe HIBI (b).
SSEP of the upper limb are obtained after bipolar transcutaneous electrical stimulation of the median nerve at the wrist. In each SSEP recording, the four tracings represent the electrical neural activity induced by the stimulus at various anatomical levels during its central propagation along the somatosensory pathway. Positive waves are downward deflections of the tracing from the baseline, and negative waves are upward deflections. Each positive or negative wave is indicated by a P or N letter, respectively, followed by a number indicating its latency from the stimulus in milliseconds. The more distal the generator of a wave from the stimulus site, the longer its latency is. The four tracings represent, from top to bottom: brachial plexus on the same side of the stimulus (EP or Erb); cervical cord (N13); cervicomedullary junction (P14) and upper midbrain and thalamus (N18); primary somatosensory cortex on the opposite side of the stimulus (N20 and P25). On the left-hand side of the figure, the N20 is present. The tracing on the right-hand side, from a patient with severe HIBI, shows no cortical N20/P25 waves.

published since 2020.[347,436–442] Use of biomarkers other than NSE may be recommended in the future if consistent thresholds for predicting a poor outcome are indentified and further evidence for their ability to predict recovery becomes available.

Importantly, a multimodal approach should be used for assessment of comatose survivors after cardiac arrest. Advantages of biomarkers include quantitative results, the relative ease of sampling and interpretation and their independence from the effects of sedatives. Limitations include availability, limited knowledge of their kinetics, and lack of standardisation across analytical methods. Most of the available evidence is limited to a time span of up to 72 h after cardiac arrest, which is relevant for most patients. However, very limited evidence supports using biomarkers after 72 h in patients who fail to awaken.

Biomarkers are released with different latency and speed following acute brain injury. Although the kinetics of NSE after cardiac arrest is incompletely known, studies have shown that NSE blood levels increase up to 72 h in patients with unfavourable outcome and tend to decrease in patients with favourable outcome.[443,444]

Large studies are needed to investigate and validate promising novel biomarkers, confirm their predictive value, assess their reproducibility outside specialised laboratories, and identify consistent thresholds for specificity that should be close to 100 %. The rationale for accepting a specificity of less than 100 % is that when using blood biomarkers, there will always be outliers that must be taken into consideration, e.g., due to poor calibration or issues with laboratory standards, haemolysis (for NSE), or due to poor technique in handling samples. Demanding 100 % specificity from a blood biomarker may lower its sensitivity to levels where its clinical use can be questioned, while allowing an FPR of 1 % or 2 % will increase its clinical relevance. With a multimodal approach, every prognostic method used to assess an individual patient must point in the same direction to be trusted. This may be particularly true for biomarkers, given their continuous nature; normal or mildly elevated levels (at the correct sampling time) should always alert the clinician to potential errors in other methods, indicating a poor prognosis.

Neuron-specific enolase

Neuron-specific enolase has been extensively studied following cardiac arrest. A large substudy of the TTM-trial identified thresholds of 48 $\mu g\ L^{-1}$ at 48 h and 38 $\mu g\ L^{-1}$ at 72 h with a false positive rate of 2 % (95 % confidence interval 1–5 %) for poor neurological outcome at 6 months.[346] The 2021 guidelines suggest using a threshold of 60 $\mu g\ L^{-1}$ at 48 h and 72 h to predict poor outcome after cardiac arrest. In 2022, a validation study of these guidelines in 660 patients found no falsely pessimistic predictions (specificity 100 [83–100]) for an NSE >60 $\mu g\ L^{-1}$ in comatose patients with a GCS motor score no better than 3 at $\geq$72 h after ROSC.[343] In the 2025 ILCOR evidence update[9] NSE values between >60 $\mu g\ L^{-1}$ and 87 $\mu g\ L^{-1}$ at 48 h from ROSC predicted poor neurological outcome with a specificity ranging from 95 % to 100 %,[440,443–447] while NSE values between 46.2 $\mu g\ L^{-1}$ and 60 $\mu g\ L^{-1}$ at 72 h from ROSC predicted poor neurological outcome with a specificity ranging from 94 % to 100 %.[443,444,446,448] In another study, NSE with a threshold of 50.2 $\mu g\ L^{-1}$ on day 4 predicted poor neurological outcome at one month with 100 % specificity and 42.1 % sensitivity.[449]

NSE decreases after 24 h in patients with good outcome and typically increases in patients with a poor outcome peaking at 48–96 h. NSE performs poorly at 24 h and best at 48 or 72 h.[346,425,449–454] However, an NSE measurement at 24 is useful as a baseline value to detect the NSE trend during the two following days. Increasing NSE from 24 to 48 or 48–72 h is a reliable indicator of a poor prognosis with similar performance as the absolute value.[455] Different chemiluminescence immunoassays were used in the included studies, which may have affected the NSE detection limits and the reference intervals.[456] Thresholds for high NSE values must be established in collaboration with the local laboratory considering the analytical method. Red blood cells contain NSE, so haemolysis (free haemoglobin) must be measured, and samples discarded if the haemolysis index threshold is exceeded because this may generate a falsely high NSE value.[456] The half-life of free haemoglobin is approximately 2–4 h compared with the 30-h half-life of NSE. Thus, the NSE value may be inappropriately increased (by NSE from red blood cells) when free haemoglobin is no longer detectable, which is a concern when using NSE for prognostication after cardiac arrest.[456]

Serum neurofilament light chain

There is an increasing interest in assessing NfL to predict neurological outcome. After the publication of the 2020 systematic review informing the 2021 guidelines,[340] several studies evaluated the ability of the blood values of NfL measured between 24 h and 72 h after ROSC to predict poor neurological outcome.[347,438–440,446,457] One study[438] investigated NfL at 12 after ROSC. In this study, NfL values of 90 pg mL^{-1} in OHCA and 207 pg mL^{-1} in IHCA predicted poor functional outcome at 2–6 months with 100 % specificity and sensitivity of 53 [48–59]% and 29 [20–39]%, respectively. Other studies investigated NfL at 24 h,[347,439,440,457,458] showing that values between 242 and 609 pg mL^{-1} predicted poor neurological outcome between hospital discharge and 12 months with 100 % specificity and sensitivity ranging from 54 [47–61]% and 66 [54–76]%. At 48 h from ROSC, NfL values between 330 and 4660 pg mL^{-1} predicted poor neurological outcome between hospital discharge and 12 months with 100 % specificity and sensitivity ranging from 35 [26–45]% to 83 [69–91]%.[347,439,440,446,457,458] Fewer studies investigated NfL at 72 h after ROSC.[347,439,458] In these studies, NfL values between 244 and 9701 pg mL^{-1} predicted poor outcome with 99–100 % specificity and a sensitivity ranging from 74 [62–83]% to 85 [76–90]%. The prognostic performance of NfL was superior to that of NSE across all time points. Most studies included fewer than 100 patients. In larger studies, the Area Under the Receiver Operating Characteristic Curve (AUROC) of NfL ranged from 0.88 to 0.97 at 48 h after ROSC.[438,440,459] Unlike NSE, NfL is not affected by haemolysis and can achieve an AUROC above 0.90 as early as 24 h after ROSC.[459] The kinetics of NfL after cardiac arrest are not entirely known. However, studies in patients after cardiac arrest[457,460] and other types of acute brain injury[461] suggest that NfL levels rise earlier and remain high for longer than those of NSE. As for NSE, a source of confounding for NfL is the presence of different assays, which may create different results across measurement methods. Blood values of NfL after cardiac arrest are comparatively lower than those of NSE. Most studies have used the ultrasensitive single molecular array (SIMOA) assay, a semi-automated research method that is not yet certified for clinical use. Several assays for NfL are available; however, most are for research use only and are not CE-marked for clinical use in Europe. A process to standardise methods is ongoing.[462]

S100B

Two observational studies investigated S100B levels immediately after ROSC and identified threshold values ranging from 3.56 to 16.6 μg L^{-1} with 100 % specificity for poor outcome but low sensitivities of 2.8 % to 26.9 %.[452,453] In the largest study, S100B discriminated best at 24 h with a threshold value of 2.59 μg L^{-1} for 100 % specificity, but with a low sensitivity of 10 %. The corresponding sensitivity for 98 % specificity (2 % FPR) was 32 % (threshold value 0.36 μg L^{-1}).[463] The authors concluded that S100B did not add value to existing prognostication models with or without NSE. S100B is rarely used in clinical practice and is not included in our recommendations.

Glial fibrillary acidic protein

Five studies published after the 2020 review evaluated the ability of the blood values of Glial Fibrillary Acidic Protein (GFAP) measured between 12 and 72 h after ROSC to predict poor neurological outcome in comatose patients after CA.[436,439,441,458,464] In these studies, high GFAP values predicted a poor neurological outcome with 98–100 % specificity at all time points; however, the thresholds for this prediction varied widely. GFAP blood values rise earlier than NSE after cardiac arrest [465] and can achieve an area under the receiver operating characteristic (ROC) curve of 0.85 at 12–24 h after ROSC,[436,458] higher than that of NSE.[464]

Serum tau

Tau is a microtubule stabilising protein expressed predominantly in the unmyelinated axons of the central nervous system.[465] Three recent studies showed that tau blood levels of >502.5 pg mL^{-1} at 12 h after ROSC in one study[436] and 40 pg mL^{-1} in one study[441] or >131 pg mL^{-1} in another study[458] predicted poor neurological outcome with 100 % specificity and 20–25 % sensitivity. All three studies measured tau using the ultrasensitive single molecular array (SIMOA) assay.

Recommendations on NfL, GFAP, and tau for neuroprognostication after cardiac arrest

Recent evidence has shown that novel biomarkers of brain injury, such as NfL, GFAP, or tau, have comparable or superior accuracy than NSE for predicting neurological outcome in patients who are comatose after resuscitation from cardiac arrest. This is especially true for NfL, whose AUROC was 0.90 or greater in some studies.[440,459] However, these biomarkers are still not widely available. Additionally, there is limited information on their kinetics during the acute phase following cardiac arrest. Finally, no consistent thresholds for predicting poor neurological outcome have been identified. For this reason, at present, the ERC/ESICM do not recommend using NfL, GFAP and tau for neuroprognostication after cardiac arrest. Further research is ongoing, and this recommendation will likely be revised in the near future.

Imaging

These guidelines are supported by evidence derived from a systematic review on prognostication and 2025 ILCOR CoSTRs. The relevant treatment recommendations in the 2025 ILCOR CoSTR (which have been adopted by the ERC/ESICM) are:

- We suggest using the presence of a marked reduction of the grey matter/white matter (GM/WM) ratio on brain CT within 72 h after ROSC or the presence of extensive diffusion restriction on brain MRI at 2 to 7 days after ROSC in combination with other predictors for prognosticating a poor neurologic outcome in patients who are comatose after cardiac arrest and who are treated with TTM (weak recommendation, very low-quality evidence).

Computed tomography (CT) of the brain

Following cardiac arrest, hypoxic-ischaemic brain injury causes cytotoxic oedema, which appears as an attenuation of the GM/WM interface, and vasogenic oedema leading to brain swelling, visible as an effacement of cortical sulci.[466] Measurement of the ratio between the GM and WM densities (GWR), expressed in Hounsfield units, is a method for quantifying the degree of oedema. The density of the GM is higher than that of the WM, so normal GWR is higher than 1. The lower the GWR, the greater the severity of brain oedema.

GWR reduction occurs early in patients with severe hypoxic-ischaemic brain injury. Most studies on reduced GWR have shown that this sign is 100 % specific for poor neurological outcome as early as 1 h after ROSC.[340] However, the sensitivity of brain CT to predict poor outcome increases over time. In one study on 2204 unconscious patients who underwent brain CT in the first 24 h after ROSC, the sensitivity of GWR for predicting in-hospital mortality increased over the first four hours post-arrest, reaching a maximum of 25 % after 5 h, while false-positive rates remained <5 % at all time points.[467] In a substudy of the TTM trial on 356 patients undergoing brain CT within seven days after ROSC, brain oedema was more common (46 % vs 10 %) at >24 h to 7 days than within 24 h after ROSC. Sensitivity increased from 14 % to 57 % and specificity from 97 % to 100 % across these two time points. Among 36 patients with repeated brain CT, 15/36 had oedema at the second CT (median 77 h after ROSC), while only one ot the 15 patients with a positive result on the second CT had oedema at the first brain CT 2 h after ROSC.[468] These results were replicated by a similar study in 95 patients.[469] In another study comparing brain CT performed within 6 h (n = 76) or 72–96 h (n = 54) after ROSC, the area under the receiver operating characteristics (AUCs) of GWR increased from 0.70 to 0.92. Nonquantitative signs of brain oedema, such as the presence of sulcal effacement, loss of boundary between grey and white matter at the basal ganglia level, and presence of the pseudo subarachnoid sign, were also more common in brain CTs performed 72–96 h after ROSC.[470]

The methods for GWR measurement varied across studies. In most of them, GWR was calculated between GM and WM areas within the basal ganglia.[340,469–473] In others, measurements within the cerebrum (centrum semiovale and high convexity area) were performed.[474–476] Finally, other studies calculated an average of the GWR in the two previous areas.[472,477,478] In almost all studies, a GWR threshold for 100 % specificity was identified. However, its value varied across studies,[340] probably reflecting differences between scanners and software,[479] and in calculation methods.

In recent studies, methods for automated GWR assessment to measure brain oedema on CT in cardiac arrest patients have been investigated. These methods showed comparable [480] or superior accuracy compared to manual GWR assessment.[481,482] Automated GWR measurement holds promise for standardising the assessment of the severity of HIBI after cardiac arrest with brain CT, making it less operator-dependent. However, the optimal method has not been established, and the evidence is limited to a few studies.

Magnetic resonance imaging (MRI) of the brain

Along with CT, magnetic resonance imaging (MRI) of the brain is the most investigated imaging-based predictive index in patients who are comatose after cardiac arrest.[340] Brain MRI is more challenging to perform in ventilated ICU patients, and MRI was generally performed later than brain CT, usually at 48 h or later from ROSC. On brain MRI, cytotoxic oedema from hypoxic-ischaemic brain injury appears as a hyperintensity on diffusion-weighted imaging (DWI) sequences.[483] In several studies, the presence of DWI lesions is associated with poor neurological outcome after cardiac arrest.[474,484–487] However, the assessment was done qualitatively, and specificity was inconsistent (range 55.7–100 %). The apparent diffusion coefficient (ADC) enables a semiquantitative evaluation of DWI changes, thereby limiting subjectivity. However, the ADC metrics in prognostication studies varied.[340] The two more common measures are the lowest mean ADC,[473,478,488,489] and the proportion of brain volume (percentage of voxels) below a given ADC threshold.[473,478,488–493] All these studies identified an ADC threshold for 100 % specificity, often with sensitivities above 50 %. All studies on ADC MRI had a small sample size, which limited their precision. In many studies, imaging was performed at the treating physician's discretion, which may have introduced a selection bias.

Unlike clinical examination and EEG, imaging studies are not prone to interference from sedative drugs. In addition, they can be assessed blindly. Their major limitation is the lack of standardisation of measurement techniques. Despite evidence showing high accuracy for both brain CT and MRI, the number of studies was limited, with a wide variability in measurement techniques, which significantly limits the reproducibility of their results. For this reason, it is reasonable to reserve the use of imaging studies for prognostication only in centres where specific experience is available. Since there is currently no standard for CT-GWR or MR-ADC measurements, these techniques can be recommended to confirm the presence of generalised and extensive ischemic injury apparent from conventional visual analysis by an experienced neuroradiologist. Finally, imaging studies cannot be performed at the bedside, and MRI may not be feasible in the most unstable patients, which limits its applicability, especially in the early post-resuscitation period. In patients undergoing ECPR, the strong magnetic field of conventional MRI may interfere with the functioning of the ECMO pump.

The 2021 prognostication algorithm

The 2021 ERC-ESICM Guidelines on Post-Resuscitation Care included an algorithm for the prediction of poor neurological outcome in patients who are comatose after cardiac arrest.[3] This algorithm recommended that, in patients who are comatose with a motor response no better than abnormal flexion at ≥72 h from ROSC after major confounders have been excluded, poor neurological outcome was predicted when at least two concordant signs indicating poor outcome are present. These signs were:

- Bilaterally absent pupillary and corneal reflex 72 h or later after ROSC; use of an automated pupillometer, when available, is recommended;
- A bilaterally absent N20 SSEP wave;

- Highly malignant EEG patterns, defined as a suppressed background ± periodic discharges or burst-suppression according to American Clinical Neurophysiology Society, after 24 h from ROSC;
- NSE blood values above 60 μg/L at 48 and/or 72 h after ROSC; increasing NSE blood levels between 24–48 h or 24/48 and 72 h further support a likely poor outcome;
- Status myoclonus, defined as continuous and generalised myoclonus for more than 30 min in the first 72 h after ROSC;
- Signs of diffuse and extensive anoxic injury on brain CT or MRI.

This algorithm was subsequently validated in three multicentre studies on a total of 1791 patients.[343,494,495] All these studies confirmed that the 2021 ERC-ESICM prognostication algorithm predicts poor outcome with a 0 % false positive rate (95 % confidence intervals 0–3.7 %). One of these studies was conducted in the KOHRN-PRO 1.0 registry in Korea, where withdrawal of life-sustaining therapy was reported in only 12 patients (0.9 % of the total cohort), resulting in a consequent low risk of self-fulfilling prophecy bias.[343] However, this algorithm also had limitations:

- In validation studies, almost half of patients remained with indeterminate outcome after applying the 2021 algorithm.[496]
- The 2021 algorithm was focused only on predicting poor neurological outcome and did not include evidence from the ERC/ESICM endorsed systematic review on the prediction of good neurological outcome published in 2022. Although the 2021 guidelines recommend caution if discordant signs indicate a potentially good outcome, no guidance was provided on incorporating these signs in a specific prognostic strategy. In studies validating the 2021 guidelines, 21 % of patients whose outcome was indeterminate after applying the algorithm experienced neurological recovery.
- No guidance was provided on the timing of SSEP or imaging. For SSEP, evidence from prognostication studies has shown that a bilaterally absent wave accurately predicts a poor outcome at 24 h or earlier after ROSC.[432,497,498] For imaging, the evidence mentioned above showed that the sensitivity of brain CT increased after 24 h from ROSC.

The 2025 writing group revised the suggested prognostication algorithm to address the limitations outlined above (Fig. 5). The changes were based mainly on evidence published after 2021 and on a recent study designed to improve the sensitivity of the previous algorithm, reduce indeterminate outcome, and allow the prediction of good neurological outcome.

Prediction of good neurological outcome

Predicting good neurological outcome after cardiac arrest has several advantages. Firstly, it can reduce uncertainty in prognostication. Recent evidence suggests that the prognosis remains indeterminate in approximately half of cases when using an algorithm based solely on the prediction of poor neurological outcome.[1,496] Secondly, detecting a chance of good neurological recovery can reassure patients' relatives and inform their discussions with clinicians. Thirdly, it may help inform decisions about escalation of organ support. Finally, it may counterbalance a falsely pessimistic signal from predictors of poor neurological outcome. In fact, no single test predicts poor outcome with absolute certainty.[340] The 2021 guidelines for post-resuscitation care acknowledged these limits and suggested using caution and repeating the assessment when discordance is present, i.e., if signs indicating a poor outcome coexist with signs indicating a potential for recovery.

Based on an ERC-ESICM-endorsed systematic review of 36 studies in 7149 adult patients with post-anoxic coma,[499] the 2025 ILCOR CoSTR identified six signs predicting neurological recovery in comatose cardiac arrest survivors.[9] These include a withdrawal or localising response to pain (motor score of the Glasgow Coma Scale [GCS-M] 4–5) in the first 4 days after ROSC, normal (<17 mcg/L) NSE blood values within 72 h after ROSC, absence of diffusion restriction on MRI between 72 h and 7 days after ROSC, and a continuous or nearly continuous normal-voltage EEG background without periodic discharges or seizures within 72 h from ROSC. Similar to unfavourable EEG patterns, the ILCOR 2025 CoSTR recommends using the American Clinical Neurophysiology Society (ACNS) EEG terminology.[200]

The ERC-ESICM review also identified a high (>4 μV) amplitude of the N20 SSEP wave as a good neurological outcome predictor after cardiac arrest.[365,433,500] However, ILCOR does not recommend using this sign yet because of variability in the methods to calculate it and concerns regarding potential interference from sedative drugs, which may reduce the sensitivity of this sign. Normal (<55 pg mL^{-1}) blood levels of NfL at 24–72 h from ROSC predicted good outcome with high specificity and sensitivity.

Two cohort studies have investigated the ability of ILCOR-recommended good outcome predictors to counterbalance discordant poor prognostic signs.[495,501] In one of these studies,[495] the coexistence of one good outcome predictor with one ERC-ESICM-recommended [502] poor outcome predictor was associated with neurological recovery in 11 % of cases, compared to 3 % when only a poor outcome predictor was present. In another study,[501] among 2245 patients who underwent prognostication, one unfavourable predictor and one or more favourable predictors coexisted in 104, of whom 33 (32 %) had a good neurological outcome at six months.

Suggested prognostication strategy

Prognostication is a continuous process that begins immediately, even if the prognostic balance is established 72 h or later after ROSC (Figs. 5 and 8). Some indices, such as EEG signs of potential recovery, are best detected within 24–36 h from ROSC, while others, such as NSE blood levels, must be recorded daily to determine their trend. Even if the accuracy of NSE values for predicting poor outcome is highest at 48–72 h, NSE values at 24 h provide a baseline.

Prognostic assessment should start with an accurate clinical examination.[503] Its main scope is to confirm that the patient is comatose because of hypoxic-ischaemic brain injury. Clinical examination should be performed daily to detect signs of neurological recovery, such as purposeful movements or to identify a clinical picture suggesting impending brain death. The latter may include fixed, dilated pupils, diabetes insipidus, and cardiovascular changes suggesting herniation, such as bradycardia associated with hypertension or unexplained haemodynamic instability. Brain death occurs in 5–10 % of patients who die after cardiac arrest resuscitation with conventional CPR and in about 25 % of patients who die after resuscitation with extracorporeal CPR.[330,502] In most cases, brain death occurs during the first 3–4 days after ROSC. A suggested algorithm for brain death screening after cardiac arrest is shown in Fig. 9.

Awakening from post-anoxic coma typically occurs within 3–4 days from ROSC.[223,290] However, patients who are initially unconscious following cardiac arrest are usually treated with sedatives and

neuromuscular blocking drugs to facilitate temperature management, mechanical ventilation and other life support measures. Therefore, to enable a reliable clinical examination, these drugs should be stopped for sufficient time to avoid interference from their effects. The World Brain Death Project consensus group recommends that clinical examination be delayed until at least five elimination half-lives of the drug administered with the longest half-life.[504] Although this recommendation has been made in the context of diagnosing brain death, it can be equally suitable for prognostic assessment. Short-acting drugs are preferred whenever possible but even a short-acting drug such as propofol has a half-life of 2.3 – 4.7 h, which implies the need to stop sedatives for at least 24 h in most cases. This will be much longer if there is renal and/or hepatic impairment or if longer-acting drugs have been given. When residual sedation or paralysis is suspected, consider using antidotes to reverse the effects of these drugs. Use caution when administering flumazenil to reverse the effects of benzodiazepines because this may precipitate seizures. Apart from sedation and neuromuscular blockade, other major confounders include hypothermia, severe hypotension, sepsis, and metabolic or respiratory derangements.

A motor response no better than abnormal flexion (M $\leq$ 3) of the Glasgow Coma Scale was the entry point of the 2021 prognostication algorithm, based on its high sensitivity for poor outcome prediction. However, this low threshold leaves out most patients destined to neurological recovery. Recent evidence showed that using M < 6 as an entry point increases the ability of the algorithm to identify patients with good outcome without reducing specificity for poor outcome.[501] Hence, the prognostication strategy described below applies to unconscious patients, defined as not being awake and obeying commands (M < 6) at $\geq$72 h after ROSC. Results of earlier prognostic tests are also considered at this time.

In an unconscious patient at $\geq$72 h from ROSC, in absence of confounders, poor outcome is very likely when two or more of the following predictors are present: no pupillary and corneal reflexes at $\geq$72 h, bilaterally absent N20 SSEP wave at $\geq$24 h, highly malignant EEG at >24 h, NSE >60 μg/L at 48 h and/or 72 h, status myoclonus $\leq$72 h, or a diffuse and extensive anoxic injury on brain CT/MRI. Most of these signs can be recorded before 72 h from ROSC. However, their results will be evaluated only when the prognosis is formulated (Fig. 8). In one study,[505] a strategy of using $\geq$2 predictors had 0 [0–8]% FPR compared with 7[1–18]% of the 2015 ERC-ESICM stepwise strategy (due to false positives for pupillary light reflexes).

Evidence from the 2013 and 2020 reviews showed that a bilaterally absent N20 SSEP wave is the most widely documented predictor of poor outcome and the most consistently associated with 100 % specificity. However, false-positive predictions have been reported occasionally. In some of these cases, the cause of a false positive result was an incorrect reading of the SSEP record because of artefacts.[506] Neuromuscular blockade improves readability of SSEPs, and it should be considered whenever possible.[507] Time after ROSC does not affect the specificity of SSEPs, which can be recorded from day 1.

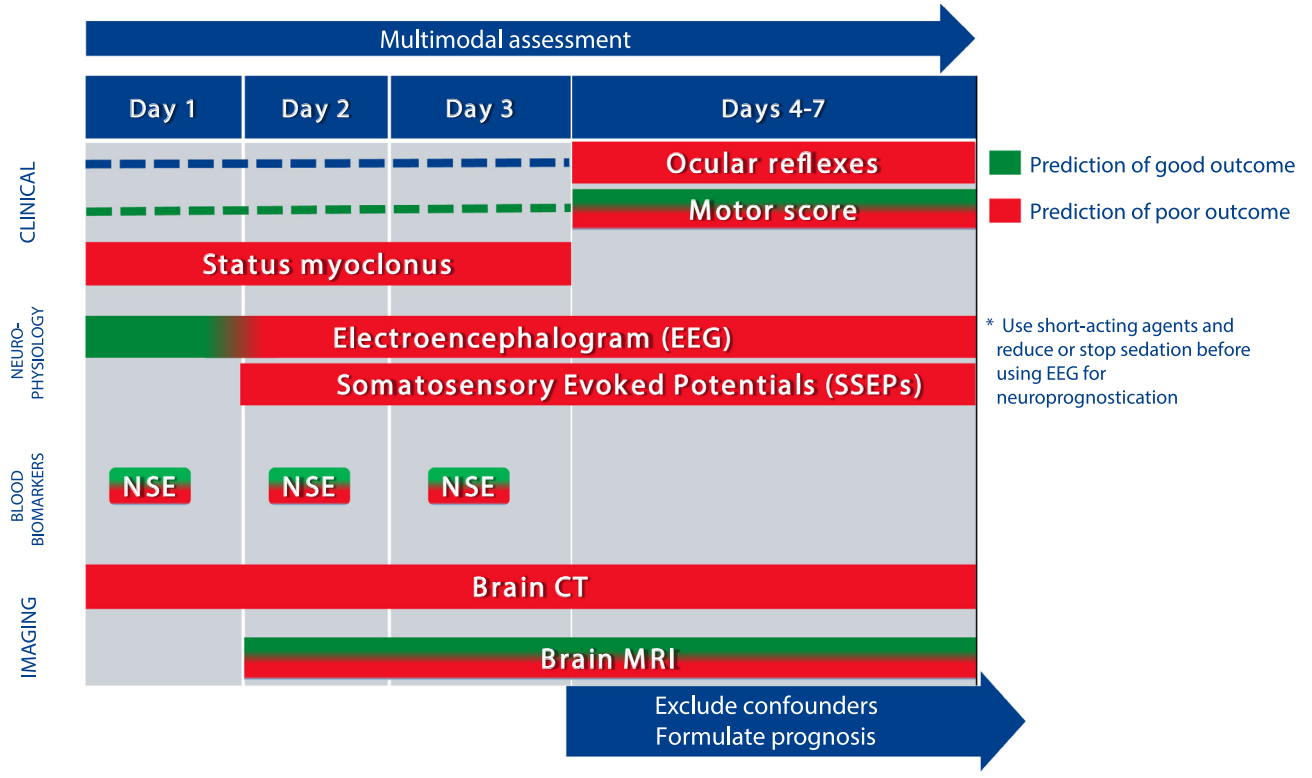


Fig. 8 – Simplified timeline showing suggested timings for recording multimodal predictors and formulating neurological prognosis in patients who are comatose after resuscitation from cardiac arrest.
Abbreviations – CT: computed tomography; MRI: magnetic resonance imaging; NSE: neuron-specific enolase.

Based on expert opinion, we suggest that both pupillary and corneal reflexes should be absent at the time of prognostic assessment to predict poor outcome. Unlike SSEPs, ocular reflexes are prone to interference from sedation. Evidence in post-anoxic coma suggests that automated pupillometry is more sensitive than the standard pupillary light reflex in detecting pupil responses to light, particularly when pupil size is small, thereby reducing the risk of false-positive results.[361] Unlike standard pupillary light reflex, automated pupillometry delivers a stimulating light source with standard characteristics (intensity, duration, and distance from the eye) and quantitatively measures pupillary response, ensuring reproducibility. For this reason, we suggest using a pupillometer to detect the absence of the pupillary light reflex, if available.

Status myoclonus is a prolonged period of myoclonic jerks. Although there is no universal definition for status myoclonus, based on our previous definition,[1] we suggest that, in comatose survivors of cardiac arrest, status myoclonus should be defined as a continuous and generalised myoclonus persisting for 30 min or more. Aside from duration and continuity, other clinical features of myoclonus suggest poor outcome. These include a generalised (vs. focal), axial (vs. distal), or stereotyped (vs. variable) distribution. Conversely, some EEG features, such as a continuous or reactive background or the presence of spike-wave discharges synchronised with the myoclonic jerks indicate a potential for good outcome.[204] We suggest recording an EEG in patients with post-arrest status myoclonus to identify epileptiform activity and detect signs associated with potential recovery.

Among unfavourable EEG patterns, those more consistently associated with poor neurological outcome are suppression and burst suppression ('highly malignant' patterns). During the first 12–24 h after ROSC, these patterns are more prevalent but carry a higher risk of false-positive prediction. Confounding from sedatives may contribute to this. We suggest using these EEG patterns for prognostication only after 24 h from ROSC. The absence of EEG background reactivity has an inconsistent specificity for poor neurological outcome, and we no longer recommend using it for this purpose.

High blood NSE values are a sign of neuronal cell damage and have long been recommended as a predictor of poor neurological outcome after cardiac arrest.[508] While prediction with 0 % FPR can be achieved anytime from 24 h to 7 days after ROSC, the sensitivity of an individual NSE measurement for prediction of poor neurological outcome with 0 % FPR is highest at 48–72 h after ROSC.[340] However, the NSE threshold value for 0 % FPR is inconsistent because of a few patients with good neurological outcome despite very high NSE values. The presence of these outliers can be partly explained by the release of NSE from extracerebral sources, such as red blood cells or neuroendocrine tumours. Repeated blood sampling and careful exclusion of extracerebral sources is recommended when using NSE for neuroprognostication. Another cause of variability in the NSE thresholds is the use of different measurement techniques.[456] In the 2020 ERC/ESICM review, the highest recorded NSE thresholds for 0 % FPR at 48 and 72 h from ROSC were 120 μg/L and 79 μg/L, respectively. However, these data refer to outliers, and in most studies the 0 % FPR threshold was 60 μg/L and 50 μg/L, respectively. Based on these data, we presume that the risk of a false-positive prediction associated with an NSE value of 60 μg/L is modest, especially because at least another predictor should confirm the NSE signal. Increasing NSE values between 24 h and 48 h or between 24/48 h and 72 h also suggests a poor outcome, even if the incremental prognostic value of adding NSE trends to a single NSE value is uncertain.[340,451,455] We suggest performing serial NSE samples at 24, 48, and 72 h after ROSC to detect NSE trends and minimise confounding from occasional haemolysis.

Although signs of diffuse and extensive hypoxic-ischaemic brain injury on brain CT can be present very early after ROSC,[340] several studies have shown that sensitivity of brain CT to detect hypoxic-ischemic brain injury increases during the first week after ROSC.[468–470,509,510] Patients who are admitted to hospital after OHCA often have their brain CT performed in the emergency department. We suggest repeating brain CT if the patient is unconscious at the time of prognostication (72 –96 h after ROSC) and the first brain CT does not show signs of hypoxic-ischemic brain injury.

Cytotoxic oedema reduces water diffusivity, which appears on magnetic resonance imaging (MRI) as a hyperintensity on diffusion-weighted imaging (DWI) with corresponding low apparent diffusion coefficient (ADC) values Because measurement methods are not standardised and multicentre validation studies using comparable measurement techniques are lacking, we suggest that predictive indices based on neuroimaging are used only in places where specific experience is available. We also suggest that centres using neuroimaging for prognostication after cardiac arrest create their own normal and threshold values based on the technique. Where specialist neuroradiology expertise is unavailable, consider telemedicine consultation for brain imaging interpretation.

When none of the criteria for poor outcome described above are present, patients should be assessed for signs of potential recovery. These include a GCS motor score of 4 or 5 at 72–96 h after ROSC, normal blood values of neuron-specific enolase (NSE) at 24 h-72 h after ROSC, a continuous background without discharges on EEG within 72 h from ROSC, and absent diffusion restriction in the cortex or deep grey matter on MRI on days 2–7 after ROSC. In a recent study on 2445 patients with GCS-M $\leq$ 5 and no concordant signs of poor functional outcome, more than 60 % of patients with at least one of these signs had a favourable outcome at six months. In those with two concordant favourable signs and no signs of a poor outcome, the neurological recovery rate was greater than 80 %.[501]

Indeterminate outcome

When neither concordant unfavourable signs nor favourable signs are present, the neurological outcome remains *indeterminate*. Although the prognosis is generally poor for most of these patients, neurological recovery is still possible. [495,501] We therefore suggest observing and re-evaluating patients with an indeterminate outcome over time to detect signs of awakening (Fig. 5).

Late awakening does not preclude full neurological recovery. However, the likelihood of awakening in resuscitated patients who remain comatose decreases progressively with time, and the rates of good neurological outcome are generally lower in late vs. early awakeners.[226,290,511,512]

In three studies, the prevalence of late awakening, defined as a recovery of consciousness at $\geq$ 48 h from the suspension of sedation, was 20/89 (22 %),[513] 56/194 (29 %),[290] and 78/228 (34 %).[226] The last awakening occurred on days 11, 12, and 23 after the suspension of sedation, respectively. The rates of good neurological outcome among late awakeners were 80 %, 90 % and 73 %, respectively. In two other studies, the last patient awoke on day 22 and day 29.[511,514] Organ dysfunction, such as post resuscitation shock or renal failure[226,290] and use of midazolam instead of propofol for sedation[226,297] were associated with

a higher likelihood of late awakening, suggesting that at least some of these cases may have been due to reduced clearance of sedation. In a before-and-after study comparing two sedative regimens (propofol-remifentanil versus midazolam-fentanyl) in 460 comatose resuscitated patients undergoing temperature control targeted at hypothermia, use of propofol-remifentanil was associated with significantly lower odds of delayed awakening after adjustment (OR 0.08 [0.03–0.2]),[290] confirming indirect evidence from a previous smaller study.[248]

Neuroprognostication in extracorporeal cardiopulmonary resuscitation

Hypoxic-ischaemic brain injury (HIBI) is common in patients resuscitated with ECPR. Because ECPR is used in patients with refractory cardiac arrest, those who are admitted to the ICU with ECPR have prolonged resuscitation times, which may increase the risk of severe HIBI.[515] In a systematic review of 23,388 resuscitated patients in 32 studies, the prevalence of brain death was three times higher in patients resuscitated with ECPR vs. those resuscitated with conventional resuscitation (27.9 vs. 8.3 %).[330] There is no validated neuroprognostication strategy for patients with HIBI after ECPR, and the general neuroprognostic principles apply to these patients. However, some special considerations are necessary in this category of patients.

Clinical examination in patients undergoing ECPR is often hampered by profound and prolonged sedation. Sedation and muscle relaxants only minimally affect the pupillary light reflex, which can provide valuable prognostic information. In a study of 100 patients undergoing veno-arterial ECMO (of whom 49 with refractory cardiac arrest and 51 with refractory cardiogenic shock), a neurological pupil index (NPi) below 3 (abnormal) anytime from 24 h to 72 h after arrest was 100 % specific for predicting 90-day mortality with 53 % sensitivity.[516]

A significant concern regarding biomarkers is haemolysis due to extracorporeal circulation, which may lead to the release of NSE from red blood cells and cause false-positive results. NSE values are linearly correlated with the degree of haemolysis and the free haemoglobin levels.[517]

Although a continuous NSE release from haemolysis due to ECPR should result in persistently high NSE, a study on 129 ECMO patients, most of whom undergoing ECPR,[518] showed that NSE decreases in patients who had neurological recovery and increases in those who had poor neurological outcome, therefore showing a similar kinetic to that in patients resuscitated from conventional CPR. Similar trends were observed during the first 48 h in another study on 190 ECPR patients.[519] Prognostic accuracy studies on ECPR patients suggest that the NSE threshold for predicting poor outcome may be higher than in patients resuscitated with conventional CPR. In a study on 256 OHCA patients from the Prague trial,[520] the NSE values corresponding to 95 % specificity for predicting poor neurological outcome were higher in the ECPR group at all three time points (84 $\mu g\ L^{-1}$ at 24 h and 48 h and 129 $\mu g\ L^{-1}$ at 72 h, compared with 60, 65, and 57 $\mu g\ L^{-1}$, respectively, in the conventional CPR group). However, the AUROCs for outcome prediction were not significantly different, suggesting that NSE had comparable overall accuracy in both groups. In a study of 159 patients treated with venoarterial ECMO, of whom 101 (64 %) had cardiac arrest, six of the 36 patients with good neurological outcome at 29 months had an NSE >100 $\mu g\ L^{-1}$ 48 h after the start of ECMO.[521] The optimal NSE thresholds for predicting poor outcome with a minimal risk of falsely pessimistic prediction in patients resuscitated with ECPR are currently unknown.

Unlike NSE, NfL is unaffected by haemolysis, and it can be particularly advantageous for neuroprognostication in ECPR patients. However, the evidence in ECPR patients is still preliminary. One study of 98 patients undergoing venoarterial ECMO, of whom 74 were in cardiac arrest, showed that suppression or burst-suppression on EEG in these patients were associated with poor neurological outcome.[522] Recording EEG is helpful in ECPR patients because of the high rate of neurological injury, prolonged sedation and paralysis confounding neurological examination, and the risk of epileptiform activity from HIBI.[523] Recording SSEPs in patients undergoing ECPR is feasible, but the small size of available studies prevents any conclusion regarding SSEP accuracy in these patients [524]

Performing MRI in ECPR patients is difficult because the strong magnetic fields (1.5–3 Tesla) of conventional MRI are incompatible with extracorporeal life support circuits. Portable MRI with lower magnetic fields has been used to identify brain injury (but not hypoxic-ischaemic brain injury) in ECPR patients.[525] However, their spatial resolution is lower than that of conventional MRI. At the time of this writing, there are no published studies on the use of MRI for prognostication in comatose ECPR patients.

Brain CT can be safely performed in patients undergoing ECPR. In a study on 30 ECPR patients, GWR had an AUROC for predicting neurological outcome ranging from 0.848 to 0.952, depending on the calculation method used.[526] In a substudy of the Prague ECPR trial including 45 patients, GWR calculated at the caudate and putamen levels on brain CT performed within 36 h from arrest predicted neurological outcome at six months with AUROCs of 0.86 and 0.77, respectively.[527] GWR was not significantly different between patients resuscitated with ECPR vs. conventional CPR. Another study, however, showed a low accuracy of brain CT performed early (<3 h from ROSC) for assessing the severity of HIBI in ECPR patients. A substudy of the Prague OHCA trial showed that GWR measured at the basal ganglia level performed poorly as a measure of brain oedema on brain CT performed at a median of 4.3 h after arrest. Almost all (93 %) patients had contrast agents administered for coronary angiography before brain CT.[527] None of the above mentioned studies assessed cerebral postanoxic oedema with standard visual assessment criteria used by neuroradiologists, such as the presence of sulcal effacement, loss of boundary at the basal ganglia level, or pseudo-subarachnoid haemorrhage sign described in other studies.[468,470]

Only a few studies specifically investigated the accuracy of standard neuroprognostic tests in predicting neurological outcomes in patients undergoing ECPR. On the other hand, there is no specific pathophysiologic reason for these tests to perform differently in comatose ECPR patients as compared to those resuscitated with conventional CPR. Pending further research, we suggest using a multimodal approach for prognostication in comatose ECPR patients. We recommend paying particular attention to the risk of confounding from haemolysis when using NSE (see above). The optimal NSE threshold for predicting a poor outcome is currently unknown. Imaging studies require transport to the imaging suite, which implies technical difficulties and potential risk in ECPR patients. Standard MRI carries the additional risk of interference with extracorporeal circuit from the strong magnetic field. Specific prospective studies are needed to assess the optimal prognostication strategy in patients resuscitated with ECPR. Assessment of

cerebral oedema on brain CT using GWR in ECPR patients is insufficiently supported by available evidence.

Withdrawal of life-sustaining therapy

While a minority of the resuscitated patients treated in an ICU die during the first few days due to cardiovascular collapse or massive brain swelling causing brain death, most deaths will be secondary to a decision to withdraw life-sustaining therapy (WLST).[329,331,353,528] Generally, a presumption that the patient's final neurological outcome will be poor is central to this decision.[331] Pre-existing co-morbidities may also contribute to a WLST decision.[528] The clinical team discussing the prognosis of an individual patient need to consider that inaccurately pessimistic prognostication could lead to WLST in patients who might otherwise achieve a good functional outcome, but also that overly conservative prognostication could leave patients in a severely disabled state undesired by themselves and their relatives.[529] Patients may not receive specific treatments because they are not available, or because there is an active decision to withhold them. The main reasons for withholding treatments are that they will not benefit the patient or, if known, the patient's wishes not to have a specific treatment.[529,530] There is little data on withholding life-sustaining therapies in post-cardiac arrest patients specifically.

The practice of WLST varies widely across Europe and impacts the proportion of cardiac arrest patients surviving with severe brain injury (CPC 3–4). Lacking high-quality data, this fraction appears to vary widely from approximately 10 % to 50 %.[243,349,356] The most apparent effects are seen for patients who remain in an unresponsive wakefulness/vegetative state (CPC 4). As an example, 1/243 (0.4 %) survivors in a northern European study[243] compared with 61/195 (31 %) in an Italian multi-centre study[349] were in CPC 4 at 6 months. Evidence for variation in WLST practice across Europe was also found in the ETHICUS Study: physicians from southern Europe were less prone to withdraw treatment compared with those from northern Europe, and there was also an effect of religion.[531] The Ethicus-2 Study has shown that the frequency of WLST and withholding decisions among general ICU patients has increased over the last 15–20 years.[532]

Studies using propensity score matching indicate that premature (<72 h from cardiac arrest) WLST for neurological reasons (WLST-N) are common and may be the cause of death for a substantial proportion of patients who might have recovered to a good outcome if their intensive care treatment had been prolonged.[533,534] A recent study found that the practice of WLST-N < 72 h varied between 20–60 % among nine US hospitals and was inversely related to the rate of neurological consultation.[535] A similar variation in the practice of early WLST was found in a nationwide UK study.[20] A high frequency of early WLST-N may indicate prognostic pessimism and lower healthcare quality.

The brain stem is more resistant to hypoxic-ischaemic injury than the cerebrum, and the recovery of functions such as spontaneous breathing and sleep-wake cycle is part of the trajectory towards an unresponsive wakefulness/vegetative syndrome. The period when the patient is still dependent on intensive care is sometimes referred to as the 'window of opportunity for death'.[536] This perception may cause a sense of urgency for the relatives and treating team, indirectly impacting decisions on premature WLST.[537,538] One qualitative study identified limitations in family-team communication as an important factor for premature WLST after cardiac arrest.[538] Caregivers' inappropriate avoidance of uncertainty may also play a role, leading to overly pessimistic perceptions of the prognosis.[539]

Although some tests show high specificity for predicting a poor outcome before 72 h, we recommend that, in general, conclusions about the neurological prognosis are postponed until at least 72 h after the cardiac arrest and the influence of sedative and metabolic factors has been ruled out. This will enable most patients with good outcome to awaken before the prognostic assessment, decreasing the risk of false predictions.[297] We encourage local protocols for collecting information about the extent of brain injury during the first days. Use all available resources to inform a multimodal assessment.[62,340] Relatives will require regular, clear, and structured information and an understanding of their role in decision-making. Early indicators of a poor prognosis may be conveyed in a balanced manner to inform relatives that the situation is grave and allow time for adjustment before critical decisions are made. The bedside nurses are confronted by grieving caregivers, which may be very stressful.[538] Allocate sufficient time for communication around the prognosis within the team and with the relatives.[540]

While the assessment of post-cardiac arrest neurological prognosis and discussions about WLST are most often linked, try to separate these processes in discussions and documentation. Decisions about WLST need to consider several aspects beyond the perceived brain injury; for example, age, comorbidities, and the prognosis for general organ function.[528] Consequently, for ethical reasons, WLST may be considered for patients in whom the neurological prognosis is uncertain or even favourable. Conversely, intensive care may be prolonged despite dismal neurological prognosis because absolute certainty is unobtainable for an individual patient.[541] The patient's preferences are central. Since the patient cannot be asked and advance directives are rare among cardiac arrest victims, the relatives are usually the primary source of information about the patient's likely wishes.

Once a decision on WLST has been made, the ERC/ESICM recommend a transition to a structured end-of-life care, to address patient symptoms, the caregiver situation and potential for organ donation. Guidelines on end-of-life and palliative care in the ICU were recently updated by the ESICM.[542]

Organ donation

These recommendations encourage providing patients and their families with the opportunity to donate organs in the event of brain death or the decision to WLST (Fig. 9). In the face of the increasing shortage of transplant organs, it is essential to remember that a significant proportion of patients who will not survive cardiac arrest represent a potential source of solid organ donors. All health systems should develop, implement and evaluate protocols designed to optimise organ donation opportunities for patients who have had a cardiac arrest.

Recent CPR is not a barrier to organ donation. A recent ILCOR systematic review identified 33 observational studies of organ donation after donor cardiac arrest.[543] For all organ grafts studied (heart, lung, kidney, pancreas, liver, intestine) there was no significant difference in graft function or recipient survival with organs from donors who died after an initially successful resuscitation, compared with donors who had not received CPR.

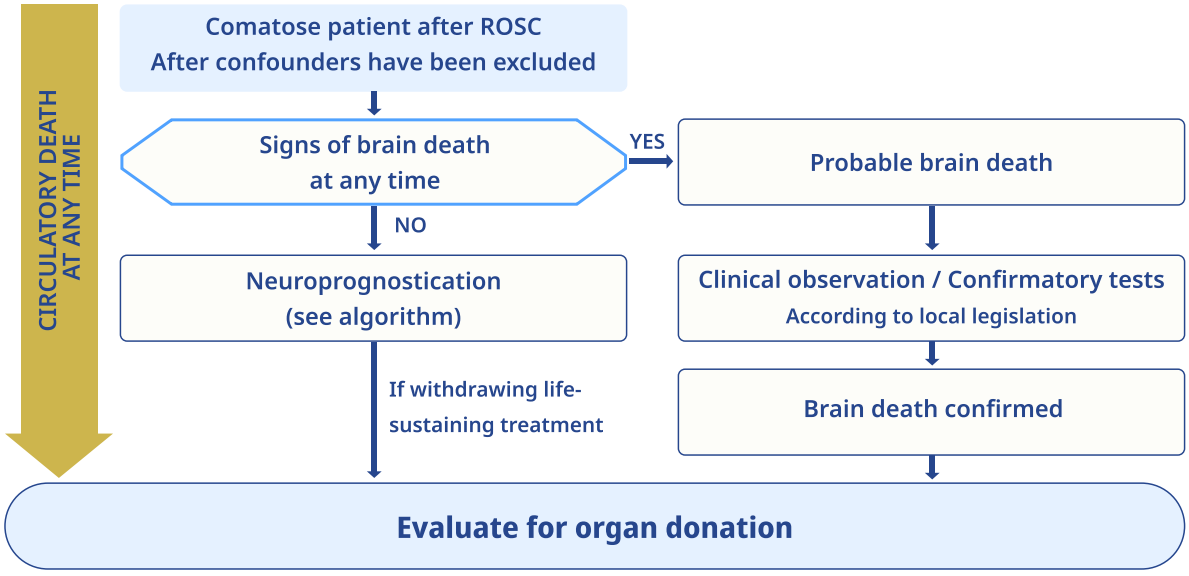


Fig. 9 – Organ donation algorithm after cardiac arrest.
Abbreviations – ROSC: return of spontaneous circulation; WLST: withdrawal of life-sustaining treatment.

Organ donation policies and practices vary internationally, and clinicians must respect local legal and ethical requirements. There are different pathways for patients with cardiac arrest to become organ donors.[544] These guidelines specifically address organ donation after brain death (DBD) or controlled donation after circulatory death (cDCD: Maastricht category III donors) in patients with ROSC or who have been treated with ECPR.[545] Challenges in implementing uncontrolled donation protocols after cardiac arrest (Maastricht category I/II donors) are discussed in the ERC Guidelines 2025 on Adult Advanced Life Support, and ethical aspects are discussed in the ERC Guidelines 2025 on Ethics in Resuscitation.[181,546]

A systematic review identified 26 studies that showed that the prevalence of brain death in ventilated comatose patients with hypoxic-ischemic brain injury who died after cardiopulmonary resuscitation was 12.6 % (95 % CI 10.2–15.2 %), with a higher prevalence after ECPR [27.9 % (19.7–36.6 %) vs. 8.3 % (6.5–10.4 %)], and that approximately 40 % of them donated organs.[330] The median time to diagnosis of brain death was 3.2 days. Patients who remain comatose after resuscitation from cardiac arrest, especially when resuscitated by ECPR, should be actively evaluated for signs of brain death. Scoring systems that may enable early detection of patients with a high probability of brain death after cardiac arrest may help increase organ donation after out-of-hospital cardiac arrest.[547,548] High-volume centres are more likely to refer and procure transplantable organs from patients with non-survivable OHCA.[549]

Even in the absence of brain death, some patients may be evaluated as possible cDCDs when WLST is considered (Maastricht III donors). Donation after controlled circulatory determination of death is an increasingly important source of organ donations. For kidneys, the proportion of cDCDs has increased from 17 % to 31 % in Australia between 2009 and 2019[550]. However, cDCDs after cardiac arrest are probably underreported. In the 2025 ILCOR-endorsed systematic review,[543] only one of the 33 included studies compared the outcome of grafts transplanted from cDCDs after CPR with those of grafts transplanted from standard brain-dead donors who did not receive CPR, showing no difference.[551] Two recent controlled studies investigated the outcomes of organs from cDCDs after cardiac arrest resuscitation and showed that the survival of kidneys[552] or hearts[551] donated by cDCDs after cardiac arrest was not inferior to that of non-CPR donors.

Implementation of ECPR to treat refractory OHCA is associated with increased organ donation and an excellent outcome of transplanted organs.[553,554] Thus, ECPR has a potential to increase not only the number of survivors of prolonged cardiac arrest but also the number of organ donors.[502,555,556] The Utstein OHCA template includes organ donation as a supplementary outcome, and we suggest that cardiac arrest registries report if organ donation after initial resuscitation from cardiac arrest occurred.[557]

Long-term outcome after cardiac arrest

Long-term outcome

In settings where WLST is rare, poor outcomes because of severe hypoxic-ischaemic brain injury are common.[558,559] In contrast, in

countries practising WLST, most survivors (82–91 %) experience a 'good' functional outcome and return home; just 1–10 % require long-term care. At one year and beyond, evidence suggests that general health status approximates normal population values.[560] However, such generic health assessments may lack sufficient granularity to capture the breadth of problems.[335,561] Cardiac arrest survivors often continue to experience symptoms such as memory difficulties, anxiety, fatigue, insomnia, and physical limitations, which can impact their health-related quality of life and societal participation.[558–560,562–567] Supplementing generic assessment with condition or problem-specific assessment is therefore recommended.[335] Older age, female sex, anxiety, depression, and impaired neurocognitive function are significantly associated with poorer health-related quality of life following OHCA.[563] A registry-based study reported significantly worse health-related quality of life in IHCA (n = 1369) survivors when compared to OHCA (n = 772) survivors.[568]

Cognition

A recent review of neurocognitive function following OHCA highlighted the substantial heterogeneity in outcome reporting and use of different cut-points,[562] with possible cognitive impairment ranging between 0–88 %. Most common impairments affect episodic memory, executive functioning, and processing speed.[562,569] Most cognitive recovery occurs within the first three to six months after the cardiac arrest.[558,559,570]

Fatigue

Up to 70 % of cardiac arrest survivors report fatigue.[558,559,571] Limited evidence suggests no significant difference in fatigue levels between 1–5 years after OHCA.[571] Both physical and mental fatigue is widely described and associated with cognitive deficits, anxiety, depression,[569,571] and low levels of physical activity.[572]

Emotional wellbeing

A review of IHCA and OHCA survivors described little change in the prevalence of short (<6-months) and long-term (>6-months) anxiety (22–24 %) and depression (19 %).[564] A further review, of OHCA survivors only, reported similar levels of anxiety (26 %), depression (19 %) and post-traumatic stress disorder (20 %), with symptom prevalence appearing to increase over time for anxiety and depression.[565] For OHCA, age and female sex are non-significant moderators for anxiety and depression.[565] However, younger survivors (<60 years) are at a higher risk of developing depressive symptoms within six months.[564]

Physical function

Survivors frequently experience mobility limitations over both the short and longer-term,[568,573–576] which are more common compared to both general[559] and matched cardiac populations.[573] Problems are more common in older individuals, females, and those with cognitive impairment, anxiety or depression.[573] Similarly, at six months post-OHCA, one-third of survivors in the TTM2 trial self-reported low levels of physical activity,[574] an important cardiovascular risk factor,[577] which were more common in those who were obese, had mobility problems, or cognitive impairment.[574]

Pain

Pain is reported by 21–58 % of survivors at 3–6 months,[566,576,578] and in 53 % of IHCA survivors at 12 months.[579]

Societal participation and return to work

Limitations in usual activities are reported at 3–6 months,[575,578] and 12 months.[579] Up to 50 % self-report difficulties performing work or other activities due to physical (50 %) or emotional (35 %) problems at six months.[576] Self-reported restrictions in societal participation are greater when compared to matched cardiac patients.[580] Cognitive impairment, depression, fatigue and restricted mobility negatively affect societal participation.[580] Younger patients also report more restrictions in returning to societal activities.[581]

Approximately 50 % return to previous work levels within six months, rising to 63 % with reduced hours; median return time is around 80 days.[581] Although a smaller sample size, similar percentages of return have been reported by others; for example, 42 % and 55 % at six and 12 months, respectively.[582] Factors reducing work return include cognitive impairment, fatigue, and female sex.[580,583–585]

Family members and close friends

Family members and close friends, often referred to as co-survivors, particularly those who witness or participate in the resuscitation, commonly experience anxiety, posttraumatic stress, and sleep disturbance.[586,587] Higher acute traumatic stress in the partners of cardiac arrest survivors was associated with symptoms of post-traumatic stress at both 3 months and 1 year.[588] These symptoms were greater in partners than in survivors. Bereaved family members also experience high levels of emotional burden.[586]

Rehabilitation and follow-up after cardiac arrest

Rehabilitation during hospitalisation

Although there are no ICU rehabilitation studies for cardiac arrest specifically, there are rehabilitation guidelines for post-intensive care syndrome, and these recommend early mobilisation, delirium management and ICU diaries.[589,590] Early mobilisation (e.g., functional/resistance exercises) within 72 h of ICU admission may reduce ventilation duration, length of stay, delirium and muscle strength.[589] Information on the type, dose and length of mobilisation is limited, and evidence for long-term outcomes is lacking.

A randomised controlled trial (N = 750) compared usual levels of ICU mobilisation (mean 8.8 (SD 9.0) min/day) with increased early mobilisation (mean 20.8 (SD 14.6) min/day).[591] Whilst there were no significant effects in any of the prespecified outcomes, the intervention group showed a trend towards more adverse events. No cardiac arrest survivors were included. A subsequent systematic review and meta-analysis report mobilisation in the ICU to be safe, and with no overall increase of adverse events.[592]

Delirium is common among cardiac arrest survivors (up to 92 %).[593] Multimodal prevention strategies and assessment, as described for general intensive care patients, may be relevant.[589,594] The Confusion Assessment Method for the ICU or the Intensive Care

Delirium Screening Checklist are recommended assessment approaches.[589] Physical and non-physical assessments are recommended before hospital discharge.[3,589] Early screening of cognitive and emotional status to predict later problems in OHCA survivors is widely supported.[595–599]

Specialised in-patient neurological rehabilitation

In-patient rehabilitation for cardiac arrest survivors is provided within general brain injury rehabilitation programmes, informed by multiple clinical practice guidelines for different types of acquired brain injuries, including hypoxic or traumatic brain injury and stroke.[600–602] Even minor improvements may reduce the burden of care on family and society.

A review of five observational studies of in-patient rehabilitation for adult cardiac arrest survivors with acquired brain injury (N = 187) reported low-quality evidence of positive effects for functional and neurological outcome (standardised mean difference 0.71, 95 % CI 0.45–0.96).[603] Additional observational studies of HIBI report similar findings.[604–606] Whilst worse recovery in HIBI patients when compared to other acquired brain injury groups has been reported,[605] where baseline function was similar, outcomes were not statistically different.[607] For those who are comatose or in an unresponsive wakefulness state, outcome was unfavourable, and they rarely recover.[608–610]

Cardiac rehabilitation

Many, but not all, cardiac arrest survivors are eligible for generic cardiac rehabilitation programs.[611] These typically include aerobic exercise, sometimes with addition of resistance training, for 20–90 min/1–7 sessions a week[612] delivered at an institution, home-based or electronically.

A recent meta-analysis including 85 RCTs (> 23,000 patients) confirmed that exercise-based cardiac rehabilitation for patients with coronary heart disease reduces cardiovascular mortality, recurrent cardiovascular events and hospitalisation; some evidence suggests cost-effectiveness and improvements in health-related quality of life.[612] Whilst there is no evidence of specific benefit following cardiac arrest, two small observational studies (N = 33) included in a recent review suggest that exercise-based rehabilitation is safe for survivors and without adverse events.[603] Moreover, exercise duration (but not capacity) increased (mean difference 3.7 min (95 % CI 0.5–7.0), p = 0.02). Cognitive and emotional problems are inadequately addressed in traditional cardiac rehabilitation programmes,[613] and access remains limited for cardiac arrest survivors.[611]

Follow up

Based on limited evidence,[614–617] a structured follow-up including screening of fatigue, cognitive and emotional status, and information provision is suggested to identify the problems and care needs of both cardiac arrest survivors and co-survivors (Fig. 10).[1,3,586] Asking about physical impairment should also be considered.[573] Information should cover both medical subjects, such as cardiac disease, risk factors, medication, and ICD, as well as other topics, including potential physical, cognitive, and emotional changes, fatigue, resuming daily activities, driving, work, relationships, and sexuality.[3] Some useful links include: Heartsight (https://ourheartsight.com/), Sudden Cardiac Arrest UK (https://suddencardiacarrestuk.org/), and Life After Cardiac Arrest (https://www.hlr.nu/wp-content/uploads/2022/04/livetefterhjartstopp_ENG.pdf). Whilst patient forums report on the benefit and value of peer support networks,[618] published studies on the effectiveness of such networks or virtual/online forums are not available.[619,620]

Screening and management of cognitive, emotional and physical status, and fatigue

Cognitive issues

Screening should include asking the survivor about cognitive complaints. Family members or close friends can offer valuable insights. Formal screening is recommended when possible. Evidence supports use of the Montreal Cognitive Assessment (MoCA) (Table 2)[621,622]; sensitivity improves when used in combination with the Symbol Digit Modalities Test (Table 2).[621] For those that screen positive, consider referral to a healthcare professional with experience in brain injury-related impairments – e.g., an occupational therapist or neuropsychologist.

Cognitive rehabilitation aims to reduce the impact of cognitive impairments on daily life.[623] Psychoeducation is an essential part of this approach. There are no studies of cognitive rehabilitation for cardiac arrest,[603] but clinical practice guidelines in other acute brain injury patients are useful.[623,624] For example, compensatory memory strategies[623,625] and metacognitive strategy training.[623,626,627] Examples of integrated cardiac and cognitive rehabilitation for cardiac arrest survivors are described but not evaluated.[613,628]

Emotional issues

The Hospital Anxiety and Depression Scale (HADS) is widely used in cardiac arrest,[564,565] but there are few psychometric evaluations of its performance in this population. [629,630] However, there is strong evidence to support the use of the Hospital Anxiety and Depression Scale in the general population and patients with cardiac disease[631] (Table 2). Although the Impact of Events Scale-revised[588,595] and the Post-Traumatic Stress Disorders Checklist (Table 2) have been used in cardiac arrest,[597,598] evidence of psychometric properties in this population is limited. For those who screen positive, consider referral to a specialist in the management of emotional problems – e.g., general practitioner, psychologist, psychiatrist, social worker. It is also important to monitor the well-being of family members and close friends.[3,558,559] Emotional difficulties could be treated in line with symptom-specific pharmacological and non-pharmacological recommendations.

There is limited evidence that psychosocial interventions specifically designed for cardiac arrest survivors can be of value.[603] A single RCT (involving 121 of the 301 patients who were cardiac arrest survivors) of a social-cognitive intervention suggests that when delivered to cardiac patients and their partners, a more positive impact on emotional well-being is reported than when delivered to patients alone.[632,633]

A small study confirmed the feasibility of an individual acceptance and mindfulness-based exposure therapy delivered digitally for cardiac arrest survivors with post-traumatic stress disorder (n = 11); the potential for outcome improvement was described.[634]

Screening and management of fatigue

Whilst assessment guidance in this population is lacking, the most widely used measures include the Modified Fatigue Impact Scale

(MFIS),[635–637] the Multi-dimensional Fatigue Inventory-20 items (MFI-20),[569,635] and the Fatigue Severity Scale (FSS)[636–638] (Table 2). Evidence from other populations (e.g., multiple sclerosis) suggests that, where both mental and physical fatigue are important, the Modified Fatigue Impact Scale is preferable to the Fatigue Severity Scale.[639] For those that screen positive, consider referral to specialist in fatigue and fatigue management – e.g. psychologist, occupational therapist, physiotherapist, rehabilitation medicine physician.

Limited evidence suggests that a telephone-delivered energy conservation and problem-solving therapy may benefit cardiac arrest survivors.[636,637] Clinical practice guidelines in other patient groups may be useful[640,641] including, for example, behavioural interventions such as pacing and prioritising activities. And whilst fatigue is a survivor-reported barrier to returning to work following OHCA,[585] compensatory strategies, such as modified work tasks and flexible work hours, can be helpful.[582,585]

Screening and management of physical challenges

Assessment guidance for physical function or physical activity in this population is lacking. Whilst patient self-reports, such as those described in a recent trial,[642,643] may over-estimate the amount of physical activity engaged in,[644] they could be useful indicators of where cardiac arrest survivors could benefit from physical activity interventions (Table 2). For those reporting low levels of physical activity or limitations in physical function, consider referral to a physiotherapist or an occupational therapist.

Rehabilitation and interventions to increase societal participation and overall health-related quality of life

Comprehensive care pathways should be multi-factorial, multidisciplinary, and tailored to an individual's needs based on the biopsychosocial model. The ultimate goals of care should support survivors in achieving optimal psychological recovery, relative inde-

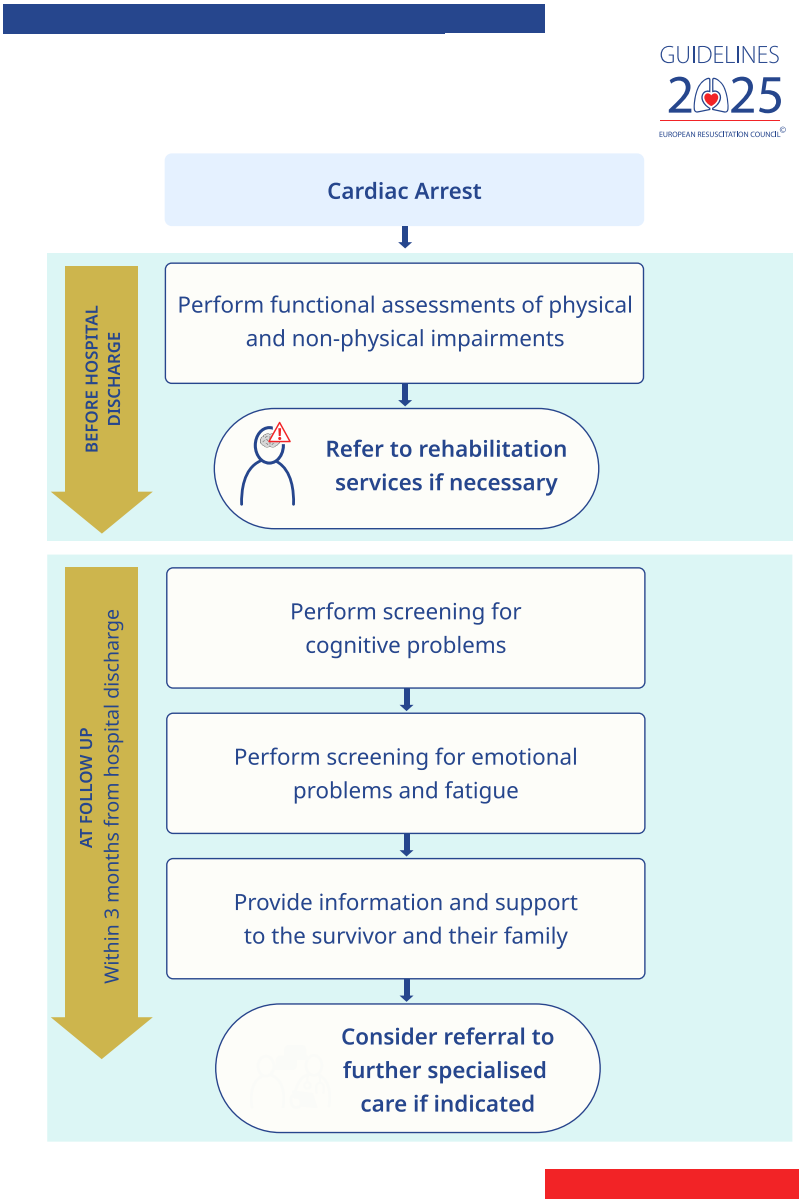


Fig. 10 – Recommendations for in-hospital functional assessments, follow-up and rehabilitation after cardiac arrest.

Table 2 – Measures of health outcome which could be used with cardiac arrest survivors.

WHAT to measure?	HOW to measure?		
Aspect of health	**Suggested measurement tool**	**Access**	**Administration**
Cognitive impairment	***Montreal Cognitive Assessment (MoCA)*** Global cognitive screening	Requires training and certification. Free for students, faculty members, academic researchers and publicly operated healthcare institutions. Access: https://www.mocatest.org	*How:* Performance based measure (approx.10 min). 10 items; each scored on a 4-point scale (0–3); higher scores, better cognitive function *Score:* item summation. Total score 0–30 *Interpretation:* scores of 26 and below may indicate cognitive impairment
	AND *(when possible)*		
	Symbol Digit Modalities Test (SDMT) Processing speed, attention and visual scanning	Requires Level 2 qualifications. Purchased by Hogrefe *https://www.hogrefe.com/group/locations*	*How:* Performance based measure. *Score:* The number of correctly paired symbols. Raw scores 0–110; higher scores, better cognition *Interpretation:* Norm adjusted scores by age and education; transformed Z-scores, where scores <−1.5 indicate possible cerebral dysfunction
Emotional problems	***Hospital Anxiety and Depression Scale*** Two domains: Anxiety (HADS-A) (7 items) Depression (HADS-D) (7 items)	Extensively available, although copyrighted. Copies and permission available through: GL Assessments (permissions@gl-assessment.co.uk) or MAPI Trust (https://eprovide.mapi-trust.org/instruments/hospital-anxiety-and-depression-scale). Cost will depend on the project and may be high.	*How:* Self-report measure (approx. 5 min) 14 items; each item scored on a 4-point scale (0–3); higher scores, greater levels of anxiety / depression *Score:* Two domain scores; item summation, with domain scores ranging 0 to 21. *Interpretation:* scores of 8 and above suggest symptoms of anxiety or depression (8–10 mild; 11–15 moderate; 16 and above severe)
	AND		
	Impact of Events Scale-revised (IESr): 2 sub-scales: Experience (7 intrusion items) and Avoiding Reminders (8 avoidance items)	Access by contacting the authors or via various websites (e.g., https://psypack.com/assessments/ies-r-impact-of-event-scale-ptsd/ OR https://www.onlinecbtresources.co.uk/impact-of-events-scale/). Free to use.	*How:* Self-report measure (approx. 5 min) 20 items; each item scored on a 5-point scale (0–4); higher scores, worse health. *Score:* Item summation, total score 0–80. *Interpretation:* recommended cut point 33.
	OR		
	Post-Traumatic Stress Disorders Checklist updated for DSM-5 (PCL-5):	Accessible via website: https://www.ptsd.va.gov/professional/assessment/adult-sr/ptsd-checklist.asp Free to use.	*How:* Self-report measure 20 items; each item scored 0–4 (higher scores, worse health). *Score:* item summation, total score 0–80. *Interpretation:* recommended cut-point 33.
Fatigue	***Modified Impact Scale (MFIS)*** Total fatigue, physical, cognitive and psychosocial impact on fatigue	Access by MAPI trust. https://eprovide.mapi-trust.org/instruments/modified-fatigue-impact-scale Free to use for clinical purposes.	*How:* Self-report measure (approx. 5–10 min) 21 items; each item scored 0–4 (higher scores, worse fatigue). *Score:* item summation: total score 0–84 (higher score, worse fatigue). *Interpretation:* scores >37 indicate fatigue

Table 2 (continued)

WHAT to measure?	HOW to measure?		
Aspect of health	**Suggested measurement tool**	**Access**	**Administration**
	OR		
	Multi-dimensional Fatigue Inventory-20 (MFI-20) 5 domains: general fatigue, physical fatigue, mental fatigue, reduced activity and reduced motivation	The MFI-20 is a registered trademark – therefore copies should be obtained from an official source. Available from EMA Smets, Academic Medical Centre, Dept of Medical Psychology, University of Amsterdam, Amsterdam, Netherlands. (e.m.smets@amsterdamumc.nl)	*How:* Self-report measure (approx. 5–10 min) 20-items; each item scored 1–5 (higher scores, more fatigue) *Score:* item summation per domain; scoring 4–20. *Interpretation:* no recommended cut-point.
	OR		
	Fatigue Severity Scale (FSS) 9 statements which rate the severity of fatigue symptoms	Original version and instructions included in the original article.{Krupp, 1989 #669} Also accessible at various websites (e.g., https://www.med.upenn.edu/cbti/assets/user-content/documents/Fatigue%20Severity%20Scale%20(FSS).pdf Free to use.	*How:* Self-report measure (approx. 5–10 min) 9 items; each scored 1–7 agreement scale (higher scores, more severe fatigue) *Score:* item summation; total score 9–63 *Interpretation:* scores of 36 and more concerns over fatigue
Physical Function	***SF-36v2 Physical Function domain (PF10):*** Self-care; mobility and other physical activities; movements such as lifting and bending.	Extensively available but copyrighted. Permission to use by Qualitymetrics and associated to a (high) cost; https://www.qualitymetric.com/health-surveys/the-sf-36v2-health-survey/	*How:* Self report measure 10 items; items scored 1–3, where 3 is most limited and 1 is not limited at all (lower scores, most limited) *Score:* Algorithm required to calculate PF score. *Interpretation:* Norm-based scoring, where the mean of the US population is set at 50 (SD10) (transformed to T-scores); scores range 0–100, with lower scores indicating worse function.
	OR		
	EuroQoL EQ-5D-5L EQ-5D descriptive system: 5 domains ***(Mobility, Self-Care, Usual Activities,*** Pain/Discomfort, Anxiety/Depression)	Free to use, but use must be registered on EuroQoL website: https://euroqol.org/ License required for use per project.	*How:* Self report measure Five 'level' (5L) response options per item ((1) no problems to (5) extreme problems; higher scores, worse health) *Score:* i) Simple descriptive domain profile (range no problems (1) to extreme problems (5)) could be used to 'simply' describe limitations in mobility, self-care, and usual activities. *Interpretation:* higher scores at domain level indicate worse health. OR ii) Single index value for general health status – underpinned by a scoring algorithm and 'value set' (all items). *Interpretation:* Index score ranges −0.59 to 1.00 (1 is best health; values <0 suggest a state worse than death. *Note*: Completion of all items produces a 5-digit number ('health state'); but the numerical numbers have no inherent arithmetic properties and should not be used to create a summary/ cardinal score.

(*continued on next page*)

Table 2 (continued)

WHAT to measure?	HOW to measure?		
Aspect of health	**Suggested measurement tool**	**Access**	**Administration**
	AND?		
	Questions about Physical Activity (included in the 6-months follow-up to the TTM2 trial)	***Question 1: Moderate intensity*** In the last week, how many days have you engaged in moderate intensity physical activities for at least 30-min a day? (could be performed in blocks that last for at least 10 min adding up to a total of 30 min or more). ***Question 2: vigorous intensity*** In the last week, how many days have you engaged in vigorous intensity physical activities for at least 20 min (in one block)?	*How:* interview / self-report *Score:* categorisation in three ordered group based on number of days of self-reported 30 min total moderate and 20 min vigorous physical activity a day during the last week. *Interpretation*: - Low level: <5 days of moderate intensity PA at least 30 min in total per day/<3 days of vigorous intensity PA at least 20 min per day - Moderate level: >/=5 days of moderate PA at least 30 min in total per day / >/=3 days vigorous intensity PA at least 20 min per day - High level: >/=2 days of moderate intensity PA at least 30 min in total per day and >/=3 days vigorous intensity PA at least 20 min per day

pendence, reintegration into society, and an improved health-related quality of life. However, underpinned by the low quality of evidence, a recent review of rehabilitation interventions was unable to determine the effectiveness of interventions on the secondary consequences of cardiac arrest survival, including health-related quality of life and neurological function.[603] Among cardiac arrest survivors working before the event, almost half report an unmet rehabilitation need at six months.[582] Further high-quality studies are urgently needed.[577,603] A small pilot study (N = 40) evaluated a residential and home-based rehabilitation program that included education, physical activity training, and psychosocial support.[603] Whilst recruitment rates were less than expected and the specialised residential component may not be feasible in many settings, patient and clinicians' satisfaction was high. Initial reports suggest a positive impact on depression, disability, and life activities.

Family members and close friends

Prior to hospital discharge and at follow-up, enhanced communication with family and close friends is important to highlight 'what to expect', signpost to helpful resources including survivor/patient organisations and, where appropriate, to seek further help from, for example, a general practitioner.[586]

Investigating sudden unexplained cardiac arrest

Unexplained cardiac arrest refers to cases where no diagnosis is evident after initial ECG, echocardiography, and coronary assessment in sudden cardiac arrest survivors.[645] Recent registry data suggest that 12.3 % of sudden cardiac arrest survivors had no diagnosis after the initial assessment, with higher rates observed in younger or exercise-related cases.[646,647] Further testing may identify a specific diagnosis in 41–61 % of patients.[647,648] Possible diagnoses include primary electrical disorders like Brugada and long QT syndromes, latent genetic cardiomyopathies (e.g. arrhythmogenic RV, hypertrophic and dilated cardiomyopathies), inflammatory heart disease (e.g. myocarditis, sarcoidosis), ischaemia without atherosclerotic coronary artery disease (e.g. coronary spasm) and conduction system abnormalities.

A thorough diagnosis after unexplained cardiac arrest is important for patient clarity, tailored treatment, and identifying at-risk family members. The latest ESC guidelines standardise sudden cardiac arrest survivor evaluations before diagnosing idiopathic ventricular fibrillation and emphasise a multidisciplinary approach.[189] Recommended diagnostic testing for patients with unexplained cardiac arrest includes blood sample collection for toxicology and genetic testing, retrieval of data from cardiac implantable electronic devices and wearable monitors, repeated 12-lead ECGs and continuous cardiac monitoring, cardiac MRI, sodium channel blocker tests, and exercise testing.[189]

Genetic testing plays an important role in identifying heritable causes of unexplained cardiac arrest.[649] A confirmed diagnosis of a heritable condition should prompt targeted genetic testing, focusing on genes with strong evidence of causative links with diagnostic yields varying by condition (e.g., ~20 % in Brugada Syndrome to ~80 % in Long QT Syndrome).[189,649] However, a negative result does not rule out a genetic cause, and family screening may still be necessary. The role of genetic testing in unexplained cardiac arrest survivors without a clear diagnosis remains uncertain, with diagnostic yields up to 17 % in unexplained cardiac arrest and ~10 % after detailed clinical assessment.[189] Long-term follow-up of unexplained cardiac arrest patients is recommended because of the high risk of recurrence of arrhythmia (16–26 %) often within the first few years. The risk is higher for those who lack a thorough initial evaluation.[650] In the absence of diagnosis at the initial phase, prolonged follow-up and repetition of investigations can help isolate a diagnosis, most often related to an electrical heart disorder.[651]

Cardiac arrest centres

There is wide variation among hospitals in the availability and type of post-resuscitation care, as well as clinical outcomes, which has given rise to the concept of the cardiac arrest centre as a means of providing post-cardiac arrest patients with uniform, high-quality treatment according to current standards of care.[652–654] Definitions of a cardiac arrest centre vary, but an expert consensus paper published by the Association for Acute Cardiovascular Care of the European Society of Cardiology, European Association of Percutaneous Coronary Interventions, European Heart Rhythm Association, European Resuscitation Council, European Society for Emergency Medicine and European Society of Intensive Care Medicine, states that the minimum requirements for a cardiac arrest centre are 24/7 availability of an on-site coronary angiography laboratory, an emergency department, an intensive care unit (ICU), imaging facilities (such as echocardiography, computed tomography, and magnetic resonance imaging), as well as a network organization.[655] Access to neurophysiological investigations is also essential so that comprehensive multimodal prognostication is facilitated.[656]

ILCOR suggests that adult patients with non-traumatic OHCA cardiac arrest should be cared for in cardiac arrest centres, and ERC/ESICM have adopted this recommendation.[41] The weak recommendation is based on low-certainty evidence from a systematic review that used the European position paper to define cardiac arrest centres.[656] The systematic review included one RCT [657] and 15 observational studies.[658–672] Of these, 13 reported survival to hospital discharge and all reported a survival benefit with care at a cardiac arrest centre, except for one, which showed no difference. However, the studies were very heterogeneous, and their interpretation is problematic because all were at moderate or serious risk of bias. The one RCT was undertaken in London, UK and randomised OHCA patients with ROSC and without ST elevation on their ECGs to be transferred to a cardiac arrest centre or the nearest acute hospital.[657] There was no difference in 30-day mortality (primary outcome), but there was also little difference in the treatment provided in the acute hospitals and cardiac arrest centres.

The optimal configuration of cardiac arrest centres will likely vary among different countries and regions; however, in many healthcare systems, the trend is to regionalise the care of cardiac arrest patients in a similar manner to the regionalisation of major trauma. Despite only low-certainty evidence supporting cardiac arrest centres, major European scientific organisations are generally supportive of their implementation. Further details on the system behind cardiac arrest centres are in the ERC Guidelines 2025 System Saving Lives.[673]

Declaration of competing interests

Declarations of competing interests for all ERC Guidelines authors are displayed in a COI table which can be found online at https://doi.org/10.1016/j.resuscitation.2025.110809.

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Practice Guideline

European Resuscitation Council Guidelines 2025 Education for Resuscitation

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Abstract

These Resuscitation Guidelines 2025 of the European Resuscitation Council (ERC) on Education for Resuscitation are based on the 2025 Consensus of Science with Treatment Recommendations (CoSTR) of the International Liaison Committee on Resuscitation (ILCOR), reviews of peer-reviewed literature and expert consensus. These guidelines provide directions for laypeople and healthcare professionals on teaching and learning the competencies (knowledge, skills, and attitudes) for resuscitation for in-hospital and out-of-hospital cardiac arrest of all age groups. Furthermore, the guidelines focus on technology-enhanced learning, simulation-based resuscitation education, assessment, feedback and debriefing, faculty development, and educational effects on patient outcomes.

Keywords: Education, Training, Learning, Cardiopulmonary resuscitation, Simulation, Guideline, ERC

Introduction

These European Resuscitation Council (ERC) Guidelines 2025 Education for Resuscitation offer evidence-informed guidance for laypeople and healthcare professionals (HCPs) about teaching and learning the lifesaving competencies of resuscitation (knowledge, skills and attitudes) with the aim of improving patient outcomes (Fig. 1). This guidance addresses the second key component of the Utstein formula of survival, namely 'educational efficiency' (Fig. 2). As education is the link between scientific findings and their implementation into practice, we present the components of education in resuscitation in more detail. The effects of educational interventions in resuscitation are maximised by incorporating educational theory.[1,2] These guidelines address education in various settings where people may teach and learn resuscitation, including every level from basic to advanced life support and for all ages of learners and all cardiac arrest victims. Key stakeholders to be targeted include governmental (healthcare, education, etc.) and political authorities who manage national and/or regional healthcare systems (Fig. 1).

The foundational principles of medical education serve as the blueprint for creating a comprehensive educational structure. This framework incorporates various learning theories and teaching strategies to offer a wider range of methods in resuscitation education. Over the last decade, simulation and technology (and more recently artificial intelligence (AI)) have gained increasing importance

Abbreviations: ERC, European Resuscitation Council, CoSTR, Consensus of Science with Treatment Recommendations, ILCOR, International Liaison Committee on Resuscitation, HCPs, Healthcare professionals, AI, Artificial Intelligence, CPR, cardiopulmonary resuscitation, BLS, Basic Life Support, AED, Automated external defibrillator, ALS, Advanced Life Support, ILS, Immediate Life Support, PBLS, Paediatric Basic Life Support, NLS, Newborn Life Support, VR, virtual reality, AR, augmented reality, VLE, virtual learning environment, EMS, Emergency Medical Services, HBB, Helping Babies Breathe, PAD, Public Access Defibrillator, RCT, Randomised controlled trial

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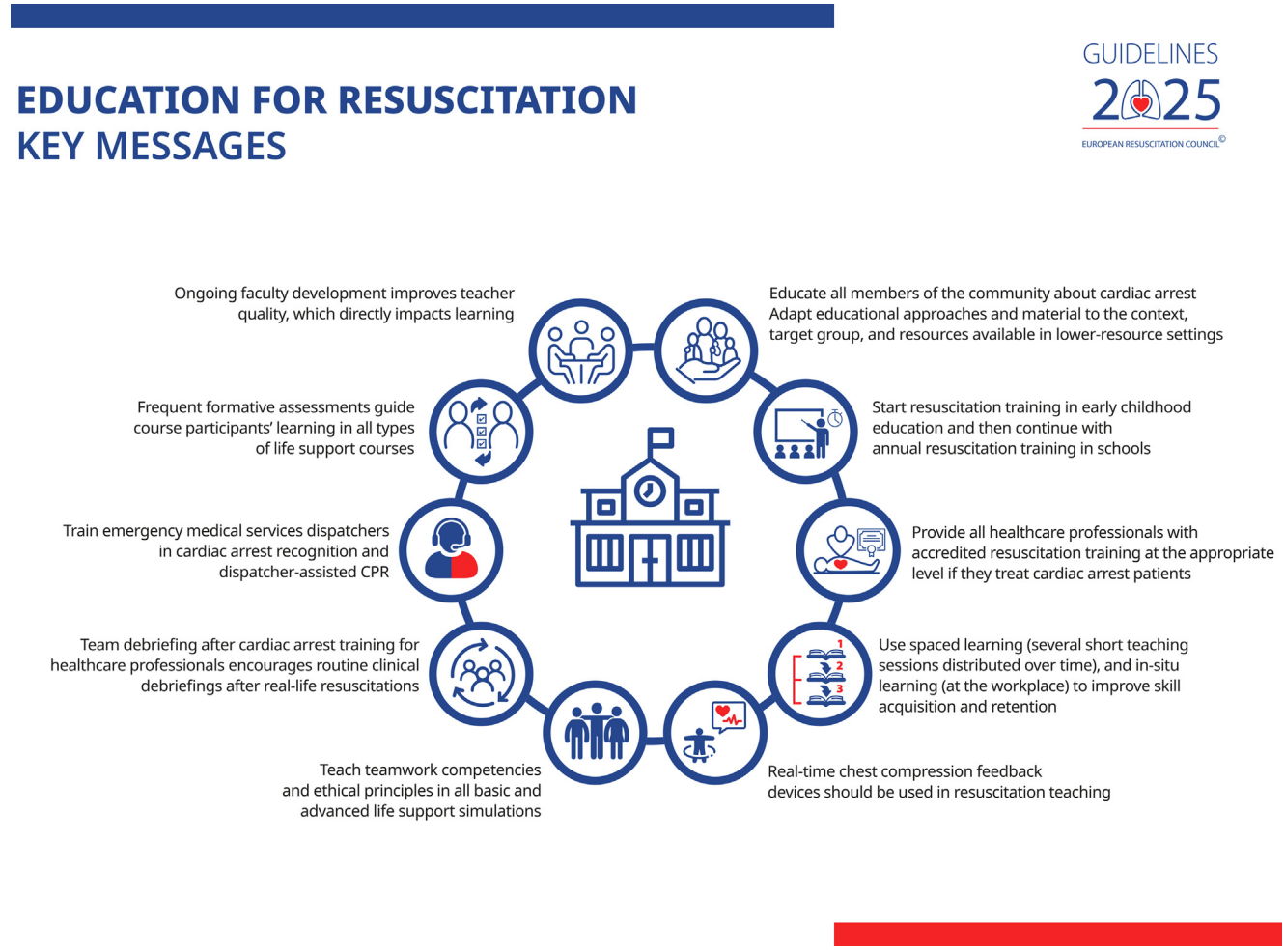


Fig. 1 – Education for resuscitation – key messages.

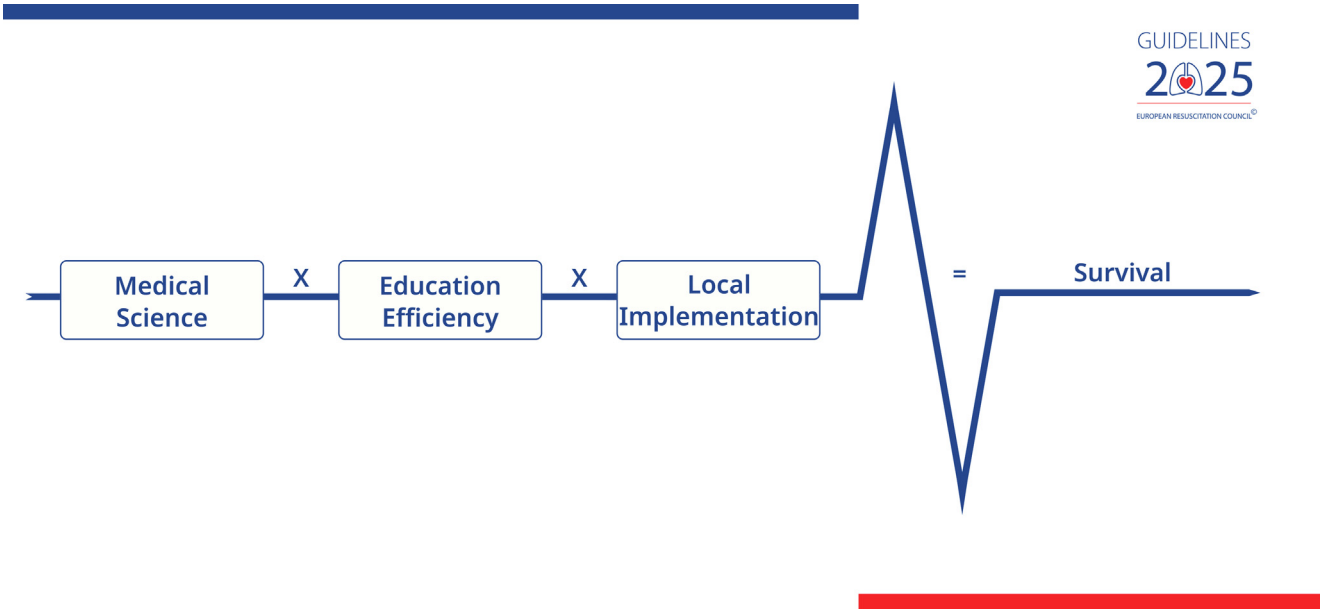


Fig. 2 – The Utstein formula of survival.

in education and have changed how ERC implements its resuscitation teaching.[3] A summary of key educational strategies referred to in these guidelines is presented in Fig. 3.

Throughout these guidelines, the term CPR relates to the specific technical skills of cardiopulmonary resuscitation (e.g., performance metrics of chest compression and ventilation), whilst resuscitation is used as a generic term covering the broader range of skills and interventions. The term bystander is used to describe rescuers who happen to be at the scene to provide help, and the term first responder is used for those who have additional training and are alerted to attend the scene of a cardiac arrest. Healthcare professionals (HCPs) are those who work in any healthcare sector (prehospital or in-hospital). Laypeople are persons not working in the healthcare sector. Basic life support (BLS) is defined as initiating the chain of survival, early high-quality chest compression, effective ventilation, and the early use of an automated external defibrillator (AED). Any form of resuscitation education beyond BLS is described generically as advanced life support (neonatal, paediatric, and adult life support). Where the term 'ALS' is used, this refers specifically to the ERC adult Advanced Life Support course. The writing group of these ERC Guidelines 2025 Education for Resuscitation considered the recently introduced ERC approach to diversity, equality, equity, and inclusion (DEI) while writing these guideline, and applied it whenever possible, recognising and realising that this is a field for improvement in the production of evidence-informed guidelines.

These ERC Guidelines on Education for Resuscitation 2025 are based on the annual Consensus of Science with Treatment Recommendations (CoSTR) of the International Liaison Committee on Resuscitation (ILCOR).[4–7] An expert group was convened to review these recommendations, along with available selected peer-reviewed literature. This body of evidence was then discussed and agreed upon within the Education Writing Group and the ERC Guidelines 2025 Steering Committee. The educational co-chairs of the corresponding ERC science and education committees reviewed and agreed on the parts concerning their specific course format. These Guidelines were posted for public comment between 5. and 30. May 2025. A total of 53 comments were submitted, leading to one change in the final version. Subsequently, the feedback was reviewed by the writing group, and the guidelines were then updated. These Guidelines were presented to and approved by the ERC Board and the ERC General Assembly in June 2025. The methodology for the development of the guidelines is outlined in the Executive Summary.[8] Table 1 summarises the main changes in the ERC Guidelines for Education for Resuscitation between 2021 and 2025 (Table 1).

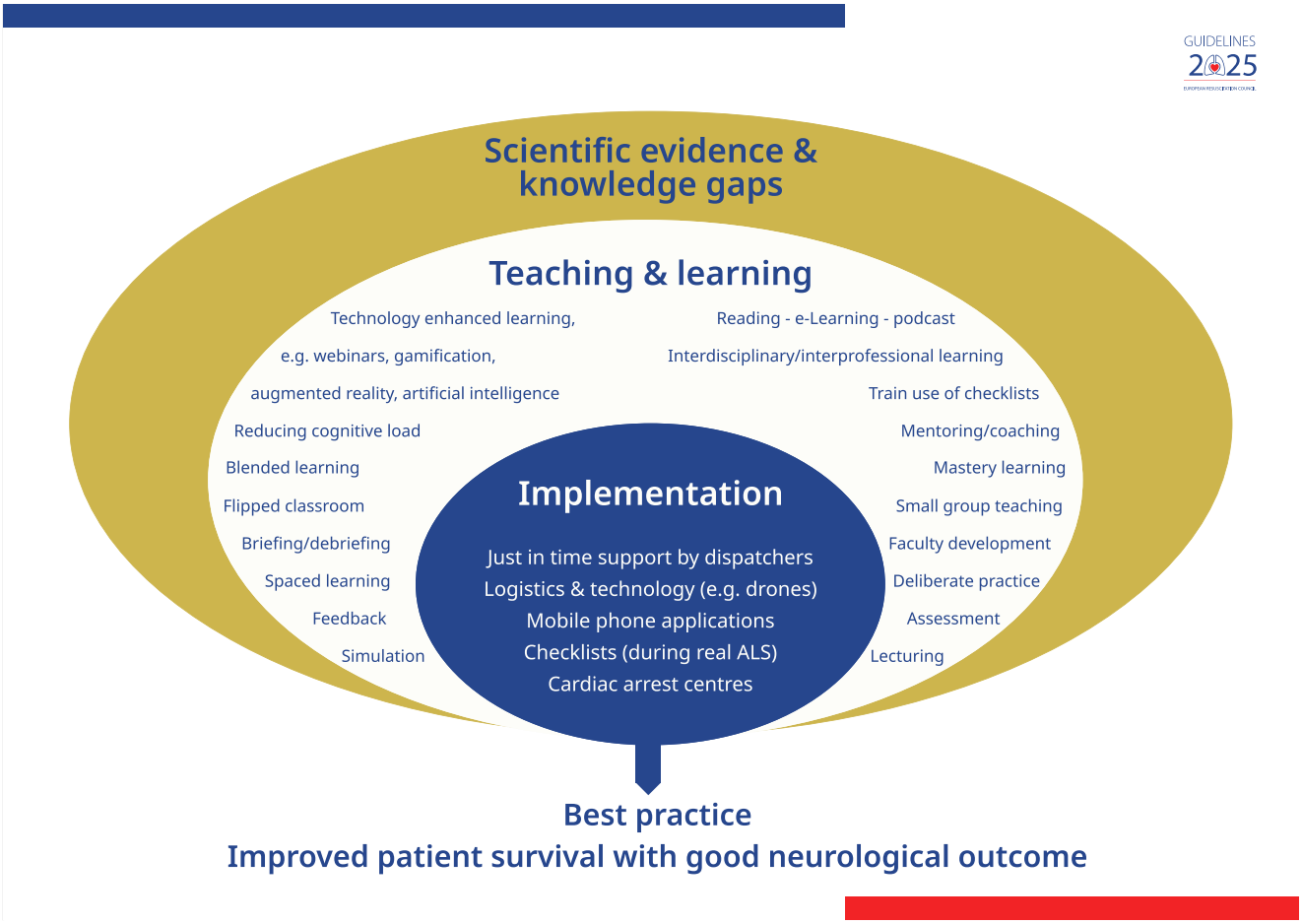


Fig. 3 – ERC educational approach to best practice and improved patient outcomes.

Table 1 – Main changes in the ERC Guidelines for Education for Resuscitation: 2021 compared with 2025.

Topic	2021 Guidelines	2025 Guidelines
Resuscitation educationtailored for specific groups of life-saving rescuers	Not included	- Introduce resuscitation training early in childhood education (around 4–6 years of age) and incorporate annual resuscitation training into school curricula. - Tailor the required CPR training to the provider's role, their specific setting, and specific patient populations. - Train emergency medical services dispatchers in cardiac arrest recognition and telephone-assisted CPR guidance.
Educational methods to teach high-quality resuscitation competencies	Not included	- Use blended and self-directed learning to provide flexibility and accessibility for all learners of resuscitation. - Consider gamified learning as a component of resuscitation training for all types of basic and advanced life support courses. - Use real-time CPR feedback devices to improve chest compression skill acquisition and accuracy. - Use Rapid Cycle Deliberate Practice as an effective learning strategy to master skills rapidly for all types of basic and advanced life support courses. - Use stepwise approaches for structured skill acquisition, but strict adherence to a four-step approach is not always necessary. - HCPs should use cognitive aids to enhance protocol adherence during resuscitation, but bystanders should refrain from using cognitive aids as this may delay critical actions. - Integrate ethical training into HCPs resuscitation education. - Include training of team competencies in all life support courses (incl. non-technical skills and human factors during resuscitation).
Technology-enhanced learning (TEL) for resuscitation	- Learning CPR can be supported by the use of smartphones, tablets, etc. - They improve retention and facilitate competency assessment in CPR. - Gamified learning may engage many learners. - Virtual learning environments are recommended as part of a blended learning approach.	- Use online learning modalities (e.g. podcasts, videos, social media) to provide flexibility in time and location for learners and to promote asynchronous learning. - Augmented reality for life support training possibly adds value to the learning process. - Applications and artificial intelligence might facilitate assessment and teaching during resuscitation courses.
Simulation-based resuscitation education	Specific team or leadership training should be included in advanced life support simulation.	- In-situ learning (at the workplace) should be considered as an option for CPR simulation where resources are readily available. - Consider the inclusion of a CPR coach as a member of the resuscitation team during CPR simulation. - Debriefing scripts support instructors during debriefing after simulation.
Faculty development	Three aspects of faculty development are important: selection of suitable instructors, initial instructor training, and maintenance and regular update of their teaching quality.	- The ERC recommends faculty development programs for all instructors teaching life support courses. - Select trainers with medical education expertise to conduct faculty development programmes.
Feedback and debriefing in life support courses	Not included	- A concise team debriefing after cardiac arrest training for HCPs can encourage routine clinical debriefings after real-life resuscitations.
Resuscitation education in low-resource settings and remote areas.	Not included	- Adapt educational approaches and materials, and awareness campaigns to the context and resources available in lower-resource settings. - Consider distance learning, technology-enhanced learning, hybrid resuscitation training, and the use of low-cost (self-made) manikins.

Concise guidelines for clinical practice

Resuscitation education tailored for specific groups of life-saving rescuers

- Educate all members of the community about cardiac arrest awareness and cardiac arrest treatment and consider the diversity of the target group.
- Introduce early resuscitation training starting in early childhood education (around 4–6 years of age) and incorporate annual resuscitation training into school curricula.
- Provide all HCPs with accredited resuscitation training.
- Tailor the required CPR training to the provider's role, their specific setting, and/or specific patient populations.
- Train emergency medical services dispatchers in cardiac arrest recognition and telephone-assisted CPR guidance.

Educational methods to teach high-quality resuscitation competencies

- Use blended and self-directed learning to provide flexibility and accessibility for all learners of resuscitation.
- Consider gamified learning as a component of resuscitation training for all types of basic and advanced life support courses.
- Use real-time CPR feedback devices to improve chest compression skill acquisition and accuracy.
- Use Rapid Cycle Deliberate Practice as an effective learning strategy to master skills rapidly.
- Use spaced learning to improve acquisition and retention of competencies.
- Use stepwise approaches for structured skill acquisition.Strict adherence to a four-step approach is not always necessary.
- HCPs should consider using cognitive aids during resuscitation training to enhance protocol adherence. Bystanders should not use them as this may delay critical actions.
- Integrate ethical training into HCP resuscitation education.
- Regardless of the rescuer's background, basic life support education should include effective chest compressions, safe use of an AED, and ventilation of the lungs.
- Teach two-person ventilation when using a self-inflating bag and mask.
- Address in BLS training barriers that rescuers might experience in performing CPR and factors increasing rescuers' willingness to perform CPR.
- Include training of team competencies in all life support courses (incl. non-technical skills and human factors during resuscitation).

Technology-enhanced learning (TEL) for resuscitation

- Use online learning modalities (e.g. podcasts, videos, social media) to provide flexibility in time and location for learners and to promote asynchronous learning.
- Use augmented reality for life support training as it possibly adds value to the learning process.
- Consider applications and artificial intelligence, which might facilitate assessment and teaching during resuscitation courses.

Simulation-based resuscitation education

- Use high-fidelity manikins when training centres/organisations have the infrastructure, trained personnel, and resources available. Use low-fidelity manikins for standard advanced life support training where high-fidelity manikins are not available.
- Use in-situ simulation (at the workplace) as an option for CPR training where resources are readily available.
- Include the teaching of teamwork competencies in basic and advanced life support simulations.
- Consider the inclusion of a CPR coach as a member of the resuscitation team during CPR simulation.
- Use debriefing scripts to support instructors during debriefing after simulation.

Assessment in resuscitation education

- Use frequent formative assessments in all life support courses to provide instructors with information for targeted feedback and to support learning.
- Use checklists to support assessment decisions.

Feedback and debriefing in life support courses

- Ensure feedback is a two-way discussion between the giver and the recipient, driven by an authentic interest in the learner's improvement.
- Consider using a concise team debriefing after cardiac arrest training for HCPs to encourage routine clinical debriefings after real-life resuscitations.

Faculty development

- The ERC recommends faculty development programs for all instructors teaching life support courses.
- Select trainers with medical education expertise to conduct faculty development programmes.
- Implement faculty development programs that enable participants to establish a positive learning climate, practice effective educative leadership, communicate learning goals, implement robust assessment and feedback strategies, and evaluate course programs for continuous improvement.

Effect of resuscitation education on outcome

- HCPs providing advanced life support to adults should attend accredited adult advanced life support training.
- HCPs providing advanced life support for newborns and babies should attend accredited neonatal resuscitation training (NRT) courses such as Newborn Life Support.
- For HCPs providing care for newborns and babies in out-of-hospital low-resource settings, we recommend participation in the Helping Babies Breathe (HBB) support program.
- Other accredited life support courses (e.g., paediatric life support) are recommended, even though less evidence on the effect on patient outcomes is available.

Resuscitation education in low-resource settings and remote areas

- Adapt educational approaches and materials, and awareness campaigns to the context and available resources.
- Consider distance learning, technology-enhanced learning, hybrid resuscitation training, and the use of low-cost (self-made) manikins.

The evidence informing the guidelines

Resuscitation education tailored for specific groups of life-saving rescuers

A systemic approach to resuscitation education is required to educate all laypeople, first responders, and HCPs to provide immediate CPR and defibrillation where appropriate for cardiac arrest. However, resuscitation education, like any other subject, is not a one-size-fits-all concept and should be tailored to the specific needs and situations of the learners, the specific patient groups, or the rescuers.[9] Various resource settings mandate different levels of training programmes, which need to be weighed against feasibility and economics.

Resuscitation providers, from laypeople to HCPs, need to acquire different competencies based on their different training requirements. The learning objectives for laypeople are the immediate call for help, cardiac arrest (CA) recognition, and early and effective initiation of BLS.[10–12]

An ILCOR scoping review found scarce evidence on tailored courses or training for specific adult populations (e.g., Down syndrome, visual or hearing impairment). Tailoring involves addressing specific impairments. In accordance with ILCOR ERC recommends that while evidence on which groups need which adaptations is limited, tailoring should be considered when feasible.[13]

In light of the known disparities of persons attending resuscitation training,[14,15] tailoring means also adapting course materials and manikins to differences like skin colour, gender or body shape, reflecting the diversity of the target population.[15,16] Specifically, course organisers and instructors should consider using diverse, race-, gender-, and/or age-adapted manikins if available.

Children can be trained in resuscitation skills from a young age through to higher education, as shown by the ERC's successful KIDS SAVE LIVES program.[17] This resuscitation education needs to be adapted to the age of the learners because of their differing abilities to perform skills and to understand the underpinning theory.[18–24] Teachers are already experts in teaching and therefore need only to learn the specific resuscitation skills they will subsequently teach to their students.[17,25,26] Such resuscitation teaching should be included in the curricula of teachers' education.[23] Evidence is scarce on which educational strategy is the most effective for teaching school children.[27–30] However, one study has derived suggestions for improving content and teaching strategies from the perspective of schoolchildren and their teachers.[24] Therefore, the format for teaching CPR will vary with local requirements and circumstances. For more details see the ERC Guidelines 2025 *Systems Saving Lives*.[31]

Emergency medical service (EMS) dispatchers play a vital role in guiding bystanders using telephone-assisted CPR. Dispatchers thus need to be proficient in recognising a cardiac arrest from the description provided by the caller.[7,32–34] While there is a small risk of performing chest compressions on someone not in cardiac arrest,[35] this risk is far outweighed by the danger of withholding compressions when they are necessary.[7,36] Common challenges include recognising agonal breathing or gasping[37,38] and engaging callers to help the victim.[32,33,39] Programmes that improve the incidence and quality of telephone-assisted CPR have improved patient outcomes,[40,41] and specific training can overcome the barriers and challenges in providing CPR.[42–44] Artificial intelligence can support dispatchers, but currently not enough evidence exists to recommend its routine use.[45,46] If a specific telephone-assisted CPR course for dispatchers is created, it should include cardiac arrest recognition and safety, engagement with callers to start CPR, indications for and performance of chest-compression-only CPR, instruction in high-quality CPR including the use of an AED, the support of arriving first responders, drones and EMS at the scene, and resuscitation debriefing.[7,47]

Resuscitation training programs for HCPs at different levels of response and duty should be mandatory because they are in regular contact with patients at risk of cardiac arrest. According to the workplace, respective training should be tailored to the required skill level, the specific setting, and the anticipated frequency of responding to emergencies (e.g., via accredited life support training courses at the appropriate level and for the appropriate age group), as well as to their specific setting.[7,48,49]

Educational methods to teach high-quality resuscitation competencies

In any teaching–learning process, the first step is to define 'what to teach'. That means defining competencies and learning objectives needed for the target audience (e.g., school students, lifeguards, and HCPs). Once the learning objectives and content are established, a well-structured educational process defines 'how to teach'. The last step in this process is the assessment of the teaching success, "Are you now able to do it?".

Effective education needs human resources (e.g., instructors) and teaching materials (e.g., simulation classrooms). The role of the instructor is to facilitate learning in a safe and motivating environment, encouraging active student participation and assessment of the learning success in all course formats and with all learners.

Educational methods for resuscitation

Integrating ethics into resuscitation education is essential for preparing all rescuers in the application of ethical principles under pressure. For laypeople, training should address key concerns such as the willingness to help, hesitation to intervene, and awareness of Good Samaritan laws that protect bystanders acting as rescuers. Healthcare professionals need to be equipped to navigate advance care planning, engage in patient-centred shared decision-making, apply do-not-attempt-resuscitation (DNACPR) decisions, and make informed decisions about when to terminate resuscitation efforts.

Ensuring equitable access to ethics education reduces uncertainty, builds confidence among providers, and promotes resuscitation decisions that respect patient rights and reflect ethical best practices. For further guidance, see the ERC 2025 Guidelines on Ethics in Resuscitation.

Blended learning,[4,50] self-directed learning,[51] gamification,[52] cognitive aids[53] and augmented reality[7,54] were assessed by ILCOR and found to be effective for CPR training for HCPs and laypeople.

Blended learning combines digital resources with on-site teaching and hands-on practice, enabling resuscitation training even in remote locations.[4,50] It also enables consistent messaging, namely for pre-course preparation.[50] Although its implementation might face barriers in low-resource settings, it remains an effective strategy, which is at least as effective as face-to-face training.[4,50,55]

Self-directed learning, in contrast to teacher-led learning, is particularly useful and effective for basic techniques such as chest compressions and AED use, especially in low-resource settings.[51] Most studies found no differences in CPR quality, AED use, knowledge, confidence and willingness to help between self-directed and

instructor-led training,[4,51,56,57] which makes self-directed learning probably cost-effective and recommendable where instructor-led training is not feasible.

Gamification refers to the use of game-like elements (competition, point systems, scaffolded levels of difficulty, leaderboards), usually in a digital format, to encourage interactive and intuitive participation by learners.[58] Gamification for CPR training enhances learners' outcomes (skill, knowledge, attitude), and participation, particularly in teamwork and problem-solving, and improves learners' attitudes during training and could be a valuable component in resuscitation training. [7,52,59] A gamification strategy could include engaging narratives, progressive challenges, immediate feedback, collaboration, and/or meaningful rewards. Most studies showed improvements in at least one domain of learner outcomes when gamified learning elements were included, but the heterogeneity in their applications results in very low certainty of evidence supporting these findings.[7,52,60–63] with one study even reporting negative effects on CPR quality and time to apply an effective AED shock.[64] An updated search identified three additional studies consistent with the previous findings.[51] Therefore, gamified learning should be considered as a component of resuscitation training for all types of basic and advanced life support courses.[7,52]

Immersive technologies, such as virtual reality (VR) and augmented reality (AR), have shown mixed results for training resuscitation skills.[54] Overall, studies find that AR results in favourable or no different learning outcomes compared with other BLS training methods,[7,54] whereas results for VR are mixed with some studies suggesting inferior learning outcomes for VR alone when compared to other training methods.[7,54,65–71] Thus, VR and AR may be used for resuscitation teaching[7,54] but VR should not be used as the sole method.

The flipped classroom approach reverses the traditional learning environment.[72] Instead of passively receiving information in a classroom, learners are first introduced to the CPR learning material outside the classroom, often through online videos, readings, or other resources organized in a virtual learning environment (VLE). Then, during the on-site in-class resuscitation course time, learners engage in active learning activities during simulations, case studies, and hands-on practice, facilitated by an instructor.

Hands-on training and feedback

Feedback is essential to ensure learning during high-quality skills training, and it can come from different sources. Use of CPR feedback devices improves chest compression quality metrics during the training of lay and professional rescuers. [73–79] However, there is insufficient evidence to determine the value of ventilation feedback devices for teaching CPR skills.

Learning strategies

Rapid Cycle Deliberate Practice (RCDP) is characterised by pausing the scenario if needed to enable correction. The learner can then repeat the skill until it is mastered.[80] In simulated ALS scenarios it significantly reduces pauses for defibrillation and medication administration.[7,81,82] While the inclusion of RCDP in both BLS and ALS courses seems reasonable, its application has mainly been limited to HCPs in training, with no studies yet in laypeople, first responders, or in low-resource settings. Skill retention outcomes are mixed, highlighting the need for further analysis of long-term effectiveness.[7,82]

Spaced learning distributes smaller or shorter training sessions over time, which improves retention of practical skills compared to massed learning.[83,84] Two recent studies concluded that spaced learning was more effective than massed learning for BLS skill retention.[85,86] Spaced learning frequency should be adapted to the needs of the learners and the organisation. However, the optimal scheduling of training sessions and the timing and frequency of sessions remains uncertain.[87] Nonetheless, the repetition of resuscitation competencies adapted to the learners' needs at least once a year seems reasonable.[83,87,88]

A stepwise approach to teach CPR skills involves organising teaching into progressive phases that optimise the acquisition of basic and advanced skills.[89] Whilst the stepwise approach to skills teaching is used widely in resuscitation training, there is no evidence to support one model over other stepwise methodologies.[6,89] An ILCOR review specifically looked into the effectiveness of Peyton's four-step approach for teaching resuscitation skills compared with alternative approaches, and 14 of 17 studies found no difference in skill acquisition or retention.[89] It is reasonable to limit stepwise skills teaching to skills of low to moderate complexity.[89–91] The ERC in line with ILCOR recommends that the number and order of steps should be adapted according to contextual factors such as the time available for teaching (with a focus on practice time), the complexity of the skill taught, and the group composition of participants (e.g., beginners vs. experts; lay persons vs. HCPs; group sizes).

Cognitive aids, such as decision-making algorithms and checklists, incorporated in resuscitation improve adherence to guidelines and reduce cognitive load during emergencies for HCPs.[53] Therefore, instructors should consider their use during resuscitation training. Bystanders should not use them as this may delay critical actions, therefore, their benefit during bystander training remains unclear.

Educational goals in basic life support courses

Basic life support education in any setting needs to teach effective delivery of chest compressions and ventilations and the safe use of AEDs. Chest compressions can be taught from early childhood (4–6 years) but the effectiveness of chest compressions depends on the physical abilities of the rescuer.[19,20] Because of their user-oriented design, even untrained users (including children) should be able to follow the instructions to use an AED safely.[92] However, training of AED use including rescuer safety is still beneficial.[93–95]

Traditionally, BLS courses teach every rescuer mouth-to-mouth/nose and/or mouth-to-mask ventilation. Ventilation is an important skill, especially in certain situations such as paediatric cardiac arrest, drowning, or asphyxia. In some cases—such as when there is a risk of infection—bag-mask ventilation may be the preferred method. However, mastering this skill can be challenging for many non-HCPs and even for some HCPs, particularly those who do not use bag-mask ventilation regularly in clinical practice. Nonetheless, improving proficiency in this technique can result in at least partial lung ventilation, which is preferable to providing no ventilation at all.

Performing two-person ventilation, with one holding the mask with two hands (two-hand mask ventilation) and the other squeezing the bag, may improve the seal of the mask and the chance of effective oxygenation and ventilation and therefore is the recommended technique.[96] The Education Writing Group suggests teaching bag-mask ventilation to first responders and HCPs who normally provide

BLS, especially when there is a risk of infection. In contrast to mouth-to-mouth ventilation, bag-mask ventilation during training on a manikin carries no risk of infection.

Basic Life Support (BLS) courses should include guidance on effective communication with EMS dispatchers, focusing on how to provide and receive accurate information to avoid unnecessary delays in starting resuscitation. First responders should also learn how to deliver a structured handover to emergency medical services (EMS) or HCPs.[97] The specific BLS competencies taught should be tailored to the needs of the learner group—there is no one-size-fits-all approach.

Resuscitation courses should address barriers to performing CPR that rescuers might experience. These include: personal factors (e.g., emotional barriers, panic), socio-economic factors (e.g., gender issues[98], cultural beliefs), physical factors (e.g., ability to place the patient flat), CPR competency (e.g., skill deficits, fear of causing injury/doing something wrong), and procedural issues (e.g., communication and language barriers, recognition of cardiac arrest).[6,14,99,100]

Factors that increase rescuers' willingness to perform CPR are prior CPR training, community CPR awareness programmes, chest compression-only programmes in massed training, and CPR-trained rescuers with a higher educational degree.[51,101] BLS education plays an important role in encouraging broader participation of rescuers in community programmes that aim to provide help for people in life-threatening situations (e.g., first aid, first responder systems, public AED programmes, and schoolchildren's CPR programmes).[51,102,103]

There is no one duration of BLS courses that suits all learners, because this depends on the previous resuscitation education of the rescuers, the specific learning goals for a given group of learners, and local societal and cultural educational factors. Examples range from very short BLS introductory sessions to 2-hour or longer BLS courses for all types of learners.[104–106] An example of the former is the ERC fan-zone training sessions that were developed for the ERC UEFA awareness campaign during the European Football Championship 2024, which had a mean duration of 5 min. The theoretical background needed for BLS of any type can be taught online as part of a blended learning approach to reserve the on-site training time for hands-on practice.

Educational goals in advanced life support

Basic life support is an integral part of any type of ALS education but needs to be adapted to the learners. Specific learning goals for neonatal, paediatric, and adult life support are airway management, manual defibrillation, vascular access, a structured approach to managing critically ill patients, application of advanced resuscitation in special situations and circumstances, treatment of *peri*-arrest arrhythmias, and immediate post-resuscitation care. The time and effort to teach these competencies should be adapted to the learners' profession and clinical duties. For this reason, ERC ILS/ALS courses have implemented a modular approach to adapt courses to the needs of participants. A core part of these courses is team competencies,[7,107] which include team leadership, task allocation, structured communication, and handovers.[108,109] The teaching of teamwork competencies should improve patient care and may reduce medical errors and improve patient safety.[109–111]

Technology-enhanced learning (TEL) for resuscitation

Technology-enhanced learning (TEL) refers to the effective use of educational technologies to achieve specific learning objectives. It can facilitate, support, and enrich both teaching and learning, making resuscitation education more accessible, engaging, and effective. These innovative tools have the potential to rapidly transform how resuscitation is taught.[112] Real-time chest compression feedback devices,[73] especially those incorporating gamified learning elements, can make training more enjoyable and effective.[52] Immersive technologies such as augmented reality enable learners to engage with complex, lifelike scenarios in a safe, controlled environment. TEL strategies promote the development of both technical and non-technical skills, including decision-making, teamwork, and situational awareness.[113] Despite these advances, several common barriers to the adoption of TEL in resuscitation education remain. These include hardware costs, software reliability, limited access, reluctance to adopt new technologies,[6] and varying levels of user proficiency.[1]

Online learning and artificial intelligence in resuscitation education

Online learning modalities, including podcasts and social media,[114] provide flexibility in time and location and enable learners to access content conveniently thus promoting asynchronous learning and emphasising learner autonomy.[50,115] Online learning is often integrated into blended learning strategies to enhance engagement and knowledge transfer for the on-site, hands-on training.[50]

Artificial intelligence (AI) simulates human intelligence, including learning, reasoning, problem-solving, and decision-making, through rules, algorithms and data processing. Generative AI may assist in resuscitation teaching.[77,78] Despite the increasing popularity of AI,[116] there is very little evidence on how AI can influence resuscitation education. A scoping review found six applications of AI in resuscitation education: measuring and providing feedback on CPR performance, personalising learning trajectories, detecting ineffective communication, generating medical images for resuscitation training, creating interactive and adaptive online simulations, and enabling AI-powered chatbots to answer resuscitation-related questions.[117] Multiple AI tools that measure successful CPR metrics have been published.[118–122] Some of them can provide direct feedback.[121,123] Further promising applications are creating personalised learning trajectories and helping detect ineffective verbal communication during resuscitation training.[118,124,125] In a test of a generative AI's (ChatGPT AI model, free research preview, March 14, 2023 version) ability to provide accurate and comprehensive answers to lay persons' questions about cardiac arrest and CPR, experts in the field agreed that the generative AI provided largely accurate, relevant and comprehensive answers.[126] However, it still needs to be optimised for use in early clinical education.[127]

Concerns about AI use in resuscitation education include the need for expert validation of content and teaching material,[128,129] and ethical concerns regarding data privacy and algorithm bias.

Simulation-based resuscitation education

Simulation has been a key component of life support education for many years. It relies on the concept of a willing suspension of disbelief, enabling learners to develop skills and behaviours that may push them beyond their comfort zone to indicate a learning process.[130–132]

The advantages extend beyond individuals to entire teams, enhancing both technical and non-technical skills and competencies training and collaboration.[109,133] By participating in simulations, learners can reinforce their real-world experiences, and this approach is especially effective for developing and managing human factors and team competencies. The recommendations on simulation for CPR training are based on new or updated evidence on various aspects (fidelity, in-situ learning, gamified learning, team competencies, CPR coaching, and scripted debriefing) that contribute to this approach.[7,51]

Fidelity

High-fidelity manikins have been introduced to enhance learner engagement by increasing physical realism. Physical realism means the presence of physical features, be it visible, palpable, and/or audible, that are designed to increase the resemblance of the manikin to an actual patient.[134] This enables participants to train in an environment that more accurately reflects real clinical practice.[135–137] A systematic review comparing the use of high-fidelity manikins with low-fidelity manikins for BLS and ALS training (adults, paediatrics and neonatal) included 21 studies.[51,134] The use of high-fidelity manikins favoured skill performance at course conclusion, CPR parameters at course conclusion, and attitudes and preferences. At course conclusion, no difference between the two groups was found for knowledge, time to task performance, or teamwork. There was also no difference in clinical performance and knowledge at 3 months or greater. In summary, high-fidelity manikins can be used for CPR training when training centres or organisations have the infrastructure, trained personnel, and resources to maintain the program. The use of high-fidelity manikins improved skill after ALS courses but did not show advantages over low-fidelity manikins in BLS teaching.[134] The substantial costs of the implementation and maintenance of high-fidelity manikins limit their adoption in lower-resource settings. When high-fidelity manikins are not available, it is reasonable to use low-fidelity manikins for standard ALS training.[134]

In-situ learning

Providing training within patient care areas has the theoretical advantage of providing learning in the context of the real clinical environment and assessing the organisational structure.[138] A systematic review comparing in-situ (workplace based) simulation-based CPR training with traditional training for HCPs included four studies.[139] One non-randomised study reported an association between in-situ training and higher odds of survival at hospital discharge in children who experienced cardiac arrest.[140] Another non-randomised study reported a lower incidence of patient complications in newborn resuscitation during the period when in-situ training was ongoing.[141] In situ simulation may be considered as an option for CPR simulation, as it might improve patient survival, clinical performance, and teamwork competencies in actual resuscitations.[51,139]

Team competencies

Team competencies can be defined as non-technical skills related to teamwork, including team-related communication, specifying goals, structured handovers, coordinated behaviours, task allocation, sharing the mental model, situational awareness, and performance monitoring.[7,107] Simulation-based resuscitation training is the domain for team competencies training and their inclusion has shown to improve performance and, whilst outcomes vary, their impact has been largely positive.[7,107,142] A systematic review, which was recently updated, included a total of 19 studies and identified variable but mainly positive outcomes in relation to team competencies.[7,107]

CPR coaching in CPR simulation

A CPR coach is a resuscitation team member whose primary responsibility is to provide real-time coaching on resuscitation quality. A systematic review comparing the use of a CPR coach with no coach in healthcare teams managing adult or paediatric cardiac arrest included seven studies.[143] CPR performance in both clinical and simulation settings was improved with use of a CPR coach. There was also greater adherence to guidelines in a simulation setting. As no harmful effects were observed and CPR coaches are already included in resuscitation teams in many hospitals, it is reasonable to include them in cardiac arrest resuscitation teams in sufficiently staffed settings.[143] Therefore, the ERC advises considering the inclusion of CPR coach training in life support courses.

Scripted debriefing

Debriefing scripts and tools have been developed to help standardise the approach to debriefing during resuscitation training.[144] None of the six studies included in a recent scoping review reported patient or process outcomes in real resuscitations.[145] However, a good practice statement supports the use of scripted debriefings after simulation in resuscitation because they may improve learning and performance.[7,145]

Assessment in resuscitation education

Learner assessment is essential to determine whether the competencies outlined in the learning objectives have been achieved. Key components of assessment include direct observation of performance, asking clarifying questions to understand the learner's reasoning, and encouraging self-assessment, which can offer valuable insights for discussion during feedback sessions. Assessment results can be documented using either advanced digital tools or traditional paper-based checklists. Reliable and validated tools are necessary for this purpose.[146] Objectively recorded CPR quality data can also support both assessment and subsequent data-driven feedback.[73] This contributes to robust and defensible assessment outcomes, ensuring credibility for course participants and for stakeholders who require certification.

An instructor's perspective during assessment enables critical reflection on participants' self-assessments, which may sometimes differ from their actual performance. Multiple assessments conducted over time by different assessors provide a more comprehensive picture of learner performance. These can be used for ongoing feedback and development (formative assessment), or to evaluate competence through small, spaced summative assessments (continuous assessment). Initial evaluations of this approach have shown no effect on pass–fail rates, but have reported increased learner satisfaction; however, more rigorous research is needed to confirm these findings.[147]

Summative assessments, typically conducted at the end of training, are used to determine whether the required competency level has been reached and usually serve as the basis for awarding course completion certificates.

Feedback and debriefing in life-support courses

Feedback and debriefing are essential elements of resuscitation courses as both strategies are powerful interventions to promote

learning.[144,148–151] Feedback and debriefing are related concepts and sometimes cannot be separated easily, yet the concepts serve different purposes and have distinct characteristics. Whilst feedback primarily aims at providing specific and timely guidance for immediate performance improvements, debriefing seeks to facilitate deeper reflection and understanding to enhance long-term development. This section provides principles of feedback for life support courses and gives a rationale for incorporating team debriefings into simulated cardiac arrest teaching.[152]

Feedback

Feedback aims to provide specific performance information to help improve future actions, mostly to promote immediate improvement. Feedback is not a 'one-way' input by the feedback provider,[153] but also requires the skill and literacy of the feedback recipient.[154] Contemporary feedback avoids ritualistic rules such as 'praise and criticism need to be balanced'.[153] Instead, feedback providers should develop an authentic interest in the learner's improvement by offering a shared perspective on the learner's performance, which includes a learning-friendly climate with sufficient psychological safety[155] and both parties agree on an educational alliance.[156] Real-time coaching, as one kind of feedback, has been shown to improve CPR quality and adherence to guidelines among HCPs predominantly in a simulated setting.[143]

Different levels of feedback have been described,[148,149] which explains its variable effects, ranging from negative (if feedback is given unspecific and with negative connotations)[157] to highly positive (if feedback focuses on identifying strengths and areas for improvement). Feedback which promotes self-regulation in learners has a significant positive impact on their development and performance. At the self-regulated level, feedback moves beyond just indicating whether an answer is right or wrong (task level) or suggesting a better process (process level). Instead, it focuses on empowering the learner to monitor their own learning, evaluate their own work, and direct their own learning.[149] It should be a conversation exploring the individual path of the learner to improve their performance. By formulating the next learning goals, the learner's motivation for achieving these is increased.

In life support courses, feedback sessions should be concise so that there is sufficient time to focus on the course's core learning objectives. However, brief reflection on key principles underlying effective performance—such as teamwork competencies—is essential. To gain learner engagement, it is helpful to begin with points raised by participants, often emerging during the team debriefing. Nonetheless, the instructor's perspective on performance is equally important and should be addressed. Because resuscitation is a team effort rather than a solo 'heroic' act, the entire group should be involved in identifying strategies for improvement. Any relevant open questions should be answered before summarising the key learning points.

Team debriefing as part of cardiac arrest scenario teaching

Debriefing as part of Kolb's learning cycle[158] aims to reflect on and analyse an activity to understand what and why it happened and how it can be improved.[150,159] Compared with feedback, debriefing tends to be less directive and less focused on specific actions,[160] as debriefing aims to change the learners' frames for long-term development.[159,160] Debriefings in clinical settings can help the resuscitation team cope with significant events (e.g., a stressful resuscitation in real life), or be used for quality assurance (e.g., after a routine resuscitation). In clinical practice, team debriefings have been shown to improve outcomes.[51,161–166] For this reason, after performing a cardiac arrest training scenario, participants should practice to perform a concise short clinical team debriefing to practice this self-reflection and encourage such a debriefing after real resuscitation situations. During training, such team debriefing can provide valuable insights for instructors and serve as a starting point for the feedback session. The team debriefing after cardiac arrest training that is performed between the course participants should not be confused with the feedback provided afterwards by instructors which is used to initiate reflection on the performance during the training.

Faculty development

The quality of teaching delivered by instructors has the largest effect on learning outcomes.[167] A systematic review of *meta*-analyses in higher education found that faculty development significantly impacted student achievement.[168] *How* a method is applied has more impact on learning than *which* method is used. Effective instructors carefully design their courses, set clear learning goals, and provide meaningful, tailored feedback.[168] Although the importance of faculty development is widely recognised and implemented in instructor curricula, evidence of which educational methods and curricula are effective is limited, especially in resuscitation training.

Faculty development programmes can be evaluated by the impact on trained instructors (e.g., are teaching skills improved), on learners (e.g., are learnt skills implemented and used), and on outcomes the learners achieve applying the learnt competencies in their own practice (e.g., is faculty development impacting patient outcomes).

Most studies on faculty development come from other medical education areas and provide indirect evidence for resuscitation.[169] The few comparative studies that explored whether trained instructors led to better learning outcomes,[170] were summarised in an ILCOR scoping review[4] and updated in 2025.[51] This recent update identified two studies indicating that instructor courses with reduced face-to-face time were as effective as traditional courses.[171,172] Two other studies showed that teaching instructors to recognise and correct common student mistakes led to better BLS performance.[173,174] This suggests that faculty development programs should focus on strategies to identify and address common errors.

Structured high-stakes education of instructors aiming to improve learner outcomes is needed, as inconsistent instructor quality and ineffective content delivery were observed in BLS courses,[175–178] or little difference between students taught by trained versus untrained instructors was described.[179]

Three aspects of faculty development are important: selection of suitable instructors, initial instructor training, and maintenance and regular update of their teaching quality.

Selection of instructors

Instructors with diverse expertise and backgrounds should be recruited to teach resuscitation targeted at different learner groups. Some of these learners, particularly in BLS training sessions, might not have a professional background in healthcare (e.g., schoolteachers, lifeguards, volunteer members of first aid or charity organisations etc.). A systematic review found that schoolteachers, peer tutors, and medical students achieved similar educational outcomes compared with HCPs in resuscitation training for schoolchildren.[30]

Non-HCP training for schoolchildren is a viable alternative, as it can be smoothly and cost-effectively integrated into school curricula.[17,30,180] Basic lifesaving skills can be learnt from engaged persons who can enthusiastically teach these competencies with relatively little content expertise. However, HCPs might be included as content experts in faculty development programmes for BLS instructors who teach schoolchildren or laypeople.

It is important to include an appropriate level of knowledge to explain the details and the evidence behind the taught CPR competencies whilst avoiding overstraining the cognitive capacity of the learners. Future instructors should be aware of becoming role models paired with an appreciation of effective learning and motivational skills. Teaching should help learners understand when and how to apply what they've learned, and how their actions can influence patient outcomes. Because resources for faculty training are limited, selecting individuals who show supportive attitudes, intrinsic motivation, appropriate communication skills, and enthusiasm for resuscitation education is of utmost importance.

Instructor training

Faculty development in the form of seminars, workshops, series of teaching sessions, and fellowships are effective.[181] Practical learning formats, when coupled with constructive feedback,[153,182] are known as experiential learning and can be effective.[183–186] Instructor training needs to cover all teaching methods applied in courses that the instructors will teach, including the teaching of practical CPR skills, facilitation of interactive small-group learning, and basic presentation skills. Future instructors need to know how to establish competency-(outcome)-based teaching and learning settings, how to provide constructive and corrective feedback, and how to conduct valid assessments to guide further learning. They need to teach how to improve human factors, non-technical skills, interprofessional team competencies,[7,107] and how to use feedback devices during resuscitation training.[51,73]

Many BLS instructors, often non-HCPs, are required to teach larger population cohorts. Their teaching programs need to include how to demonstrate and perform high-quality CPR skills, how to provide immediate feedback on skills performance, how to answer questions properly, and how to use checklists for assessment. Their effective teaching can increase learner self-efficacy and learners' motivation to intervene promptly in an emergency.[187] Before teaching on actual courses, assessment of instructor competencies is needed. This should happen when future instructors teach courses under supervision with immediate peer support and feedback.

Maintenance of competencies

Maintaining competencies is essential for instructors, course directors, and educators to keep up with the developments in resuscitation and education science. This is the domain of self-directed, continuous professional development to avoid individuals 'doing their own thing'. Proposed strategies available are deliberate reflective practice, peer coaching, and establishing communities of practice. However, how educative competencies might best be maintained over time is unknown. Deliberate reflective practice describes self-reflection on one's performance to further improve performance,[188] including self-assessment[189,190] and acting as a role model.[191]

Peer coaching provides a valuable outside perspective, promotes mutual learning between peers, and strengthens communities of practice.[192,193] This can be performed within instructor teams during any course format. It requires mutual trust between instructors and might be the first step towards the development of communities of practice.

Communities of practice influence educational practice by sharing aims and views on teaching, and teaching materials, promoting peer coaching, and facilitating faster spread of information by helpful organisational support.[194] An example of such support is the ERC virtual learning environment CoSy, with virtual web-based formats of interaction, webinars and networking, or the educational instructor days.

Effect of resuscitation education on outcome

The ERC has a long history of delivering accredited life support training for HCPs covering the basic and advanced resuscitation of neonatal, paediatric, and adult patients. Participant attendance in life support courses incurs financial and time-related costs for both individuals and their institutions. It is therefore important, to show whether this participation has any meaningful impact on patient outcomes. Systematic reviews, including recent updates, showed improved survival of patients of all age groups if HCPs attended accredited advanced life support courses.[1,6,48,195]

The evidence is much more conclusive for the impact of hospital-based neonatal resuscitation training.[196] Overall, neonatal resuscitation training significantly improved patient outcomes, including the risk of stillbirths, neonatal mortality and perinatal mortality except for the 28-day neonatal mortality in low- to middle-resource settings. Helping Babies Breathe (HBB) is a simple and low-cost simulation-based training course designed to train HCPs in immediate neonatal resuscitation in resource-limited settings. A systematic review showed a reduced risk of intrapartum-related stillbirth and 1-day neonatal mortality after implementation of HBB training,[197] and an updated literature search included one further study reporting that implementation of HBB training was associated with significantly reduced perinatal mortality.[198]

The provision of accredited adult advanced life support training and neonatal resuscitation training is recommended for HCPs. Training such as Helping Babies Breathe is also recommended for HCPs in out-of-hospital low-resource settings. In the absence of demonstrable harm, it is reasonable to recommend similar accredited life support courses for e.g. paediatric life support, despite lacking evidence on their impact on patient outcomes.[51]

Resuscitation education in low-resource settings and remote areas

Resuscitation education in low-resource settings will be most effective when it is relevant to the learners' context. Recent narrative reviews from low-middle income countries[199–202] highlight that educational efforts need to be cognisant of factors such as cultural views and norms around death,[199–203] existing levels of community first aid knowledge, levels of training of HCPs dealing with out-of-hospital and in-hospital cardiac arrests, and resource availability.[204] Context may vary widely, even within countries,[202,205] and an adaptive approach towards available resources is advised.[206]

Four components of education highlighted in this context are: raising general awareness about resuscitation; BLS education for laypeople; community first responder programs, and school children resuscitation teaching programs.[206] Distance, virtual, hybrid and blended learning methods[50] offer opportunities to educate in these areas at relatively low costs, although the content will require adaptation to the local context. Artificial intelligence chatbots might help translate resuscitation teaching material and support wider dissemination, though evidence suggests they are not yet reliable enough.[207] Mnemonics[21] and low-cost mannikins[208] may be particularly useful in low-resource settings. Ideally, training should be offered at no cost to participants.[209] Evidence about the effectiveness of particular resuscitation education in low-resource settings is limited. Useful examples for future interventions are:

Educating the community (laypeople, first-responders, and children)

A recent scoping review identified 55 interventions aimed at improving the community response to OHCA in resource-limited settings.[210] In low/low-medium income countries, only CPR and AED training (conducted via a range of modalities) has been evaluated. Most studies demonstrated resuscitation training increased short-term knowledge, and some showed increased CPR skills. This might impact upon subsequent care for patients in cardiac arrest, but no data on outcome is available.

Educating healthcare providers (HCPs) worldwide

Helping Babies Breathe is an example of content tailored to causes of neonatal death in low- to middle-income countries, that improved outcomes for babies.[49,197,211] The World Health Organization's basic emergency care training initiative increased confidence in frontline providers with content and language perceived as appropriately tailored to the local context,[212,213] although patient outcome data is not available.

Multiple countries highlight the investment and years required to develop emergency medicine specialists who can then train the emergency medical services workforce.[200,201] The Global Resuscitation Alliance[212] recommends a graded approach to strengthening systems in low-resource settings, which is consistent with an ILCOR consensus statement.[206] This recommends that education needs to be aligned with each graded development, e.g., public education alongside the introduction of an emergency medical system, or public access defibrillator familiarisation before or concurrent with the placement of public access defibrillators within communities. Resuscitation organisations that provide educational or research opportunities to early-career professionals should ensure equitable access to those from low-resource settings.[213]

It is acknowledged that most recommendations made in this education guideline have been derived from studies in high-resource settings. The evidence about their effectiveness or applicability in low-resource settings is lacking.[214]

Remote areas

Remote resuscitation training uses technologies like videoconferencing, telemedicine approaches, and smartphone applications, to deliver instruction in life-saving skills to individuals with limited access to traditional in-person curricula. Simulation-based remote paediatric resuscitation training was reported as effective.[215,216] Significant research on remote neonatal resuscitation training compared remote versus in-person training methods,[217] investigated the utility of digital technologies and smartphones,[218] and tele-simulation[219–221] over time. The studies showed either noninferiority to standard training or that neonatal resuscitation skills were improved from baseline. A recent scoping review summarises that lower-cost digital methods such as mobile applications, simulation games and/or mobile mentoring engage HCPs in skills learning and improve neonatal resuscitation.[222] Remote tele-coaching improved performance.[223] Virtual feedback, debriefing, and skill assessment via videoconferencing technologies were used successfully,[224–229] and virtual instructor training exists.[172]

Collaborators

The following individuals contributed as collaborators to the 2025 version of this guideline, Patricia Conaghan and Kevin Mackie.

Declaration of competing interest

Declarations of competing interests for all ERC Guidelines authors are displayed in a COI table which can be found online at https://doi.org/10.1016/j.resuscitation.2025.110739.

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Practice Guideline

European Resuscitation Council Guidelines 2025 Ethics in Resuscitation

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Abstract

These Guidelines of the European Resuscitation Council (ERC) on Ethics in Resuscitation provide evidence-informed recommendations on the ethical considerations of resuscitation, focusing on advance care planning, the involvement of bystanders and first responders, family presence during resuscitation, termination of resuscitation, and ethical considerations for systems, education, research, and low-resource settings. The recommendations in this chapter are informed by the Consensus on Science and Treatment Recommendations (CoSTR) by the International Liaison Committee on Resuscitation (ILCOR), focused reviews by the ERC Ethics Writing Group of the ERC Guidelines 2025 on Ethics in Resuscitation, and expert consensus within the writing group.

We have emphasised considerations for out-of-hospital cardiac arrest, in-hospital cardiac arrest, and paediatric cardiac arrest throughout the guidelines. These guidelines aim to ensure that resuscitation decisions are made in alignment with patient values and preferences, and they emphasise the importance of a patient-centred approach to care. The Guidelines also address the balance between beneficence and autonomy, stakeholder involvement, transparency and the use of artificial intelligence in resuscitation research, and the multiple aspects for education in ethics in resuscitation.

Keywords: Resuscitation, Cardiopulmonary resuscitation, Cardiac arrest, Ethics, Advance care planning, Termination of resuscitation, Organ donation, Bystander, Family involvement, Low-resource setting, Suicide, Education and systems, Research ethics

Introduction

The ethical dimensions of resuscitation have become increasingly important as the field evolves. Ethics as an integrated part of medical care involves the principles and decision-making frameworks that guide the management of patients in cardiac arrest, ensuring that interventions are aligned with the values and preferences of patients and their families. This section of the European Resuscitation Council (ERC) Guidelines 2025 provides evidence-informed recommendations for the ethical aspects of resuscitation and end-of-life care of adults and children (Table 1).

We base these guidelines on the International Liaison Committee on Resuscitation (ILCOR) Consensus on Science and Treatment Recommendations (CoSTR), focused reviews undertaken by the Writing Group of the ERC Guidelines 2025 Ethics in Resuscitation, and expert consensus when no evidence was available. Considering the complexity of ethics, we included a patient representative and an

Abbreviations: ERC, European Resuscitation Council, EU, European Union, ILCOR, International Liaison Committee on Resuscitation, CoSTR, Consensus on Science and Treatment Recommendations, DNACPR, Do-not-attempt cardiopulmonary resuscitation, TOR, Termination of resuscitation, CPR, Cardiopulmonary resuscitation, OHCA, Out-of-hospital cardiac arrest, IHCA, In-hospital cardiac arrest, $ETCO_2$, End-tidal CO_2, ROSC, Return of spontaneous circulation, AI, Artificial Intelligence, RCT, Randomised controlled trial

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ethicist as collaborators for the writing group to provide perspectives for the included topics, the expert consensus, and guideline text. For these guidelines, we conducted focused literature reviews on the ethical aspects for each of the topics: (1) advance care planning, (2) the ethical involvement of bystanders and first responders, (3) family presence during resuscitation, (4) termination of resuscitation (TOR), (5) uncontrolled organ donation after circulatory death, (6) suicide attempts, (7) education and systems, (8) ethical challenges in low-resource settings, and (9) resuscitation research (Fig. 1). Additionally, we compiled key ethical considerations to strengthen visibility of selected core issues across topics. We did not review do-not-attempt cardiopulmonary resuscitation (DNACPR) orders as specific topic but rather considered DNACPR as a part of advance care planning. Likewise, we did not review shared decision-making as a specific topic but refer to other international guidelines on this including the 2021 ERC Ethics Guidelines.[1–4]

These guidelines were drafted and agreed upon by the Ethics Writing Group and the Guidelines Steering Committee, before being posted for public comment. A total of 29 individuals submitted 32 comments, leading to four changes in the final version. The guidelines were presented to and approved by the ERC Board and the ERC General Assembly in June 2025. The methodology for the guideline development is outlined in the Executive Summary.[5]

We use 'CPR' in these ERC Guidelines 2025 Ethics in Resuscitation as the entire procedure of resuscitation and not just in the context of chest compressions and ventilation. We used the term 'family' to include all significant others, close friends, or co-survivors (Fig. 1).

Concise guidelines for clinical practice

Advance care planning

- Healthcare systems should offer advance care planning to all patients expressing wishes to discuss goals of care.
- Decisions of DNACPR are best made in the broader context of advance care planning.
- Anticipatory decisions, whether to attempt CPR or not, should be taken regardless of the time of the day in all patients with a significant risk of cardiac arrest. For patients not under imminent risk, it is appropriate to plan for the discussion and decision-making to take place at daytime.
- Document decisions of DNACPR and on which of the three different grounds the decision is based: (1) CPR will not be appropriate since death is expected; (2) CPR not in a beneficial balance between the medical assessment and the patient's values; (3) or the patient does not wish to receive CPR.
- For patients with cognitive impairment, invite a substitute decision maker to ensure concordance in goals of care over time.
- Offer patient-centred education about advance care planning to patients before discussions on this topic.

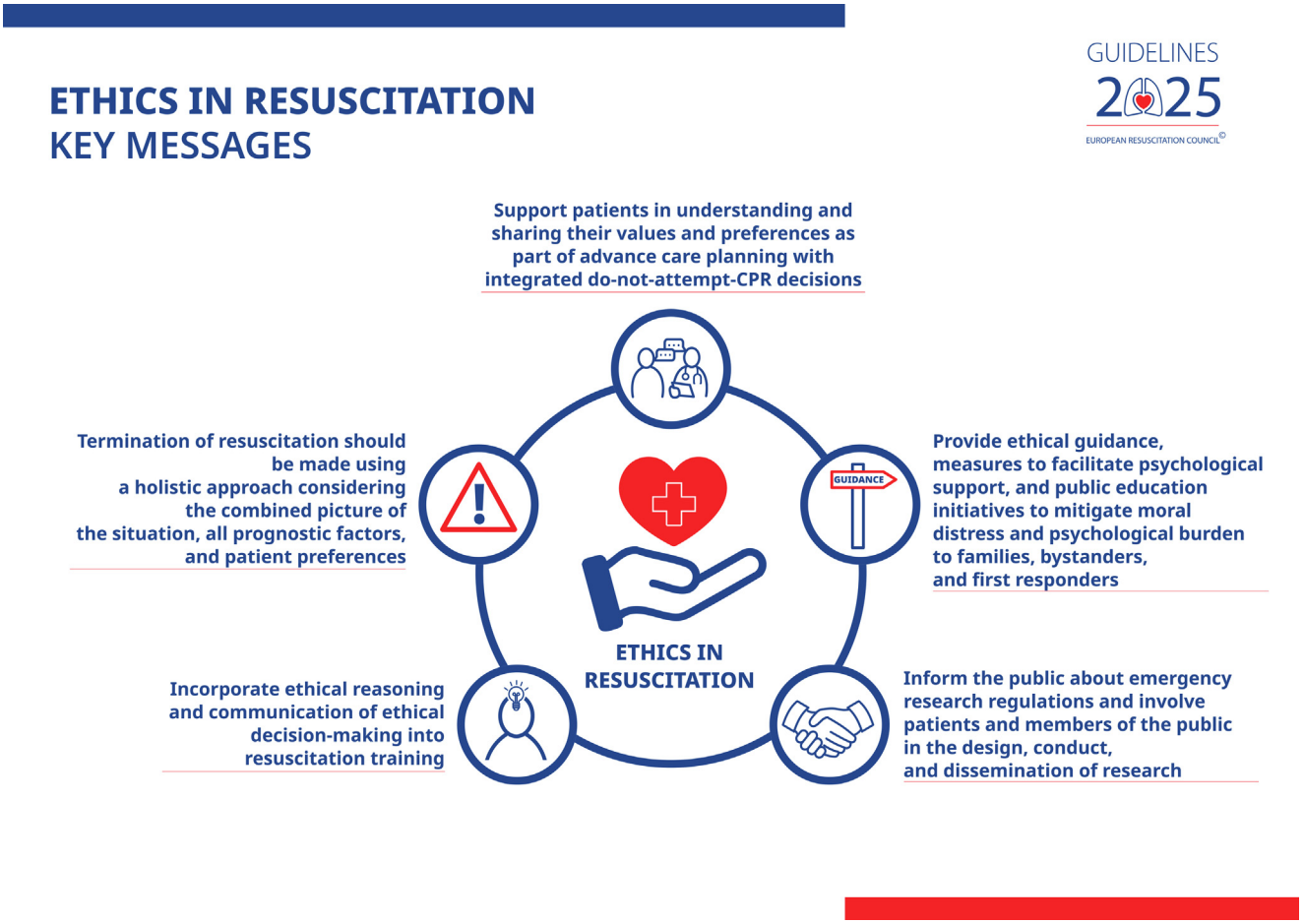


Fig. 1 – Ethics in resuscitation – key messages.

Table 1 – The major changes in the ERC Guidelines 2025 for Ethics in Resuscitation.

Topic	2021 Guidelines	2025 Guidelines
Advance care planning	Advance care planning recommended for patients at high risk of cardiac arrest or poor outcome.	Advance care planning is recommended for patients at risk; re-assess regularly, especially when situations change. Provide patient-centred advance care planning education before initiating advance care planning discussions.
Bystanders and first responders involvement	Bystander CPR is voluntary; no moral or legal obligation to perform. Dispatch-assisted CPR is recommended but is seen as a tool to increase bystander participation.	Maintains recommendations and adds that strategies to reduce biases in bystander CPR, such as cultural and gender sensitivity education should be introduced. Provide mental health resources and mechanisms to reach bystanders and first responders in need of further support.
Family presence	Offers the option for family members to be present during resuscitation, as long as it is safe, and a team member is available for support.	Recommends structured and culturally sensitive procedures for family presence during resuscitation. Recommends designating a team member to support family members during resuscitation.
Termination of resuscitation (TOR)	Systems should implement criteria for termination of CPR. TOR rules may be used for all cardiac arrest patients.	TOR is a team-based decision using a holistic approach. TOR rules should only be used for adult out-of-hospital cardiac arrest patients following local validation. Debriefing should be sought following termination.
Uncontrolled organ donation after circulatory death	Ethical guidance for organ donation in general	Healthcare systems should assess policies, education, communication, and strategies regarding organ donation to improve organ availability and ensure that TOR practices do not conflict with possible organ donation. Transparent procedures should be accessible for uncontrolled donation.
Ethics of education and systems	Not addressed.	Emphasises integration of ethical reasoning as a core competency in resuscitation education. Standardise institutional policies and develop formal education programs to address moral distress and ethical decision-making.
Cardiac arrest as a result of a suicide attempt	The decision to withhold or withdraw CPR in suicide attempts is based on the patient's values and wishes, including advance directives.	Provide individualised, context-sensitive approaches. Start resuscitation by default whilst assessing clinical and contextual information.
Ethical considerations in low-resource settings	Not addressed.	Stresses the particular importance of DNACPR in low-resource settings. Emphasises that TOR rules for OHCA may be a cost-effective strategy to minimise futile transports.
Resuscitation research ethics	Advocates for high-quality emergency research with emphasis on the necessity of pre-enrolment consent models. Recommends transparency and respect for patient dignity, with institutional ethical review committee involvement for all research.	Deferred consent model expanded to include non-drug investigational interventions, with safeguards for patient autonomy. Calls for education of the public on applicable regulations and the necessity of deferred consent for emergency research. Addresses benefits and risks related to the use of artificial intelligence in emergency research.

Abbreviations: Do-not-attempt-cardiopulmonary-resuscitation (DNACPR); cardiopulmonary resuscitation (CPR); return of spontaneous circulation (ROSC); termination of resuscitation (TOR); Out-of-hospital cardiac arrest (OHCA).

- Document advance care plans in a consistent manner that is available in emergency care settings (e.g. electronic registries, standardised documentation templates).
- Use advance care planning to identify treatments and interventions that should be avoided upon hospital admission at the end of life.
- Reassess advance care plans regularly and when a patient's situation changes.
- Facilitate patient and family caregivers' understanding of their preferences, as mutual understanding can optimise the decision-making process for all involved.
- Organise local educational hubs focusing on skills and competencies when undertaking goals of care discussions.
- Communication skill training should be part of the continuous professional development for healthcare providers involved in advance care planning and end-of-life care.

Ethics of bystander and first responder involvement

- Ensure that bystanders are not forced or unduly compelled into performing CPR, respecting their personal autonomy in resuscitation decision-making, while acknowledging the 'duty to help'.
- Mitigate moral distress among bystanders and first responders by offering ethical guidance for navigating situations involving difficult or distressing interventions.
- Health care systems should implement measures to facilitate psychological support for bystanders and first responders following out-of-hospital cardiac arrest (OHCA), e.g. through surveys or defusing to identify people in need of additional support and/or by providing contact information for further psychological support.
- Clarify legal and ethical protection for bystanders to reduce hesitation due to fear of liability or moral responsibility.
- Implement strategies to minimise the impact of biases in bystander intervention, ensuring that factors such as gender, cultural background, or the patient's social identity do not influence resuscitation decisions.
- Clearly articulate the ethical boundaries of bystander responsibility in OHCA response, carefully distinguishing between moral obligations and legal or medical duties and delineating how these distinctions can be navigated effectively within the context of the legal-moral duty to assist.
- Implement safeguards in bystander alert systems to protect patient autonomy and prevent unwanted or inappropriate resuscitation attempts, while also ensuring that the bystanders' autonomy is respected in their decision to intervene.

Family presence

- Resuscitation teams should offer the family of cardiac arrest patients the choice to be present during the resuscitation attempt.
- Healthcare systems should establish clear, contextualised, and culturally sensitive procedures for the involvement of family members.
- Healthcare systems should specifically train their teams to support family members during resuscitation.
- As far as reasonably practicable, healthcare systems should have a trained team member who can be designated to this task as part of the overall CPR strategy and choreography.

Termination of resuscitation

- Make a team-based decision to terminate resuscitation based on a holistic approach considering patient values and preferences and the combined picture of prognostic factors including duration of CPR, the absence of reversible causes, and the absence of response to advanced life support.
- TOR should be carried out in a planned manner and all team members should have the opportunity to weigh in before termination.
- The team should conduct a debriefing immediately following termination.
- TOR may be considered when the patient has persistent asystole despite 20 minutes of advanced life support in the absence of any reversible cause when no other clinical factors suggest against.
- TOR rules may be used to aid decision-making for adult patients with OHCA following local validation and considering local values and preferences.
- TOR rules should not be used for in-hospital cardiac arrest (IHCA) and for paediatric patients in any setting due to insufficient evidence.
- Persistently low end-tidal CO_2 ($ETCO_2$) is a strong prognostic marker that may be used to aid decision making on top of other factors but should not be used in isolation.
- Other factors such as cardiac ultrasound, blood gases, and pupil reactiveness are not valid factors for termination of resuscitation.

Uncontrolled organ donation after circulatory death

- Healthcare systems should assess their current policies and strategies regarding organ donation to improve organ availability while considering their sociocultural and religious context.
- Healthcare systems should invest in education and communication for both citizens and healthcare professionals.
- In healthcare systems that offer uncontrolled donation after circulatory determination of death, transparent procedures should be accessible to all those involved. These procedures should cover aspects such as donor identification, consent, organ preservation, and procurement.
- Moreover, TOR practices within these systems should be reviewed and adjusted to ensure they do not conflict with the possibility of uncontrolled organ donation after circulatory death.

Ethics of education and systems

- Establish ethical reasoning as a core competency in resuscitation education to strengthen critical thinking, ethical judgment, and decision-making that respects patient autonomy, follows medical best practices, and aligns with societal values.
- Implement simulation-based ethics training to provide healthcare professionals with hands-on experience in ethically complex resuscitation scenarios, including cases involving communication and decision-making regarding advance care planning, DNACPR decisions and TOR decisions.
- Introduce ethical preparedness education for resuscitation providers to develop strategies for managing moral distress, addressing ethical dilemmas, and overcoming institutional constraints that impact decision-making in high-pressure situations.

- Standardise institutional policies on advance care planning, DNACPR decisions, and TOR by embedding structured ethical frameworks that provide clear, legally and professionally aligned guidance for resuscitation decisions.
- Develop formal education programs to equip healthcare professionals with the skills to navigate institutional constraints, legal uncertainties, and policy inconsistencies in ethically complex resuscitation cases.
- Establish ethical oversight mechanisms within resuscitation policies to promote patient-centred, transparent, and ethically sound decision-making at institutional levels.

Cardiac arrest as a result of a suicide attempt

- In making decisions about withholding or withdrawing resuscitation in patients after attempted suicide, teams should consider various factors, such as context, patient motivations, and competing rights.
- In the existence of an advance directive, we still suggest initiating resuscitation until the context and background–clinical and ethical–of that advance directive is fully known.
- The response to the clinical situation should be tailored to the individual patient and not be dogmatic.
- If resuscitation likely results in significantly more harm than benefit, then the cause (being suicide) becomes irrelevant.

Resuscitation research ethics

- Systems should support the delivery of high-quality emergency research, as an essential component of optimising patient-centred cardiac arrest outcomes.
- Regulatory and procedural barriers to high-quality emergency research related to consent models should be minimised by legal improvements. For example, clear legal support for deferred consent may be extended to non-drug investigational interventions to minimise any pertinent ambiguity, while still maintaining adequate safeguards for patient and family autonomy, dignity and privacy.
- For observational research (e.g. in the context of registry data collection and/or DNA biobank data sampling and analyses) we suggest consideration of a deferred consent model, with concurrent implementation of appropriate safeguards aimed at preventing data breaches and patient reidentification.
- Researchers should involve patients, and members of the public as community advisors, throughout the research process, including design, delivery and research dissemination.
- Systems should promote education of the public regarding applicable regulations and the necessity of using deferred consent for emergency research. This initiative may enhance willingness for research participation.
- The use of a core outcome set, along with standardised corresponding terminology, should be harmonised across trials investigating clinical effectiveness.
- Communities or populations in which research is undertaken and who bear the risk of research-related adverse events, should be given the opportunity to benefit from its results.
- Researchers should comply with best practice guidance to ensure integrity and transparency of research, including study protocol registration, prompt reporting of results, allocation of authorship according to international criteria for authorship, and data sharing.
- Policies of governments, public health bodies, international societies, and non-profit organisations should aim to ensure that funding for cardiac arrest research is sufficient to effectively address the high societal burden caused by cardiac arrest-associated morbidity and mortality.
- Health authorities should augment systems' resilience to pandemic-associated (or other calamity-induced) disruption of resuscitation research by cost-effective use of available computer

Table 2 – ERC Guidelines 2025 consensus definitions and statements, adapted from ERC Guidelines 2021.[2]

Definitions and statements related to advance directive(s)	
Advance directive	An instrument that relays information concerning an individual's preferences and goals regarding medical procedures and treatments, especially those used for end-of-life care. Advance directives are intended to extend the patient's autonomy to situations in which he/she is unable to express his/her preferences regarding treatment decisions. They reflect a patient's individual moral, cultural, and religious attitudes. They are represented in three formats: Living will (or instruction directive), appointment of a healthcare proxy (or proxy directive), and legal status of preferences.
Advance directives criteria	Advance directives must fulfil three criteria: Existence, validity (partly realised through periodic review), and applicability.
Definitions and statements related to advance care planning	
Advance care planning	A process that enables individuals to define goals and preferences for future medical treatment and care, to thoroughly discuss these goals and preferences with family and healthcare professionals, and to record and review these preferences if appropriate. The main objective is to help ensure that people receive medical care consistent with their values, goals, and preferences during serious, chronic, and/or acute/life-threatening illness.
Advance care plans	Plans that should be updated or re-reviewed, considering the availability of new and improved therapies that might affect patient preferences. Patient preferences may also evolve over time independently of available treatment options.
Definitions and statements related to shared decision-making	
Shared decision-making	A collaborative process that enables patients, or their surrogates, and a multidisciplinary team of healthcare professionals to identify treatment strategies and interventions that align with the patient's values, goals, and preferences. This process includes life-support limitation and palliative care, taking the best available scientific evidence into account, and fostering trust and partnership between patient/surrogate(s) and clinician(s).

and telecommunication/telemedicine technology and infrastructure, and other occasion-specific measures, such as personal protection and widespread/prompt vaccination.

- Use of artificial intelligence (AI) in research should be regulated according to rigorous ethical and scientific safeguards for beneficence, autonomy/privacy and justice. As an example, development of new AI algorithms should be based on broad datasets from the general population, rather than datasets from socioeconomically privileged groups.

The evidence informing the ethics in resuscitation guidelines

Advance care planning

An international consensus defined advance care planning *as a process that supports adults at any age or stage of health in understanding and sharing their personal values, life goals, and preferences regarding future medical care. The goal of advance care planning is to help ensure that people receive medical care that is consistent with their values, goals and preferences during serious and chronic illness. For many people, this process may include choosing and preparing another trusted person or persons to make medical decisions in the event the person can no longer make his or her own decisions.*[6] The ERC Ethics in Resuscitation Writing Group recognises that the definition only considers adults but we reviewed evidence and provide recommendations for both adults and children (Table 2).

Advance care planning takes a holistic, patient-centred approach, incorporating clinician-led discussions about limitation in life-sustaining treatment (Fig. 2). Healthcare professionals and patients are more likely to encounter a DNACPR decision than an IHCA, as observational studies show that only about 3–8 % of patients who die in the hospital actually receive CPR.[7,8] Further, about one in ten of acutely admitted patients receives a DNACPR decision and among those dying, in-hospital death most often occurred after several days.[9,10] Yet, a recent scoping review has demonstrated more barriers than facilitators of good practice of DNACPR decisions, barriers relate to timing, time-pressure, communication and ethical uncertainty.[11] Studies have shown that inappropriate or absent documentation of DNACPR decisions can result in either unwanted attempts of CPR or moral trauma among staff, who may hesitate or delay resuscitation efforts due to uncertainty.[12,13] Findings from two 2024 scoping reviews[11,13] align with a systematic review from 2014,[14] highlighting the need for education and attention to DNACPR in guidelines. The rationale for a DNACPR decision can be divided in three categories[15,16]

(1) CPR is inappropriate because the patient is dying from an irreversible condition irrespective of the outcome of CPR,
(2) CPR is not considered beneficial, weighing the prognosis against the patients' values and preferences,
(3) CPR is not aligned with the patient's will even after a clarifying discussion of consequences including death if CPR is not performed.

The two latter grounds underline the integration of DNACPR decisions within advance care planning. Further, CPR can be conditioned. An example of a conditional decision is to initiate CPR and give up to three defibrillations in the case of a shockable initial



Fig. 2 – Step-by-step advance care planning for the patient.

rhythm, but not to prolong treatment if the arrhythmia is refractory and to withhold CPR in the case of a non-shockable initial rhythm.[17,18] This kind of conditional decision might be of relevance in the elderly in-hospital population, where survival differs between 3 % and 41 % based on the initial rhythm.[19]

Advance care planning training can be provided as a single session delivered by healthcare professionals or trained facilitators using a physical booklet or computer assistance.[20,21] A meta-analysis showed that video decision aids reduce patient preferences for life-prolonging care, CPR and intubation while increasing patients' willingness to discuss goals of care.[22] Recent reviews emphasise that single consultations and repeated sessions might help family involvement[23] and underscore an active nurse role instead of serving as intermediaries between doctors, patients and family.[24] A systematic review suggested that communication training increases comfort, self-efficacy, and preparedness of healthcare professionals to deliver end-of-life care.[25] Likewise, systematic continuous professional development might reduce barriers to patient understanding. [24] Studies found that documentation of advance care planning in electronic health care records being available at the point of care improved completion of DNACPR orders and patient engagement.[26]

Across multiple systematic reviews, advance care planning has been associated with more treatment consistent with patients' wishes,[27] decreased use of life-sustaining treatment,[28] prevention of hospitalisation,[27–29] higher likelihood of dying in nursing homes,[27] lower healthcare costs[27,30] improved quality of life, and reduced symptom burden.[30] Further, advance care planning is linked to increased palliative care use [29,30] resulting in increased patient and caregiver satisfaction.[30] Likewise, advance care planning increases the patient-preferred place of death,[29] while evidence for better dying experiences is lacking.[21] There are conflicting results on the use of resources including hospices.[27,28,30,31] One meta-analysis found that among older people in the community, advance care planning decreased the incidence of CPR, use of nasogastric lavage and in-hospital mechanical ventilation but reported no difference for place of dying.[32] In patients with cancer, advance care planning reduced chemotherapy, ICU admissions, hospital admissions, hospice use, and hospital deaths compared with cancer patients without advance care planning.[33]

Two systematic reviews on end-of-life care in children showed that parents try to protect children by avoiding discussions about death and medical personnel delay discussions until death is imminent. However, the patients themselves want to be informed about their prognosis, and siblings express a desire to be involved.[34,35] Moreover, a systematic review has shown that children with heart disease benefit from involvement of paediatric palliative care specialists through increased documentation of advance care planning including resuscitation decisions while relieving parental stress.[36]

Advance care planning is associated with increased caregiver-patient congruence in end-of-life care preferences, improved satisfaction with healthcare quality and communication and partly associated with improvements in caregivers' depressive symptoms.[20] Among people living with dementia, advance care planning involving substitute decision makers is a method to maintain concordance of goals over time. However, there is no evidence supporting that people living with dementia make the decisions themselves or that decisions taken by a substitute align with the patient's own values. Further, there is a lack of evidence demonstrating a patient preference for making these decisions in earlier or later stages of dementia.[37]

A systematic review on palliative care showed that preferences and priorities for care between patients and family caregivers were aligned for pain and symptom management but not for other types of care.[38] Family caregivers tended to favour more active treatments, while patients worried about burdening family caregivers. To optimise the decision-making process, the review advocated for strategies that increase patient and family caregiver understanding of each other's preferences.

Ethics of bystander and first responder involvement

The ethical complexities surrounding bystander, lay rescuer, and first responder decision-making during OHCA have been extensively examined in international resuscitation guidelines and systematic reviews. This topic has not been reviewed by ILCOR. Equity concerns persist, particularly in lower bystander CPR rates observed in women and socioeconomically disadvantaged individuals. Concerns over physical contact, social norms, and perceived appropriateness contribute to hesitancy in performing CPR, reinforcing implicit biases in emergency response.[39,40] The 2021 ERC Guidelines emphasised structured ethical frameworks that balance public health benefits with respect for individual autonomy in CPR decision-making.[2]

Dispatch-assisted CPR is recognised as an effective mechanism to increase intervention rates, yet ethical concerns exist regarding potential undue influence, particularly when bystanders' express reluctance to intervene.[41] Ethical considerations related to bystander hesitation and willingness to intervene have been widely explored. Fear of causing harm, lack of confidence, and emotional distress in high-pressure situations are consistently reported as key psychological barriers.[42] Cultural and legal contexts further influence bystander decision-making, with CPR being less socially accepted in certain regions or legally ambiguous, reinforcing disparities in interventions.[43] Concerns over physical contact, social norms, and perceived appropriateness contribute to hesitancy in performing CPR, particularly when the victim is female.[40] Moral distress is commonly reported among bystanders who feel obligated to intervene despite personal hesitation, with the psychological burden of resuscitation efforts, particularly in ethically complex cases involving children or family members, contributing to long-term avoidance of future interventions. This underscores the importance of reducing moral distress through provision of mental health resources for both bystanders and first responders to mitigate the long-term psychological impact.[44] In addition, healthcare systems should seek to identify those in need for further psychological support through e.g. post-event defusing or surveys to first responders.[45,46]

Legal considerations play a crucial role in CPR decision-making. While Good Samaritan laws are designed to protect bystanders, their impact is inconsistent, and uncertainty about these protections remains a deterrent in jurisdictions where legal frameworks are unclear.[47] Scoping reviews emphasise that bystanders are more likely to intervene when legal protections are clearly communicated, underscoring the importance of effective public messaging about liability and protections.[41,48]

First responders, particularly community-based volunteers, face additional ethical challenges. Role ambiguity and lack of institutional recognition contribute to moral distress, particularly when responders are pressured to continue resuscitation despite clear indicators of medical futility.[49] The ethical dilemmas surrounding professional

recognition, expectations for prolonged intervention, and psychological distress underscore the need for structured support mechanisms for first responders. The recommendations emphasise ethical transparency in bystander intervention, ensuring individuals are not coerced into performing CPR but are supported in ethical decision-making.[41] Legal and ethical clarity in public messaging, alongside cultural and gender-sensitive CPR training, is necessary to promote equitable resuscitation and ensure ethical consistency in prehospital emergency care.[40] Based on expert consensus, the Ethics in Resuscitation Writing Group recommends that safeguards should be implemented within bystander alert systems to protect patient autonomy and prevent unnecessary or inappropriate resuscitation attempts, provided that the autonomy of bystanders in their decision to intervene is also respected.[2] Addressing these challenges is essential to fostering informed, confident, and ethically guided decision-making (Fig. 3).

Family presence

The sudden death of a person is a distressing event that can have a long-lasting impact on the biopsychosocial health of those close to the victim. The suddenness of the event increases the risk of compli-

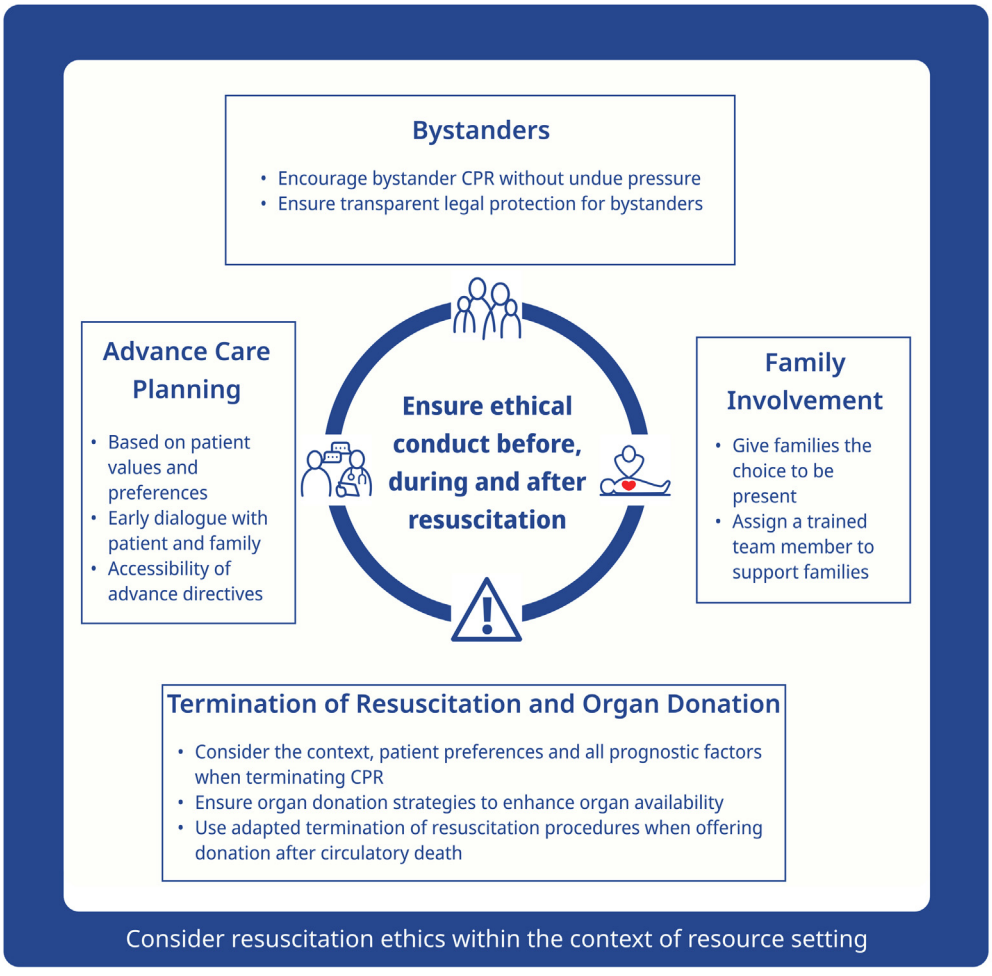


Fig. 3 – Ethical considerations before, during and after resuscitation.

cated grief and post-traumatic stress disorder symptoms, especially for parents losing a child.[50,51] Allowing families to be present during resuscitation efforts can help alleviate these effects but is only a small part of a much-needed bereavement counselling strategy.

The concept of allowing families to be present during a resuscitation attempt has received significant attention in recent years. Following the literature search for the 2021 ERC Guidelines,[2] two ILCOR systematic reviews and one Cochrane review were published.[50,52,53] Current guidance further integrate findings from by two umbrella reviews[54,55] 11 additional reviews[56–66] two simulation randomised controlled trials (RCTs) [67,68] and 32 recent observational studies, most of which were survey-based. [69–100] Eleven additional papers provided relevant background information, despite being outside the primary search criteria.[51,101–110]

Regardless of religious, cultural, or educational background, most patients and family members support the idea of family presence during resuscitation, even if they acknowledge potential risks. Many resuscitation experts and scientific societies strongly advocate for family presence during resuscitation based on ethical arguments, as part of a patient-centred healthcare paradigm shift. The evidence indicates no clear negative impact on patient resuscitation outcomes and suggests potential improvements in biopsychosocial outcomes of family members. However, concerns primarily revolve around healthcare professionals' well-being and the resuscitation team's performance.

A noticeable gap exists between expert advice in favour of family presence during resuscitation and actual daily practice in most hospitals worldwide, even when official policies are in place.[2] The implementation of family presence during resuscitation is frequently hampered by medicolegal or safety concerns, fear of miscommunication, behavioural disturbances and complaints, a lack of resources or space in the resuscitation room, and most importantly, fear of patient harm due to impaired team performance and skewed clinical decision-making in the presence of families.

A significant worry is the role of the family member present as surrogate decision maker. Family members present during resuscitation may experience intense emotional distress, potentially impairing their ability to represent the patient's end-of-life preferences accurately. It is therefore crucial to emphasise that the withdrawal of life-sustaining treatments is a medical team's decision, based on assessing the individual patient's values and preferences and balancing the benefits and harms. Clear and unequivocal informed consent should be reached with the present families.

Effective implementation of family presence during resuscitation requires assigning a specifically trained team member to support family members during resuscitation,[50,66] to address the emotional, physical, and informational needs of families. Their role includes assessing the suitability of these families for safe observation, providing clear and appropriate explanations, responding to their questions, and offering comfort measures without giving false hope. Adequate education, which includes theoretical knowledge, communication skills training, and performance training through simulations, is essential to successfully fulfil this role.[73,103]

Termination of resuscitation (TOR)

TOR is an ethical decision considering patient preferences and values, including considerations of harm outweighing potential benefits, safety for the healthcare professionals, and medical futility.[2] Disagreements regarding TOR are frequent during resuscitation,[111] and resuscitation attempts can affect healthcare professionals psychologically.[112] Therefore, TOR should be a team decision where the ongoing resuscitation effort should be summarised and all team members should be able to weigh in prior to termination. A 'hot debriefing' immediately after resuscitation attempts should be sought to identify providers in need of emotional support and address ethical concerns.[112]

Various methods have been proposed to determine medical futility, including TOR rules,[113,114] different physiologic markers,[115–117] and several other unvalidated factors that healthcare professionals sometimes use.[118] The use of physiologic markers and TOR rules should be weighed in terms of potential benefits and harms. No single factor can accurately predict futility in cardiac arrest patients including TOR rules. [2,113–116] However, physicians are also unable to predict survival outcomes [119] and there is a large heterogeneity between physicians in terms of TOR practices,[120] reports of unvalidated factors used in decision-making,[118] and possibly premature TOR by clinicians in some cases.[121] Thus, TOR rules and physiologic markers may be serve as aids to support clinicians and ensure that all patients get a fair chance prior to TOR.

An ILCOR review on TOR rules for IHCA identified no sufficiently reliable TOR rule for IHCA which resulted in a strong recommendation against the use of TOR rules for IHCA.[114] In contrast, for OHCA, ILCOR identified numerous TOR rules derived from historical cohort studies of which several performed well - although none perfectly - in avoiding TOR of patients who could survive.[113,122] Accordingly, ILCOR made a conditional recommendation for the use of TOR rules in adult OHCA.[113,122]

Notably, different TOR rules have variable performance across different cohorts and decreasing performance with improving survival rates and therefore they should be validated locally prior to being used.[113,123] A major limitation of some TOR rules is the challenge of applying them prospectively. Many rely on factors such as absence of shock delivery and lack of prehospital return of spontaneous circulation (ROSC), which perform well in retrospective analyses but are dependent on the duration of prehospital CPR—making them difficult to apply in real-time decision-making.[124]

Moreover, it should be noted that in places where TOR rules have been applied, patients have often been transported in spite of the TOR rule recommending to stop[125] and some of these patients may survive, particularly patients with pulseless electrical activity, shorter transport time, and younger age, in spite of a TOR rule suggesting futility.[126]

Recent studies have evaluated existing TOR rules for paediatric patients as well as deriving new TOR rules for paediatric patients.[127–131] Overall, performance varied and ILCOR found that the evidence seems yet insufficient to recommend application of any TOR rule in paediatric patients. To be consistent with previous guidelines, we nevertheless suggest that the ERC rule of 20 minutes of asystole in spite of advanced life support and no reversible causes to correct may be considered for termination across all age groups.

End-tidal CO_2 ($ETCO_2$) may correlate with CPR quality and survival outcomes during adult CPR.[115] Various cut-offs, durations, and trends for $ETCO_2$ and medical futility have been proposed.[115,132,133] Single measurements of $ETCO_2$ are likely an insufficient marker of mortality in both adults and children,[132,134] but persistently low $ETCO_2$ measurements over at least 20 minutes is a marker of very low chance of survival in adult cardiac arrest.[115,133] The ILCOR review identified that an $ETCO_2$ <10 mmHg (<1.33 kPa) after 20 min of CPR is associated with a 0.5 % likelihood of ROSC for adult cardiac arrest.[115]

Reviews by ILCOR and others on cardiac standstill during CPR found that cardiac standstill is a snapshot of the heart being associated with worse survival outcomes but remains a poor predictor of no chance of survival.[116,135] The studies used various timings of ultrasound with various definitions of wall motion.[116] Furthermore, the interrater reliability for identifying cardiac standstill is poor.[136]

Other non-validated factors have been considered to determine futility during CPR, e.g. neuron specific enolase measurements, regional cerebral oxygen saturation, pupillometry, blood gas measurements, patient age, and certain comorbidities.[117,118,137] Due to insufficient evidence and/ or data suggesting the inability to predict survival, these factors should not be used for TOR.

Uncontrolled organ donation after circulatory death

Despite a general societal acceptance of organ donation as a concept, provided it is conducted in a trustworthy manner, there remains a significant shortage of donor organs. The reasons for that are varied and complex.[138]

ILCOR has published a scientific statement on organ donation, recommending that all health systems should develop, implement, and evaluate protocols designed to optimise organ donation opportunities for patients who have an OHCA and failed attempts at resuscitation.[139] The primary aim of resuscitation is to benefit the individual victim. However, there may be value in prolonging resuscitation to allow for organ perfusion and subsequent organ donation. Organ donation following sudden cardiac arrest – provided short no-flow times and adequate CPR – will significantly increase the number of available organs and thus improve outcomes for patients currently on the transplant waiting list. Despite an elevated risk of primary non-function of the transplanted organs, outcomes of uncontrolled organ donation after circulatory death have proven to be acceptable. This is also the case for extracorporeal CPR that likewise provides an opportunity for uncontrolled organ donation for non-survivors.[140,141] Importantly, while withdrawing resuscitation prehospitally may appear ethically justified for various reasons, this practice may keep deceased patients from becoming organ donors. Although the actual organ donation process cannot be initiated prehospitally, the resuscitation team is responsible for allow it to happen subsequently.

Since conducting the literature search for the 2021 ERC Guidelines,[2] we have identified three additional narrative reviews[138,142,143], an ILCOR scientific statement [139], and three observational studies.[144–146] To further inform current guidelines, we also considered 17 background papers – not strictly on topic or other publication type – that offered valuable supplementary information and insights.[147–163]

These Guidelines focus specifically on uncontrolled organ donation after circulatory death Maastricht category II (unsuccessful CPR: witnessed OHCA with unsuccessful CPR),[164] acknowledging that there are obviously other pathways to organ donation, each with their own, sometimes overlapping, procedural and ethical issues.

Various strategies such as communication programs or 'opt out' legislation have been implemented in different countries to expand the pool of potential deceased donors. However, uncontrolled organ donation after circulatory death is a recent approach and is not permitted in all jurisdictions. Even where permitted, uptake remain low due to sociocultural, religious, logistical, and legal barriers. Many misconceptions and concerns persist among both public and healthcare professionals. Enhanced education and transparent communication about uncontrolled organ donation after circulatory death may help address these changes.

One ethical concern is that clinicians may be perceived as prioritising organ retrieval over patient resuscitation. To prevent such perception, the resuscitation team should be distinct from the team responsible for decisions regarding uncontrolled organ donation after circulatory death. At every stage, regardless of a country's opt-in or opt-out policy, families must retain the freedom to make fully informed and independent decisions. Importantly, healthcare professionals should always approach the family of a potential donor. While many families may decline uncontrolled organ donation after circulatory death, failing to engage families removes their opportunity to make an autonomous decision and potential benefits from the experience of honouring the patient's wish or finding meaning in the loss. The timing of this conversations is crucial, as premature discussions may cause distress.

A second concern involves the concept of death. For non-living donations, the donor must be legally and ethically dead – a principle known as the 'dead donor rule'. With the advent of intensive care medicine, death has been defined as the irreversible cessation of brain functions, although this definition can yield false positives and negatives. Given the potential benefit for both organ recipients and the donor's family, and considering ethical principles such as justice, equity and autonomy (beyond the traditional beneficence-nonmaleficence framework), several countries have moved to permit donation after circulatory determination of death. After a specific period of circulatory arrest (which varies by country), death is considered permanent and thereby meets the medical, ethical, and legal criteria for declaring death. If no further resuscitative measures are undertaken – aligned with the known values and preferences of the patient and their family – 'permanent' is ethically equivalent with 'irreversible.' Once death is declared, resuscitation may be restarted to preserve organ viability, a practice that remains ethically debated.

Restarting resuscitation after death can raise additional concerns, including physical trauma to the body (which may distress the family), theoretical risk of regained consciousness due to resumed brain perfusion, or confusion and renewed grief when observable signs such as a heartbeat return. These issues are further complicated by the increasing use of extracorporeal CPR and post-mortem organ perfusion.

Importantly, if it is clear that the deceased would have wished to donate their organs, and this is supported by their family, then Kantian objections – such as the claim that individuals should not be used merely as a means to an end–are not applicable. In that context, the donation also serves the interest if the deceased and their family.[142] At this stage, the clinical team should make every reasonable effort to facilitate the donation. Families should be informed in advance that organ procurement may not succeed, and the entire process should be explained transparently, including any steps of the process that may improve the likelihood of a successful uncontrolled organ donation after circulatory death outcome.

Ethics of education and systems

Ethical preparedness in resuscitation is essential to ensure that healthcare professionals can navigate complex decisions related to advance care planning, DNACPR, TOR, and shared decision-making with clarity and consistency. However, current evidence reveals significant gaps in ethical education and institutional policies, resulting in variability in decision-making and increased moral distress among professionals.[165–167]

The 2021 ERC Guidelines highlight the importance of embedding structured ethical reasoning within resuscitation education to equip providers to apply ethical principles in high-pressure scenarios.[2] Institutional structures and legal frameworks exert a strong influence on ethical decision-making in resuscitation. However, the absence of standardised policies contributes to uncertainty, reinforcing the need for ethical reasoning to be systematically integrated into resuscitation curricula.[122] Systematic reviews and observational studies indicate that structured ethical education enhances ethical decision-making and reduces variability in practices.[108,167,168] RCTs showed that healthcare professionals who received formal ethical education report greater confidence in decision-making, better alignment with patient values, and reduced moral distress in ethically challenging situations.[108]

Ethical reasoning is not an inherent skill, it requires structured learning and experiential practice to ensure consistent application in resuscitation settings.[108,167,168] Simulation-based training has proven effective in providing controlled exposure to ethical dilemmas, enabling providers to refine their approach before facing real-world encounters.[167] Evidence suggests that simulation improves the ability to handle DNACPR discussions and TOR decisions, decreasing hesitancy and promoting ethically sound interventions.[168] Additionally, embedding standardised frameworks into resuscitation curricula enhances clarity during advance care planning conversations and ensure greater consistency in end-of-life decision-making.[165]

Ethical challenges extend beyond individual education into broader institutional policy domains. Variability in advance care planning, DNACPR, and TOR policies contributes to ethical ambiguity and inconsistencies in resuscitation practices.[165,166,169] In the absence of clear, enforceable ethical guidelines, resuscitation decision-making is often influenced by subjective judgment rather than established ethical principles.[165,166,169] Observational studies highlight that institutional inconsistencies in advance care planning and DNACPR protocols generate uncertainty and leave providers without a standardised framework for addressing ethically complex cases.[166] This inconsistency increases moral distress and undermines patient-centred care.[169]

System-wide ethical oversight and standardised policies are essential to ensure ethical consistent DNACPR and TOR decision-making.[165–167] Moreover, disparities in access to structured ethics education further affect ethical preparedness. Evidence indicates substantial variation in the availability of education across healthcare settings.[108,167,170] Universal access to ethics education and harmonising institutional policies is critical to ensure fairness and transparency in resuscitation care.[165,167,170]

Education in the ethics of resuscitation must be both standardised and adaptable to diverse healthcare contexts, enabling all providers to make ethically sound decisions regardless of institutional or systemic constraints.[167] These recommendations support the 2021 ERC Guidelines, which advocate for the integration of ethical decision-making as core component of resuscitation education and system policies, rather than treating it as an optional or secondary consideration.[2] Ethical preparedness training, institutional standardisation, and equitable access to ethical education are fundamental to reducing uncertainty, enhancing provider confidence, and aligning resuscitation practices with patient rights and ethical best practices (Table 3).[171–174]

Cardiac arrest as a result of a suicide attempt

Cardiac arrest resulting from a suicide attempt presents an ethical conundrum, challenging the boundaries of autonomy and the concept of having mental capacity. The duties and principles that typically guide clinicians in their role as caregivers may become more complex in cases of attempted suicide, where the patient autonomy may conflict with the principle of beneficence. Perspectives among healthcare professionals and society vary widely and are often influenced by the legal, religious and sociocultural context in which care is provided.

Only two recent observational studies have added to the evidence base summarised in the 2021 ERC Guidelines.[2,175,176] Another six publications were reviewed that discuss ethical reflections and philosophical issues in suicide.[177–184] We strictly focused on the withholding or withdrawal of life-sustaining treatment in the context of sudden cardiac arrest due to suicide, explicitly excluding physician-assisted suicide and euthanasia.

In cardiac arrest after attempted suicide, healthcare professionals' beliefs about the moral permissibility of honouring refusals of life-sustaining treatment are central.[175,178] These beliefs are shaped by their assessment of the patient's decision-making capacity – regardless of motive – but are not neutral; they are influenced by personal values, preferences, and perceptions of the treatment's worth.

The ERC recommends that advance directives should be honoured, those made in the context of suicide require additional scrutiny. If a suicide attempt is understood as a clear expression of the patient's wish not to receive resuscitation—and if the patient possesses medical decision-making capacity and autonomy at the time—then, from a patient-centred perspective, such a wish should be respected. However, many argue that suicidal ideation is often transient and closely associated with mental disorders that may impair decision-making capacity. In these circumstances, the principle of beneficence—protecting individuals suffering from potentially treatable conditions—may take precedence over autonomy to prevent harm from impulsive actions. This may apply even if the suicide attempt is supported by an advance directive, which may or may not have been created when the patient was fully mentally capable. Until the context and background of any possible advance directive is known, it is therefore advisable to start or continue resuscitation in this situation.

A further ethical dilemma arises when we consider that withdrawal of life-sustaining therapy is often viewed as acceptable—or even advisable—in cases of severe physical suffering or poor quality of life, where the burden of treatment clearly outweighs its potential benefit. It is then questionable what the position should be when the source of suffering is mental illness. Some authors argue that most psychiatric illnesses can be managed and quality of life improved, why it is very difficult to predict terminal outcomes and justify withdrawal of life-sustaining therapy.[177,178] However, expert opinion remains divided. For some individuals, existing treatments may be ineffective, leading to a persistently unacceptable quality of life.[178]

Decisions about withholding or withdrawing life-sustaining treatment are typically made by the treating team in collaboration with surrogate decision-makers. Yet, in the context of attempted suicide, surrogates may be particularly influenced by their own experiences and values.[178] They might have suffered significant emotional distress from previous suicide attempts, substance use, or prolonged mental or physical illness of their relative. As a result, they may feel

Table 3 – Structured approach to ethics education in resuscitation: key components and methods.

What to train	Definition	Distinctive focus or contribution	Examples for how to train
Ethics education (foundational knowledge & application)[171]	Provides baseline knowledge of ethical principles in resuscitation, including advance care planning, shared decision-making, do-not-attempt cardiopulmonary resuscitation, and termination of resuscitation	Focuses on teaching core ethical concepts and frameworks so providers understand ethical principles before applying them in clinical settings.	Lectures & online modules covering ethical frameworks in resuscitation, case-based discussions exploring advance care planning, shared decision-making, do-not-attempt cardiopulmonary resuscitation, and termination of resuscitation scenarios.
Ethical reasoning (critical thinking & judgment in ethical dilemmas)[172]	Strengthens decision-making skills by helping providers analyse ethically complex resuscitation cases and apply ethical reasoning to align with patient values, medical best practices, and societal considerations while professionals can reflect on their own values and motives.	Goes beyond ethical education by focusing on critical thinking and problem-solving when making ethical resuscitation decisions and focuses on healthcare professionals' own values and motives that may affect decision-making.	Ethical dilemma discussions (e.g., weighing patient autonomy vs. medical futility in termination of resuscitation cases) Role-play scenarios on leading shared decision-making conversations with families in emergency settings.
Ethical preparedness (resilience, coping with moral distress & systemic challenges)[173]	Develops strategies to manage moral distress, ethical dilemmas, and institutional constraints that affect ethically sound resuscitation decision-making in high-pressure situations.	Unlike ethics education and reasoning, this focuses on managing ethical stress and systemic barriers that impact decision-making (e.g., legal uncertainties, policy constraints).	Simulation-based training: high-pressure resuscitation scenarios where providers must make real-time ethical decisions under institutional constraints. Workshops on managing moral distress and ethical conflicts in termination of resuscitation cases. Ethical rounds.
Institutional & policy education (standardising ethical decision-making across healthcare settings)[174]	Ensures healthcare professionals understand and navigate institutional policies, legal constraints, and ethical frameworks related to advance care planning, do-not-attempt cardiopulmonary resuscitation, termination of resuscitation, and shared decision-making.	Focuses on system-level understanding of ethical policies, ensuring consistency in how ethics is applied across different healthcare settings.	Policy education workshops on institutional do-not-attempt cardiopulmonary resuscitation and termination of resuscitation policies. Case reviews of real-world resuscitation policies in emergency medical services, intensive care units, and emergency departments.

resentment or a pessimistic view of the patient's potential for recovery. Conversely, others may respond to stigma surrounding suicide by insisting on prolonged life-support, even when this may conflict with patient's known or presumed wishes.

Ethical considerations in low-resource settings

Ethical decision-making in resuscitation within low-resource settings may differ from that in high-resource settings due to scarce resources, different health care priorities, and different psychological, sociocultural, and religious considerations on resuscitation and end-of-life care.[185] Allocation of limited resources in any context should be non-discriminatory, ethical, considering equity and with maximal efficiency.

Ethical considerations for resuscitation in low-resource settings have been addressed in ILCOR statements and consensus-based reviews, which highlight challenges related to inconsistent policies, limited resources, and the absence of structured frameworks for advance care planning , shared decision-making, DNACPR orders, and TOR criteria.[40,122,185,186] The 2021 ERC Guidelines highlight variability in legal frameworks, ethical complexities, and disparities in the application of DNACPR and TOR across different healthcare settings.[2]

Use of advance care planning and DNACPR may be considered of particular importance in low-resource settings to enable fair allocation of resources.[187] However, there are multiple barriers and facilitators to proper implementation of DNACPR discussions. Barriers may include sociocultural norms, lack of legal clarity, organisational policies, societal and family views, religious and ethical beliefs, and diverging views among healthcare professionals.[187] Moreover, patient preferences are often undocumented, unacknowledged, or overridden in DNACPR discussions, resulting in clinician-driven DNACPR decisions made without formal input from patients or their families. [9,14,186,188,189] In contrast, education in DNACPR and clear legislation including local protocols may be important facilitators for efficient implementation.[187]

In some countries, a very large proportion of patients with OHCA may be transported to hospitals in spite of many cases being considered futile, potentially leading to large healthcare expenditures.[125,190] In such cases, TOR rules may be a cost-effective solution to reduce the number of transports to hospitals with ongoing resuscitation where the chance of survival is extremely low.[125,191,192] This may be an important consideration for low-resource settings as ethical challenges may arise during prolonged resuscitation attempts when survival is unlikely but resuscitative efforts persist due to systemic

pressures or societal expectations.[193,194] Evidence from prehospital emergency medical services systems in low-resource settings indicates that workforce shortages, limited equipment and medications, and a lack of consistent ethical guidance contribute to significant variability in how resuscitation decisions are made.[125,189,190,195,196]

When considering patient prognosis during resuscitation as part of the TOR decision, the options for treating the reversible causes are important. Limitations to e.g. medication or access to cardiac laboratory or extracorporeal life support may change what is perceived reversible causes in the situation. Thus, the situation (incl. location), the available resources, and the safety of the providers should always be considered as part of the holistic, team-based process of TOR.

Resuscitation research ethics

The current Guidelines are supported by evidence from five systematic reviews, five scoping reviews, 23 narrative reviews, one randomised controlled trial and 33 observational, descriptive or survey studies. These were identified through systematic searches corresponding to eight population-concept-context frameworks. The recommendations are further supported by a 2018 ILCOR advisory statement on core cardiac arrest outcome,[197] as well as additional published evidence sourced from the reference lists of the 2021 ERC Guidelines.[2]

In addition to this main text, a more detailed and structured presentation of the evidence underpinning the research ethics guidelines is provided in the accompanying Supplement A.

The critical balance between patient/family autonomy and emergency research

In cardiac arrest research, immediate treatment is essential, leaving no opportunity to obtain valid informed consent at the time of enrolment.[198,199] According to the Helsinki Declaration, low-risk RCTs or studies evaluating resuscitation interventions may proceed without prior informed consent, provided that consent is sought afterwards from the patient or their legally representative or decision-maker.[2,198,200] This approach is consistent with the deferred consent model.[198,201,202] Deferred consent is widely regarded as an acceptable safeguard of patient and family autonomy until the emergency research participant regains decisional capacity.[198] This consent model is endorsed by international ethics guidelines and reflected in Article 35 of the currently European Union (EU) Clinical Trials Regulation No. 536/2014.[200,203,204] This regulation supports and harmonises low-risk, multicentre and multinational emergency research that has the potential to provide clinical benefit.[2,198]

Patient and public involvement in research is increasingly used and can be considered in all phases, including the design, delivery, and dissemination[205,206] while variations remain in its implementation across countries and medical fields.[207] Researchers should define clear and collaborative roles for patient and public advisors and provide adequate support. Patient and public involvement in research is considered important as it can enhance the focus on patient-relevant outcomes and the acceptability of research for all.[208] Additionally, including patients and the public fosters equality between researchers and patients, allowing them to engage in research that is meaningful to them.[208] Moreover, patient and public involvement may improve the quality of other research aspects, including enrolment, funding acquisition, study design, implementation, and dissemination.[209]

Methodologically robust development of core outcome sets may enhance the clinical and societal value of future RCTs by enabling harmonised and consistent reporting of patient outcomes.[197,210] Core outcome sets may include in-hospital survival, functional outcome at 30 days or discharge and health-related quality of life at 90 days or at intervals up to 1 year.[197]

The inclusion of core patient-centred outcome sets in large registries - such as the European Registry of Cardiac Arrest,[211,212] the Cardiac Arrest Registry to Enhance Survival,[213,214] and Get With The Guidelines®[212,215] may (1) facilitate identification of relevant predictor variables and assess the relative effectiveness of different treatments used in clinical practice; and (2) provide insights into the impact of evidence-based guideline implementation on key outcomes.[2]

In the context of big data observational research,[2,216,217] a panel of 29 European experts in cardiac arrest research, medical ethics, and health law recently recommended that deferred consent should be the preferred model, with data placed on hold until the patient regains decisional capacity.[218] A broad consent model was also considered ethically acceptable,[219219] though requiring specific consent for each study was seen as potentially burdensome.[218] Ethical oversight of data, harmonisation of governance requirements across Europe, and the development of a code of conduct created by interdisciplinary experts in collaboration with patient representatives were also recommended.[218]

Artificial intelligence and emergency research

Current and emerging applications of AI in emergency and resuscitation care are summarised in Supplement A. With AI performance expected to continue improving and its integration into resuscitation practice expanding,[220] several important ethical concerns arise. These include:

(1) Beneficence vs privacy and autonomy – while AI-driven preemptive advice, warnings, or interventions may offer lifesaving potential, they must be balanced against possible infringements on patients' personal or mental privacy and their right to self-determination. Such interventions could become paternalistic, potentially compromising the integrity of an individual's personal life;[220]
(2) Justice – disparities in access to advanced healthcare technologies may widen based on socioeconomic status, particularly in low-resource settings. Moreover, AI algorithms trained on population- or group-specific datasets may be ineffective—or even harmful—when applied to populations with different characteristics, especially if those groups lack the capacity to generate representative datasets.[221]

To address these concerns, EU Regulation 2024/168921 has been introduced with the following aims:

(1) to classify and manage AI risk and impact levels;[220]
(2) to prohibit misuse of AI, such as unauthorised use of facial images or exploitation of individual vulnerabilities; [220]
(3) to promote responsible AI use by requiring scientific safeguards, transparency, and ethical precautions;[220]
(4) to support innovation and ensure the free movement of AI-based goods and services across EU member states.[222]

Despite these regulatory efforts, there remains a need for a comprehensive ethical and scientific framework, concurrently addressing ethical concerns and ensuring the rigorous evaluation of technological advancements.[220] Achieving this requires ongoing cooperation among technology experts, healthcare professionals, researchers,

ethicists, and legal authorities to prevent potential harm to patient autonomy, privacy, or safety.[220]

Collaborators

The following individuals contributed as collaborators to the 2025 version of these Guidelines: Professor Ulrik Kihlbom, an academic ethicist, Karolinska Institutet, Stockholm, Sweden and Paul Swindell, Essex, United Kingdom, cardiac arrest survivor and founder of Sudden Cardiac Arrest UK.

Declaration of competing interest

Declarations of competing interests for all ERC Guidelines authors are displayed in a COI table which can be found online at https://doi.org/10.1016/j.resuscitation.2025.110734.

Appendix A. Supplementary material

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Practice Guideline

European Resuscitation Council Guidelines 2025 First Aid

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Abstract

The European Resuscitation Council has produced these First Aid Guidelines based on the 2025 International Consensus on Science with Treatment Recommendations on First Aid of the International Liaison Committee on Resuscitation (ILCOR), reviews of the expert group composed to write these recommendations, and available selected peer-reviewed literature after discussion and agreement within this experts' group. General topics include expectations of a first aid provider, first aid courses, contents of a first aid kit, how to approach a person with impaired responsiveness, recovery position, use of a pulse oximeter and administration of oxygen. Medical emergencies include anaphylaxis, choking, asthma, chest pain, hypoglycaemia, opioid overdose, recognition of stroke, and suicidal thoughts. Trauma-related emergencies include cervical spinal motion restriction, control of life-threatening bleeding, management of open chest wounds, concussion and preservation of an amputated body part. Environmental emergencies include drowning, hypothermia, hyperthermia and snake bite. First aid procedures for the prevention and management of life-threatening conditions that could progress to cardiac arrest, have been included. The management of cardiac arrest is described in the 2025 ERC Guidelines Basic Life Support.

Keywords: Emergency treatment, Pre-medical treatment, Helping behaviours, Emergency care, Immediate actions

Introduction and scope

First aid is described as a helping behaviour by anyone for any emergency condition, in any situation, including self-care. Its provision typically involves recognising, assessing, and prioritising needs, providing care within the provider's competencies whilst recognising their limitations, and seeking additional help such as activating the emergency services. All resuscitation, including basic and advanced life support, begins with first aid interventions: assessing scene safety, recognising decreased responsiveness or abnormal breathing, positioning the person appropriately, and responding to life-threatening conditions. First aid serves as a crucial first link in the chain of survival. Since 2021, the ERC has focussed its scope and now emphasises the importance of first aid in the cardiac arrest chain of survival, i.e. in reducing morbidity and in preventing cardiac arrest. The ERC Guidelines 2025 First Aid focus on life-threatening conditions and conditions where first aid could reduce morbidity and prevent progression to cardiac arrest. Therefore, topics which were previously included, and are not directly related to the revised scope, may not be included this year (see Table 1). The Guidelines are based on the 2025 International Liaison Committee on Resuscitation (ILCOR) Consensus on Science with Treatment Recommendations (CoSTR) for First Aid[1] and Basic Life Support.[2] When developing these guidelines, the ERC First Aid Writing Group used published systematic reviews and scoping reviews, together with the CoSTRs including careful consideration of the Evidence to Decision tables, the narrative reviews and Task Force discussions specified under justifications. For topics not reviewed by ILCOR, other systematic reviews, single studies or expert consensus of the Writing Group members have been used to inform the Guidelines. In total these guidelines includes 24 topics, subdivided into seven general principles, eight medical emergencies, five trauma emergencies, and four environmental emergencies.

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The importance of first aid may further increase in remote or low-resource settings when the availability of professional medical care is delayed. Therefore, in these first aid guidelines, the World Health Organization (WHO) tool for equity, WHO-INTEGRATE,[3] was used when formulating concise guidelines for clinical practice. A community advisor (LB) was a full member of the Writing Group involved in every step of the process to ensure universal understanding by all readers. Likewise, one writing group member (KT) experienced in working in low-resource settings has screened all advice for clinical practice with guidance from the equity lens INCLEN.[4,5] Full details of how equity has been considered in every step of the development of the guidelines can be found in Appendix A. Finally, an online survey distributed through social media and open between 22/01/25 and 09/04/25, with 1406 respondents from 37 countries, has been used to inform clinical practice (Appendix B).

All First Aid Writing Group members and the Guidelines Steering Committee agreed to this version, which was posted for public comment between 15 May and 30 May 2025. A total of 115 individuals submitted 115 comments, leading to 18 changes in the final version. The guidelines were presented to and approved by the ERC Board and the General Assembly in June 2025. The methodology used for guideline development is presented in the Executive summary (Fig. 1).[6] A summary of the key changes since the 2021 guidelines is presented in Table 1.

Concise guidelines for clinical practice

Implementation of first aid guidelines and considerations for different settings

Considering differences across these four essential domains will support guidelines implementation (Table 2)

- First aid recipient
- First aid provider
- Treatment
- Setting and environment

Expectations of a first aid provider

As a first aid provider, you may minimise further injury, improve health and prevent death by following these three key principles:

- Check for scene safety.
- Call your local emergency number as soon as possible.
- Only use available equipment or medications you have been trained to use.

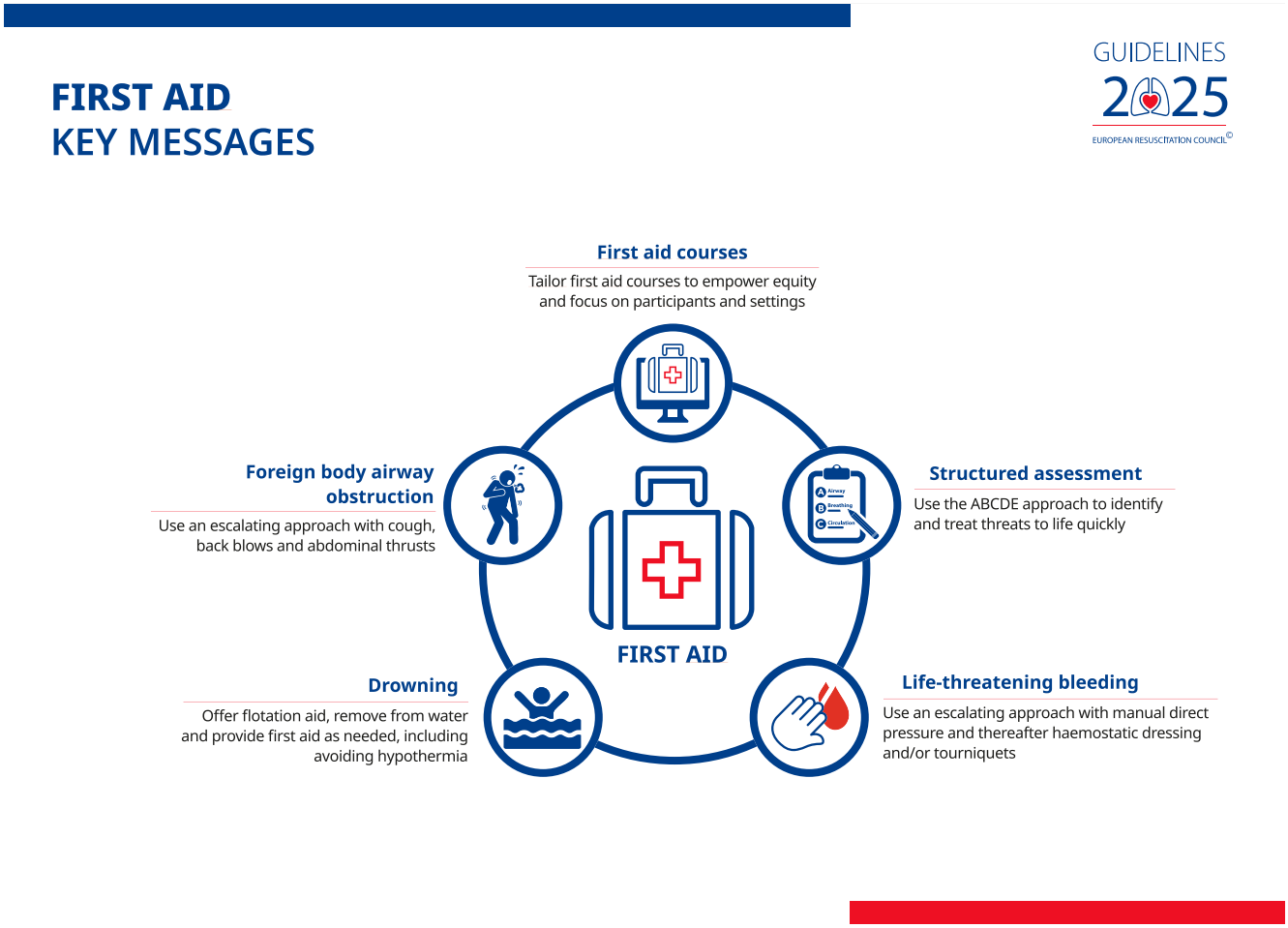


Fig. 1 – First aid – key messages.

Table 1 – The major changes in the ERC Guidelines 2025 First Aid.

ERC Guidelines 2021 First Aid	ERC Guidelines 2025 First Aid
Not included	**Expectations of a first aid provider** – Always call for help as a general principle and only use equipment or medications you have been trained to use.
Not included	**First aid courses** – Should empower equity and be tailored to national/regional requirements rather than conducted in a standard format. They should expand on psychological preparedness training, and how to cope with anxiety and distress before and after providing first aid.
Not included	**First aid kits** – A tailored kit based on risks and users should be clearly marked and available in homes, vehicles, buildings, public spaces, etc.
Recovery position **Optimal position of shock**	**Approach to and body positioning of a person with impaired responsiveness** – Structured first assessment of a person appearing ill or injured (ABCDE). Cardiac arrest, recovery position and optimal position in shock have been merged into a single algorithm.
Not included	**Use of pulse oximetry and administration of oxygen** – Use a pulse oximeter to titrate the administered oxygen to a saturation of 94–98 %. In persons with known chronic obstructive pulmonary disease, aim for an oxygen saturation of 88 – 92 %.
Not included	**Choking** – Use an escalating strategy from encouragement to cough to back blows to abdominal thrusts.
Not included	**Opioid overdose** – Administer nasal naloxone in an unresponsive person with suspected opioid overdose who is not breathing or is breathing abnormally .
Not included	**Suicidal thoughts** – Ask about suicidal ideation, offer hope and help to contact professionals.
Not included	**Preservation of amputated body part** – Keep the part cold without freezing and transport it with the injured person to the hospital.
Not included	**Drowning** – Untrained first aid providers should not enter the water but instead provide a flotation device or lifebuoy. If trained and appropriate to do so, enter the water with flotation devices. After removal from the water, if unresponsive, call for help, provide 5 rescue breaths and continue standard BLS.
Not included	**Snake bite (European Viper)** – Keep the person calm and with the bitten body part immobilised whilst transferring to a medical facility.
• Oral rehydration solutions for treating exertion-related dehydration • Management of presyncope • Cooling of thermal burns • Thermal burn dressings • Dental avulsion • Compression wrap for closed extremity joint injuries • Straightening an angulated fracture • Eye injury from chemical exposure	Not included. Since 2021, the ERC has focussed its scope and now emphasises the importance of first aid in the cardiac arrest chain of survival, i.e. in reducing morbidity and in preventing cardiac arrest. As these topics were not directly related to this revised scope, they were no longer included.

First aid courses

- First aid courses should be accessible to the widest possible audience and promote equal opportunities in both providing and receiving first aid.
- Course providers should tailor content based on the needs of participants, their context (low-resource settings, rural areas), sociocultural appropriateness and feasibility.
- Courses should teach awareness of the regional Good Samaritan laws.
- Courses should include measures to help bystanders, lay rescuers and professional first aid providers to overcome fear, anxiety and moral distress during and after providing first aid.

First aid kits

- All workplaces, leisure centres, public buildings, homes and cars should have first aid kits.
- Public first aid kits should meet local legal requirements, be clearly marked and readily accessible.

Table 2 – Essential domains to consider when implementing first aid guidelines to ensure accuracy and promote equity.

First aid domains for evidence evaluation and treatment recommendations	Examples of characteristics
First aid recipient	Age, sex, gender, health status, capacity to provide consent
First aid provider	Knowledge, training/education, preparedness, familiarity, duty to respond, professional scope, capability
Treatment	Invasiveness, skills required, technology, efficacy and effectiveness, cost
Setting and environment	Low- or high-resource, safety, cultural norms and values, urban or remote

- The content of the kits should be based on the setting, expected risks and the users.
- All first aid kits should be inspected regularly and properly maintained.

Cardiac arrest

- If you suspect a cardiac arrest, call the emergency number (112) and follow the dispatcher instructions on how to perform cardiopulmonary resuscitation (CPR).
- Start CPR without worrying about accidentally hurting the person. It is more important to try to save their life than worry about causing an injury.
- Continue CPR until professional help arrives and takes over or tells you to stop.

Structured first aid assessment of a person appearing ill, injured or in shock (ABCDE)

- Pay immediate attention to safety, responsiveness of the victim, and catastrophic bleeding (Fig. 2).

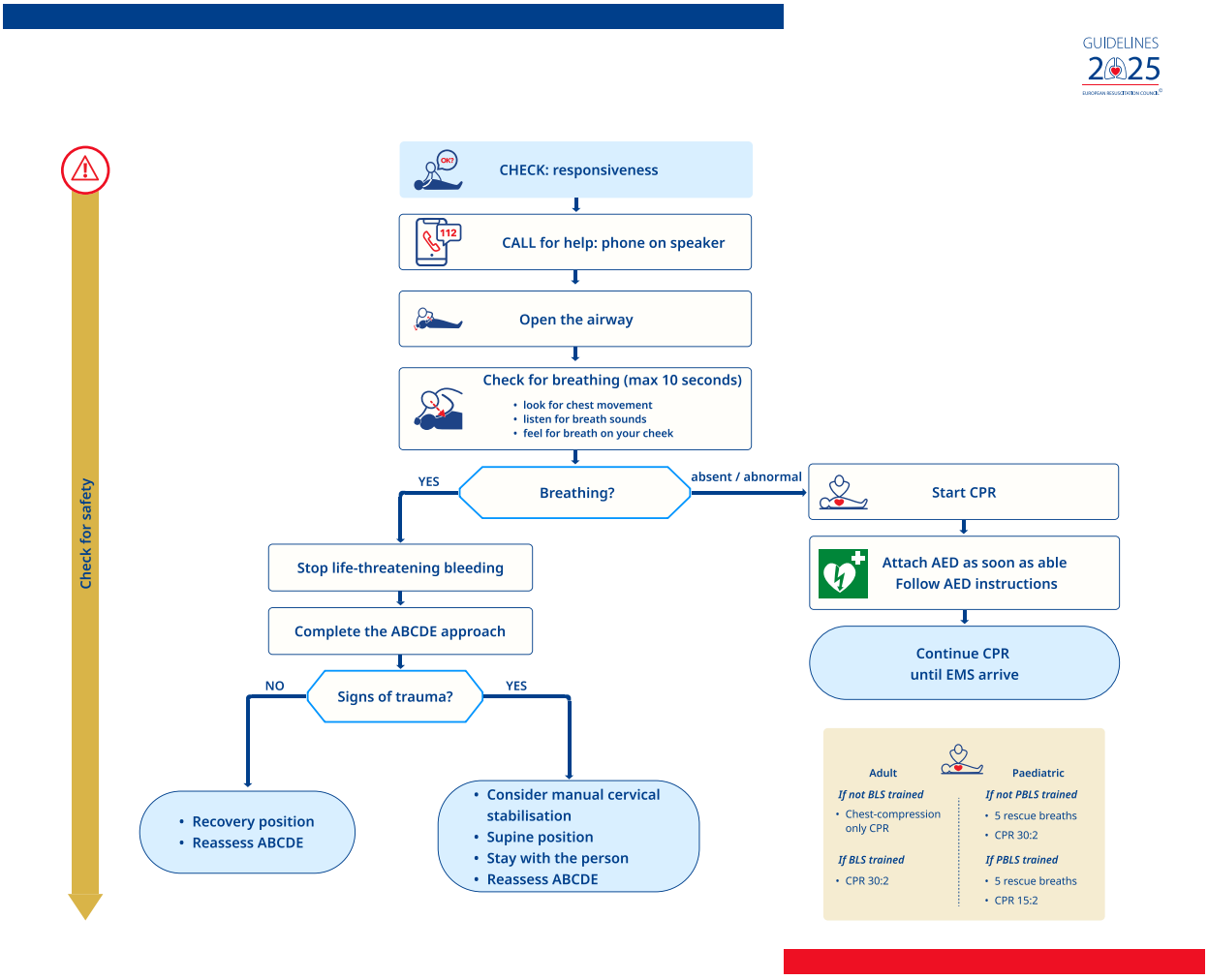


Fig. 2 – Approach to a person with impaired responsiveness and positioning their body.

- Use the ABCDE framework to structure your assessment of a person in need (Table 3).

Recovery position

- Place adults and children with decreased level of responsiveness who do NOT meet the criteria for CPR into a lateral (side-lying) recovery position (Fig. 3).
- In cases of agonal breathing or trauma, do NOT move the person into the recovery position.

Use of a pulse oximetry and use of oxygen for acute difficulty breathing

- Give oxygen to a person with difficulty breathing and looking cyanosed (blue tinged) but only if you are trained in its use.

Table 3 – The ABCDE for a first aid provider.

	Assess	Possible immediate action for an adult person
Safety	Is it safe to approach the person? (Road traffic? Spilled chemicals? Violent persons?)	
Responsiveness	Gently stimulate the person. Ask loudly "Are you ok?"	
Life-threatening Bleeding	Are there any signs of life-threatening bleeding?	Stop the bleeding with direct manual pressure, gauze dressings, haemostatic dressings or a tourniquet (Fig. 9).
A-Airway	Is the person´s airway open? Has the person fallen from a height or experienced major trauma? (Consider cervical spine injury)	Place one hand on the forehead and the fingertips of your other hand under the point of the chin, gently tilt the persons head back, lifting the chin to open the airway (QR-code 1). Do not move the person unless they are in an unsafe situation. Apply cervical spinal motion restriction (QR code 1)
B- Breathing	Is the person breathing? "Look, Listen, Feel" for normal breathing (maximum 10 s). Listen for wheezing or stridor. Is there any obvious swelling of the oral airway? Is the person choking and unable to cough? Ask "are you choking?" Are there any signs of hypoxia (bluish discoloration of lips, nails or skin)? Assess oxygen saturation level with a pulse oximetry.	If unresponsive and not breathing normally, call your local emergency number and start CPR according to dispatcher instructions. If suspected anaphylaxis, if trained, administer adrenaline 0.5 mg intramuscular (Fig. 4). If suspected choking give back blows and abdominal thrusts (Fig. 5). If trained and indicated, administer oxygen to improve oxygen saturation to 94–98 %.
C-Circulation	Does the person have chest pain? Is there any pain in the chest, neck or arm; or a 'severe pressure in the chest' feeling? Are there any signs of a low blood pressure or shock: o Very fast or very slow heart rate? o Skin pale, cool or clammy? o Dizziness or confusion?	Make the person comfortable. If suspected cardiac chest pain – administer 150–500 mg chewable aspirin. Consider the use of passive leg raising as a temporising measure while waiting for advanced emergency medical care. Continue to monitor person carefully for deterioration or loss of responsiveness (possible cardiac arrest).
D-Disability	Assess level of responsiveness using the acronym ACVPU; Use a scale for stroke assessment if appropriate • A-Alert • C-Confusion- any new or deterioration? • V- Verbal- respond to your voice • P- Pain- respond to pain from squeezing their shoulder • U- Unresponsive	If suspected concussion, – remove from physical activity. If suspected hypoglycaemia, – administer glucose or dextrose tablets (15–20 g) via mouth. If suspected opioid overdose, – administer nasal naloxone (Fig. 6).
E-Exposure	Check for external injuries by checking the whole body surface area (head, neck, trunk and limbs). Measure core temperature (if possible).	Prevent hypothermia –remove wet clothes and use blankets. Hyperthermia – start active cooling. Preserve amputated parts in cooled container and bring them to the same hospital as the injured person.

Use the recovery position in a person with a decreased level of responsiveness of nontraumatic aetiology, who is breathing normally and does not require immediate resuscitation interventions (Fig. 3).

Reassess for signs of airway occlusion, inadequate or agonal breathing, and unresponsiveness.

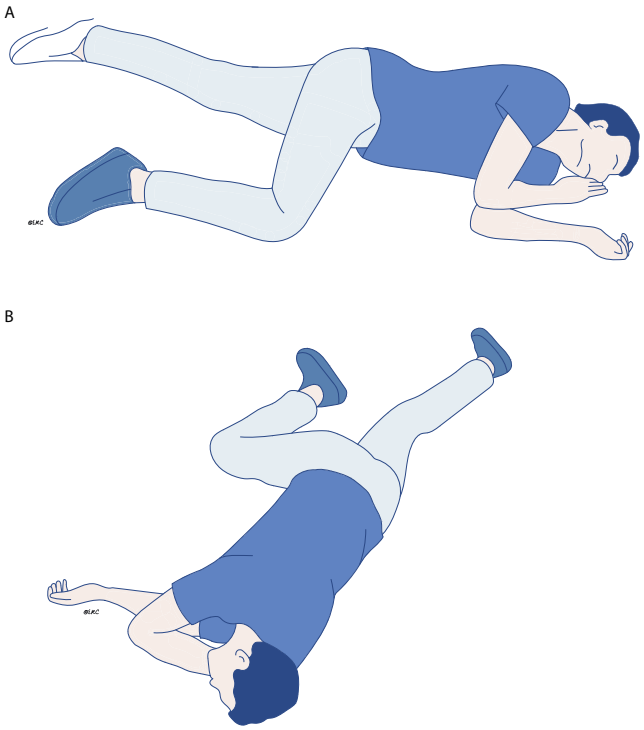


Fig. 3 – Recovery position to maintain an open airway with arm bent (a) and arm straight (b).

- Use a pulse oximeter to titrate the administered oxygen.
- Give oxygen via a simple facemask or non-rebreathing mask and then titrate flow rate to maintain an oxygen saturation of 94–98 %.
- If the person has chronic obstructive pulmonary disease, titrate the oxygen flow to maintain an oxygen saturation of 88–92 %.
- In the presence of life-threatening hypoxaemia (oxygen saturation <88 %) give oxygen with a higher flow to everyone, including persons with chronic obstructive pulmonary disease having difficulty in breathing in the out-of-hospital setting.

Medical emergencies

Anaphylaxis

- Suspect anaphylaxis if someone has:
  - o Stridor (which could be due to upper airway swelling), wheezing (which could be due to lower airway obstruction) or breathing difficulties
  - o Flushing, rash (hives), cold or clammy skin or is feeling faint
  - o Abdominal pain, vomiting, or diarrhoea
  - o A recent exposure to known food allergens or insect stings
- Call your emergency number (112).
- Ensure that the person remains in a seated or lying position.
- Give intramuscular adrenaline as soon as possible via autoinjector into the outer thigh in the recommended dose (self-administered or given by trained individuals) (Fig. 4),
  - o 0.15 mg for children aged 1–5 years
  - o 0.3 mg for children aged 6–12 years
  - o 0.5 mg for adults
- If an autoinjector is not available, use a device for intranasal administration.
- Give a second dose of adrenaline, if symptoms persist 5 min after administration.

Choking in an adult person

- Suspect choking if a person is suddenly unable to speak or cough, particularly if eating.
- Ask the person – “Are you choking?”
- Encourage the person to cough.
  - If the person is unable to cough or the cough becomes ineffective, give up to 5 back blows (Fig. 5).
  - If back blows are ineffective, give up to 5 abdominal thrusts (Fig. 5).
  - If choking has not been relieved after 5 abdominal thrusts, continue alternating 5 back blows with 5 abdominal thrusts until choking is relieved, or the person becomes unresponsive.
  - Call your emergency number (112).
  - Do NOT use blind finger sweeps to try and remove a foreign body from the mouth or airway.
  - If the person becomes unresponsive, start CPR.
  - Any person successfully treated for choking with abdominal thrusts or chest compressions should be evaluated by a healthcare practitioner since complications and injuries may occur.

Asthma

- If a person with asthma is experiencing breathing difficulties, a first aid provider should help them to use their own reliever inhaler, using a spacer device if one is available.

Chest pain

- Reassure the person and sit or lie them in a comfortable position.
- Encourage and assist a person with cardiac sounding chest pain in self-administering 150–500 mg of chewable aspirin as soon as possible whilst awaiting transport to hospital (but not to adults with known aspirin allergy).
- Assist a person with known angina to self-administer their nitroglycerine spray or tablets.
- Stay with the person until professional help arrives.

Hypoglycaemia (low blood sugar value)

- Suspect hypoglycaemia in someone with diabetes or chronic malnutrition AND sudden impaired responsiveness or behavioural change.
- Give glucose or dextrose tablets (15–20 g), by mouth if the person is awake and able to swallow.
- If feasible, measure capillary blood sugar using a blood glucose meter and treat if low (a value less than 4.0 mmol/L or 70 mg/dL) and repeat measurement after treatment.
- If glucose or dextrose tablets are not available give other dietary sugars, such as a handful of sugary sweets or 50–100 ml of fruit juice or sugar containing soda.
- If oral glucose is not available, give a glucose gel (partially held in the cheek, and partially swallowed).
- Repeat giving oral glucose if the symptoms are still present and not improving after 15 min.
- If the person has a prescribed glucagon autoinjector, this could be administered under the skin in the outer thigh (self-administered or by trained individuals). Some diabetics may have glucagon syringes for nasal use.

- For children, consider administering half a teaspoon of table sugar (2.5 g) under the child's tongue, if they are uncooperative with swallowing oral glucose.
- Call your emergency number (112) if the person is/or becomes unresponsive or the condition does not improve.
- Following recovery from symptoms (5–10 min after sugar intake) encourage the person to eat a light snack.
- For unresponsive persons, do not give oral sugar due to the risk of aspiration, instead call your local emergency number (112).

QR code 1 – Airway opening, jaw thrust (a) and chin lift (b).

Opioid overdose

- Suspect an opioid overdose if the person is breathing is slowly, irregularly or not at all, is extremely drowsy or unresponsive, or has pinpoint (very small) pupils.
- If the person is unresponsive and not breathing normally, start CPR and call your local emergency number (112) (Fig. 6).
- Administer intra-nasal naloxone, or if you are trained, use an intramuscular naloxone autoinjector.
- Reassess the person according to ABCDE (Table 3).
- Follow package instructions on when to give another dose of naloxone.

The management of general intoxications and opioid overdose has been described in the ERC Guidelines 2025 Special Circumstances in Resuscitation.

Stroke

- Use a stroke assessment scale to decrease the time to recognition and call for help.
- Give oxygen only if you are trained in its use and the person is showing signs of hypoxia (bluish lips and rapid breathing).

Suicidal thoughts

If you think a person might harm themselves;

- Ask the individual "Are you alright?" "How do you feel and why?" (Fig. 7)
- Ask if the person has suicidal thoughts and plans (How? Where? When?).
- Summarise to the person your understanding of how and why they have certain feelings.
- If the person has made concrete threats or plans for suicide, tell them you are going to ask for help, and call your emergency number (112).
- Give hope.

Trauma emergencies

Cervical spinal motion restriction

- Suspect a cervical spine injury in a person who fell or dived from a height, was crushed by machinery or a heavy object, was involved in a road traffic, or a sporting accident.
- Minimise movement of the neck if the person is awake and alert and encourage them to self-maintain their neck in a comfortable stable position.
- Never force an uncooperative person into any position, as this may exacerbate an injury.
- In unresponsive persons lying on their back, kneel behind their head and immobilise their head and neck using head or trapezius squeeze (Fig. 8).
- Consider the need to open the person's airway using the 'jaw-thrust' technique (QR code 1).
- If the person is unresponsive and is lying face-down, check if their airway is open and hold their neck in a stable position.
  - If you need to open their airway, ask others to help you carefully roll them as a unit onto their back whilst keeping their neck in line with their body and as stable as possible. Then apply the head or trapezius squeeze.
- First aid responders with specialised training (e.g. ski patrol, lifeguard) may consider the selective use of spinal motion restriction using their existing protocols.

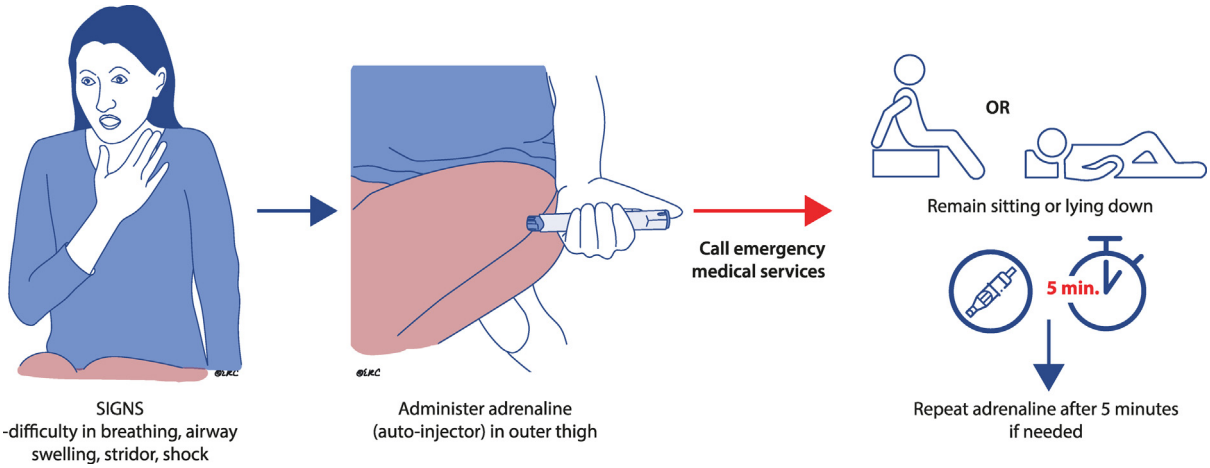


Fig. 4 – Order of actions for anaphylaxis.

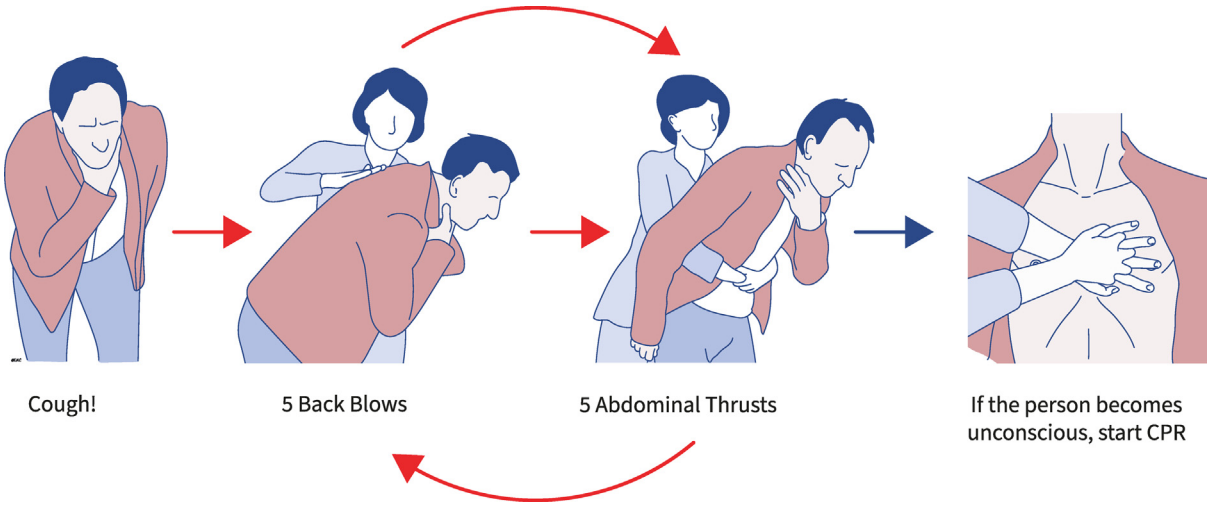


Fig. 5 – Order of actions for choking.

Control of life-threatening bleeding

- Apply firm direct manual pressure to the bleeding injury (Fig. 9).
- Apply a standard or haemostatic dressing directly into the bleeding injury and then apply firm direct manual pressure on top of the dressing.
- Once bleeding is under control, apply a pressure dressing.
- Apply a tourniquet as soon as possible for life-threatening extremity bleeding that is not controlled by direct manual pressure.
- Write the time of application on the tourniquet.

Open chest wounds

- Leave an open chest wound exposed to freely communicate with the external environment.
- Do not apply a dressing or cover the wound.
- If necessary, control localised bleeding with direct pressure.
- If you are trained and the equipment is available, apply a specialised non-occlusive or vented dressing, ensuring a free outflow of air when breathing out.
- Observe the wound for air flow obstruction due to bleeding or clotted blood.

Concussion

- Suspect a concussion if a person has difficulties with thinking/remembering, displays physical symptoms (headache, change in vision, dizziness, nausea or vomiting, seizures, sensitivity to light/noise), emotional changes or changes in behaviour (increased sleepiness, reduction in normal activities, loss of responsiveness, confusion).
- Remove the person from physical activities.
- Refer to a healthcare professional for assessment and further advice.

Preservation of an amputated body part

- Manage any severe bleeding first (see 'Control of life-threatening bleeding').
- Retrieve the body part as quickly as possible and keep it cold without freezing (Fig. 10).
  - o Wrap the part in a sterile dressing or a clean cloth moistened with saline or water.
  - o Place the wrapped part in a clean watertight plastic bag or container.
  - o Put the bag or container holding the body part, inside another bag containing ice or ice-water. If ice is unavailable, you can use a cooler with instant cold packs.
- Keep the part cooled at all times. Avoid direct contact with ice or freezing. Label the container with the person's name and time the part was stored.
- Transport the part with the injured person to the same hospital as quickly as possible.

Environmental emergencies

Drowning

- Do not enter the water as you might risk drowning yourself if you are not trained in water rescue.
- If the person is awake and responsive, stay on land and reach out to the person through floatation devices, lifebuoy, rescue tube or other rescue equipment.

Trained first aiders or lifeguards in the water or on a boat (Fig. 11).

- Call for help before you enter the water.
- Provide a flotation device, lifebuoy, rescue tube or other rescue equipment.
- Keep the person´s head out of the water.
- Assess if the person is unresponsive and not breathing. If feasible and safe (with an effective flotation device), provide 5 rescue breaths in the water as soon as possible.
- Retrieve the person to land or a rescue boat as soon as possible.
- Once out of the water, provide 5 rescue breaths if the person is not breathing, if necessary, start standard CPR.
- Attach an AED, if available and after drying the chest, and follow the instructions.

On land, if the person has drowned and is unresponsive and not breathing:

- If feasible and safe, provide 5 rescue breaths and start standard CPR.

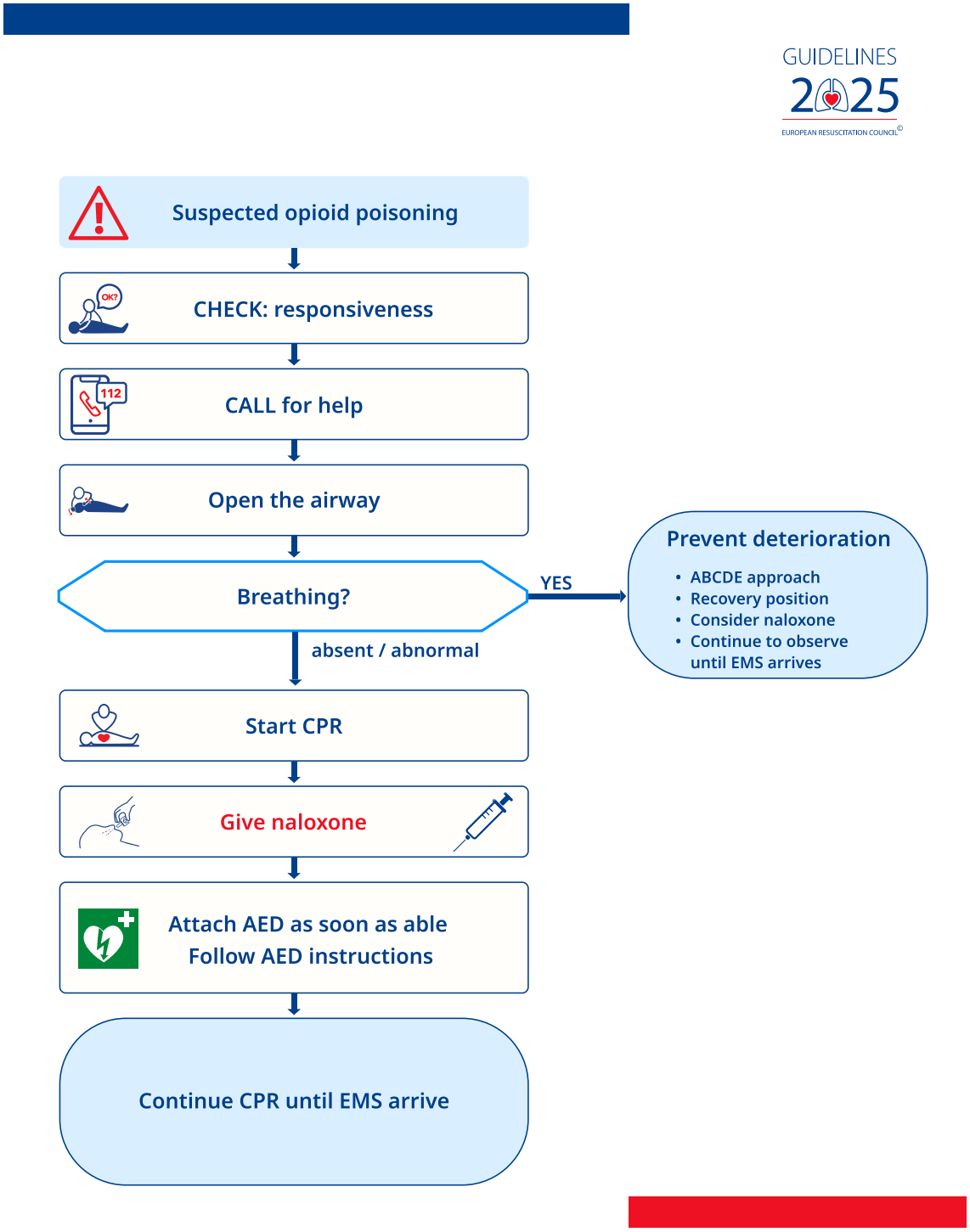


Fig. 6 – Order of actions for opioid overdose.

- Attach an AED, if available and after drying the chest, and follow the instructions.

Prevention of hypothermia

- Insulation: Cover the individual with dry blankets or clothing to minimise heat loss.
- Wind protection: Shield the person from wind using barriers or by moving them to a sheltered area.
- Wet clothing removal: Gently remove wet clothing and replace it with dry garments to prevent further cooling.
- Ground isolation: Place insulating materials, such as blankets or pads, between the individual and the cold ground.
- In settings where hypothermia might be common, implement tailored prevention plans and training for first aid providers.

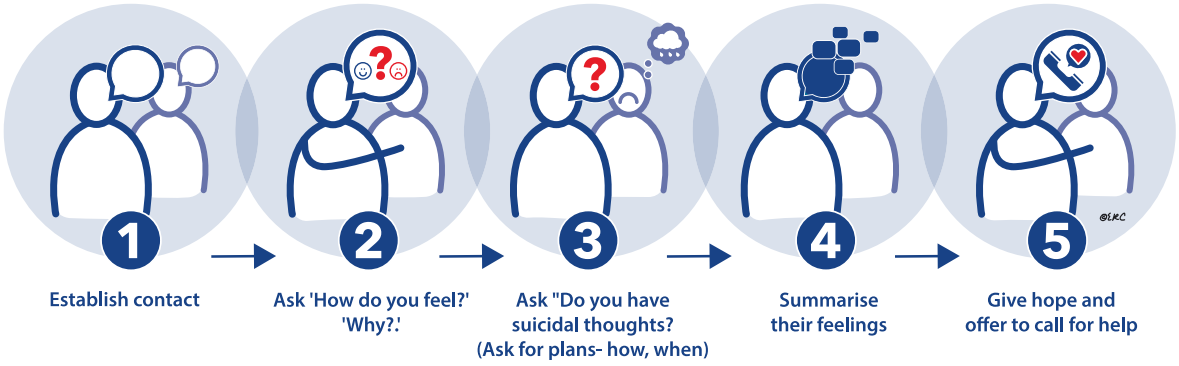


Fig. 7 – Chain of first aid actions in mental health crisis.

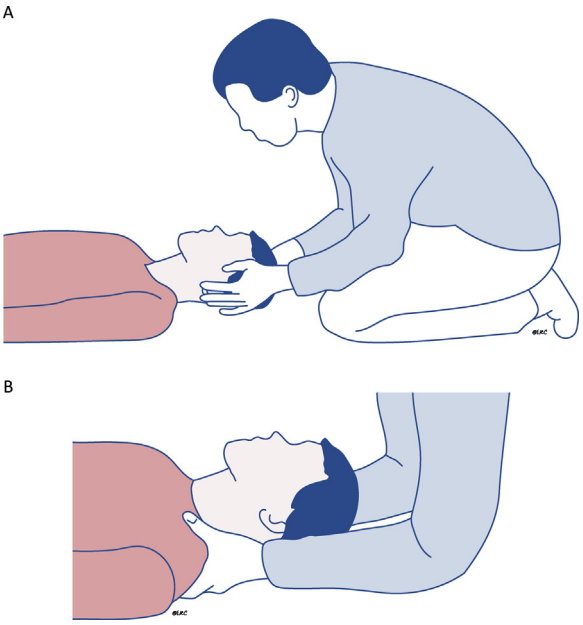


Fig. 8 – Spinal motion restriction to maintain an open airway with the head squeeze method (a) and the trapezius squeeze method (b).

Heat stroke

- Consider symptoms of heat stroke with high ambient temperature, like elevated core body temperature, confusion, agitation, disorientation, seizures or unresponsiveness.
- Prevent exertional heat stroke (i.e. during long-distance sport events in a hot climate) by adequate preparation and provide tools to support recognition (e.g. rectal temperature probes) and cooling (e.g. immersion ice-water baths).
- With suspected heat stroke remove the person from the heat source and commence passive cooling by removing excess clothing and placing the person in a cooler/shaded location (Fig. 12).
- Use any technique immediately available to provide active cooling, if core temperature >40 °C.
- Use whole body (neck down) cold water (1 to 26 °C) immersion until the core temperature falls below 39 °C. Alternatives are: tarp-assisted cooling oscillation (TACO) (Fig. 13) ice sheets, commercial ice packs, fan alone, cold shower, hand cooling devices, cooling vests and jackets or evaporative cooling (mist and fan).
- Where possible monitor core temperature (rectal thermometer).
- If a core temperature cannot be obtained, continue cooling for 15 min or until neurological symptoms resolve, whichever is first.
- Remember: cool first, transfer second.
- Continue cooling as needed during transportation to a medical facility for further evaluation.

Snake bite

The only indigenous highly venomous snake in Europe is the European Viper, which has a haemolytic toxic venom.

- Call your local emergency number (112).
- Keep the person calm and at rest.
- Keep the bitten body part still and immobilise the affected limb as this may slow venom spread.
- Remove tight clothes, rings or watches from the affected limb.
- Avoid harmful actions:
  - Do not apply a pressure dressing, ice, heat, or use tourniquets.
  - Do not cut the wound and never try to suck out the venom (QR code 2).

QR code 2 – ERC Guideline 2025 First Aid in pictures.

The evidence informing the first aid guidelines

Expectations of a first aid provider, first aid courses, implementation of first aid guidelines and considerations for different settings

These guidelines provides evidence-informed recommendations aimed at improving the immediate response to injury and sudden illness. Research in first aid is limited and indirect evidence from prehos-

pital studies have been used to inform these guidelines. Put simply, all resuscitation starts with first aid and first aid is often just the start of interventions needed to save lives. First aid is the helping behaviour that could be lifesaving. For some first aid providers, the only step will consist of calling the local emergency number for help. For others, calling for help will be the first step in a series of interventions. All first aid providers should only use the equipment and medication they have been trained to use. A systematic review[7] and two cohort studies[8] suggest that simple manoeuvres such as opening the airway or stopping a bleed might prevent death. An ILCOR scoping review suggests that these helping behaviours and the willingness to train is stronger in first aid providers who have witnessed someone collapsing.[9]

When teaching first aid and implementing first aid guidelines, four essential domains should be considered: the recipient, the provider, the treatment, and the setting (Table 2). Taking these domains into account will support implementation across various provider skill levels, ranging from untrained bystanders to healthcare professionals, and across diverse environments including remote and low-resource areas. Remote and low-resource settings may highlight the increased importance of first aid when there is a longer delay before professional medical care is available. In many settings first aid providers are legally protected by Good Samaritan laws.[10] The ethical aspects of first aid have been described in the ERC Guideline 2025 Ethics in Resuscitation,[11] while the educational aspects are in the ERC Guideline 2025 Education for Resuscitation.[12]

First aid courses are designed to equip participants with the knowledge, skills, and confidence needed to act in a wide range of situations, fostering a community prepared to respond effectively when emergencies arise. The ERC promotes structured educational programs reducing known barriers to training such as advanced age, lower socioeconomic and educational status, as well as being part of minority groups due to race or language.[13]

Helping severely ill or injured persons as a first aid provider may be stressful.[14,15] An ILCOR scoping review[9] suggested that courses with a tailored content based on the participants' needs and requirements, related to specific environmental risks, may be more effective than the delivery of standardised one-size-fits-all courses.[9] Course directors should promote equity by delivering courses that reduce disparities between disadvantaged and privileged populations. Furthermore, the content should be socio-culturally appropriate, and the knowledge and skills taught should be appropriate for use within the regional health system.[3,5] The comprehensive and multifaceted aspects of education within resuscitation have been described in the ERC Guidelines 2025 Education for Resuscitation.[12]

First aid kits

The ERC recommends that all workplaces, leisure centres, public buildings, homes, and vehicles should be equipped with appropriate first aid kits. The content of a first aid kit should be tailored to the environment and to potential medical emergencies that may arise. In workplaces and public spaces, these kits should comply with local legal health and safety requirements, be clearly marked, and remain easily accessible.[16] For the home or vehicle use, individuals can purchase a pre-filled first aid kit or assemble one themselves if local laws allow. A well-stocked first aid kit should include essential supplies such as adhesive dressings, medium and large wound dressings, roller bandages, triangular bandages, safety pins, adhesive tape, disposable gloves, disposable face masks, plastic aprons, hand sanitisers, and a face shield or a pocket mask, all stored in a suitable well-marked watertight container. Additional useful items can include scissors, tweezers, and tough cut shears. In many countries, car first aid kits must include a warning triangle and a high-visibility jacket to improve first aid provider safety and to meet legal

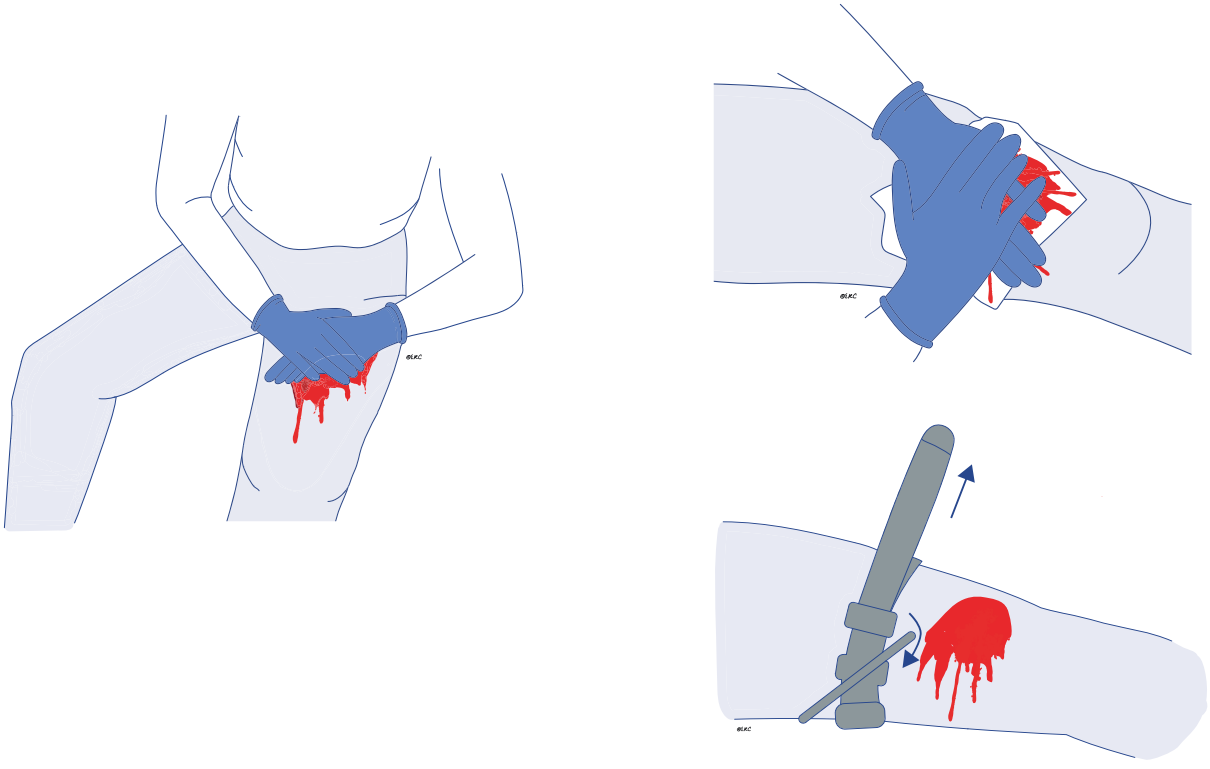


Fig. 9 – Control of life-threatening bleeding.

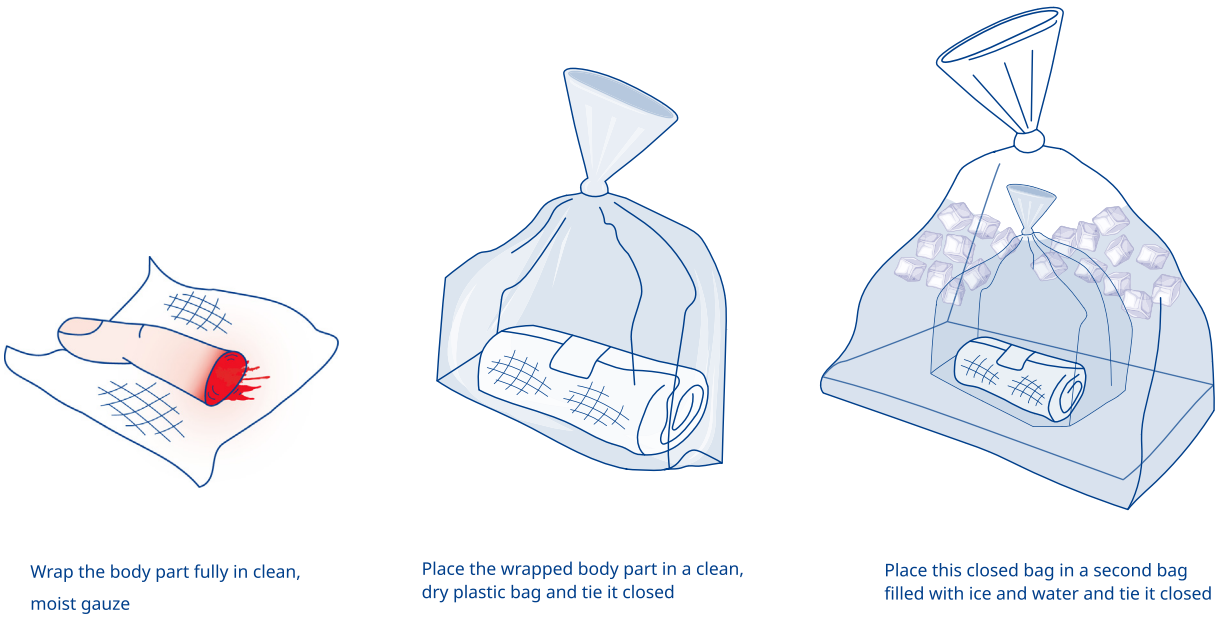


Fig. 10 – Steps for preservation of an amputated body part.

requirements. Specialised first aid equipment should be included in first aid kits based on the specific risks associated with a job or location.

An online survey by this Writing Group (Appendix B) found that tourniquets (for life-threatening bleeding) and naloxone (for opiate overdose treatment) are becoming more widely available and used, underscoring the growing understanding of their significance in first aid and emergency response situations.

First aid kits in workplaces with a high risk of life-threatening bleeding, such as forestry or construction, should contain tourniquets and haemostatic dressings. The presence of bleeding control kits in public spaces has been shown to improve confidence of lay responders[17] who are more likely to use them, particularly if they have received prior training in these techniques. Additionally, bystander training programs such as 'Stop the Bleed' have demonstrated that individuals equipped with trauma first aid kits are more confident and effective in hemorrhage control.[17] High-risk environments for opioid-related medical emergencies, such as substance abuse treatment centers, nightclubs, and public transportation hubs, should have naloxone readily available for immediate overdose intervention,[18] if compatible with local legislation. Those providing first aid in extreme weather outdoor settings should consider adding a compact survival bag, splinting, wound dressings, a flashlight, and a whistle to first aid kits.

Cardiac arrest

The delivery of high-quality chest compressions is a key step in the chain of survival for patients in cardiac arrest and immediate CPR initiated by first aid providers is associated with improved outcomes. However, there may be reluctance amongst first aid providers to initiate CPR for fear of causing harm. Injuries resulting from CPR performed on persons with prolonged cardiac arrest are common and mainly involve rib and sternal fractures, and lung and abdominal organ injuries.[19,20] On the other hand, the risk of harming persons by doing CPR while they are actually not in cardiac arrest, is largely unfounded. A systematic review of persons who received chest compressions but were not in a cardiac arrest undertaken by the ILCOR First Aid Task Force included five observational studies with 1031 patients,[21] with only 9 (<1 %) experiencing injuries, including rib fractures and different internal bleedings, and 24 (2 %) reporting symptoms such as post incident chest pain.[21] First aid providers and other rescuers such as trained bystanders, healthcare professionals and those with a duty to respond, should initiate CPR for presumed cardiac arrest without concerns of causing unintentional injury, even if a person might not be in cardiac arrest. The initial management of a cardiac arrest has been described in the ERC Guidelines 2025 Adult Basic Life Support.[22]

Structured first aid assessment of a person appearing ill, injured or in shock (ABCDE)

A recent scoping review[23] including 57 studies reported 39 different assessment tools for healthcare professionals or healthcare students. Of these, 23 used the structured ABCDE approach.[23] The reasons for variation between the 23 different ABCDE approaches related to different assessor competencies and specific overall goals for the assessment. Time to completion of the first assessment in the scoping review was between two to six minutes in a simulated environment. The ERC recommends the use of the ABCDE structured assessment, or a similar assessment framework for all healthcare professionals and first aid providers.

Following an initial check for scene safety, the first aid assessment begins with checking for responsiveness and the presence of any immediate life-threatening conditions such as life-threatening bleeding or cardiac arrest. To assess a responsive person, observe their appearance, ask questions to learn about their symptoms, allergies and medical history and, after obtaining permission, check for physical signs of any illness or injury. The framework ABCDE could

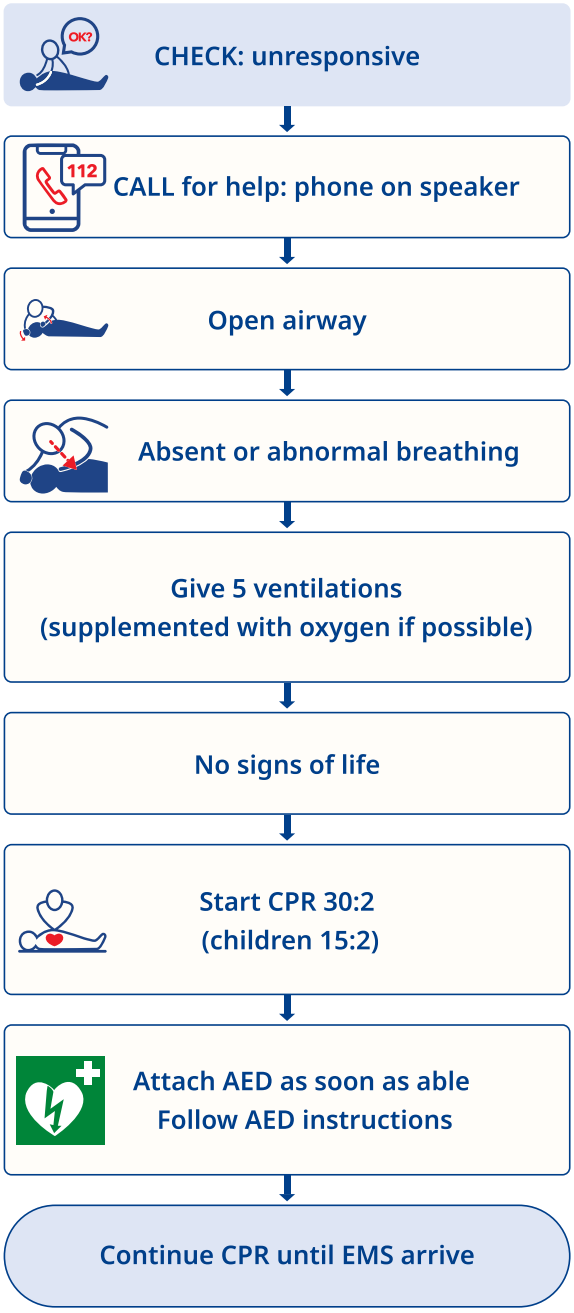


Fig. 11 – CPR after drowning.

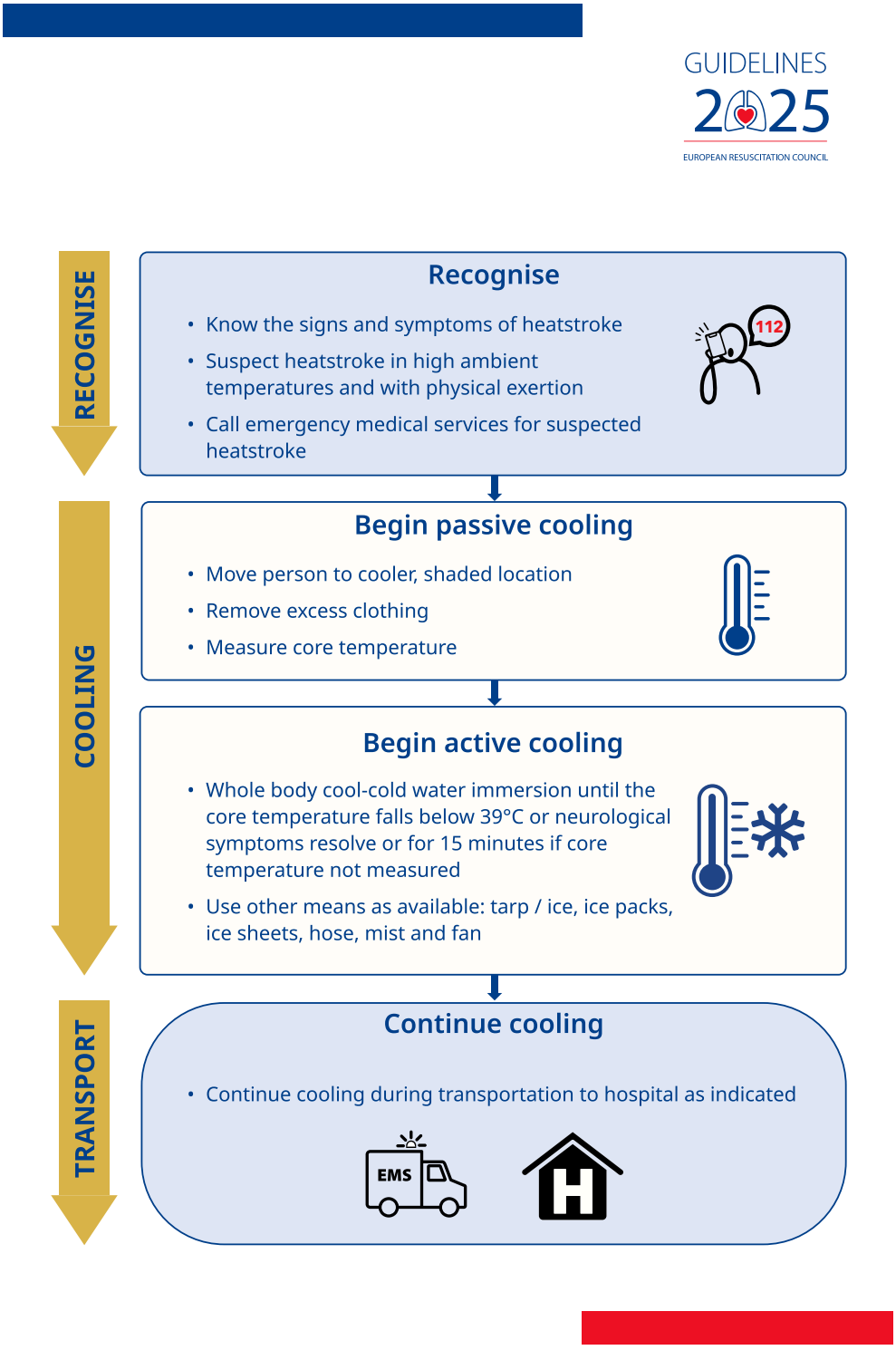


Fig. 12 – Management of heatstroke and exertional hyperthermia.

be used to structure the assessment of a person appearing ill or injured. Table 3 is a summary of the assessment process and immediate actions to undertake, details are provided under each subsection. The assessment should be thorough but only take a few minutes to complete. The assessment of an ill or injured child is described in the ERC Guidelines 2025 Paediatric Life Support.[24]

The European Society of Intensive Care Medicine has defined shock as a life-threatening, generalised form of acute circulatory failure associated with inadequate oxygen utilisation by the cells.[25] Shock has multiple causes, however the main aim for a first aid provider should be to recognise further deterioration by reassessing vital signs as well as by keeping the person in a supine position, rather



Fig. 13 – Tarp assisted oscillating cooling in heat stroke.

than by moving them into an alternative position.[26] The use of passive leg raising may provide a transient (<7 min) improvement in heart rate, mean arterial pressure, cardiac index, or stroke volume for those with no evidence of trauma.[27,28] The optimal degree of elevation has not been determined, with studies of passive leg raising ranging between 30–60-degrees elevation. Because improvement with passive leg raising is brief and its clinical significance uncertain, it is not recommended as a routine procedure, although it may be appropriate in some first aid settings. These recommendations place an increased value on the potential, but uncertain, clinical benefit of improved vital signs and cardiac function, by positioning a victim with shock in the supine position (with or without passive leg raise), over the risk of moving the victim.

Recovery position

An ILCOR scoping review of the recovery position in adults and children with decreased levels of responsiveness—due to medical illness or non-physical trauma and not meeting criteria for CPR—identified 34 studies.[26] Most of these were conducted in awake, healthy volunteers and focused on comfort and ensuring non-occlusion of the vascular supply to the dependent arm. A recent randomised controlled trial (RCT) on volunteers positioned in recovery position with bent or straight arm showed no difference in upper arm vascular supply or comfort,[29] therefore either position may be used. It can be used in persons with reduced responsiveness to maintain a clear airway and, in children, results in decreased hospitalisation rates.[30] However, in a single observational study, the semi recumbent position was favoured over the lateral position in opioid overdose.[31] Based on the ILCOR scoping review, the ERC recommends positioning the person in a lateral, side-lying recovery (lateral recumbent) position as opposed to leaving the person supine. A person placed in the recovery position should be monitored for continued airway patency, breathing and their level of responsiveness. If these critical signs deteriorate the person should be repositioned into a supine position and, if required, CPR initiated. For a person with agonal breathing or who has suffered trauma, you should not use the recovery position. Persons with a known trauma should be kept in supine position.

For adults and children with a decreased level of responsiveness due to medical illness or non-physical trauma, who do NOT meet the criteria for the initiation of rescue breathing or chest compressions (CPR), place the person into a lateral (side-lying) recovery position (Fig. 3):

- Make sure that the person's legs are straight.
- Place the arm nearest to you out at a right angle to the body. The arm can be straight (Fig. 3a) or bent (Fig. 3b).
- Bring the far arm across the chest and hold the back of the hand against the person's cheek nearest to you.

- With your other hand, grasp the far leg just above the knee and gently lift the knee up, keeping the foot on the ground, to bend the knee.
- Keeping the hand pressed against the cheek, pull on the far, bent leg to carefully roll the person towards you onto their side.
- Adjust the upper leg so that both hip and knee are bent at right angles.
- Carefully tilt the head back to make sure the airway remains open.
- Adjust the hand under the cheek, if necessary, to keep the head tilted and facing downwards to the side to allow liquid material to drain from the mouth.
- Check regularly for normal breathing.
- Only leave the person unattended, if necessary, to seek help.

In cases where there is a large size difference between the first aid provider and the unresponsive person, you may consider positioning the knee first, to reduce the stretching required to reach the far arm.

Use of pulse oximetry

A pulse oximeter is a non-invasive device that sends red and infrared light through a fingertip, earlobe or other tissue and, using a sensor, measures the oxygen saturation (the level of oxygen bound to haemoglobin) in the blood and the pulse rate. A 2022 ILCOR scoping review did not identify any studies evaluating the use of pulse oximetry specifically in the first aid setting.[32] However, pulse oximeters have been widely used by the public for daily self-monitoring of blood oxygen saturation and heart rate during COVID-19 and other respiratory infections, and in patients with chronic obstructive pulmonary disease (COPD), pulmonary embolism, asthma, and cystic fibrosis.[32] Pulse oximeters are now commonly included in many first aid kits and wearables such as watches and fitness bands. Use of a pulse oximeter should never replace or delay a structured ABCDE assessment (Table 3). Hypoxaemia may be missed due to an overestimation of oxygen saturation in persons with dark skin and others with high levels of skin pigmentation.[7,33–36] Pulse oximeter readings may also be inaccurate or unreadable in shock or low perfusion states, with increased nail thickness or polish, a low battery level, movement or vibration, and in extremes of temperature.[37]

Use of oxygen for acute difficulty of breathing

Not all first aid providers are trained or allowed to administer oxygen. However, some first aid organisations train and equip their members to safely and effectively give supplementary oxygen for specific conditions associated with hypoxia, such as following drowning, or carbon monoxide poisoning.

A 2015 ILCOR review suggested the use of supplementary oxygen in persons with symptoms of hypoxia.[38,39] More recently, the use of supplementary oxygen in persons with an acute exacerbation of COPD was highlighted in a 2025 ILCOR scoping review.[40] One RCT[41] evaluated the emergency medical service use of fixed flow oxygen of 8–10 L/min via a nonrebreathing face mask compared with titrated oxygen via nasal prongs to maintain an oxygen saturation between 88–92 % in persons with diagnoses of COPD and acute shortness of breath. The use of titrated oxygen in persons with an acute exacerbation of COPD was found to reduce mortality by 58 % compared with high-flow oxygen. Similarly, retrospective studies have also found uncontrolled oxygen flow in acute exacerbations of COPD to be associated with an increased risk of death, assisted ventilation or respiratory failure.[42–44] No evidence was found in the scoping review to suggest against the first aid administration of oxygen in adults or children exhibiting signs or symptoms of acute shortness of breath or hypoxia in the out-of-hospital setting. The indirect evidence identified suggests that uncontrolled oxygen may be harmful for persons with acute exacerbations of COPD. These first aid recommendations are based on an ILCOR good practice statement that suggests that supplementary oxygen administration should be titrated to an oxygen saturation of 88–92 % for patients with an acute exacerbation of COPD.[40] However, in the presence of life-threatening hypoxaemia (oxygen saturation <88 %), high-flow or high concentration oxygen should not be restricted.

Medical emergencies

Anaphylaxis

Anaphylaxis is a severe, life-threatening hypersensitivity reaction that can be fatal if not promptly identified and treated. Foods, drugs, insect stings or venom and latex are the most common triggers in Europe according to a systematic review.[45] About one quarter of all cases in the European Anaphylaxis Registry occur in children, with the most common trigger being food (tree nuts, cow´s milk, chicken eggs) while bee stings are most common in adults.[46,47] Fatal anaphylaxis can occur rapidly following exposure. The time to reaction depends on route of exposure and type of allergen—within five minutes for iatrogenic reactions, 15 min for insect stings or venom, 30 min for food-related reactions and up to a delay of more than 4 h for oral drugs.[46] These timeframes underscore the critical importance of effective first aid strategies for managing anaphylaxis.[48]

Recognition of anaphylaxis. Recognising and diagnosing anaphylaxis can be challenging due to a wide constellation of symptoms that often mimic allergic and non-allergic disorders.[49] An updated 2023 ILCOR scoping review lists the most common signs and symptoms for anaphylaxis as anxiety, breathing difficulties (including noisy breathing, wheezing or persistent cough), airway narrowing, swelling of the face and the tongue, difficulty in talking and/or a hoarse voice, abdominal pain, diarrhoea, nausea and vomiting, hives, welts and flushing, signs of shock (including confusion or agitation, pallor and floppiness, loss of responsiveness), and cardiac arrest.[50] The same ILCOR scoping review identified recent studies on education, action plans, protocols, and factors affecting adrenaline auto-injector use which suggest that training improves anaphylaxis recognition.

Treatment of anaphylaxis. Positioning the person lying supine with raised legs, or in case of breathing problems sitting with legs stretched, might prevent circulatory deterioration (expert opinion).[51,52]

The World Allergy Organisation recommends the administration of intramuscular adrenaline as the first-line treatment for anaphylaxis, at a dose of 0.01 mg/kg up to a maximum of 0.5 mg for adults and teenagers. For children this is equivalent to 0.15 mg for those aged 1–5 years and 0.3 mg for children aged 6–12 years.[53] Adrena-

line is typically self-administered via an autoinjector and can be given by trained individuals, including family members, friends, and first aid providers. Prompt administration is critical, and in persons where symptoms persist, a second dose may be necessary (Fig. 4).

The ILCOR scoping review identified three studies related to second-dose adrenaline administration for anaphylaxis, but none focused on the first aid setting. One study found that patients receiving multiple doses of adrenaline for anaphylaxis had higher hospital admission rates, but no data were reported on symptom resolution or adverse effects.[54] A second study documented that anaphylaxis patients needing multiple doses of adrenaline experienced more severe symptoms but ultimately were more likely to have resolution of symptoms compared with those not receiving multiple doses.[55] The third study compared the pharmacokinetics and pharmacodynamics of three different adrenaline delivery methods: intramuscular injection, autoinjectors, and intranasal administration and concluded that intranasal administration might be a safe and effective option, particularly for persons reluctant to carry and use injection devices.[56] Based on an ILCOR scoping review[57] and a 2025 evidence update[1], we recommend that a second adrenaline dose may be injected after 5 min when symptoms of severe anaphylaxis fail to resolve.[58] The management of anaphylaxis has been described in the ERC Guidelines 2025 Special Circumstances in Resuscitation.[59]

Choking

Choking, or foreign body airway obstruction (FBAO), is a common problem and occurs most frequently in young children and in elderly persons.[60,61] Children, in particular, tend to put various objects in their mouths that can easily obstruct their airway,[62] while adults tend to choke on meat, nuts, grapes, and other food.[62,63] The ERC guidelines are informed by the 2020 ILCOR systematic review[64] and ILCOR 2025 evidence update and CoSTR including justifications.[1]

Recognition and Immediate intervention. A foreign body can lodge in the upper airway, trachea, or lower airway (bronchi and bronchioles).[65] In a partial airway obstruction, air may still pass around the obstruction, allowing some ventilation and the ability to cough or to speak. With complete obstruction, no air can pass around the obstruction and a person is unable to speak, has a weakening or absent cough, and is struggling or unable to breathe. If untreated, complete airway obstruction will rapidly cause hypoxia, loss of responsiveness and cardiac arrest in a few minutes.

Evidence from the 2025 ILCOR evidence update[1] supports existing recommendations for bystanders to undertake foreign body removal as soon as possible after recognition. When performed *prior* to cardiac arrest, bystander first aid interventions for foreign body removal have been shown to be effective and to improve survival.[60,66–68] The largest observational cohort study to date evaluated the effectiveness of FBAO interventions in both responsive and unresponsive patients with out-of-hospital FBAO.[60] A bystander performed the initial FBAO intervention in 643 cases (90.7 %) and was successful in relieving the obstruction in 492 patients (76.5 %). Of the 492 patients who had relief of their FBAO with bystander intervention, 480 (97.6 %) survived. A second multicentre observational study of 407 patients transported to the emergency department after a FBAO reported that bystanders attempted to intervene in 192/352 (55 %) of witnessed cases and successfully relieved the obstruction in 93/192 (48 %) of witnessed cases. Survival was significantly higher with bystander interventions, and 96/407 (24 %) of patients had a favourable neurological outcome.[69]

Treatment of the awake, responsive person with foreign body airway obstruction. A person who is awake, responsive and able to cough, should be encouraged to do so as coughing generates high and sustained airway pressures and may expel the foreign body.[70–72] Back blows, abdominal and chest thrusts are reserved for persons who have signs of severe complete airway obstruction, such as inability to cough or speak. If the person starts to show signs of fatigue, back blows are the recommended initial intervention. Compared with back blows, abdominal thrusts and chest thrusts or chest compressions as a first intervention are associated with decreased odds of FBAO relief and more reports of intervention-associated injuries.[60] Although guidelines recommend alternating back blows and abdominal/chest thrusts, many FBAOs may be resolved using a single technique. In a 2024 cohort study, only 16 % of responders reported alternating techniques[60]

If unable to cough or the cough becomes ineffective, give up to 5 back blows (Fig. 5):

- Stand behind the person.
- Use the heel of your hand to apply blows between the shoulder blades in the centre of the back.

If back blows are ineffective, give up to 5 abdominal thrusts (Fig. 5):

- Stand behind the person and put both your arms around the upper part of their abdomen.
- Lean the person forward.
- Clench your fist and place it between the umbilicus (navel) and the ribcage.
- Grasp your fist with the other hand and pull sharply inwards and upwards.

If choking has not been relieved after 5 abdominal thrusts, continue alternating 5 back blows with 5 abdominal thrusts until choking is relieved, or the person becomes unresponsive.

We have not identified any studies on a person being alone when choking and therefore lack data on the situation and what's feasible to do.

Treatment of the unresponsive person with foreign body airway obstruction. If at any point, the choking person becomes unresponsive with absent or abnormal breathing, chest compressions must be initiated in accordance with standard BLS and CPR continued until the person recovers or emergency services arrive. The rationale for this is that chest compressions generate higher airway pressures than abdominal thrusts and may potentially alleviate the obstruction, whilst also providing a cardiac output.[73,74]

A blind finger sweep, as a means of removing unseen solid material, may worsen airway obstruction or cause soft tissue injury.[75] Only attempt a finger sweep when an obstruction can be clearly seen in the mouth.

Suction-based devices for choking. In recent years, manual negative-pressure (suction-based) devices have become increasingly available and promoted for the removal of FBAO. The devices work by attaching a mask to a plunger unit with a one-way valve, placing the mask over the choking person's face and pulling on the plunger handle to create suction. One version of the device includes a phalange attached to the mask and that must be inserted into the patient's mouth. A 2020 ILCOR systematic review[75] and CoSTR included a single observational study that reported relief of the FBAO and survival in 10 patients with FBAO who were treated with a suction-based device. The evidence was insufficient to make any recommendation related to use of these devices. Since 2020, several new studies of these devices have been published. The largest study, conducted in Japan, was a prospective multicentre observational study of 407 patients transported to the emergency department after a FBAO.[69] The study reported that bystanders attempted to intervene in 55 % of witnessed cases and successfully relieved the obstruction in 48 % (92/192). The use of a suction device was the most common first intervention (25 %, n = 101/407) followed by back blows (21 %, n = 85/407)). However, it was not clear what type of suction device was used in this study (e.g., portable powered, vacuum, or manual airway clearance device).

Six case series reported relief of FBAO with use of a suction-based device in a total of 595/610 cases (97.5 %).[76–81] Two of these case series focused on children (320 cases, total),[77,79] while two[76,81] focused on use of a specific suction-based device by healthcare providers in an adult daycare/senior centre. In the case study by Bhanderi,[76] the device use was part of a protocol and was introduced after 2 rounds of 5 back blows alternating with 5 abdominal/chest thrusts failed to resolve the FBAO. An additional case series[67] noted relief of FBAO in 3/8 cases with suction from a vacuum cleaner. In the 2023 case series by Dune[78] use of a suction-based device was the last intervention before resolution of FBAO signs and symptoms in 96.2 % of 157 cases with one type of airway clearance device, and for 93.1 % of 29 cases with a second type of device. Most case series used data supplied from the manufacturers, which creates serious bias because only the positive or successful results are typically reported and the denominator is missing. A simulation study showed equally successful number of attempts but higher positive pressure gradients in the thorax with abdominal thrusts than with the use of a specific suction-based device.[82]

The reported number of 'pulls' or suction manoeuvres required for FBAO relief varies between case series, with one study[81] reporting 54 % requiring a single pull and 37 % requiring 2–3 pulls. The case series by Costable[77] reported relief of the FBAO required between 1 and 10 pulls with the device. Following use of a device, a finger sweep or rolling the person onto their side was required to completely remove the foreign body in up to a third of cases reported in one series.[78]

Few complications have been reported with use of suction-based devices for choking. Two cases of perioral bruising felt to be due to the device were reported by Dunne.[78] For other reported adverse events, including airway oedema (3 cases), intraoral abrasions/pain (3 cases) and oesophageal perforation (1 case), it was unclear if these were due to the FBAO, other BLS interventions before use of the device, or due to the device itself. Dental injury was reported with the use of one brand of device in 1/25 (3 %) of patients in a retrospective analysis[81] and a single case of abrasions to the oropharynx and gingiva was reported with the use of the same brand device in the case series by Dunne.[78] Device malfunctions reported include occasional separation of the mask from the plunging unit.[78]

The evidence supporting the use of back blows and abdominal thrusts also comes primarily from case reports.[64] However, these interventions can be applied immediately, with minimal training and at no additional cost, with success reported in over three-quarters of cases. Users of devices would have to remove the device from packaging, assemble it and unless trained refer to device instructions, which may delay delivery of care using established FBAO protocols. Users of these devices should be aware of potential adverse effects and issues such as lack of adequate suction, lack of efficacy, oral injury, poor outcomes, and potential delay in performing CPR once a choking person becomes unresponsive. ILCOR did not make a recommendation because of insufficient evidence[1] and, for the same reason, the ERC is also unable to make a recommendation for or against the use of these devices.

Aftercare and referral for medical review. There are multiple case reports of serious injuries following treatment of FBAO with abdominal thrusts, and fewer reports of injuries following chest thrusts/compressions and back blows, as well as reports from the use of suction devices.[64,78] Any person successfully treated with these measures should therefore be examined by a healthcare practitioner.

The management of choking in children has also been described in the ERC Guidelines 2025 Paediatric Life Support.[24]

Asthma

A 2022 scoping review from ILCOR identified no significant harm from bronchodilators administered to individuals with asthma and respiratory symptoms.[1] The ERC agrees with the ILCOR First Aid Task Force recommendation that first aid providers should help to administer the persons own bronchodilators in individuals with asthma who are experiencing difficulties in breathing.

Chest pain

Chest pain is the most common symptom of an acute coronary syndrome also known as a 'heart attack'.[83] The pain is often described as pressure in the chest, with or without radiation of the pain to the neck, lower jaw, or left arm. According to the European Society of Cardiology, a quarter of women report jaw pain, nausea or shortness of breath instead of the classic symptoms which may delay diagnosis and treatment.[84] Patients with diabetes might express pain in the epigastric region or shortness of breath.[83]

An 2020 ILCOR systematic review found that early prehospital aspirin improved survival compared with later in-hospital administration and there was no significant difference in the risk of complications.[85] Although harm from aspirin in individuals with nontraumatic chest pain is uncommon, the ILCOR systematic review found no studies evaluating the risks of aspirin administration in the first aid setting.[85] Therefore, we continue to recommend the early prehospital administration of 150–500 mg aspirin to those with cardiac chest pain, by first aid providers before the arrival of EMS, unless there is a potential contraindication such as aspirin allergy. For persons with known angina pectoris, we recommend first aid providers assist them to self-administer their own nitro-glycerine spray or tablets.

Hypoglycaemia

Hypoglycaemia is most often defined as a blood glucose level below 4 mmol/L (or 70 mg/dL).[86,87] There are several different wordings of the definition of hypoglycaemia. A cross-sectional study from the US has shown that the wording of different definitions is associated with misinterpretations and therefore discrepancies in the prevalence of severe hypoglycaemia and the number of severe hypoglycaemia episodes.[88] People with lower education, lower household income and self-identified racial minorities were associated with these discrepancies.[88] Hypoglycaemia most commonly occurs in individuals with diabetes who use insulin or other glucose-lowering medications, but it may also occur in persons without diabetes because of prolonged fasting, excessive alcohol consumption, or critical illness.[87] Symptoms of hypoglycaemia can range from sweating, tremors, and palpitations to confusion, seizures, and unresponsiveness.[86]

An ILCOR systematic review from 2017 demonstrated that early recognition and intervention significantly reduced the risk of severe hypoglycaemia-associated complications, including cognitive impairment and cardiac arrhythmias.[89] An ILCOR systematic review from 2019 compared different administration routes and concluded that oral glucose is preferred above buccal administration.[89] The review also showed that sublingual administration has better results than oral administration in children with hypoglycaemia and moderate clinical symptoms of concomitant malaria or respiratory tract infections.[89] A 2018 review article highlighted the importance of structured education programs for individuals with diabetes to enhance the awareness and self-management of hypoglycaemia symptoms.[90] The European Diabetes Working Group emphasise the role of continuous glucose monitoring in reducing severe hypoglycaemic episodes, particularly in insulin-dependent individuals.[91]

Treatment of hypoglycaemia. The 2017 ILCOR systematic review identified evidence supporting that if the hypoglycaemic person is responsive and able to swallow safely, they should be encouraged to consume 15–20g of fast-acting carbohydrates, such as glucose or dextrose tablets, fruit juice, or regular (non-diet) soda.[88a] Blood glucose values should be rechecked 15min after ingestion of sugar and, if hypoglycaemia persists, an additional 15g of carbohydrates should be given.[88a] If symptoms improve, the person should follow up with a balanced meal to prevent recurrent hypoglycaemia.

Oral sugars should not be provided to unconscious persons due to risk of blocking the airway and aspiration. Sublingual sugar should be considered for children, if they are uncooperative with swallowing oral glucose.[89] First aid providers may administer glucagon, either via injection or nasal spray, as per the manufacturer's instructions if it is available and if they have been trained in its administration.[87] Early administration of glucagon in severe hypoglycaemia has been shown to improve recovery outcomes and to reduce the risk of prolonged hypoglycaemia-induced complications.[92] The implementation of public training programs, especially among schoolteachers, in glucagon administration has significantly improved response times and outcomes.[93–95]

Opioid overdose

Opioid overdose causes central nervous system depression (sleepiness, unresponsiveness) and respiratory depression, which, if untreated, can progress to respiratory arrest, cardiac arrest and death. Naloxone is a safe and effective antidote that reverses the effects of opioid overdose, restoring responsiveness and breathing.[96,97] Naloxone is only effective for opioid overdoses and it can take several minutes to work. Naloxone is not effective once cardiac arrest has occurred.

This guideline is based on the 2024 ILCOR recommendation[40] and on the 2024 American Heart Association and American Red Cross Guidelines for First Aid.[98] According to a 2025 online survey conducted by the ERC First Aid Writing Group (Appendix B), naloxone is used by a wide range of individuals, from doctors to bystanders, regardless of whether they have received formal training. Respondents indicated that naloxone was most often administered in confirmed opioid overdoses (82 %, n = 903) or in unresponsive individuals with suspected opioid overdose (71 %, n = 787). Only one-third of respondents reported the existence of formal training programs for naloxone use. Kits most commonly included injectable naloxone or autoinjectors (90 %, n = 874), followed by intranasal formulations (40 %, n = 394). Intranasal naloxone has less efficacy but higher usability than intramuscular administration[99,100] and is now widely available in many countries. It was the preferred option among respondents, largely due to its ease of use by non-medical personnel. In most countries, naloxone may be administered by doctors, nurses, and paramedics. In some countries, police officers and lay persons are also authorised to use it.

Individuals who respond to an opioid overdose with naloxone should remain under observation after administration due to the risk of respiratory depression recurring. Training in opioid overdose recognition and naloxone administration increases the likelihood of effective intervention, although study findings are variable.[101,102] One RCT found that individuals who received practical training were more likely to use naloxone than those who received only passive education.[103] ERC recommend that first aid providers administer naloxone to individuals with suspected opioid overdose. The management of opioid overdose and general intoxication are both outlined in the ERC Guidelines 2025 Special Circumstances in Resuscitation.[59]

Stroke

The global burden of stroke is high and increasing.[104] Over the last 20 years, new treatments such as the rapid administration of thrombolytic therapy or endovascular reperfusion techniques for ischaemic stroke, together with the medical or surgical treatment for haemorrhagic stroke, have significantly improved outcomes.[105] Therefore, the European Academy of Neurology and the European Stroke Organisation strongly recommend stroke recognition campaigns for laypeople, tools facilitating early detection of stroke and prenotification of the hospital.[105] An ideal stroke assessment system for first aid use must be easily understood, learned and remembered, must have high sensitivity and must take a minimal time to be completed.

The 2024 evidence update[1] of the ILCOR First Aid task force did not identify any relevant article concerning the recognition of stroke since the previous systematic review published in 2020.[106] Neither the review nor evidence update could find evidence supporting the use of one scale over another. There are several suitable stroke scales for first aid providers, such as the BE-FAST (Balance, Eyes, Face, Arm, Speech, Time)[107] or FAST (Face, Arm, Speech, Time)[108] or CPSS (Cincinnati Prehospital Stroke Scale).[109] Further, the use of MASS (Melbourne Ambulance Stroke Screen)[110] or LAPSS (Los Angeles Prehospital Stroke Screen)[111] can increase the specificity of stroke recognition if glucose measurement is available.

Suicidal thoughts

About 720,000 people die worldwide from suicide every year.[112] Suicidal thoughts might be the result of exposure to a stressful event and subsequent mental shock.[113] Two meta-analyses have shown that a structured public health program such as 'Mental Health First Aid' increases knowledge and reduces negative attitudes towards persons with mental health problems.[114,115] However, one Cochrane review could not demonstrate the long-term effects of Mental Health First Aid programs.[116] An evidence-based guideline by the Belgian Red Cross-Flanders informed by systematic literature searches[117] listed the warning signs of suicide as threats of suicide or self-injury, planning of suicide (how, where, when) and communicating (verbally or writing) about death or suicide. On recognising that someone is experiencing a mental health crisis or expressing suicidal thoughts or concrete plans, a first-aid provider may feel concerned about maintaining confidentiality.[117] However, it is important to seek professional help for a thorough assessment of any mental health problem or suicide risk. Talking through suicidal ideas with someone may decrease the risk of suicide.[117] Experts recommend five principles for providing help in a mental health crisis: promote calmness, a sense of safety, a sense of self- and community efficacy, instil connectedness and infuse hope.[118–120] Fostering calmness aims to reduce immediate reactions, and it can be done by taking a deep breath or just sitting down. Safety can be promoted by communicating that it is safe to talk and that you will listen. Enabling of self and collective efficacy is about helping the person to take an active role and thereby receive control and influence their own recovery. Instilling connectedness is done by avoiding isolation and reminding them that they are not alone. Lastly hope can be infused by reminding the person that they will have capacity to recover and feel better after some help.

Trauma emergencies

Cervical spinal motion restriction

A 2015 systematic review by the ILCOR First Aid Task Force suggested that first aid providers should not use cervical collars.[58] A 2024 ILCOR scoping review identified 46 experimental and 20 observational studies on the effectiveness of different types of spinal motion restriction.[121] The scoping review[1,122] identified evidence from 35 studies that supports not routinely applying cervical collars because although they decrease the range of cervical motion, they may impair respiration and swallowing, as well as contribute to a raised intracranial pressure.[123] In 2024, the ILCOR First Aid Task Force acknowledged that this treatment recommendation should not, however, preclude trained first aid providers (e.g. lifeguards treating a person with a diving injury) from using spinal motion restriction devices (such as cervical collars) in accordance with existing local spinal motion restriction protocols. Based on the 2019 ILCOR scoping review[124] with no identified contradicting evidence in the 2024 scoping review,[121] the ERC suggests that manual stabilisation may be applied by either head squeeze or trapezius squeeze techniques to limit cervical spine movement.

Head squeeze (Fig. 8a):

- Place your elbows on the ground or on your knees.
- Hold the person's head between your hands.
- Position your hands so that your thumbs are above their ears and your other fingers are below their ears.
- Do not cover their ears so that the person can still hear.

Trapezius squeeze (Fig. 8b):

- Place your elbows on the ground or on your knees.
- Slide your hands onto the person's shoulder muscles on either side of their head.
- Make sure that your thumbs point downwards on the front of the muscles and your fingers are parallel to the spine on the back.
- Move your forearms inwards to support their head. Firmly immobilise the head between your forearms at ear-height.

- Consider the need to open the person's airway using the 'jaw-thrust' technique (QR code 1).
- If the person is unresponsive and is lying face-down, check if their airway is open and hold their neck in a stable position.
- If you need to open their airway, ask others to help you carefully roll them as a unit onto their back whilst keeping their neck in line with their body and as stable as possible. Then apply the head or trapezius squeeze (Fig. 8b).
- First aid providers with specialised training (e.g. ski patrol, lifeguard) may consider the selective use of spinal motion restriction using their existing protocols.
- Never force an uncooperative person into any position, as this may exacerbate an injury.

Control of life-threatening bleeding

Uncontrolled bleeding is a potentially preventable cause of death in trauma.[125] The order of actions (Fig. 9) for the control of life-threatening bleeding are based on interventions included in ILCOR's evidence update from 2025[1] and two initial 2021 systematic reviews.[126,127]

Pressure devices or pressure points. Since the 2021 systematic review, the ILCOR evidence update[1] found seven new studies comparing pressure device to add pressure local on the wound or proximal to it or pressure points proximal to the wound with direct manual pressure on the site of the wound. While findings in these studies suggested some potential benefits for the use of pressure points or pressure devices in some settings, there were insufficient data to change any ILCOR recommendations. The ERC agrees with ILCOR's continued recommendation to use direct manual compression instead of pressure devices or pressure dressings, and against the use of pressure points.

Tourniquets. Since the 2021 systematic review, the ILCOR evidence update[1] identified data from 29 new studies demonstrating reduced in-hospital mortality and a lower incidence of shock with the use of tourniquets, thereby supporting their use to limit life-threatening bleeding. Commercial tourniquets were shown to be simpler to apply and, compared with improvised tourniquets, achieved better arterial occlusion. However, a systematic review and meta-analysis from 2025 did not demonstrate a significant reduction in mortality or blood products with the use of prehospital tourniquets.[128] Recent studies from Ukraine have raised a concern about secondary avoidable injuries due to prolonged usage of tourniquets.[129,130]

Use a manufactured tourniquet, if available:

- Place the tourniquet around the traumatised limb 5–7 cm above the injury, but not over a joint.
- Tighten the tourniquet until the bleeding slows and stops. This may be painful for the person.

- Write the time the tourniquet was applied on the device.
- Do not release the tourniquet. It should only be released by a healthcare professional.
- In some cases, you may need to apply a second tourniquet, above the first tourniquet, to slow or stop the bleeding.

The 2021 ILCOR systematic review compared the effectiveness of different types of paediatric tourniquets. Based on two cohort studies, ILCOR suggested the use of a manufactured windlass tourniquet for the management of life-threatening extremity bleeding in children.[127] There was insufficient evidence to recommend for or against the use of other tourniquet types in children. For infants and children with extremities that are too small to allow the effective application of a tourniquet before activating the circumferential tightening mechanism, direct manual pressure is recommended, with or without the application of a haemostatic trauma dressing.

Haemostatic dressings. Since the 2021 ILCOR systematic review, an ILCOR evidence update[1] identified five new articles suggesting that haemostatic dressings decrease the duration of bleeding and improve survival with low reported rates of side effects when compared to conventional gauze dressings. Therefore, use of haemostatic dressings is recommended by the ERC for first aid providers.

Open chest wounds

The correct management of an open chest wound is important because inadvertent sealing of the wound through the use of an occlusive dressing or device may result in the potential life-threatening complication of a tension pneumothorax.[131] The 2015 ILCOR CoSTR suggested that first aid providers should not apply an occlusive dressing or device to individuals with an open chest wound because of lack of human studies. A 2024 ILCOR evidence update found that it is reasonable for the trained first aid provider to apply a specialised non-occlusive or vented dressing if available.[1] This statement was based on identification of five porcine studies,[132–136] one experimental study of chest seal adhesion on healthy volunteers,[137] and one retrospective observational study from prehospital data on penetrating chest trauma.[138] ERC agrees with the ILCOR good practice statement and recommends that chest wounds be primarily left open to freely communicate with the external environment, but if trained, an appropriate non-occlusive or vented dressing could be applied, ensuring a free outflow of air when breathing out and observing the wound carefully for air flow obstruction due to bleeding or clotted blood.

Concussion

Concussion (often called minor traumatic brain injury) is common in adults and children following head injury. Head injury is important to recognise because if the primary injury is missed it can lead to secondary brain injury and a worse outcome. Concussion is difficult to recognise because of the complexity of the symptoms and signs and the variation from immediate to delayed onset. Furthermore, no consensus definition of concussion exits despite extensive work on finding such.[139] Symptoms such as difficulties with thinking/remembering, physical symptoms (headache, change in vision, dizziness, nausea or vomiting, seizures and a sensitivity to light/noise), emotional changes or changes in behaviour (increased sleepiness, reduction in normal activities, loss of responsiveness, confusion) can all indicate a concussion.

The 2015 ILCOR CoSTR[58] as well as the ERC First Aid 2021 Guidelines[140] made no recommendation on a specific tool over another to recognise concussion but acknowledged the role that a simple, validated, single-stage concussion scoring system could play in the recognition of concussion by first aid providers. One study of lay responders identified insufficient confidence and knowledge to make a decision about how to act in a head injury scenario other than seeking medical assistance.[141] The following validated concussion assessment tools designed for use by trained healthcare providers were identified but they do not fulfil the requirements for reliable concussion assessment to be made by first aid providers because of their complexity or need to perform neurocognitive testing: Glasgow Coma Scale (GCS),[142] Alert Verbal Pain Unresponsive scale (AVPU),[143] Concussion Recognition Tool (CRT 6),[144] Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT),[145] Standardized Assessment of Concussion (SAC),[146] and the Sport Concussion Assessment Tool (SCAT 6).[147] Sports related guidelines and studies[139,148,149] refer to the memorable phrases 'recognise, remove and refer' or 'when in doubt, sit them out' approach. The ERC recommends that persons with a suspected concussion of any cause, be removed from physical activities and seek immediate medical review.

Preservation of an amputated body part

The ERC recognises that the top priority when approaching a patient with an amputated or avulsed body part is to stop the bleeding and to resuscitate the person. However, retrieval and preservation of the amputated body part should not be overlooked, as surgical reimplantation may be attempted. A 2024 ILCOR scoping review identified 37 publications, mostly case reports and observational studies, documenting various techniques for preserving amputated and avulsed body parts prior to arrival at a hospital.[150] The evidence from this review supports non-freezing cold storage of amputated body parts. This storage method is associated with higher rates of successful reimplantation, even after longer time intervals between the injury and surgery.

The recommended preservation method is: Wrap the body part in a sterile gauze dressing or clean piece of cloth moistened with saline or water. Place the wrapped body part in a clean watertight plastic bag or container. Cool the bag or container containing the body part, inside another bag with ice or ice-water (Fig. 10). The retrieved body part should be transported with the injured person to the hospital. No matter which part gets amputated or avulsed (ear, nose, lip, scalp, penis), the rates of successful reimplantation are surprisingly high. Even when cold storage is not possible and the transport time is more than 6 h, it may still be possible to reimplant the body part successfully. Fingertips and fingers especially, appear to tolerate a lack of cooling better than other tissues.[150]

Environmental emergencies

Drowning

Drowning is the process of experiencing respiratory impairment from submersion or immersion in liquid.[151] Children under five years of age account for nearly a quarter of all deaths among the 300,000 annual drownings worldwide.[152]

Drowning rescue stresses prevention, recognition, provision of flotation, removal from water and further care as required (Fig. 14). According to a 2021 scoping review, the risk of an untrained rescuer dying while trying to rescue a drowning person could be reduced using a non-contact approach.[153] A non-contact approach means

reaching out to the person via a pole, rope, or flotation equipment without entering the water.[153] When balancing which actions to undertake in water versus on ground, time to be on the ground has to be considered. This is something that can be discussed in courses and training sessions.

The main medical problems in drowning are hypoxia, hypovolaemia and hypothermia. The 2022 ILCOR systematic review recommended in-water resuscitation to start with ventilations only and on-boat resuscitation to be either ventilations only or standard CPR based on feasibility and safety.[154] The initial number of rescue breaths lacks scientific evidence but for clarity the ERC recommends five initial ventilations. A retrospective case-matched observational study on oxygen administration by lifeguards did not show an increase in oxygen saturation or survival.[155]

The 2022 ILCOR systematic review stratified actions between lay persons and those with a duty to respond such as lifeguards. Lay persons are recommended to start resuscitation with chest compressions to prioritise the initiation of simple and fast resuscitation. This should be followed by mouth-to-mouth or the use of a pocket mask to provide expired air ventilation, if appropriate. Those with a duty to respond should consider providing initial rescue breaths with a bag-mask since the time to ventilation is critical in 'non-cardiac arrests' and may prevent deterioration to a cardiac arrest.[156]

A minority (6 %) of drowning victims who deteriorate to cardiac arrest have a shockable rhythm.[157] The use of an AED has been given lower priority than initial rescue breaths, however for those with a shockable rhythm, early use of an AED will increase the chances of survival. The management of drowning is described in the ERC Guidelines 2025 Special Circumstances in Resuscitation.[59]

Prevention of hypothermia

Accidental hypothermia, defined as an unintentional drop in core body temperature to below 35 °C poses significant risks, including cardiac arrest. First aid providers play a crucial role in the prevention and initial management of hypothermia. Prehospital insulation, fast transfer to a hospital and rewarming are key interventions. A prospective observational study has shown that first aid interventions such as removing wet clothes, drying the person's body, the use of (isothermal) blankets and the use of heating pads, all individually increased core temperature in trauma patients.[158] A two-step RCT among fire fighters has shown that active methods such as rewarming with warm air could be beneficial during a technical rescue in challenging terrain and it has been shown that fleece blankets will stop, but not correct heat loss.[159] An RCT involving trauma patients compared standard interventions such as removing wet clothing, providing clean dry garments and applying localised coverings for warmth with a more proactive strategy that included a tailored prevention plan and targeted training.[160] The study found that the tailored approach led to improved temperature regulation, enhanced quality of temperature management, better coagulation function, and a reduced incidence of adverse reactions.[160]

The full management of accidental hypothermia has been described in the ERC Guidelines 2025 Special Circumstances in Resuscitation.[59]

Heat stroke and exertional hyperthermia

Heat stroke is a severe heat-related illness that occurs when the body's thermoregulation system becomes overwhelmed or stops working. It is a true medical emergency and can lead to severe organ damage, cardiovascular collapse and death.[161] Non-exertional heat stroke typically occurs after prolonged exposure to the sun and is often seen during heat waves. However, it may occur during periods of hot weather in persons with impaired heat regulation, such as in elderly people or children. Exertional hyperthermia presents similarly but is associated with strenuous exercise.

Recognition and immediate care. Suspect heat stroke in the setting of high ambient temperatures, in a person with a high core body temperature exceeding 40 °C, and with altered mental status (confusion, disorientation, agitation, coma) or seizures. Similar signs and symptoms are present in a person with exertional heatstroke due to strenuous physical activity. Although a core body temperature above 40 °C is an important finding in someone with suspected heat stroke, the measurement of core body temperature in first aid can be problematic as it requires availability of a specialised thermometer that is inserted into the person´s rectum.[162,163] In addition to privacy and cultural considerations, training in the use of a core thermometer may be necessary. The tympanic temperature can be measured but it will only provide an approximation and not a definitive core temperature measurement. Similarly, oral and cutaneous thermometer measurements have been found to be inaccurate[164] although when a temperature is elevated with one of these devices, it may support clinical suspicion of hyperthermia and heat stroke.

The management of heat stroke and exertional hyperthermia is immediate, rapid cooling. A cooling rate of $\geq$0.15 °C /min has been shown to be associated with survival without medical complications for exertional heat stroke.[165,166] Moving a person with suspected heat stroke out of the sun or away from a hot environment to a cooler, shaded location, removing excess clothing, and limiting exertion will initiate the cooling process (Fig. 12). Emergency medical services should be summoned simultaneously while beginning cooling, and cooling is continued during transportation to the hospital until a target core temperature below 39° C is reached.[167,168]

Active cooling. Active cooling interventions actively remove heat from the body and provide faster cooling for heat stroke than passive cooling. These interventions can include cool or cold/ice water total body immersion, spraying or misting water and fanning, and application of ice packs to the axilla and groin. A 2020 ILCOR systematic review of cooling methods for heat stroke summarised the rate of cooling achieved with various techniques from 63 studies.[169] The evidence supports active cooling using whole body (from the neck down) water immersion at 1 to 6 °C until a core body temperature below 39 °C has been reached. If the measurement of the core body temperature is not feasible, American first aid guidelines recommend to continue cooling for up to 15 min or until neurological symptoms resolve, whichever is first.[98] Water immersion cooled faster than all other forms of active cooling, however ice and cold water may not always be available. Alternative methods of cooling include ice packs to the axillae, groin and neck, use of showers, ice sheets or towels, and misting/fanning but they are less effective than water immersion. There are no studies of cooling techniques in children or in people with non-exertional heatstroke, but the evidence from the ILCOR systematic review supports rapid cooling with similar modalities in these populations.[169] In the first aid setting, improvisation may be necessary to provide active cooling. Placing the heat-injured person in a baby pool filled with water from a hose or wrapping a tarp around the person (filled with ice and gently oscillating the tarp) are alternative ways to provide active cooling in the outdoor setting (Fig. 13).

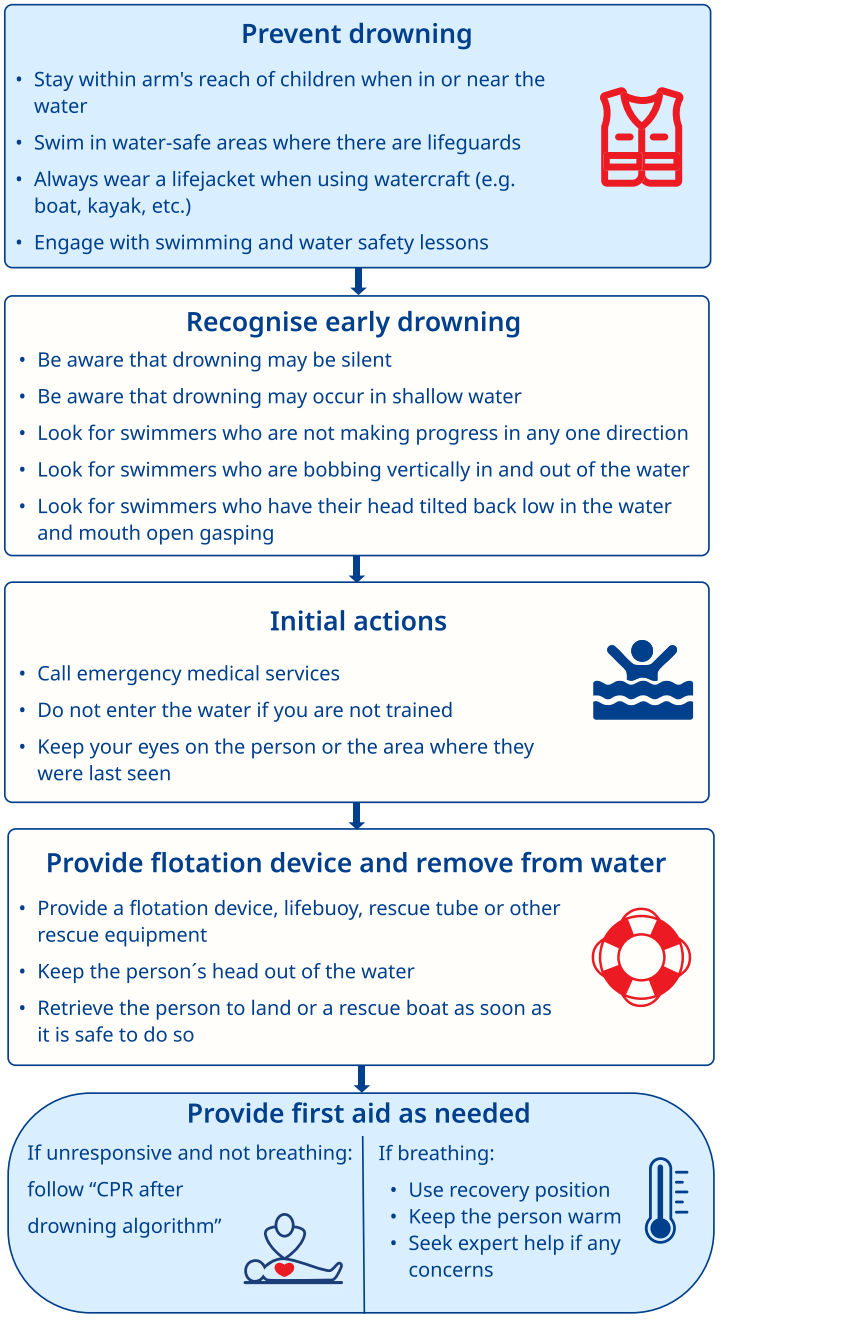


Fig. 14 – First aid in drowning.

Cooling techniques reviewed in the systematic review were, in decreasing order of effectiveness, ice water immersion (15 °C), temperate water immersion (20 to 25 °C), cold water immersion (14 to 17 °C), colder water immersion (8 to 12 °C), commercial ice packs, showers (20 °C), ice sheets and towels (3 °C), hands and feet cold water immersion (16–17 °C), cooling vests and jackets, cold intravenous fluids, fanning, passive cooling, hand cooling devices and evaporative cooling.[169] The full management of accidental hypothermia and heat stroke has been described in the ERC Guidelines 2025: Special Circumstances in Resuscitation.[59]

Snake bite

Snakebites in Europe are relatively uncommon, with approximately 7992 cases reported annually, of which 15 % are classified as severe.[170] Most incidents involve vipers of the Vipera genus, such as the common European Viper or Adder (Vipera berus), the asp viper (Vipera aspis), and the nose-horned viper (Vipera ammodytes). However, there are many rare and dangerous snakes which are kept as pets. Envenomation's (bites) often result in localised symptoms, including pain, swelling, and bruising, while severe cases may lead to systemic complications like coagulopathy and, in rare instances, organ failure. Two systematic review on first aid for snakebites[171,172] and an expert opinion[173] emphasise minimising movement, immobilising the affected limb, and avoiding ineffective or harmful interventions such as tourniquets, wound incisions, or venom suction. Seeking immediate medical attention remains crucial for effective management. European health organisations, the World Health Organization and National Health Service UK,[174,175] provide specific protocols for treatment. Unlike elapid snakebites with non-swelling neurotoxic venom,[175] which may benefit from pressure immobilisation, viper envenomation's require simple limb immobilisation without compression.

Declaration of competing interest

Declarations of competing interests for all ERC Guidelines authors are displayed in a COI table which can be found online at https://doi.org/10.1016/j.resuscitation.2025.110752.

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Appendices A and B. Supplementary material

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