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Part 1: Executive Summary: 2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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ABSTRACT: This executive summary provides an overview of the *2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care*, which is organized around the Utstein Formula for Survival and provides updated recommendations aimed at improving survival rates and neurological outcomes following cardiac arrest. This executive summary outlines key changes, emphasizing the importance of high-quality chest compressions, early defibrillation, and the integration of advanced resuscitation techniques. These Guidelines also highlight critical post–cardiac arrest care strategies, including targeted temperature management and hemodynamic stabilization. Additionally, they stress the need for population-specific resuscitation approaches, particularly for pediatric patients, pregnant individuals, and individuals with cardiac arrest due to special circumstances. A strong focus is placed on continuous training and education for both medical professionals and lay rescuers to enhance the implementation and effectiveness of these lifesaving interventions. The 2025 Guidelines also highlight the importance of an integrated system of people, protocols, policies, and resources to achieve quality improvement in cardiac arrest care. An overview of ethical considerations relevant to emergency cardiovascular care, resuscitation, and approaches to decision-making surrounding cardiac arrest is also included. By following these updated recommendations, the American Heart Association seeks to optimize resuscitation efforts and improve patient outcomes in cardiac emergencies.

Key Words: AHA Scientific Statements ■ arrhythmias, cardiac ■ cardiopulmonary resuscitation ■ critical care ■ delivery of health care ■ ethics ■ heart arrest ■ life support care

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INTRODUCTION

The *2025 American Heart Association* (AHA) *Guidelines for Cardiopulmonary Resuscitation* (CPR) *and Emergency Cardiovascular Care* (ECC) provide a comprehensive review of evidence-based recommendations for resuscitation and ECC. The Guidelines for CPR were first published in 1966 in response to requests from several organizations and agencies about the need for standards and guidelines regarding training and response.[1]

Since then, the CPR Guidelines have been reviewed, updated, and published periodically by the AHA.[2–10] As with prior Guidelines, this document is closely aligned with evidence evaluation conducted by the 2025 International Liaison Committee on Resuscitation (ILCOR) and associated member councils. ILCOR was formed in 1992 to provide a forum for liaison between principal resuscitation organizations worldwide. At the time of this publication, ILCOR comprises representatives of 9 member organizations.[11] Although the AHA generally publishes its Guidelines on a 5-year cycle, since ILCOR transitioned to a continuous evidence-evaluation process in 2015, the AHA has published focused updates between formal Guidelines when there is a substantial need for updated treatment recommendations based on new scientific evidence. This allows for expedited

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review and incorporation of significant changes in science directly into the Guidelines if deemed appropriate, increasing the potential for more timely transitions from guidelines to bedside. Since the publication of the 2020 Guidelines, there has been a significant expansion in the number of writing groups and chapters, including the addition of new chapters on post–cardiac arrest care, special circumstances, and ethics. The AHA ECC Committee has also strengthened partnerships with other organizations, such as collaborating with the American Academy of Pediatrics (AAP) to jointly publish and cochair the writing groups for Pediatric Basic Life Support (PBLS), Pediatric Advanced Life Support (PALS), and Neonatal Resuscitation. Efforts have also been made to enhance synergy and streamline content across chapters and disciplines, ensuring consistency in overlapping topics, concepts (eg, a single Chain of Survival), terminology (eg, *breaths*, *rescue breaths*, *ventilations*), and algorithms. The chapter writing group members updated evidence reviews specific to the scientific questions considered of greatest clinical significance, with a focus on topics with new evidence.

Epidemiology and Outcomes

In the half century since the initial Guidelines were published, cardiac arrest remains a leading cause of mortality and morbidity in the United States and worldwide, making this work still incredibly relevant. Despite advances in treatment, incidence of cardiac arrest remains high, and survival remains low. We recognize and acknowledge the negative impact of COVID-19 on resuscitation survival outcomes and on health care and lay rescuer response to cardiac arrest. Epidemiologic trends since 2023 demonstrate a modest upward trend in out-of-hospital cardiac arrest (OHCA) survival rates.[12] Recognizing the continued threat of infectious disease transmission, these 2025 Guidelines also include recommendations to reduce the risk of transmission of high-consequence respiratory pathogens during treatment of cardiac arrest (refer to Part 10: Adult and Pediatric Special Circumstances of Resuscitation).[13]

OHCA

As reported in the 2024 Cardiac Arrest Registry to Enhance Survival (CARES) Annual Report, the incidence of emergency medical services (EMS)–treated, OHCA in people of any age in the United States was 378.7 individuals per 100 000 population, with great variation in incidence and survival between states.[12] There were an estimated 263 711 EMS-treated, nontraumatic OHCA cases in the United States in 2024. Survival to hospital discharge after EMS-treated adult OHCA was 10.5%, and favorable neurologic survival was 8.2%. Bystander-witnessed adult arrests where bystander CPR was initiated had a 13.0% survival to hospital discharge compared with the 7.6% survival to discharge for unwitnessed arrests ($P<0.0001$); however, only 41.7% of OHCA adult patients received bystander CPR. Survival to hospital admission after EMS-treated nontraumatic OHCA was 25.7% for all presentations. Survival to hospital discharge was higher when the cardiac arrest occurred in a public place (21.1%) than if it occurred in a residential setting (8.9%) ($P<0.0001$). Only 12.6% of patients who experienced cardiac arrest in public had an automated external defibrillator (AED) applied by a lay rescuer. As reported in the "2025 Heart Disease and Stroke Statistics: A Report of US and Global Data from the American Heart Association,"[14] 83% of the EMS-treated OHCAs in children were in private residences while 16.7% were in public places. Survival to hospital discharge was 7.4% for 1587 children <1 year of age, 14.1% for 1225 children 1 to 12 years of age, and 18.5% for 854 children 13 to 18 years of age.

In-Hospital Cardiac Arrest

Incidence of in-hospital cardiac arrest (IHCA) in adults each year in the United States is estimated to be about 292 000 patients as extrapolated using the AHA's Get With The Guidelines Resuscitation data.[14] According to the 2023 data used in this report, survival to hospital discharge was 23.6% for adult patients with IHCA and among survivors, 79.2% had favorable neurologic outcome (Cerebral Performance Category 1 or 2) at hospital discharge.[12] Survival to hospital discharge after IHCA in pediatric patients (children and infants 0–18 years of age) increased from 18.9% to 45.2% between 2000 and 2023 in the Get With The Guidelines®-Resuscitation data.[12] The notable increase in survival is multifactorial in nature, including early recognition of deterioration and the provision of high-quality CPR.

Disparities and Differences

Despite advances in resuscitation care, inequities in survival outcomes persist. In the 2025 AHA Statistics Update, it was noted that survival and neurological recovery after cardiac arrest were worse in minoritized racial and ethnic groups, including Hispanic, Black, and Asian individuals, compared with non-Hispanic White individuals. White people had a higher chance of a favorable neurologic outcome than those from minoritized groups (34.4% versus 21.7%, respectively; $P=0.015$).[14] Individuals from racial and ethnic groups that have been historically marginalized are also more likely to have early severe electroencephalogram (EEG) or computerized tomography anoxic changes (25.0% versus 15.8%, respectively; $P=0.03$).[14]

The causes of these disparities are complex and are closely associated with socioeconomic disadvantage and unequal access to care. Unequal provision of CPR and use of an AED by lay rescuers contribute to worse

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cardiac arrest outcomes and are the result of unequal access to lay rescuer CPR and AED training opportunities.[15] There is also increasing evidence of differences based on population density—eg, rural versus metropolitan—with the odds of OHCA survival to hospital discharge being approximately 50% lower in rural areas compared with metropolitan areas.[16] Thus, the translation of guidelines and science into educational resuscitation training products must consider the needs of all patients in their development with additional emphasis on equitable delivery and accessibility, especially in low-resource settings. This topic is discussed further in "Part 12: Resuscitation Education Science" of the 2025 Guidelines. Furthermore, despite the existence of evidence-based treatment guidelines, implementation varies widely due to unequal resource availability and access to care.[17] The AHA ECC 2030 Impact Goals have an explicit focus on health equity and ensuring that cardiac arrest survival and access to care are equitable for all.[15] In alignment with the ECC 2030 Impact Goals, the 2025 Guidelines highlight areas of opportunity to save more lives by prioritizing equitable delivery of lifesaving interventions throughout the Chain of Survival and including equitable outcomes as a measure of success. Additional considerations related to equity are included in "Part 3: Ethics."

Chain of Survival and Newborn Chain of Care

Much of the variation in survival rates is thought to be due to differences across the Chain of Survival (Figure 1), the critical actions that must occur in timely succession to maximize survival from cardiac arrest.[18] A sixth link in the Chain of Survival was introduced in the 2020 Guidelines, with different versions for adult, pediatric, IHCA, and OHCA.[19] The 4 chains introduced in 2020 have now been consolidated to a single 6-link chain of survival for the 2025 Guidelines. Missing from this chain is the topic of prevention, which the writing group considered important but would like to better define before adding a seventh link.

Similarly, successful neonatal resuscitation depends on a continuum of integrated lifesaving steps that begins with careful assessment and preparation in advance of birth as well as resuscitation and stabilization at the time of birth and through the first 28 days after birth. The 2025 Guidelines introduce the Newborn Chain of Care (Figure 2), which addresses the broader context in which neonatal resuscitation occurs. With the recognition that the care and, therefore, the outcomes of parents and newborns are inextricably linked, the 7-link Newborn Chain of Care differs from the Chain of Survival in that it starts with how health systems provide prenatal and intrapartum care (prevention), extending to postpartum, postresuscitation, and follow-up care that can optimize outcomes for parents and their newborns.

Terminology

Standardized terminology helps improve communication and accuracy in emergency response education. The 2025 Guidelines clarify the distinction between *breaths* and *ventilations* to ensure consistency in training and guidelines. To simplify nomenclature, the term *rescue breaths* is no longer used. Instead, *breaths* should be used when a person has a pulse but is not breathing and when breaths are given in conjunction with CPR, as in *CPR with breaths*. Ventilations should be reserved for health care professionals when providing assisted breathing through a mechanical device, such as a bag-mask device or an advanced airway device.

Similarly, *lay rescuer* was selected as the preferred term over *layperson* or *lay responder* when discussing care provided by non–health care professionals. The term *lay rescuer* is favored over *bystander* as it encourages action. *Bystander* can imply someone who is merely present but not taking action. The term *lay rescuer* clarifies the role and encourages action, reinforcing the vital role that people without medical training can play in an emergency.

The 2025 Guidelines also recognize the differential use of the abbreviations *ROSC* (return of spontaneous circulation) versus *ROC* (return of circulation) in the

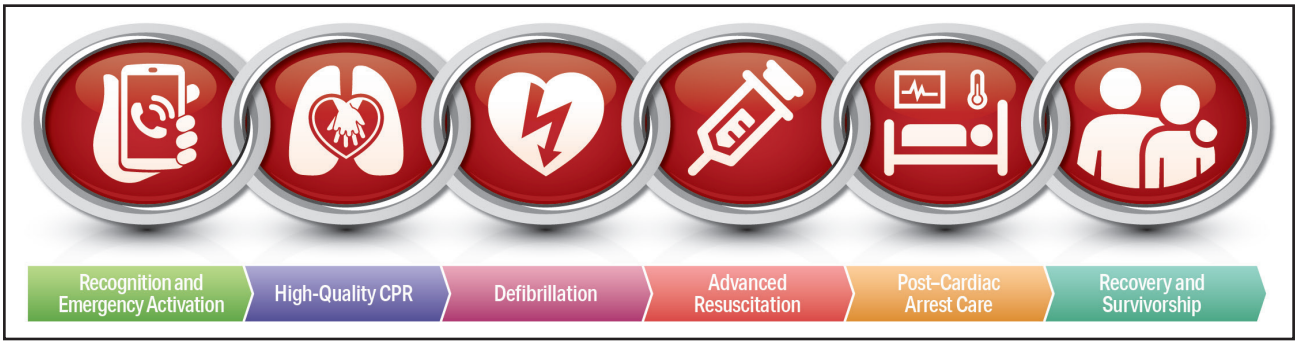

Figure 1. Cardiac arrest Chain of Survival.
CPR indicates cardiopulmonary resuscitation.

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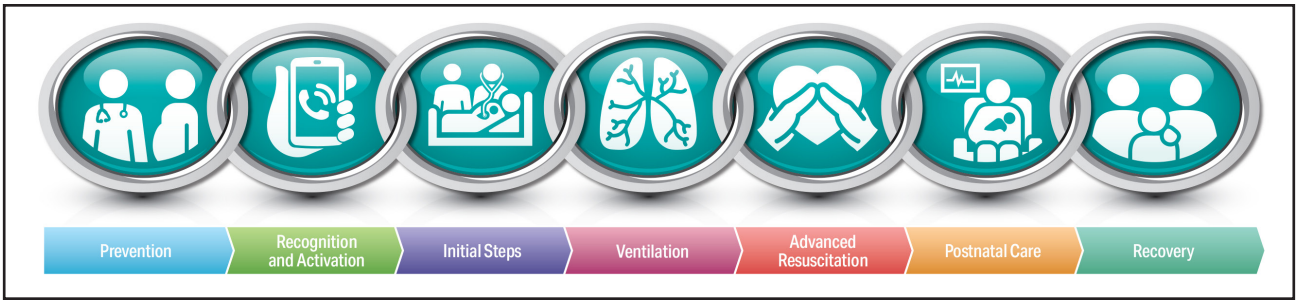

Figure 2. Newborn Chain of Care.

literature. For the purposes of these Guidelines, when return of circulation after CPR is achieved by mechanical means (eg, extracorporeal membrane oxygenation), the term *ROC* is preferentially used. When return of spontaneous circulation is due to recovery of cardiac function without mechanical intervention, the term *ROSC* is used.

Utstein Formula for Survival

This executive summary provides an overview of and orientation to the 2025 Guidelines, which are organized around the Utstein Formula for Survival (Figure 3).[20] The Utstein Formula emphasizes that survival depends on 3 interactive factors: guideline quality (science), efficient education of patient caregivers (education), and a well-functioning Chain of Survival at a local level (local implementation). Local implementation, in turn, is largely dependent on systems of care (SOC), which incorporate the links within the Chain of Survival. Each section in this summary describes the scope of each Part of the Guidelines, along with a list of the most significant and impactful new or updated recommendations for that Part. Each section also includes a list of critical knowledge gaps that highlight important research questions and significant opportunities for enhancing the Chain of Survival. This executive summary does not contain extensive external reference citations; refer to Parts 2 through 12 for more detailed reviews of the scientific evidence and corresponding recommendations.

EVIDENCE EVALUATION AND GUIDELINES DEVELOPMENT

The 2025 Guidelines are designed to present a comprehensive compilation of guidance for CPR and ECC.[21] These guidelines are based on an evidence evaluation process conducted by ILCOR,[22] published as systematic reviews, scoping reviews, and evidence updates published since the 2020 Guidelines as well as an independent evidence review process conducted by the 2025 Guideline Writing Groups. Together, these resulted in a description of the literature that facilitated guideline development.

Each chapter of the 2025 Guidelines is organized in knowledge chunks that are grouped into discrete modules of information on specific topics or management subjects. Each modular knowledge chunk includes a table of recommendations; a brief introduction or synopsis; recommendation-specific supportive text; hyperlinked references; and, when relevant, figures, flow diagrams or algorithms, and additional tables. Each chapter has undergone blinded peer review by subject matter experts and was also reviewed and approved for publication by the AHA Science Advisory and Coordinating Committee and the AHA Executive Committee. Chapters with pediatric content (Neonatal Resuscitation, Pediatric Basic Life Support, and Pediatric Advanced Life Support) were also cochaired by the AAP and reviewed and approved by the AAP Board of Directors. The AAP also submitted names for peer review of the 2025 Guidelines and appointed one writing group member

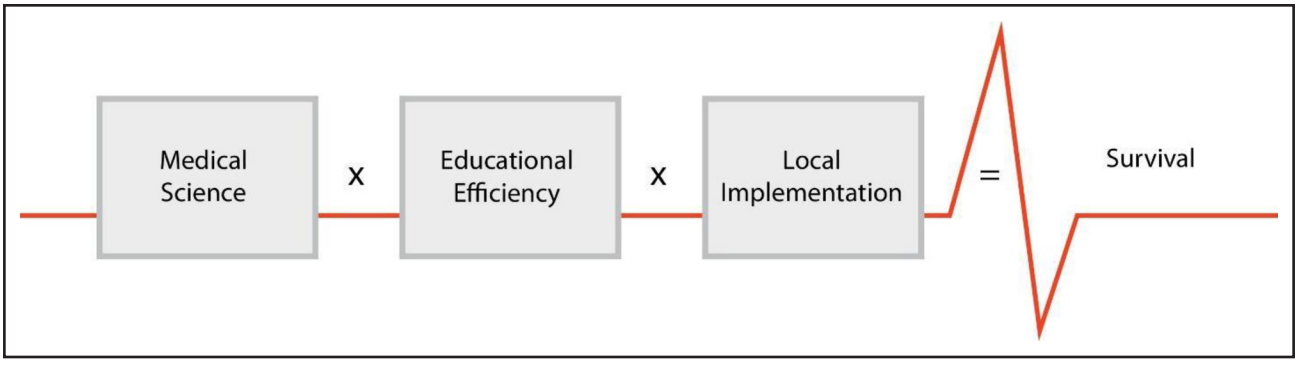

Figure 3. The Utstein Formula for Survival, emphasizing the 3 components essential to improving survival.[20]
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to each of the Evidence Evaluation, Ethics, Special Circumstances, and Systems of Care Writing Groups.

Each 2025 writing group reviewed all relevant and current *AHA Guidelines for CPR and ECC*,[10,19,23–27] pertinent evidence evaluations and recommendations published in the *International Liaison Committee on Resuscitation Consensus on Science With Treatment Recommendations* since 2020, AHA Focused Updates,[28–37] and all AHA evidence evaluation worksheets to determine if current guidelines should be reaffirmed, revised, or retired or if new recommendations were needed. The writing groups then drafted, reviewed, and approved recommendations after a thorough review of the literature for each topic, assigning to each a Class of Recommendation (COR; ie, strength) and Level of Evidence (LOE; ie, quality), as first described by Levine, et al. (2019)[38] and outlined in Table in "Part 2: Evidence Evaluation and Guidelines Development" of this supplement.[21] Each knowledge chunk presents an overview of insights, including knowledge gaps and research priorities identified by writing group consensus discussions. A summary of knowledge gaps identified by the writing groups is included in this Executive Summary below. AHA policy requires that official positions and guidelines of the AHA must be reviewed and approved by the Board of Directors and/or its Executive Committee. Upon completion of peer review, these guidelines were reviewed and edited for publication by the AHA Science Advisory and Coordinating Committee and the AHA Executive Committee following the standard review process for all official AHA documents with legal, communications and science staff to ensure risk mitigation and accurate alignment with AHA mission.

The 2025 Guidelines contain 760 recommendations (Table). Despite recent improvements in support for resuscitation research, 38% of these recommendations are based on limited data. This highlights the persistent knowledge gaps in resuscitation science that need to be addressed through expanded research initiatives and funding opportunities.

ETHICS

"Part 3: Ethics" provides an overview of ethical considerations that are particularly relevant to ECC and resuscitation.[39] This discussion is divided into 4 main sections. First, the chapter provides an overview of key frameworks in medical ethics that provide a structure through which health care professionals can analyze difficult decisions. In addition to principlism, which is organized around the principles of autonomy, justice, beneficence, and nonmaleficence and is currently the dominant medical ethical framework, the discussion highlights the importance of dignity and equity in ECC. Second, the authors summarize common approaches to ethical decision-making in ECC, including advanced directives, protocols, and shared decision-making. The chapter then discusses the specific decision to withhold or terminate CPR in adults and special populations, such as geriatric patients, children, and newborn infants. Additional consideration is given to the ethical complexity of prognostication and uncertainty, decisions to withhold or withdraw potentially ineffective therapies, and cultural and religious considerations. Finally, authors considered other selected ethical topics of importance in ECC. These include the process of research and knowledge generation (including guidelines development); the impact on health care professionals, patients, and families of those providing, receiving, or witnessing

Table. Recommendations in the 2025 Guidelines

Classification	SOC	Neonatal	PBLS	BLS	PALS	ALS	Spec Circ	PCAC	Education	Total	%
Class (Strength) of Recommendation											
1 (strong)	13	21	19	25	36	19	66	23	11	233	31
2a (moderate)	19	24	11	21	25	18	84	6	9	217	29
2b (weak)	6	18	6	15	45	29	58	41	16	234	31
3: No benefit (moderate)	0	1	0	3	12	8	21	9	1	55	7
3: Harm (strong)	0	3	1	3	2	5	6	0	1	21	3
Totals	38	67	37	67	120	79	235	79	38	760	100
Level (Quality) of Evidence											
A	1	3	0	0	1	2	2	0	2	11	1
B-R	4	8	0	6	3	22	9	21	9	82	11
B-NR	21	13	4	7	32	20	32	41	6	176	23
C-LD	9	30	20	40	61	29	67	12	20	288	38
C-EO	3	13	13	14	23	6	125	5	1	203	27
Totals	38	67	37	67	120	79	235	79	38	760	100

ALS indicates advanced life support; BLS, basic life support; PALS, pediatric advanced life support; PBLS, pediatric basic life support; PCAC, post–cardiac arrest care; SOC, systems of care; and Spec Circ, special circumstances.

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resuscitation; crisis standards of care; advanced therapies, such as mechanical circulatory support; and organ and tissue donation. Ethics is most relevant to complex situations where there is not a single correct course of action and the process of knowledge generation differs from other medical domains. Thus, the chapter is presented in narrative format, rather than as modular chunks, and refrains from making evidence-based treatment recommendations.

SYSTEMS OF CARE

Survival after cardiac arrest requires an integrated system of people, protocols, policies, and resources along with ongoing data acquisition and review to achieve quality improvement. Such SOC, which are highly influenced by the environment in which they operate, produce efficiency and effectiveness in responding to cardiac arrest. Within the Utstein Formula for Survival (refer to Figure 3), SOC represents the operational means by which local implementation occurs. The objective of a cardiac arrest SOC is to quickly, efficiently, and effectively perform each step within the Chain of Survival.

Part 4 of the 2025 Guidelines, "Systems of Care," focuses on elements that are relevant to a broad range of resuscitation situations.[40] Previous SOC guidelines have identified a Chain of Survival (refer to Figure 1), beginning with prevention and preparedness to resuscitate and proceeding through resuscitation to post–cardiac arrest care, survivorship and recovery. The SOC guidelines include recommendations on training of specific personnel, implementation of protocols that have been demonstrated to be effective, and incorporation of nonhuman resources to optimize cardiac arrest care with ongoing debriefing and quality-improvement strategies. Germane to OHCA, this Part contains recommendations about EMS team composition and transport, community initiatives to promote lay rescuer response, public access to defibrillation and naloxone, and the role of emergency telecommunicators. Germane to IHCA are recommendations about cardiac arrest prevention and code team composition. Finally, this Part includes recommendations about extracorporeal membrane oxygenation CPR, cardiac arrest centers, organ donation, survivorship systems, and performance measurement across the continuum of resuscitation.

Significant New and Updated Recommendations

Prevention of IHCA

We have combined the recommendations for adult and pediatric early warning systems and rapid response teams and recommend both as a means for preventing IHCA (early warning systems: COR 2a, LOE B-R; rapid response teams: COR 2a, LOE B-NR). The use of safety huddles is now recommended for patients identified as high risk to prevent IHCA (COR 2a, LOE B-NR).[41–43]

Public Access to Naloxone

Two new recommendations advise the implementation of public policies that permit the use of naloxone in cases of suspected opioid overdose without fear of prosecution (COR 1, LOE B-NR)[44–46] and that support public distribution of naloxone through various means (COR 2a, LOE B-NR).[47,48]

Community Initiatives to Promote Lay Rescuer Response to OHCA

Prior recommendations on mobile technologies were combined into this knowledge chunk aimed at using various means to encourage lay rescuer CPR and use of AEDs. Recommendations are now provided on community education (COR 2a, LOE B-NR),[49–52] mass media campaigns (COR 2b, LOE C-LD),[53] policies supporting mandatory CPR certification (COR 2b, LOE C-LD),[54,55] the use of mobile technologies (COR 2a, LOE B-NR),[56–58] and bundled approaches (COR 2a, LOE B-NR) to achieve higher rates of lay rescuer response.[59–62]

Telecommunicator Recognition and Instructions

Recommendations regarding telecommunicator recognition of OHCA were strengthened (COR 1, LOE C-LD),[63] and the LOE for providing compression-only instructions in adult OHCA was raised (COR 1, LOE A) in recognition of a meta-analysis of randomized trials that supports this recommendation.[64]

Team Composition for OHCA and IHCA

New recommendations are provided on the resuscitation team composition within the in- and out-of-hospital settings. These support the inclusion of at least one team member with advanced cardiac life support training (OHCA: COR 2a, LOE B-NR; IHCA: COR 1, LOE B-NR) and the delineation of roles with sufficient team size to achieve these roles (OHCA: COR 2a, LOE B-NR; IHCA: COR 2a, LOE B-NR).

On-Scene OHCA Resuscitation

New recommendations are made supporting ongoing resuscitation at the scene of OHCA in most cases, as opposed to early transport to a hospital (COR 2a, LOE B-NR).[65–67] This strategy will necessitate termination of resuscitation on scene in many cases, and, therefore, it is recommended that EMS be trained in death notification to family and friends, which is a challenging task (COR 1, LOE B-NR).[68–70]

Cardiac Arrest Centers

In light of a recent randomized controlled trial (RCT) that did not support transport of post–cardiac arrest patients to regionalized centers of excellence,[71] and acknowledging the lack of certainty about criteria that define a cardiac arrest center, the class of this recommendation was reduced from 2a to 2b and the LOE was increased to B-R (COR 2b, LOE B-R).

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Extracorporeal Membrane Oxygenation CPR SOC

A new knowledge chunk pertaining to the components of an SOC intended to support extracorporeal CPR (ECPR) has been added. Four new recommendations provide guidance on the components of an SOC that are needed to support ECPR. These include recommendations regarding patient selection (COR 2a, LOE C-LD), cannulation strategies (COR 2a, LOE C-LD), regionalization of ECPR (COR 2a, LOE C-LD), and intra-arrest transport to regionalized ECPR centers (COR 2b, LOE B-R).

Organ Donation

Included is a new Class 1 recommendation (COR 1, LOE C-EO) that institutions develop SOC intended to evaluate patients who have had a cardiac arrest and who are unlikely to have a favorable outcome for the possibility of organ donation.

Survivorship and Rehabilitation Systems

We now recommend (COR 2a, LOE B-R) that institutions create SOC that span inpatient and outpatient domains to evaluate cardiac arrest survivors for disabilities and to provide them ongoing support to optimize recovery.[72–77]

Clinical Debriefing

We reiterated prior recommendations on clinical debriefing and added a new recommendation to consider incorporating immediate (hot) and delayed (cold) debriefing as a means to achieve system improvement (COR 2a; LOE C-EO).

Knowledge Gaps

Resuscitation science continues to evolve, with a growing understanding as new literature emerges of how integrated SOC impact clinical outcomes. Although many areas still require further study, the writing group felt that the following questions represent the most important knowledge gaps in SOC and, therefore, deserve the highest priority for future research:

- How can mobile technologies best be used to increase witness status in OHCA and resuscitation by lay rescuers to maximize opportunities for early intervention?
- What are the most cost-effective and feasible community interventions (including use of novel mobile technologies and drones) to optimize lay rescuer response to OHCA?
- Does telecommunicator-assisted conventional CPR (with breaths) offer improved outcomes compared with telecommunicator-assisted compression-only CPR in pediatric OHCA?
- Do specific etiologies of OHCA (eg, opioid-associated OHCA) warrant telecommunicators encouraging lay rescuers to perform conventional CPR (with breaths) over compression-only CPR?
- What are the patient characteristics wherein rapid response team and medical emergency team programs provide the greatest outcome benefits? Which interventions are most effective? Should automated early warning scores be linked to rapid response team or medical emergency team programs?
- What are the optimal timing, methods, and specific components of feedback or debriefing after attempted cardiac arrest resuscitation?
- How should behavior and leadership skill training be applied to code teams and EMS systems to optimize resuscitation?
- How can out-of-hospital and in-hospital datasets best be integrated as part of quality-improvement programs and research within SOC?
- Which patients warrant transport to a hospital with ongoing CPR, and what are the safest means of doing so while maintaining high-quality CPR?
- What constitutes a regionalized cardiac arrest center justifying longer transport times based on improved outcomes?

NEONATAL RESUSCITATION

Part 5 of the 2025 Guidelines, "Neonatal Resuscitation," includes recommendations on following the resuscitation algorithm through steps of anticipation and preparation, umbilical cord management at delivery, initial actions, temperature maintenance, heart rate monitoring, respiratory support, chest compressions, intravascular access and therapies, withholding and discontinuation of resuscitation, and postresuscitation care.[78] These recommendations were developed by a multidisciplinary team of experts led by volunteer experts from the AHA and AAP. Consistent with the Utstein Formula for Survival (refer to Figure 3), the 2025 Guidelines provide a comprehensive review of recommendations for neonatal resuscitation, including new and updated recommendations that are based on the latest evidence from studies published in the medical literature and reviews completed by ILCOR.[79] These recommendations are also inclusive of and have updated upon the 2023 update to the neonatal resuscitation guidelines.[80]

Significant New and Updated Recommendations

Umbilical Cord Management

Deferring umbilical cord clamping in most instances for at least 60 seconds after birth can be beneficial in both term (COR 2a, LOE B-R) and preterm (COR 1, LOE A) newborn infants who do not require immediate resuscitation.[37] For nonvigorous term newborn infants (and late preterm infants ≥35 weeks' gestation), intact cord

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milking may be reasonable when compared with immediate cord clamping (COR 2b, LOE B-R) because it may reduce the need for cardiorespiratory support.[81] Cord milking is not recommended for newborn infants <28 weeks' gestation because it is associated with intraventricular hemorrhage (COR 3: Harm, LOE B-R).[82]

Oxygen

Oxygen concentration should be adjusted using pulse oximetry to target goals (COR 1, LOE C-EO). The initial oxygen concentration when providing ventilation is 21% for term and late preterm newborn infants ≥35 weeks' gestation (COR 2b, LOE C-LD).[83] For preterm newborn infants 32 to 35 weeks' gestation, it may be reasonable to begin with 21% to 30% oxygen, with higher initial oxygen concentration for preterm infants <32 weeks' gestation (COR 2b, LOE C-LD), as a recent meta-analysis reported that high initial oxygen concentration may be associated with lower mortality.[84,85]

Providing Assisted Ventilation

For term newborn infants, initial peak inflation pressures of up to 30 cm H_2O are reasonable, with adjustment of peak inflation pressures as needed (COR 2a, LOE C-LD).[86] For preterm newborns, initial peak inflation pressures of 20 to 25 cm H_2O are reasonable, with adjustment of peak inflation pressures as needed (COR 2a, LOE C-LD).[87]

Ventilation Corrective Maneuvers

Ventilation corrective maneuvers can be useful when initial positive pressure inflations are not effective in newborn infants who require ventilation (COR 2a, LOE C-LD).[88] Video laryngoscopy compared with traditional laryngoscopy can be useful for newborn infants who require endotracheal intubation (COR 2a, LOE B-R).[79]

Devices and Interfaces

A laryngeal mask, also referred to as a *supraglottic airway*, can be used as the primary interface to provide ventilation for newborn infants ≥34 weeks' gestation (COR 2b, LOE C-LD).[89] It can also be an alternative airway used in the process of corrective ventilation steps when facemask ventilation is not effective (COR 2a, LOE C-LD).[90] A T-piece resuscitator can be beneficial to administer ventilation to newborn infants, particularly for preterm infants, because it may reduce the duration of ventilation and decrease the risk of bronchopulmonary dysplasia (COR 2a, LOE B-R).[91]

Newborn Chain of Care

The Newborn Chain of Care addresses the broader context in which neonatal resuscitation occurs and how systems, starting from prenatal care and extending to postresuscitation and follow-up care, can optimize neonatal outcomes.

Knowledge Gaps

Some of the most pertinent gaps in neonatal resuscitation research include the following:

- What is the optimal initial oxygen concentration and oxygen titration strategy for preterm newborn infants requiring resuscitation?
- What is the optimal interval between birth and clamping the umbilical cord, and what interventions should be provided during this interval?
- Which term infants are best supported with continuous positive airway pressure versus supplemental oxygen or close observation without intervention?
- What are optimal adjustment strategies after starting assisted ventilation for positive end-expiratory pressure and peak inflation pressure?
- Can algorithms using large data sources predict which babies will require resuscitation or predict the likelihood of death or very poor neurodevelopmental outcome, and can corresponding tools impact clinical outcomes?

PEDIATRIC BASIC LIFE SUPPORT

Part 6 of the 2025 Guidelines, "Pediatric Basic Life Support," includes recommendations for the treatment of pediatric OHCA and IHCA for patients outside of the newborn period.[92] In contrast to the 2020 Guidelines, which combines PBLS and PALS in the same chapter ("Part 4: Pediatric Basic and Advanced Life Support"),[25] this 2025 summary focuses solely on PBLS. These recommendations were developed by a multidisciplinary team of experts led by volunteer experts from the AHA and AAP. The causes, treatment, and outcomes of cardiac arrest in children differ from those of cardiac arrest in adults. For example, pediatric cardiac arrests are more often due to respiratory causes that progress to cardiac arrest rather than a primary cardiac event. These Guidelines contain recommendations for PBLS that are based on the best available resuscitation science. These apply to infants and children up to signs of puberty in the prearrest and intra-arrest phases of care in multiple settings, including the community, prehospital, and hospital environments. Topics reviewed include cardiac arrest in special circumstances, such as severe foreign body airway obstruction (FBAO). This summary highlights the new and updated recommendations in PBLS since 2020 that will have a significant impact on process- and patient-related outcomes from cardiac arrest. Additional recommendations related to pediatric resuscitation can be found in "Part 4: Systems of Care" and "Part 10: Adult and Pediatric Special Circumstances of Resuscitation."

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Significant New and Updated Recommendations

Emphasis of Breaths With Chest Compressions

Despite increasing frequency of compression-only CPR in adults and children and mixed results when comparing conventional CPR (chest compressions and breaths) and compression-only CPR, large observational studies in children with OHCA show the best outcomes with conventional CPR.[93–104] A small observational study of school-aged children found similar outcomes between conventional and compression-only CPR (COR 1, LOE B-NR).[104] Large observational studies of children with OHCA do, however, show that compression-only CPR is superior to no lay rescuer CPR (COR 2a, LOE B-NR).

Elimination of 2-Finger Compression

In infants, systematic reviews and meta-analyses from simulation studies suggest that the 2 thumb–encircling hands technique is a superior technique when compared with 2-finger compressions, particularly for depth.[105–109] In a multicenter, prospective observational registry study, the 1-hand technique resulted in greater compression depth than the 2-thumbs technique in infants, with no difference in chest compression rate between hand positions.[110] The 2-finger technique was utilized rarely in this study but, when used, no chest compression segments were compliant with AHA pediatric guidelines (COR 1, LOE B-NR).[110]

Minimizing Perishock Pauses

Prolonged pauses in chest compressions before and after shock delivery decrease blood flow and oxygen delivery to vital organs, such as the brain and heart, and are associated with decreased survival (COR 1, LOE C-EO).[111,112]

Foreign Body Airway Obstruction

A recent observational study of adult FBAO suggests improved clearance of a foreign body with the use of back blows over abdominal thrusts.[113] To create consistency for instructional purposes, and in the absence of inferiority from pediatric data, management of severe FBAO in children now starts with cycles that alternate 5 back blows, followed by a series of 5 abdominal thrusts, repeating as necessary (COR 1, LOE C-LD).

Knowledge Gaps

Some of the most pertinent gaps in pediatric resuscitation research include the following:

- What are the optimal chest compression metrics for pediatric resuscitation regarding compression depth, rate, and fraction (to include details about the timing and duration of pauses)? Do the optimal performance metrics change according to age or etiology?
- With what frequency should the rhythm and pulse be checked during CPR?
- What is the optimal ventilation rate during CPR in patients with or without an advanced airway? Is it age dependent?
- What is the optimal position for performing chest compressions (eg, on a step stool, kneeling on the bed, standing)?
- What is the effect of leaning on the chest and providing incomplete expansion of the chest in between chest compressions?
- What is the ideal concentration of oxygen to deliver when performing CPR?
- What is the ideal compression-to-ventilation ratio?
- What are the optimal timing and dosing of defibrillation for ventricular fibrillation (VF) and pulseless ventricular tachycardia (VT) and its interface with CPR?
- What clinical tools can be used to help in the decision to terminate pediatric IHCA or OHCA resuscitation?
- What is the effectiveness of a single shock compared with sequential (stacked) shocks in pediatrics?
- What is the adverse impact of shocking nonshockable rhythms with a manual defibrillator in IHCA?
- Is the time to shock with self-adhesive pads significantly different than with paddles?
- Is there an optimal pad position for defibrillation in pediatrics? If so, is it anteroposterior or anterolateral?
- Are there comparative pediatric population-based data for FBAO interventions (chest compressions versus abdominal thrusts)?
- What are the safety and efficacy of commercial devices to treat FBAO?

ADULT BASIC LIFE SUPPORT

Part 7 of the 2025 Guidelines, "Adult Basic Life Support," provides recommendations for adults experiencing cardiac arrest, respiratory arrest, and FBAO.[114] Early provision of high-quality CPR and prompt defibrillation are the key interventions to improve outcomes from adult cardiac arrest. The chapter addresses the recognition of cardiac arrest, the initial steps of CPR, and specific aspects of performance, such as rate and depth of chest compressions. Algorithms are provided to illustrate the sequence of resuscitation for adult cardiac arrest and interventions for FBAO. One notable change to the adult basic life support (BLS) algorithm is the inclusion of naloxone use by lay rescuers during respiratory and cardiac arrest. For purposes of these Guidelines, persons with signs of puberty are treated using the recommendations for adult BLS, while prepubertal children are treated using the recommendations in "Part 6: Pediatric Basic Life Support."

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Significant New and Updated Recommendations

Foreign Body Airway Obstruction

Based on additional evidence of effectiveness and safety, the use of back blows is now recommended as the initial step for conscious adults with FBAO, followed by abdominal thrusts (COR 1, LOE B-NR).[113] As in 2020, once the person becomes unresponsive, the recommendation is to initiate CPR (COR 1, LOE C-LD), with inspection of the mouth for presence of a foreign body prior to delivery of breaths (COR 1, LOE C-EO). A new algorithm for treatment of FBAO for adults is included.

Fundamentals of Ventilation

The use of breaths with chest compressions is recommended for both health care professionals (COR 2a, LOE C-LD) and lay rescuers (COR 2a, LOE B-R) when they are willing and capable. For lay rescuers who are willing to perform breaths, the use of a pocket mask, a face shield, or mouth-to-mouth breaths is acceptable. Providing breaths by using a pocket mask has been shown to deliver more effective breaths than using a face shield, so a pocket mask should be used if available. Observational studies suggest that breaths provided during CPR are often inadequate, so rescuers and health care professionals are advised to deliver each breath until there is visible chest rise (COR 2a, LOE C-LD).[115]

Positioning and Location for CPR

The effectiveness of chest compression delivery can be improved through optimizing rescuer hand position, rescuer body position, and patient position. Whenever possible, CPR should be performed on a firm surface. A rescuer should position themselves so that their knee is aligned with the patient's torso, either by kneeling next to the patient or using a step stool for improved chest compression quality (COR 1, LOE B-NR). During the COVID-19 pandemic, the use of prone positioning for patients with hypoxic respiratory failure led to increased experience with the use of prone CPR. While the supine position is preferred, rescuers can consider providing CPR in the prone position if the supine position is not possible or would lead to significant delays in initiation of compressions (COR 2b, LOE C-LD).[116]

Feedback Devices and Mechanical CPR

Based on additional studies, the use of real-time feedback devices during CPR is recommended to improve manual CPR performance (COR 2a, LOE B-R).[117] Studies comparing mechanical to manual CPR have shown that mechanical CPR is no better than manual CPR in improving patient survival. At present, the routine use of mechanical CPR devices is not recommended (COR 3-No Benefit, LOE B-R) but may be considered in specific circumstances in which high-quality CPR cannot be maintained or for health care professional safety, such as during transport to a hospital (COR 2b, LOE C-LD).

Knowledge Gaps

Questions that address some of the most pertinent gaps in adult resuscitation research include the following:

- What is the optimal sequence of interventions for adults with severe FBAO?
- What are the most reliable indicators to quickly and accurately identify cardiac arrest in adults?
- Should health care professionals check for a pulse prior to initiation of CPR?
- What is the optimal pad configuration (eg, anterior-lateral versus anterior-posterior) to improve defibrillation success?
- What is the optimal time interval for duration of chest compressions after shock delivery and prior to reassessing rhythm? Are there methods to assess presence of a perfusing rhythm prior to the current 2-minute interval?
- Are asynchronous breaths or ventilations effective during continuous chest compressions without an advanced airway?
- What is the optimal chest compression depth, rate, and duty cycle for adult cardiac arrest?
- What is the optimal chest compression fraction during CPR by trained lay rescuers and health care professionals?
- Are there noninvasive techniques for measuring blood flow during CPR that could guide performance of chest compressions?
- What are the appropriate targets for ventilation volumes and rates during BLS care of an adult patient who is in cardiac arrest?
- Can respiratory volume monitoring provide accurate measurements during CPR? What is the optimal ventilation rate and volume for an adult with absent or abnormal breathing but with presence of a pulse?

PEDIATRIC ADVANCED LIFE SUPPORT

Part 8 of the 2025 Guidelines, "Pediatric Advanced Life Support," includes recommendations for the treatment of pediatric OHCA and IHCA, including postarrest care and survivorship.[118] These Guidelines contain recommendations for PALS and are based on the best available resuscitation science. These recommendations were developed by a multidisciplinary team of experts led by volunteer experts from the AHA and AAP. For the purposes of the PALS guidelines, pediatric patients are infants and children up to 18 years of age, excluding newborn infants. In contrast, PBLS guidelines apply to infants and children without signs of puberty.[119]

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Additions to PALS recommendations include post–cardiac arrest care, neuroprognostication, and recovery. This 2025 summary focuses solely on PALS and highlights new and updated recommendations that will have important impacts on process and patient-related outcomes from cardiac arrest. Additional pediatric-specific guidance and recommendations are provided for PBLS in "Part 6: Pediatric Basic Life Support,"[92] recommendations about the training of resuscitation professionals in "Part 12: Resuscitation Education Science,"[120] recommendations about SOC in "Part 4: Systems of Care,"[40] recommendations for special circumstances in "Part 10: Adult and Pediatric Special Circumstances of Resuscitation,"[13] and considerations around ethics in "Part 3: Ethics."[39]

Significant New and Updated Recommendations

Early Epinephrine

The goal of epinephrine administration during CPR is to optimize coronary perfusion pressure and maintain cerebral perfusion pressure. Earlier administration of epinephrine during CPR is associated with favorable outcomes for infants and children. For infants and children in cardiac arrest with initial nonshockable rhythm, it is reasonable to administer the initial dose of epinephrine as early as possible (COR 2a, LOE C-LD).[121–126] Similarly, for infants and children in cardiac arrest with initial shockable rhythm, it may be reasonable to administer epinephrine after 2 attempts at defibrillation or sooner if rapid defibrillation is not possible (COR 2b, C-LD).[127,128]

Diastolic Blood Pressure to Guide CPR

For patients with continuous invasive arterial blood pressure monitoring in place at the time of cardiac arrest, it is reasonable for health care professionals to use diastolic blood pressure to assess the child's response to resuscitation efforts (COR 2a, LOE B-NR).[129–131] Ideal blood pressure targets during CPR are now provided for infants and children with continuous invasive arterial blood pressure monitoring in place during CPR. In these cases, it may be reasonable for health care professionals to target a diastolic blood pressure ≥25 mm Hg in infants and ≥30 mm Hg in children ≥1 year of age (COR 2b, LOE C-LD).[129–131]

Post–Cardiac Arrest Blood Pressure Monitoring and Targets

Hypotension is common following resuscitation from cardiac arrest in infants and children and can exacerbate brain and myocardial ischemic injury. Post–cardiac arrest hypotension has been associated with lower rates of survival to hospital discharge. After cardiac arrest in infants and children, continuous arterial pressure monitoring is recommended to identify and treat hypotension when appropriate resources are available (COR 1, LOE C-EO).[132–138] In addition, after cardiac arrest in infants and children, it is recommended to maintain systolic and mean arterial blood pressure ≥10th percentile for age (COR 1, LOE B-NR).[132–138]

Neuroprognostication

Early and reliable neurological prognostication after resuscitation from pediatric cardiac arrest is essential to guide treatment, enable accurate counseling, and provide family support. In addition, accurate neurological prognostication is critical to avoid inappropriate withdrawal of life-sustaining therapy in patients who may have a meaningful recovery, while also avoiding life-sustaining treatments in cases of futility.

Health care professionals are instructed to avoid using single data elements (exam findings such as pupillary light reflex or Glasgow Coma Scale, biomarker, EEG, or magnetic resonance imaging finding) at any given time point to predict good or poor neurologic outcome. Multiple data points are needed to accurately access prognosis for pediatric cardiac arrest survivors (COR 1, LOE B-NR).[133,139–151]

Knowledge Gaps

Some of the most pertinent gaps in PALS research include the following:

- What is the appropriate age and setting to transition from (1) neonatal resuscitation protocols to pediatric resuscitation protocols and (2) from pediatric resuscitation protocols to adult resuscitation protocols?
- What is the optimal method to transition from weight-based dosing to fixed-dose medication administration during cardiac arrest in adolescents or children with high body mass index?
- With what frequency should doses of epinephrine be administered after the initial dose?
- Should epinephrine dosing strategies be individualized to patients based on hemodynamic response or blood pressure targets?
- Are there specific situations in which advanced airway placement is either beneficial or harmful in OHCA or IHCA? Do they differ based on the etiology of cardiac arrest?
- Can echocardiography or cerebral monitoring improve CPR quality or outcomes from cardiac arrest?
- What is the role of ECPR for infants and children with OHCA and IHCA due to noncardiac causes?
- What is the optimal timing and dosing of initial defibrillation for VF or pulseless VT or subsequent defibrillation for refractory VF or pulseless VT?
- What clinical tools can be used to help in the decision to terminate pediatric IHCA and OHCA resuscitation?

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- How can postarrest prognostication be improved with current modalities or new modalities?
- What rehabilitation therapies and follow-up should be provided to improve outcomes after cardiac arrest?
- What are the most effective and safe medications for adenosine-refractory supraventricular tachycardia?
- Are there specific modifications to the cardiac arrest algorithm that should be used when treating a patient with specific conditions, such as myocarditis, cardiomyopathies, single-ventricle congenital heart disease, or pulmonary hypertension?

ADULT ADVANCED LIFE SUPPORT

Part 9 of the 2025 Guidelines, "Adult Advanced Life Support," includes recommendations for the treatment of adult cardiac emergencies, including immediate arrhythmia management in stable and unstable patients.[152] These recommendations are also inclusive of, and have updated upon, the 2023 AHA Focused Update on Adult Advanced Life Support.[153] When those arrhythmias result in OHCA or IHCA, these Guidelines also review and recommend the appropriate electrical, medical, and airway management and when and how to consider terminating resuscitation if ROSC is not achieved.

This chapter does not encompass recommendations for BLS, the training of responding health care professionals, special circumstances regarding the provision of advanced life support (ALS) care, post–cardiac arrest care, or the incorporation of ALS techniques or personnel into a resuscitation system of care.[24,154] These topics are each addressed in their own chapters to provide the appropriate attention to those recommendations and the volume of literature analyzed ("Part 2: Evidence Evaluation and Guidelines Development,"[21] "Part 4: Systems of Care,"[40] "Part 5: Neonatal Resuscitation,"[78] "Part 6: Pediatric Basic Life Support,"[92] "Part 7: Adult Basic Life Support,"[114] "Part 8: Pediatric Advanced Life Support,"[118] "Part 10: Adult and Pediatric Special Circumstances of Resuscitation,"[13] "Part 11: Post–Cardiac Arrest Care,"[155] "Part 12: Resuscitation Education Science").[120] Additionally, considerations around ethics of resuscitation are provided in "Part 3: Ethics."[39]

Significant New and Updated Recommendations

Cardioversion of Atrial Fibrillation or Flutter

Uncontrolled tachycardia resulting from atrial fibrillation or flutter increases myocardial oxygen demand while simultaneously impairing compensatory measures (ie, ventricular filling, cardiac output, coronary perfusion) to meet that demand. Patients who are unstable and those with rate-related ischemia caused by atrial fibrillation or flutter should undergo urgent electrical cardioversion (COR 1, LOE C-LD). Previous editions of these Guidelines advocated for an incremental approach (using a low initial energy setting and escalating until success); however, it is now recommended to begin at 200 J because new evidence demonstrates greater initial shock success, reduced likelihood of inducing VF, shorter duration of anesthesia (if appropriate), and a smaller cumulative electrical burden with this approach (COR 2b, LOE C-LD).[156]

Double Sequential Defibrillation

Combined with CPR, successful biphasic defibrillation, creating current across the thorax from electrode pad to pad, is ≈75% effective in terminating VF and VT.[157] Double sequential defibrillation has emerged as a potential treatment for those patients with shock-refractory VF.[158] Technology to reliably identify shock-refractory VF, in contrast to recurrent VF following defibrillation, and precisely deliver double sequential external defibrillation in the optimal therapeutic window, defined in milliseconds, requires further investigation before being recommended for routine practice (COR 2b, LOE B-R).

Head-Up CPR

Head-up CPR seeks to augment conventional supine CPR to increase cerebral perfusion pressure with the goal of improving favorable neurological outcome.[159] Head-up CPR is a bundle of care studied as a combination of mechanical chest compressions, an impedance threshold device, and application of an automated device to control sequential elevation of the head and thorax during compressions.[160] Current evidence regarding head-up CPR is limited, and in the absence of RCTs or evaluations with contemporary comparisons, its use is not recommended outside of well-designed clinical trials with the appropriate community consent (COR 3 No Benefit, LOE C-LD).

Polymorphic Ventricular Tachycardia

Sustained polymorphic VT results in reduced ventricular filling and eventual cessation of cardiac output and coronary perfusion, inevitably rendering the patient clinically unstable. While previous editions of these Guidelines have suggested multiple treatment modalities on the basis of clinical stability, it is now recommended that all adult patients with sustained polymorphic VT receive immediate defibrillation (COR 1, LOE B-NR). While other medical treatments may be useful in preventing polymorphic VT or its recurrence on the basis of the underlying pathology (ie, prolonged QT interval; COR 2b, LOE C-LD), these modalities should not delay defibrillation to terminate polymorphic VT.

Knowledge Gaps

Some of the most pertinent gaps in adult ALS research include the following:

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- How can technologies developed to diagnose the underlying cardiac rhythm during CPR be used to guide patient management with ALS techniques (ie, timing or vector of defibrillation, administration of epinephrine)?
- How can echocardiography, independent of method (transthoracic or transesophageal), augment the performance of CPR and outcomes from cardiac arrest?
- What is the optimal application of termination of resuscitation guidelines on the basis of the makeup of the responding EMS agency?
- What is the optimal dosing, timing, and route of delivery for epinephrine to maximize neurologically intact survival?
- How should ALS techniques, or the order of their performance, change in the setting of OHCA or IHCA in an adult with congenital heart disease?
- What are the most effective and safe methods for termination of adenosine-refractory supraventricular tachycardia?
- What is the best method to incorporate measures of acute physiology (end-tidal carbon dioxide, arterial blood pressure, etc) into resuscitation decision-making, including the consideration of terminating efforts?
- How do alternative positions for CPR (head-up CPR, etc) affect or improve its performance and the subsequent outcomes (ROSC, neurologically intact survival)?
- Are there specific situations or health care professional characteristics in which the choice of advanced airway placement is either beneficial or harmful in OHCA or IHCA? Do they differ based on the etiology of cardiac arrest?
- What is the role of noninvasive methods of aortic occlusion in successful resuscitation from cardiac arrest?

ADULT AND PEDIATRIC SPECIAL CIRCUMSTANCES OF RESUSCITATION

Part 10 of the 2025 Guidelines, "Adult and Pediatric Special Circumstances of Resuscitation," includes modifications to basic and advanced life support for adults and children in special situations.[13] Depending on the data available, recommendations are made for the management of patients in cardiac arrest or for patients with life-threatening conditions inclusive of cardiac arrest. In the 2020 Guidelines, special circumstances of resuscitation were included within the recommendations for adult basic and advanced life support.[24] For the 2025 Guidelines, we emphasized the review of evidence for both the adult and pediatric populations and provided recommendations for the population where applicable. Adult and pediatric recommendations were provided concurrently when the COR and LOE aligned, and, otherwise, pediatric recommendations were separately provided.

These recommendations are also inclusive of, and have updated upon, the 2023 AHA toxicology focused update[161] and the 2024 AHA drowning focused update.[162] Additionally, new recommendations were provided for the following topics: interposed abdominal compression, electrocution, gas embolism, high-consequence respiratory pathogens, hyperthermia, durable left ventricular assist device (LVAD), amniotic fluid embolism in peripartum patients, and poisoning following volatile hydrocarbon exposure. In all, the updated special circumstances of resuscitation modified 44 recommendations and added 140 new recommendations (many of which were pediatric specific).

Significant New and Updated Recommendations

Extracorporeal Life Support

While not available in every setting or generalizable to undifferentiated cardiac arrest, adults and children in cardiac arrest or a periarrest state with a potentially reversible etiology are being supported with extracorporeal life support devices, such as venoarterial extracorporeal membrane oxygenation in disease processes such as anaphylaxis (adults and children: COR 2a, LOE C-EO), asthma (adults and children: COR 2a, LOE C-LD), cardiac surgery (adults: COR 2a, LOE C-EO; children: COR 2a, LOE C-LD), cardiac interventional laboratory (adults: COR 2a, LOE C-LD), hypothermia (adults: COR 2a, LOE B-NR; children: COR 2a, LOE C-LD), pregnancy (COR 2a, LOE B-NR), and pulmonary embolism (adults: COR 2a, LOE B-NR; children: COR 2a, LOE C-LD) and in poisonings by agents such as β-blockers, calcium channel blockers, cocaine, local anesthetics, sodium channel blockers, and sympathomimetics. Refer to the guideline for individual COR and LOE for extracorporeal life support use in each of the poisoning agents in adults and children.

High-Consequence Respiratory Pathogen

Chest compressions, bag-mask ventilation, defibrillation, suctioning, and endotracheal intubation should be considered aerosol-generating procedures that pose a risk of infection to resuscitation team members (COR 1, LOE C-LD).[163–169] However, a real-world study found that rates of SARS-CoV-2 transmission to resuscitation team members with personal protective equipment were low.[170]

Hyperkalemia

Clinical evidence supporting IV calcium (adults and children: COR 2b, LOE C-LD) or IV sodium bicarbonate (adults and children: COR 2b, LOE C-EO) administration are limited in humans and uncertain to improve survival

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or favorable neurological outcomes.[171,172] The utility of other therapies such as insulin and glucose (adults and children: COR 2b, LOE C-EO) and inhaled β-agonist (adults and children: COR 3 No Benefit, LOE C-EO), intended to lower potassium concentrations in the setting of cardiac arrest, is unclear when weighing the possible benefits against the risk of harm if potentially interrupting well-established interventions like CPR.[171,172]

Hyperthermia

Adults and children with life-threatening hyperthermia from environmental causes (adults and children: COR 1, LOE C-EO), cocaine poisoning (adults: COR 1, LOE C-LD; children: COR 1, LOE C-EO), or sympathomimetic poisoning (adults: COR 1, LOE C-LD; children: COR 1, LOE C-EO) should be rapidly cooled, ideally at a rate of at least 0.15 °C/min (adults: COR 2a, LOE C-LD; children: COR 2a, LOE C-EO).[173] This is best achieved with immersion in ice water (adults: COR 2a, LOE B-R; children: COR 2a, LOE C-EO).[174]

Left Ventricular Assist Device

The absence of a palpable pulse can make confirming cardiac arrest in adults and children with an LVAD difficult, so assess perfusion by surrogate markers such as cool skin temperature, central cyanosis, poor capillary refill, and a low mean arterial pressure.[175] Treatment includes prioritization of CPR (adults and children: COR 1, LOE C-LD) while simultaneously assessing and attempting to restart LVAD function if a second rescuer is available (adults and children: COR 2b, LOE C-LD).

Pregnancy

Management of cardiac arrest during pregnancy is a complex clinical scenario that requires resuscitation strategies that accommodate the physiological changes of pregnancy.[176–178] Manual left lateral uterine displacement during chest compression should be provided for a pregnant cardiac arrest patient when the fundal height is at or above the umbilicus to allow for optimal cardiac output by relieving the compression on the inferior vena cava and aorta (COR 1, LOE C-LD).[179] Anatomic and physiologic changes of pregnancy add difficulty to airway management given the lack of tolerance for hypoxia and risk of aspiration. Airway management should be prioritized during the resuscitation of a pregnant patient in cardiac arrest (COR 1, LOE C-LD).[177] Resuscitative delivery relieves aortocaval compression and returns sequestered uterine blood back to the systemic circulation in efforts to resuscitate the pregnant patient. Team preparation should begin at the recognition of cardiac arrest, and delivery of the fetus should be complete by 5 minutes (COR 1, LOE B-NR).[177]

Opioids

For trained rescuers assisting an adult or child with suspected opioid overdose who has respiratory depression or respiratory arrest and has a definite pulse, breaths or bag-mask ventilation should be provided (COR 1, LOE B-NR). For lay rescuers assisting an adult or child with suspected opioid overdose who is unresponsive and not breathing normally, CPR with breaths should be provided (COR 1, LOE B-NR). An opioid antagonist (eg, naloxone) should be given to people with respiratory arrest from suspected opioid overdose (COR 1, LOE B-NR). Trained rescuers, lay rescuers, and members of the general public can all administer naloxone.

Knowledge Gaps

Some of the most pertinent knowledge gaps in adult and pediatric special circumstances include the following:

- Does a higher dose of epinephrine, such as 5 mg administered intramuscularly in adults, confer benefit in cardiac arrest from anaphylaxis?
- Is there survival benefit to the use of intracoronary epinephrine to treat adult cardiac arrest in the cardiac intervention laboratory?
- Is there a benefit to 3 stacked shocks in VF in adults after cardiac surgery compared with standard measures for ALS?
- How does resuscitation using airway-breathing-compressions versus compressions-airway-breathing affect outcomes in cardiac arrest following drowning?
- Is drying the chest before using an AED on a drowned child or adult necessary for safe defibrillation, and does it improve rates of success?
- How can teams mitigate the effects of personal protective equipment on resuscitation team performance and health care professional fatigue?
- What is the benefit or harm of calcium in the treatment of hyperkalemia and cardiac arrest?
- In adults and children with cardiac arrest due to environmental hypothermia, what is the optimal temperature to rewarm to prior to defibrillation and administration of epinephrine?
- What is the best method to confirm cardiac arrest in an adult or child with an LVAD?
- What is the optimal airway management device and timing in cardiac arrest in pregnancy?
- What is the optimal amount of time chest compressions should be continued after patients in cardiac arrest from pulmonary embolism receive systemic fibrinolytics?
- Does high-dose insulin therapy for adults and children with life-threatening β-blocker or calcium channel blocker poisoning, administered in addition to or instead of standard vasopressors, reduce mortality or ischemic complications?

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- What is the benefit of naloxone when given to adults and children in cardiac arrest with suspected opioid overdose?

POST–CARDIAC ARREST CARE

Overview

Part 11 of the 2025 Guidelines, "Post–Cardiac Arrest Care," includes recommendations for the care of adult patients after ROSC.[155] These recommendations are also inclusive of, and have updated upon, the 2023 AHA adult life support focused update.[153] This encompasses management in the prehospital, emergency department, and in-hospital settings. The management of patients in the post-ROSC period is critically important and spans the Chain of Survival from the acute resuscitation period through survivorship. These Guidelines contain recommendations for post–cardiac arrest care that are based on the best available resuscitation science. This summary highlights new and updated recommendations that may improve outcomes from cardiac arrest.

Significant New and Updated Recommendations

Post-ROSC Diagnostics

Twelve-lead electrocardiogram, echocardiography, point-of-care cardiac ultrasound, and computed tomographic imaging are used in postarrest patients to identify clinically significant diagnoses requiring intervention, including evaluating for the underlying cause of cardiac arrest as well as identification and treatment of complications from cardiac arrest and CPR. A 12-lead electrocardiogram should be performed (COR 1, LOE B-NR), and it may be reasonable to perform computed tomography (COR 2b, LOE B-NR), echocardiography (COR 2b, LOE C-LD), or point-of-care cardiac ultrasound (COR 2b, LOE C-LD) for adult patients after ROSC. The use of these diagnostic modalities is reviewed, and the recommendations regarding ultrasound and computed tomographic imaging are new additions.

Duration of Temperature Control

Temperature control refers to the entire period of active temperature management, either to a hypothermic or normothermic target. Maintaining a temperature between 32 °C and 37.5 °C in patients unresponsive to verbal commands after ROSC is recommended for adults (COR 1, LOE B-R). In settings where a hypothermic target is used initially, a period of fever prevention or temperature control to a normothermic target may follow. Trials are heterogeneous in their durations of temperature control, for both hypothermic and normothermic targets. One RCT found no difference in outcomes comparing hypothermic temperature control for 24 hours versus 48 hours.[180] Another RCT found no difference in outcomes comparing a period of device-based fever prevention of 12 hours versus 48 hours after an initial 24-hour period of temperature control to 36 °C (36 hours versus 72 total hours of temperature control).[181] Other RCTs protocolized all patients to 72 hours of total temperature control.[182,183] Recognizing evolution of evidence and definitions with respect to temperature control, 36 hours of total temperature control is the shortest recommended duration (COR 2a, LOE B-R).

Management of Post-ROSC Shock

Hypotension requiring vasopressors is common in post–cardiac arrest patients.[184,185] There are no large-scale RCTs comparing clinical outcomes between different vasopressors. Data from patients in cardiogenic shock, many of whom experienced cardiac arrest, suggest epinephrine and dopamine have been associated with a less favorable safety profile; however, this was not found in a recent meta-analysis of the literature focused on cardiac arrest patients.[186–188] Thus there is insufficient evidence to recommend a specific vasopressor to treat low blood pressure in adult patients after cardiac arrest (COR 2b, LOE B-NR). Additionally, temporary mechanical circulatory support devices have been used to increase blood pressure and cardiac output in patients with cardiogenic shock, often as an adjunct to vasopressor therapy. In highly selected adult patients with refractory cardiogenic shock after cardiac arrest and ROSC, temporary mechanical circulatory support may be considered (COR 2b, LOE B-NR).

Invasive Neuromonitoring

Hypoxic-ischemic brain injury leads to disruptions in the physiological processes involved in cerebral homeostasis, leading to risks of secondary brain injury.[189] Neurologic injury is the primary cause of death in patients who initially survive to ROSC; thus, there is interest in improving neurologic care in the postarrest period. While several studies have examined different approaches to invasive neurologic monitoring for hypoxic-ischemic brain injury, methodological limitations exist that limit the ability to make a recommendation about any invasive neuromonitoring technique. A discussion on the usefulness of monitoring intracranial pressure, cerebral blood flow, and brain tissue oxygenation was included in the Guidelines, acknowledging the growing body of literature on this topic and the movement toward personalized neurologic care in the post–cardiac arrest period. The usefulness of these different invasive neuromonitoring modalities has not been established (COR 2b, LOE C-LD).

Management of Seizures and Myoclonus

Seizures and status epilepticus are common acute neurologic complications in the post–cardiac arrest period, occurring in 10% to 35% of patients who do not follow commands after ROSC.[190–195] Myoclonus is a clinical

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exam finding that may be a manifestation of a seizure if it occurs time locked with an EEG correlate, or myoclonus may occur without an EEG correlate. Thus, after ROSC, promptly performing and interpreting an EEG is recommended for the diagnosis of seizures in adult patients with myoclonus (COR 1, LOE C-LD). Recommendations addressing diagnosis and management of myoclonus and management of EEG findings on the ictal-interictal continuum are important additions.

Neuroprognostication for Favorable Outcome

Accurate neuroprognostication is important to avoid inappropriate withdrawal of life support in patients who may otherwise achieve a favorable outcome and to avoid ineffective treatment when an unacceptable or unfavorable outcome is inevitable.[196] Neuroprognostication has historically focused on identifying prognostic tests that predict unfavorable outcome with high specificity. There is increasing focus on developing prognostic tests that predict favorable outcome. Recommendations focused on prognosis for favorable outcome are new additions to these Guidelines.

Health Care Professional Burnout

An important addition to the Guidelines is acknowledging the stressors placed on health care professionals who care for patients with cardiac arrest. Burnout among health care workers is common[197] and negatively impacts health care professionals' productivity (eg, absenteeism, turnover)[198] and patient care (eg, reduced patient satisfaction, increased errors by health care professionals).[199] Randomized controlled trials targeting burnout in health care workers have led to some improvement in at least one dimension of burnout or mental health outcome.[200–206] Variability in intervention methods and outcome measures, considerable attrition, and high risk of bias inherent in behavioral trials limit the degree to which any one well-being intervention method can be recommended. Nonetheless, interventions to address health care professional burnout may be beneficial (COR 2b, LOE B-NR).

Knowledge Gaps

Questions that address some of the most pertinent knowledge gaps in post–cardiac arrest care include the following:

- How does one select target temperature?
- What is the optimal timing for initiation and duration of temperature control?
- Should the approach to temperature control vary based on patient characteristics?
- Is there a preferred method of cooling and rewarming?
- How does one select physiologic targets (blood pressure, oxygenation, ventilation, etc) for individual patients in the postarrest period?
- How does one achieve optimal physiologic targets in the postarrest period (eg, vasopressor selection, role of mechanical circulatory support, role of intracranial monitoring)?
- Do subgroups of patients (eg, chronic lung disease, immunocompromised status) benefit from early antibiotic administration after ROSC?
- What is the optimal combination of prognostic tests (eg, clinical examination in combination with neuroimaging or EEG to predict outcome)?
- What is the optimal timing for obtaining prognostic tests?
- What are threshold cutoffs that predict unfavorable outcome?
- How can prediction of favorable outcome be improved?
- How can future neuroprognostication research mitigate biases introduced from withdrawal of life-sustaining treatment?
- When is the optimal time to assess survivors and caregivers for emotional distress?
- What are optimal components of psychosocial interventions to address survivor and caregiver emotional distress?
- What are optimal interventions to address burnout in health care professionals?

RESUSCITATION EDUCATION SCIENCE

Part 12 of the 2025 Guidelines, "Resuscitation Education Science," includes recommendations about various instructional design features in resuscitation training, including CPR feedback devices, rapid-cycle deliberate practice, scripted debriefing, gamified learning, spaced learning and booster training, teamwork and leadership training, manikin fidelity, virtual and augmented reality, and the use of cognitive aids.[120] Recommendations for these instructional design elements have been split into those for health care professionals and those for lay rescuers. The second section of Part 12 describes how specific health care professional considerations may influence the impact of educational interventions, including disparities according to sex, gender, race, socioeconomic status, and language as well as factors that act as barriers or facilitators to lay rescuer willingness to perform CPR.

Significant, New, and Updated Recommendations

Feedback Devices During CPR Training

It is recommended that feedback devices be used during training for health care professionals (COR 1, LOE A) and lay rescuers (COR 1, LOE A). Feedback devices for CPR provide objective, real-time data to learners during

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training. This is an advantage over visual observation of CPR by an instructor, which has been shown to be unreliable.[207–209] A meta-analysis of 17 RCTs among health care professionals found that CPR feedback devices had a moderate to large positive effect on CPR quality metrics. A separate meta-analysis of 3 randomized trials in lay rescuers found that depth and rate compliance were improved.

Disparities in CPR Education

It is recommended to focus and tailor lay rescuer CPR training to specific racial and ethnic populations and neighborhoods and incorporate awareness efforts in the United States (COR 1, LOE B-NR). Cohort studies have shown that residents of Black and Hispanic neighborhoods are less likely to be trained in or to receive CPR.[210–215] Additional studies have shown that neighborhood mapping to identify areas for targeted training is feasible.[216,217]

It is recommended to prioritize low socioeconomic status populations and neighborhoods for lay rescuer CPR training and awareness efforts (COR 1, LOE B-NR). Cohort studies have shown that low socioeconomic status is associated with less CPR training and lower likelihood of receiving lay rescuer CPR.[212,218–232]

It is recommended to address barriers to lay rescuers performing CPR on females, through educational training and public awareness efforts (COR 1, LOE B-NR). Women are less likely to receive lay rescuer CPR in public places.[233,234] Studies of potential lay rescuers have shown prevalent misconceptions about causing injury and concern about being accused of inappropriate contact with people experiencing cardiac arrest.[235,236]

It is reasonable to address barriers to linguistically isolated communities by increasing availability and access to CPR training materials in diverse languages (COR 2a, LOE C-LD). Language barriers in communities have been associated with lower rates of lay rescuer CPR.[237–242]

It is reasonable to consider cost-effective methods for CPR training and promoting safe access to CPR training for low socioeconomic status populations and settings (COR 2a, LOE C-LD). Cost, safety concerns, and insufficient information availability are barriers to CPR training in low socioeconomic status neighborhoods.[239,241–244]

CPR Training in Schoolchildren

It is recommended that children aged 12 through 18 years be trained to perform high-quality CPR (COR 1, LOE C-LD). Multiple studies have shown that children ≥12 years can learn and perform effective chest compressions.[245–249]

It is recommended to start CPR training children <12 years in order to increase willingness and self-confidence in later years (COR 1, C-LD). Schoolchildren from the age of 4 to 7 years of age can adequately make an emergency call[250–255] or follow the instructions of an AED.[251–254] Moreover, a playful approach to CPR at early ages promotes motivation and interest in schoolchildren <12 years and annual repetition can increase the willingness and self-confidence related to the initialization of resuscitation measures in later years.[255]

Virtual and Augmented Reality

It may be reasonable to use virtual reality (VR) to support knowledge acquisition in basic and advanced life support training for lay rescuers and health care professionals (COR 2b, LOE B-R). *Virtual reality* refers to training with simulated patients via interactive scenarios within 3-dimensional replications of actual care environments. Four studies of VR use in BLS education found better knowledge acquisition than with other forms of training.[256–259]

Virtual reality should *not* be used to teach CPR skills in laypeople and health care professionals (COR 3: Harm, LOE B-R). Multiple studies of CPR quality performance comparing VR-based training to standard training found that VR resulted in poorer compliance with guidelines for chest compression depth, rate, and recoil.[260–264]

The use of augmented reality to provide real-time CPR feedback may be considered for BLS training of laypeople and health care professionals (COR 2b, LOE CL-D). *Augmented reality* refers to the use of holographic images overlaid onto a real clinical environment. Four RCTs using augmented reality for CPR feedback during training yielded mixed results, with one study showing better overall CPR performance[265] and other studies showing no difference.[266–268]

Gamified Learning

It may be reasonable to use gamified learning elements as a component of resuscitation training for health care professionals (COR 2b, LOE C-LD). Gamified learning involves the use of game-like elements during resuscitation training. These elements can include competition, point systems, scaffolded levels of difficulty, and leaderboards. Gamification has been shown to increase learner engagement and enhance recall of content.[269]

Scripted Debriefing

It may be reasonable for an instructor to use a debriefing script during resuscitation education (COR 2b, LOE C-LD). Scripted debriefing involves the creation of a written plan for debriefing learners during and following life support training. These scripts aim to standardize debriefing during resuscitation training, supporting facilitators with a clear plan and guiding discussion. Standardized debriefing helps to maintain consistency in the delivery of debriefings across training centers and resuscitation programs. Randomized controlled trials in resuscitation

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training settings showed that scripted debriefing was associated with improved CPR quality,[270] improved team leadership and knowledge acquisition,[271] and improved debriefing quality among novice instructors.[272]

Rapid-Cycle Deliberate Practice

It may be reasonable to incorporate rapid-cycle deliberate practice as part of basic or advanced life support training for health care personnel (COR 2b, LOE C-LD). *Rapid-cycle deliberate practice* is defined by rapid cycling between deliberate practice and directed feedback until skill mastery is achieved.[273] Multiple studies have demonstrated that this training is associated with faster initiation of chest compressions, defibrillation, ventilation, and epinephrine administration, as well as improved compression fraction and shorter pauses before defibrillation.[273–277]

Alternative Objects for Chest Compression Training Lay Rescuers

The usefulness of alternative objects (as an alternative to a manikin) to train laypeople in chest compressions is not well established (COR 2b, LOE C-LD). Barriers to CPR training in low-resource settings include cost, access to training centers, and time constraints. Studies of low-cost, easy-access objects as an alternative to manikins (eg, pillow, foam blocks, toilet paper, rolls, plastic bottles), which allow lay rescuers in low-resource settings to train in chest compressions, have yielded mixed results.[278–284]

Knowledge Gaps

Some of the most pertinent gaps in resuscitation education research include the following:

- What are the optimal methods for identifying and targeting areas with lower prevalence of CPR training and lower lay rescuer CPR rates? What methods best overcome barriers to training for people living in those areas?
- Which educational interventions most impact real-world performance and clinical outcomes, as opposed to educational outcomes or performance in training?
- How can instructional design features be combined or blended to optimize outcomes? Future studies should evaluate the synergistic effects of instructional design features when used in a blended manner.
- What are the most effective ways to train and develop resuscitation instructors? Future research should evaluate the impact of various faculty development strategies on instructor skills and learner outcomes.
- What is the impact of varying levels of cost, resource and personnel availability, and training center infrastructure on the ability to implement technology-dependent instructional design features (eg, high-fidelity manikins, VR)?

SUMMARY

Cardiac arrest remains a serious condition with high morbidity and mortality, impacting individuals of all ages, sexes, genders, races, geographic regions, and socioeconomic backgrounds. While survival rates have seen some improvements since 2020, substantial efforts are still needed to reduce the significant burden of this disease. This executive summary outlines updated and new recommendations from the 2025 Guidelines, developed through rigorous evidence evaluation, and new horizons of ethical challenges that result from advancing resuscitation science.

Continued progress over the next decade will require strengthening the Chain of Survival and enhancing coordinated SOC. The knowledge gaps identified in the 2025 Guidelines highlight critical research questions that should be addressed, presenting key opportunities for future funding in resuscitation science. While developing Guidelines is a crucial first step, their implementation and ongoing research will be essential in driving meaningful improvements in patient outcomes. Funding for such research is a critical priority in reducing death and disability from cardiac arrest.

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*Modest.

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*Modest.

†Significant.

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Part 2: Evidence Evaluation and Guidelines Development: 2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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ABSTRACT: The *2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care* is based on the extensive evidence evaluation performed in conjunction with the International Liaison Committee on Resuscitation. The Adult Basic and Advanced Life Support, Pediatric Basic and Advanced Life Support, Neonatal Resuscitation, Resuscitation Education Science, Special Circumstances, Post–Cardiac Arrest Care, Ethics, and Systems of Care Writing Groups drafted, reviewed, and approved recommendations, assigning to each recommendation a Class of Recommendation (ie, strength) and Level of Evidence (ie, quality). The 2025 Guidelines are organized in knowledge chunks that are grouped into discrete modules of information on specific topics or management issues. Each chapter of the 2025 Guidelines underwent blinded peer review by subject matter experts and was also reviewed and approved for publication by the American Heart Association Science Advisory and Coordinating Committee and the American Heart Association Executive Committee. Chapters with pediatric content (Neonatal Resuscitation, Pediatric Basic and Advanced Life Support) were also co-led by the American Academy of Pediatrics, and thereby the content was reviewed and approved by the American Academy of Pediatrics Board of Directors. The American Heart Association has rigorous conflict of interest policies and procedures to minimize the risk of bias or improper influence during development of the guidelines. Anyone involved in any part of the guideline development process disclosed all commercial relationships and other potential conflicts of interest.

Key Words: AHA Scientific Statements ■ cardiac arrest ■ evidence evaluation ■ resuscitation

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INTRODUCTION

This section describes the process of creating the *2025 American Heart Association* (AHA) *Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care* (ECC), including the process of evidence evaluation and the format of the guideline document; the formation of the AHA and AHA/American Academy of Pediatrics (AAP) Writing Groups; the guideline development, review, and approval process; and the management of potential conflicts of interest.

METHODOLOGY AND EVIDENCE REVIEW

The 2025 Guidelines are designed to present a comprehensive compilation of guidance for cardiopulmonary resuscitation and ECC. These guidelines, including those for adult basic and advanced life support, pediatric basic and advanced life support, neonatal resuscitation, resuscitation education science, special circumstances, post–cardiac arrest care, ethics, and systems of care, are based on an evidence evaluation process conducted

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Table 1. GRADE Terminology for Strength of Recommendation and Criteria for Evidence Certainty Assessment[9]

Strength of recommendation			
Strong recommendation = We recommend		Weak recommendation = We suggest	
Assessment criteria for certainty of effect			
Study design	Certainty of effect begins at this level	Lower if	Higher if
Randomized trial	High or moderate	Risk of bias Inconsistency Indirectness Imprecision Publication bias	Large effect Dose response All plausible confounding would reduce demonstrated effect or would suggest a spurious effect when results show no effect
Observational trial	Low or very low		

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation.

by the International Liaison Committee on Resuscitation (ILCOR) published as the *2025 ILCOR Consensus on Science With Treatment Recommendations* (CoSTR),[1] and an independent evidence review process conducted by the 2025 Guideline writing groups.

The ILCOR Scientific Advisory Committee, consisting of experts in evidence review, created a methodological governance process for evidence evaluation used to develop the 2025 CoSTR.[1] This process produced 3 types of evidence reviews: systematic reviews, scoping reviews, and evidence updates. New for the 2025 Guidelines, the AHA also developed an internal evidence review process to address specific content areas not reviewed by the ILCOR evidence review process that were deemed important to users of the AHA guidelines.

ILCOR Systematic Review

Systematic reviews were conducted by ILCOR task force members with expertise in systematic reviews and the content area following standardized procedures.[2] The methodology was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses[3] and the approach proposed by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group.[4] The overall process was coordinated by the Scientific Advisory Committee of ILCOR and guided by the task force Scientific Advisory Committee representatives.

In brief, each ILCOR task force identified and prioritized questions to be addressed by using the PICOST (population, intervention, comparator, outcome, study design, time frame) format.[5] A detailed search for relevant publications was performed on MEDLINE, Embase, and Cochrane Library databases, with identified publications screened for further evaluation. Two systematic reviewers conducted a risk-of-bias assessment for each relevant study by using Cochrane and GRADE criteria for randomized controlled trials,[6] Quality Assessment of Diagnostic Accuracy Studies, version 2, for studies of diagnostic accuracy,[7] and GRADE criteria for observational and interventional studies informing therapy or prognosis questions.[4] In addition to assessing scientific bias, the Cochrane risk-of-bias tool also considers both the source of funding and potential conflicts of interest of authors of the study. The reviewers created evidence profile tables containing information on all study outcomes. Using the GRADE approach,[8] the certainty of evidence (ie, confidence in the estimate of the effect) was categorized as high, moderate, low, or very low on the basis of the study methodologies. The certainty of evidence was upgraded for a dose-response or large effect, and downgraded for bias, inconsistency, indirectness, imprecision, or publication bias (Tables 1 and 2).[9] Any unresolved disparity between reviewer assessments was resolved through discussions and consensus with the task force representative of the Scientific Advisory Committee and, if disagreement remained, by the larger task force.

The ILCOR task forces reviewed, discussed, and debated the studies and systematic review analyses, drafting a consensus on science statement and a written summary of identified evidence and evidence certainty for each outcome. When there was consensus, the task force developed consensus treatment recommendations, labeled as strong or weak and either for or against a therapy, prognostic tool, or diagnostic test, noting the certainty of the evidence. In addition, each topic summary included the PICOST question and a justification and evidence-to-decision framework section, capturing the values and preferences considered by the task force as well as a list of knowledge gaps. Public input was sought for the draft CoSTR statements.[10] The task forces considered all public comments when finalizing the CoSTR statements. A task force insights approach was used rather than a formal CoSTR when there were insufficient data to support a recommendation. All CoSTR statements from 2021 to 2025 underwent peer review by at least 5 subject matter experts and were endorsed by the ILCOR board before publication.

ILCOR Scoping Review

The purpose of a scoping review is to provide an overview of the extent, range, and nature of research activity; to

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Table 2. GRADE Terminology[9]

Term	Explanation
Risk of bias	Study limitations in randomized trials include lack of allocation concealment, lack of blinding, incomplete accounting of patients and outcome events, selective outcome reporting bias, and stopping early for benefit. Study limitations in observational studies include failure to apply appropriate eligibility criteria, flawed measurement of exposure and outcome, failure to adequately control confounding, and incomplete follow-up.
Inconsistency	Criteria for inconsistency in results include the following: Point estimates vary widely across studies; CIs show minimal or no overlap; statistical test for heterogeneity shows a low *P* value; and the I^2 is large (a measure of variation in point estimates resulting from among-study differences).
Indirectness	Sources of indirectness include data from studies with differences in population (eg, OHCA instead of IHCA, adults instead of children), differences in the intervention (eg, different compression-ventilation ratios), differences in outcome, and indirect comparisons.
Imprecision	Low event rates or small sample sizes will generally result in wide CIs and therefore imprecision.
Publication bias	Several sources of publication bias include the tendency not to publish negative studies and the influence of industry-sponsored studies. An asymmetrical funnel plot increases suspicion of publication bias.
Good practice statements	Guideline panels often consider it necessary to issue guidance on specific topics that do not lend themselves to a formal review of research evidence. The reason might be that research into the topic is unlikely to be located or would be considered unethical or infeasible. Criteria for issuing a nongraded good practice statement include the following: There is overwhelming certainty that the benefits of the recommended guidance will outweigh harms, and a specific rationale is provided; the statements should be clear and actionable to a specific target population; the guidance is deemed necessary and might be overlooked by some providers if not specifically communicated; and the recommendations should be readily implementable by the specific target audience to which the guidance is directed.

CI indicates confidence interval; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; IHCA, in-hospital cardiac arrest; and OHCA, out-of-hospital cardiac arrest.

clarify key concepts; to identify gaps; or to identify topics for future systematic reviews.[11] One difference between scoping reviews and systematic reviews is that scoping reviews attempt to provide an overview of a broad topic with a large and diverse body of literature, and to produce a summary of the studies, but not a magnitude of effect. Systematic reviews address a narrow, more clearly focused research question. Scoping reviews are helpful in examining emerging areas of research, clarifying key concepts, and identifying gaps in knowledge. Additionally, scoping reviews do not include formal evaluation of the certainty of evidence or risk of bias and are not assessed according to GRADE recommendations. Due to these differences, unlike the treatment recommendations that can arise from a systematic review, scoping reviews cannot result in CoSTR without an additional systematic review. Scoping reviews can, however, result in the development of good practice statements. Although ILCOR does not create or alter treatment recommendations without a systematic review, if the topic of a scoping review is thought to be of particular interest to the resuscitation community, good practice statements are often made. Good practice statements represent expert opinion informed by the very limited evidence available.[12]

The methodology for conducting a scoping review was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews.[3,13,14] Each task force identified questions to be reviewed, presented in the PICOST or population, concept, context format. MEDLINE, Embase, and Cochrane databases were searched to identify relevant publications, with additional databases searched where appropriate. Those performing the scoping reviews extracted data to create summary tables. The task force then reviewed the studies and the evidence tables, developing a consensus narrative summary of the evidence and an overview of the task force insights including knowledge gaps and research priorities. Each topic narrative summary and overview of task force insights (including why the topic was reviewed, narrative evidence summary, and a narrative report of the task force discussions), as well as the complete scoping review, were posted on the ILCOR website for public review and input,[13] with final versions included in the appendix and summarized in the body of the relevant task force CoSTR publication. When ILCOR task forces believed there was a need to make a clinical recommendation after performing a scoping review or evidence update (because no treatment recommendations can be made without a full systematic review under ILCOR policy), task forces were permitted to make expert consensus-based good practice statements. These statements were designed to reflect what experts in the resuscitation science community believe are the current best practices when sufficient data are not yet available to support such conclusions. In such cases, ILCOR expects that such statements can be replaced with formal treatment recommendations through the CoSTR process in the future as more research becomes available.

ILCOR Evidence Update

ILCOR evidence updates involve a systematic way of searching the literature and updating an overview of the evidence available on a particular PICOST topic of interest for ILCOR.[15] The evidence updates may be done to evaluate the existence of new research related to an already commissioned PICOST or may be done as preliminary work related to a newly developed PICOST topic. The evidence update reviewers used PubMed to conduct searches of English language publications indexed in the MEDLINE database. When the search strategies from previous reviews were available, these

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were repeated. Searching beyond the MEDLINE database was optional and at the discretion of the reviewer. Reviewers identified relevant new studies, guidelines, and systematic reviews, and completed an evidence update worksheet, which included the research question, the search strategy, and a table summarizing any new evidence.[13] After review by the ILCOR Science Advisory Committee Chair, the evidence update worksheet was included in the relevant 2025 CoSTR task force publication appendix and cited within the body of the manuscript. As mentioned, a good practice statement could be added by an ILCOR task force after an evidence update was performed.

AHA Evidence Evaluation

An internal AHA evidence evaluation process was used to support recommendation updates or the development of new recommendations if applicable. These reviews are specifically conducted when current ILCOR evidence synthesis outputs (eg, systematic review, scoping review, or evidence update) are not available. Evidence reviewers followed a standard operating procedure for evidence review developed by the AHA ECC Committee based on systematic review methodology and supported by designated information specialists with expertise in systematic literature review methodology.[4,15] The process was designed to provide a comprehensive synthesis of all available evidence on a topic to support the development of specific guidelines. It was designed to ensure rigor and feasibility, providing guidance and support for writing group members to conduct the searches and evidence synthesis for submission to the writing group chair and section authors.

Where possible, evidence reviews were conducted by 2 independent reviewers assigned by the writing group chair. Reviewers defined the elements of a PICOST research question if the clinical area under review allowed for this. The determination of these elements was set *a priori* to guide the development of the search strategy in collaboration with the AHA librarians, to assist in the development of inclusion and exclusion criteria for article selection, and to guide data abstraction when relevant articles were identified. If the PICOST approach was not relevant for a particular area, reviewers defined the clinical area of interest, the specific terms used to define that area, and as many of the elements of the PICOST as possible. Reviewers codeveloped search strategies with the AHA librarians. Depending on the topic area and availability of published data, literature searches were limited to randomized clinical trials, or expanded to include nonrandomized trials, observational studies, or case studies. Literature searching included the following online databases: MEDLINE, PubMed, Embase, and the Cochrane Library. For guideline updates, searches were limited to the time period following the last search date reported in the prior version of the guideline. In the case of a new guideline or full revision, no time limits on searches were imposed unless the writing group determined that a different time frame was appropriate. The 2 reviewers then independently reviewed citations for inclusion, and evaluated included studies for risk of bias using the Robins-I tool for nonrandomized studies[16] and the Cochrane risk-of-bias tool for randomized control trial designs.[6] Disagreements in study selection, risk-of-bias evaluation, and data abstraction were resolved through consensus building between the 2 reviewers. When consensus could not be reached, a third reviewer was used to resolve the disagreement.

The output from this process, including data abstracted from each study relevant to the PICOST question, was documented in a standardized evidence review form, and then returned to the writing group chair for distribution to the members. Reviewers used their review of the literature, with risk-of-bias assessments considered, to propose a summary of the evidence and to suggest either no change to prior recommendations, to suggest modifications to existing recommendations, or to draft entirely new recommendations. The results of these reviews by the Writing Groups were under embargo and therefore were not posted for public comment.

Adolopment of External Guidelines

One opportunity to enhance and streamline the 2025 guideline process has been the ability to integrate external systematic reviews and guidelines into the AHA guideline process. This can be in the form of adopting existing recommendations or developing recommendations based on the available evidence synthesis termed adolopment. An adolopment evaluation process was used when a writing group identified a need for guidance on a particular topic, but existing guidelines or systematic reviews from external organizations, not directly affiliated with ECC, already provided valuable, high-quality information.[17] Instead of creating new guidelines, adolopment allowed writing groups to leverage this information, provided the external guideline fit specific criteria. When a writing group identified the need for adolopment of external publications, there was first an initial comprehensive search of existing AHA guidelines (eg, AHA/American College of Cardiology, AHA/American Stroke Association) to ensure no conflicts existed between the adopted adolopment and current AHA recommendations. The writing group then presented their justification for adolopment along with their AHA guideline search results to the Science Subcommittee leadership [Chair (MD), Vice Chair (JB) and Immediate Past Chair (ARP)], and the AHA Vice President for Science and Innovation (CS) for approval. Once approved, the writing group conducted a thorough assessment of the external guideline's methodology to ensure rigor. Key elements such as the search strategy, inclusion/exclusion criteria, data extraction, bias assessments, GRADE evidence

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profile tables, and meta-analyses were evaluated. Writing groups were permitted to incorporate guidelines from other organizations, even if their development process was less rigorous (eg, did not use multiple databases), provided their evidence review process was transparent. These requests were evaluated on a case-by-case basis, with input from Science Subcommittee leadership and AHA staff. Alternatively, writing groups could choose to conduct an evidence review that included these external guidelines and their recommendations, using them as part of the broader body of evidence to inform recommendations. With this approach, rather than adolopment of external guidelines, external guidelines could be used to contribute to the overall evidence base for guideline development by the writing groups.

GUIDELINE FORMAT

Similar to the 2020 Guidelines, the 2025 Guidelines are organized in knowledge chunks, grouped into discrete modules of information on specific topics or management issues.[18] Each modular knowledge chunk includes a table of recommendations, a synopsis, recommendation-specific supportive text, and, when appropriate, figures, flow diagrams of algorithms, and additional tables. Hyperlinked references are provided to facilitate quick access and review.

With the addition of "Part 3: Ethics" in the 2025 Guidelines, a narrative review format was also used to allow for detailed discussion of complicated ethical issues. The science review for ethics content followed a more traditional literature review process without development of a standard knowledge chunk format that resulted in recommendations, synopses, and recommendation-specific supporting text found elsewhere in the 2025 Guidelines. After a review of the literature by 2 or more writing group members, it was then reviewed and refined by all writing group members. There was no generation of recommendations with Class of Recommendation and Level of Evidence as found in other chapters.

FORMATION OF THE GUIDELINE WRITING GROUPS

The AHA strives to ensure that each guideline writing group includes requisite expertise and diversity, representative of the broader medical community by selecting experts from a wide array of scientific backgrounds, geographic regions of North America, sexes, races, ethnicities, intellectual perspectives, experience levels, and scopes of clinical practice. Volunteers with an interest and recognized expertise in resuscitation are nominated by the writing group chair, selected by the AHA ECC Committee, and approved by the AHA Manuscript Oversight Committee. All volunteer selection is conducted by volunteers through the AHA ECC Committee without AHA staff influence.

The Adult Basic and Advanced Life Support Writing Group included experts in emergency medicine, critical care, cardiology, toxicology, neurology, emergency medical services, education, research, and public health. The Pediatric Basic and Advanced Life Support Writing Group consisted of pediatric clinicians, including intensivists, cardiac intensivists, cardiologists, emergency physicians, and emergency medicine nurses. The Neonatal Resuscitation Writing Group included neonatal physicians and nurses with backgrounds in clinical medicine, education, research, and public health, and an obstetrician-gynecologist. The Pediatric Advanced Life Support, Pediatric Basic Life Support, and Neonatal Resuscitation Writing Groups were jointly appointed by AHA and AAP, with a co-chair and half the writing group members appointed by each organization. The Resuscitation Education Science Writing Group consisted of experts in resuscitation education, clinical medicine (ie, pediatrics, intensive care, emergency medicine), nursing, prehospital care, and health services and education research. The Systems of Care Writing Group included experts in clinical medicine, education, research, and public health. The Ethics Writing Group included experts in emergency medicine, critical care medicine, neurocritical care, cardiology, and emergency medical services, including experts in neonatal, pediatric, adult medicine, and medical ethics in each domain. Before appointment, writing group members completed a disclosure of relevant relationships with industry. Writing group members also adhered to all AHA requirements for management of any potential intellectual and financial conflicts of interest. The AAP appointed a writing group member to the Education Science, Ethics, Evidence Evaluation, Special Circumstances, and Systems of Care Writing Groups. For each Writing Group, the exact constituents, affiliations, and conflicts of interest are noted at the end of their respective Guideline chapter.

GUIDELINES DEVELOPMENT, REVIEW, AND APPROVAL

Each writing group reviewed all relevant and current AHA guidelines for cardiopulmonary resuscitation and ECC,[19–25] pertinent CoSTR evidence and recommendations from 2020 through 2025,[1,9,10,26–33] all relevant ILCOR evidence updates, and all AHA evidence evaluation worksheets to determine if current guidelines should be reaffirmed, revised, or retired, or if new recommendations were needed. Recommendations were eligible for retirement if the topic became accepted best practices such that alternative treatments were not considered in practice, no additional studies were published or underway since the last published guideline, and future research

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Table 3. Applying Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care (Updated December 2024)*

CLASS (STRENGTH) OF RECOMMENDATION

Class 1 (STRONG) — Benefit >>> Risk

Suggested phrases for writing recommendations:
- Is recommended
- Is indicated/useful/effective/beneficial
- Should be performed/administered/other
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is recommended/indicated in preference to treatment B
  - Treatment A should be chosen over treatment B

Class 2a (MODERATE) — Benefit >> Risk

Suggested phrases for writing recommendations:
- Is reasonable
- Can be useful/effective/beneficial
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is probably recommended/indicated in preference to treatment B
  - It is reasonable to choose treatment A over treatment B

Class 2b (WEAK) — Benefit ≥ Risk

Suggested phrases for writing recommendations:
- May/might be reasonable
- May/might be considered
- Usefulness/effectiveness is unknown/unclear/uncertain or not well-established

Class 3: No Benefit (MODERATE) — Benefit = Risk (Generally, LOE A or B use only)

Suggested phrases for writing recommendations:
- Is not recommended
- Is not indicated/useful/effective/beneficial
- Should not be performed/administered/other

Class 3: HARM (STRONG) — Risk > Benefit

Suggested phrases for writing recommendations:
- Potentially harmful
- Causes harm
- Associated with excess morbidity/mortality
- Should not be performed/administered/other

LEVEL (QUALITY) OF EVIDENCE‡

Level A
- High-quality evidence‡ from more than 1 RCT
- Meta-analyses of high-quality RCTs
- One or more RCTs corroborated by high-quality registry studies

Level B-R (Randomized)
- Moderate-quality evidence‡ from 1 or more RCTs
- Meta-analyses of moderate-quality RCTs

Level B-NR (Nonrandomized)
- Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies
- Meta-analyses of such studies

Level C-LD (Limited Data)
- Randomized or nonrandomized observational or registry studies with limitations of design or execution
- Meta-analyses of such studies
- Physiological or mechanistic studies in human subjects

Level C-EO (Expert Opinion)
- Consensus of expert opinion based on clinical experience

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR 1 and 2a; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely-used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

was unlikely. All retired recommendations were listed in a table at the end of the guideline chapter with the related PICOST.

Following evaluation of all relevant evidence, the writing groups drafted, reviewed, and approved recommendations, assigning to each recommendation a Class of Recom-

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mendation (ie, strength) and Level of Evidence (ie, quality; Table 3). The process for recommendation development followed was as previously described and set forth by the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines.[34] Consistent with these standards, recommendations were drafted following the knowledge chunk format applied in the 2020 AHA Guidelines.[18] Once drafted, each knowledge chunk was reviewed by the AHA ECC Science Subcommittee leadership [Chair (MD), Vice Chair (JB), and Immediate Past Chair (ARP)] for science and content. The knowledge chunks were also reviewed by the AHA Vice President for Science and Innovation (CS) and Senior Science Editors (ID and SS) for consistency of language and format. Feedback was then returned to the writing group for consideration. All final guideline decisions were made by vote of the writing group members and was solely the purview of the writing group.

Each of the 2025 Guidelines articles was submitted for blinded peer review to 5 to 10 subject matter experts nominated by the AHA and AAP, as appropriate. Subject matter expert reviewers were required to disclose relationships with industry and any other potential conflicts of interest, and all disclosures were reviewed by AHA staff. Peer reviewer feedback was provided for guidelines in draft format and again in final format. AHA policy requires that official positions and guidelines of the AHA must be reviewed and approved by the Board of Directors or its Executive Committee or both. Upon completion of peer review, these guidelines were reviewed and edited for publication by the AHA Science Advisory and Coordinating Committee and the AHA Executive Committee following the standard review process for all official AHA documents with legal, communications, and science staff to ensure risk mitigation and accurate alignment with the AHA mission. To maintain the highest level of methodological rigor and transparency, the 2025 AHA/ECC Guidelines were developed consistent with the domains of the Appraisal of Guidelines for Research & Evaluation II Instrument,[35] and a description is provided in the online Supplement to this Part.

MANAGEMENT OF POTENTIAL CONFLICTS OF INTEREST

The AHA, AAP, and ILCOR have rigorous conflict of interest policies and procedures to minimize the risk of bias or improper influence during development of the CoSTRs and the AHA guidelines. All 3 organizations followed these policies[34,36,37] throughout the 2025 evidence evaluation and document preparation process. Anyone involved in any part of this process was required to disclose all commercial relationships and other potential conflicts (including intellectual) both before joining the writing group and during writing group activities. These disclosures were reviewed before assignment of task force chairs and members, writing group chairs and members, consultants, and peer reviewers. In keeping with the AHA conflict of interest policy, the chair and most members (>50%) of each ILCOR task force and each AHA/AAP writing group had to be free of relevant conflicts. Writing group members were not allowed to participate in drafting recommendation text or to vote on any final recommendation for which they had a relevant conflict. Writing group members who recused themselves from voting on a topic due to a relevant conflict were documented. Importantly, recognizing the potential for conflict for AHA staff, no AHA employee or leadership were involved in guideline recommendation development or voting. Appendix 1 lists writing group members' disclosures information for this Part. Peer reviewers were also required to disclose relationships with industry and any other potential conflicts of interest; these disclosures appear in Appendix 2.

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Disclosures

Appendix 1. Writing Group Disclosures

Writing group member	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
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Jaylen I. Wright	American Heart Association	None	None	None	None	None	None	None
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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

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Appendix 2. Reviewer Disclosures

Reviewer	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
Marc Berg	Stanford University	None	None	None	None	None	None	None
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Benson Hsu	University of South Dakota	None	None	None	None	None	None	None
Eddy Lang	University of Calgary (Canada)	None	None	None	None	None	None	None
Vinay M. Nadkarni	Children's Hospital Philadelphia, University of Pennsylvania Perelman School of Medicine	Zoll Medical (Research Grant to my institution)†; Laerdal Foundation (Foundation Research Grant to my institution)†; Nihon Kohden Corporation (Research Grant to my Institution)*; RQI Partners (Research Grant to my Institution)*; Philips Medical (Research Grant to my Institution)*; Defibtech (Research Grant to my Institution)*; Nicoletti Family Philanthropy (Unrestricted grant to my institution)*; National Institutes of Health (pICECAP: Multicenter Cardiac Arrest Cooling trial for children (Co-I))†; National Institutes of Health (ICU-RESUS: Multicenter bundled intervention for pediatric cardiac arrest (Co-I))†; National Institutes of Health (OPTIVENT)†; National Institutes of Health (PEDICA)†; US Department of Defense (Mitochondrial Health: pGz)†; NovoNordisk (WECAN)†; Agency for Healthcare Research and Quality (P-WIN)†; Agency for Healthcare Research and Quality (Patient Safety Learning Laboratory)†	None	None	None	None	Citizen CPR Foundation Board*; International Liaison Committee on Resuscitation Board*	Society of Critical Care Medicine (President (2023-2024))†

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Part 3: Ethics: 2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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ABSTRACT: In this chapter, the American Heart Association provides guidance on ethical considerations relevant to cardiopulmonary resuscitation and emergency cardiovascular care. An overview is provided of ethical frameworks that provide a structure through which difficult decisions can be analyzed. These include principlism, currently the predominant medical ethical framework, which considers moral principles of beneficence, nonmaleficence, respect for autonomy, and justice. Additional consideration is given to the value of dignity, and other ethical frameworks such as narrative ethics, crisis standards of care, utilitarianism, virtue ethics, and deontology. The importance of equity and the imperative for health care professionals and their organizations to actively address structural inequities, social determinants of health and resulting disparities related to Emergency Cardiovascular Care is highlighted. Processes for decision-making are discussed, including guidance on advance directives and shared decision-making. Decisions to initiate or withhold and subsequently to continue or terminate resuscitation are reviewed at length. In addition to considering this decision in adults and geriatric patients, specific attention is given to decision-making in children, newborn infants, and pregnant patients. The impact of prognostic uncertainty on these decisions is discussed, as well as the evaluation of potentially ineffective therapies and cultural and religious considerations. Other ethical topics are addressed briefly, including processes for research and knowledge generation; the impact of resuscitation on health care professionals, survivors, laypersons, families, and caregivers; family presence during resuscitation; crisis standards of care; advanced therapies, including extracorporeal support; and organ and tissue donation.

Key Words: AHA Scientific Statements ■ cardiopulmonary resuscitation ■ decision-making ■ delivery of health care ■ ethics ■ heart arrest ■ life support care ■ problem solving

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TOP 10 TAKE-HOME MESSAGES

1. This guideline discusses selected ethical considerations relevant to resuscitation and emergency cardiovascular care (ECC) and emphasizes the importance of deliberate consideration of individual decisions and their unique circumstances.
2. Principlism is the most well-known of the many ethical frameworks that together identify and clarify the obligations of health care professionals (HCPs) and organizations and that provide a framework through which difficult decisions can be analyzed.
3. Multiple ethical frameworks, a preponderance of scholarship and expert consensus in this writing group support the imperative that HCPs and their organizations should actively address inequities in social determinants of health, thereby eliminating resulting disparities in cardiac arrest and emergency cardiovascular care.
4. Portable orders for life-sustaining treatment (POLST) are the best method to document advance care plans (ACPs) specific to cardiopulmonary resuscitation (CPR), are available throughout the United States, and should be honored by HCPs.
5. In most situations, shared decision-making (SDM) is the preferred approach to making patient-centered treatment decisions.

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6. Decisions to withhold or terminate CPR are complex, so set protocols can provide guidance, reduce bias, and prevent moral distress.
7. Special legal and ethical considerations apply to resuscitation of children and newborn infants.
8. The process and outcomes of resuscitation can have lasting consequences for HCPs, survivors, laypersons, families, and caregivers.
9. Allowing family presence during resuscitation (FPDR) is the recommended approach in most situations because it can improve short- and long-term psychological outcomes.
10. Organ and tissue donation should be considered in all patients resuscitated from cardiac arrest who progress to death by neurological criteria or for whom withdrawal of life-sustaining therapies is planned.

INTRODUCTION

Medical ethics provides theoretical frameworks that identify and clarify the obligations of HCPs and their organizations and offers a structure through which difficult decisions can be analyzed (Figure 1). The 2015 Guidelines Update discussed decisions to withhold or terminate CPR for adults, prognostication after cardiac arrest, and organ and tissue donation.[1] That Guideline focused on practical treatment recommendations rather than the underlying ethical principles. The 2020 Guidelines did not include a writing group, literature reviews, or output focused specifically on ethics, although some ethical considerations were integrated into the Guidelines chapters and supporting recommendations.

To address this gap, a comprehensive reevaluation of the literature pertinent to the ethics of CPR and ECC was undertaken to develop this guideline. Processes for topic identification, literature review, evidence synthesis, and writing are addressed in "Part 2: Evidence Evaluation and Guidelines Development." This guideline focuses on those aspects of medical ethics most pertinent to CPR and ECC. The Guideline refers to HCPs and their organizations throughout, which are intended to be broadly inclusive of the many allied health professionals who participate in ECC, including emergency medical services (EMS), nurses, pharmacists, respiratory therapists, social workers, clinical ethicists, physicians, educators, and others and the institutions through which they provide services. HCPs have a prima facie obligation to follow institutional policies regarding ethical issues in resuscitation in addition to the guidelines in this document. In turn, institutions have an obligation to develop ethically sound policies, educate HCPs on both policies and ethical guidelines, and provide the resources necessary to adhere to these standards and resolve difficult issues when they arise.

The Ethics Writing Group included a diverse group of content experts with backgrounds in emergency medicine, critical care medicine, neurocritical care, cardiology, and EMS, including experts in neonatal, pediatric, and adult medicine as well as medical ethics in each domain. Group members were appointed by the American Heart Association (AHA) Emergency Cardiovascular Care Science Subcommittee and approved by the AHA Manuscript Oversight Committee, with a member also appointed by the American Academy of Pediatrics. Writing group members were selected to

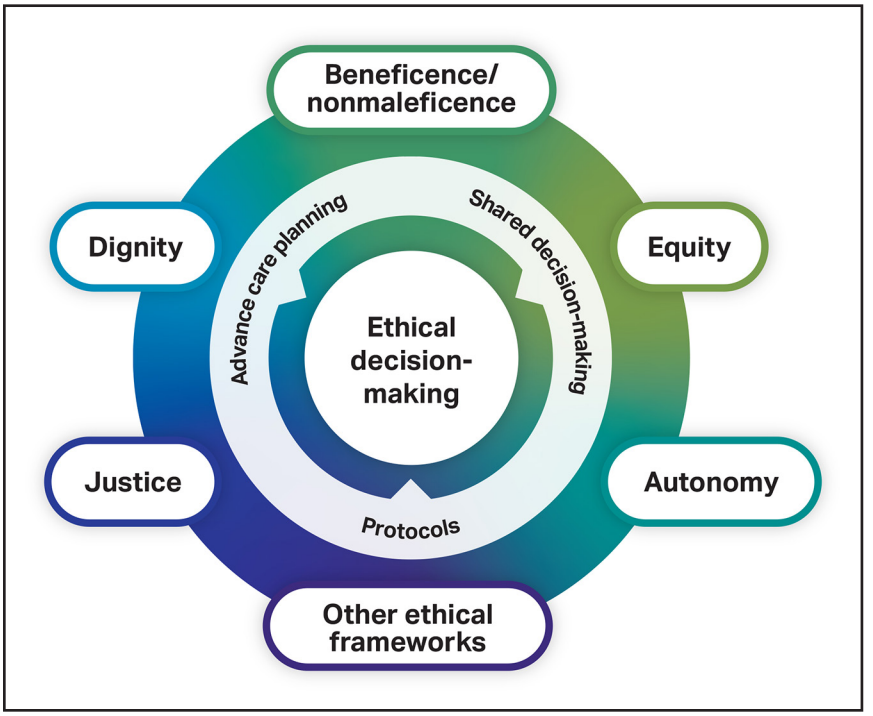

Figure 1. A conceptual framework for ethical decision-making in resuscitation and emergency cardiovascular care.
Medical ethics offers frameworks through which health care professionals can analyze difficult decisions. Principlism considers moral principles of autonomy, beneficence, nonmaleficence, and justice and is currently the predominant ethical framework. Related values of dignity and equity are of particular importance in emergency cardiovascular care. In addition to principlism, other ethical frameworks, including ethics of care, deontology, narrative ethics, and others, offer complementary perspectives. Together, these frameworks, principles, and values informed development of ethical treatment protocols (common in the prehospital care environment), advance directives, and in-the-moment shared decision-making.

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represent many backgrounds in clinical medicine and ethics to form a group that was institutionally diverse and inclusive of women, underrepresented racial and ethnic groups, and early career participants. The AHA has rigorous conflict of interest policies and procedures to minimize risk of bias or improper influence during the development of guidelines. Before their appointment, writing group members disclosed all relevant commercial relationships and other potential (including intellectual) conflicts. These procedures are described in "Part 2: Evidence Evaluation and Guidelines Development." This chapter uses a narrative review format to allow for detailed discussion of complex ethical issues. This differs substantially from the format used in other AHA clinical practice guidelines. The process used for inclusion of ethics content followed a traditional literature review without development of standard "knowledge chunks" or PICO-format questions. Because ethical knowledge is not advanced through traditional clinical research, the writing group did not assign Class of Recommendation (COR) and Level of Evidence (LOE) to the practice recommendations. Instead, multiple ethical frameworks, a preponderance of scholarship and expert consensus in this writing group support the recommendations contained in this document.

FOUNDATIONAL ETHICAL PRINCIPLES

Principlism

Principlism, as initially described by Beauchamp and Childress, is a deliberative ethical process centered on 4 moral principles: respect for autonomy, beneficence, nonmaleficence, and justice.[2] The intent is that no single principle is superior or takes precedence over another, allowing for a balanced framework to consider the issue or issues at hand. Because of their own biases or preferences, HCPs may consciously or unconsciously rank or prioritize one principle over another, with additional influences from society, culture, institutional norms, or the specifics of an individual case. Critiques of principlism highlight the potential for interprinciple conflict without a clear path for resolution; inadequacy in dealing with moral problems; lack of unifying relationship between the individual principles; and the White, male, European origins of the framework that may neglect or bias against groups or individuals.[3,4]

The principlist approach may be helpful when considering a patient in the context of their individual circumstance but also within a care team, institution, or community. Evaluating each principle and any conflict between it and each of the others provides a systematic method of ethical evaluation and identifies any accommodations that may be necessary. When operationalized in practice, a bioethical question may be evaluated through the lens of each individual principle, which offers multiple perspectives that can be synthesized into a pluralistic approach. This 4-categories method is commonly used for ethical decision-making and uses the principles as foundational themes toward collecting information, data, and perspectives.[5]

Respect for Autonomy

Respect for autonomy focuses on honoring individuals' rights to make informed decisions about their own health care. In the context of resuscitation, this principle guides clinical decisions by ensuring that, whenever possible, clinicians elicit and respect patients' values and preferences regarding decisions to refuse, withhold, or withdraw life-sustaining therapies and end-of-life (EOL) care. Respecting autonomy requires honest communication and SDM with patients, their surrogate, or both.[6–8] This can include bidirectional sharing of facts and perspectives, correcting misconceptions, and challenging all parties to structure decisions that are aligned with the patient's goals and values. Including loved ones at the bedside to witness resuscitative efforts can also facilitate the autonomy of patients and their loved ones (refer to Impact on Laypersons, Families, and Caregivers).[9–12]

The limits of autonomy become apparent when patients are unable to make decisions or communicate their wishes. Ideally, patients with capacity have considered and documented their preferences regarding balance of benefits and harms of resuscitation in advance (refer to Beneficence and Nonmaleficence and Advance Directives). In the absence of capacity (eg, most pediatric patients and adults who never had or lost capacity) or clear evidence of previously capable adult patients' wishes, such as advanced directives, decisions about the best balance of benefits and harms fall to surrogate decision-makers (refer to Ethical Decision-Making in Resuscitation). A surrogate may be an appointed health care proxy or family member, such as a parent for a pediatric patient. When a patient lacks capacity, autonomy can be respected when a surrogate uses substituted judgment, providing insight into what a patient's wishes would be if they could relay them.[13] When a patient's wishes are unknown, clinicians and surrogates make decisions based on what they believe to be in the patient's best interest (refer to Beneficence and Nonmaleficence). If there are no surrogate decision-makers, clinicians must determine the balance of benefits and harms.[14] In this circumstance, resources like ethics consultation or an ethics committee may be helpful, when available.[14] When there is uncertainty, the default approach is generally to initiate resuscitation while continuing efforts to determine a patient's wishes regarding EOL care.

Beneficence and Nonmaleficence

Beneficence and nonmaleficence are 2 closely related principles. Beneficence guides clinicians to make

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medical decisions that benefit patients. Nonmaleficence is the ethical obligation for clinicians to not harm patients. Often, it is relatively straightforward to apply these 2 principles to medical decisions. For example, when lifesaving emergency surgery is necessary, the benefits outweigh risks of morbidity and mortality, even if substantial. However, there are circumstances when balancing potential benefits and harms can be complicated. When uncertainty about diagnosis, prognosis, or treatment outcomes exists, benefits and harms may be difficult to assess and HCPs are guided to balance likely benefits over possible harms. Additionally, there are times when a beneficial decision is also harmful (eg, opioids for dyspnea at EOL causing respiratory depression). Under such conditions, the doctrine of double effect—an ethical doctrine justifying an action that has both a positive (intended) effect and negative (unintended) effect when the positive effect is not achievable without the negative effect—permits HCPs to make ethical decisions that benefit the patient even when anticipating potential for harm.[15] These decisions must be limited to circumstances in which there are no better alternatives, harm is not intended to achieve the benefit, and all efforts are made to minimize the harm.

It can be challenging for HCPs to make thorough assessments of benefits and harms under conditions of urgent decision-making, limited medical information, and prognostic uncertainty.[16] Initiating resuscitation can be lifesaving but entail risks, including physical or emotional suffering, existential harm, and indignity. There may be other benefits and harms to consider as well, such as peace of mind for surviving family members to believe all attempts were made to save their loved one's life, or the harm of a resuscitation that results in survival with an unacceptable quality of life. Assessments of benefits and harms may be value based and differ among patients, surrogate decision-makers, and medical team members. HCPs can ethically forgo resuscitation in the absence of a surrogate decision-maker if they determine a lack of potential benefit, such as choosing to not initiate resuscitation when there is objective evidence of irreversible death (refer to Withholding or Terminating CPR in Adults).[17]

Assessing the balance of benefits and harms can be challenging. This may especially be the case when clinicians and surrogates disagree, for example, or when HCPs have biases that impact their assessment, or when a patient's life cannot be saved and goals turn to offering the opportunity for organ and tissue donation, and balancing benefits to patients with risk of harm to HCPs. These ethical challenges are explored in subsequent sections of this chapter.

Justice

Justice is defined as fairness, specifically the fair, equitable, and appropriate treatment of persons.[2,18] *Procedural justice* refers to the fairness of the processes used to make decisions or allocate resources, while *distributive justice* refers to the fairness of the outcomes of decision-making.[19,20] These perspectives may overlap, as demonstrated during crisis standard of care scenarios. In the setting of resuscitation, the principle of procedural justice requires patients to be treated in a fair and equitable manner with the best available care. Issues related to distributive justice can include the allocation of scarce resources, such as time and attention from HCPs and the equipment necessary to deliver high-quality care. If specific resources are scarce, allocation of these resources should be based on evidence-based determinants of expected outcomes (refer to Crisis Standards of Care). Decisions regarding EOL care should be founded on justice and may include considerations like urgency, expected benefit, change in quality of life, and patient preferences. Explicit (with conscious awareness) or implicit (without conscious awareness) biases should be recognized and minimized when making resuscitation decisions.[21] Institutions that develop policies should also aim to promote fairness and justice. Historically, this has not always occurred. For example, significant concerns were raised about the impact of race, ethnicity, and disability on access to care under many triage guidelines developed during the COVID-19 pandemic, thereby disadvantaging certain populations.[22,23] Justice requires that all backgrounds and identities be valued and treated equally to avoid resuscitation bias.[24–26]

Other Ethical Frameworks

Over the last century, a shift from paternalism to patient-centered medicine in the United States has resulted in better-informed and individualized care. Along with advances in treatments and technology, this has led to myriad ethical issues and challenges. Many ethical frameworks are available to help HCPs navigate these dilemmas. A combination of frameworks is often necessary to consider fully how best to respond to an ethical conflict. Religious and cultural perspectives of HCPs, patients, and surrogates also inform their views and may affect their valuation or interpretation of certain principles relative to the issue at hand. We discuss these considerations with regard to patients and families in this section and also recognize that the influence of these factors on HCPs themselves is important and valid.

Ethical frameworks provide a pathway to navigate an issue and hopefully come to a resolution, yet the frameworks themselves vary in ways beyond their focus and the values they prioritize. Some frameworks provide insight or reasoning to build knowledge and guide action, including principlism and narrative ethics, which focuses on the details and nuance of a case to better understand someone's unique perspective and needs.[27–29] Other

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frameworks are tailored to specific situations and are not always broadly applicable. An example is crisis standards of care, which work to maximize survival while best using scarce resources.[25] Others are underpinned by substantive ethical theories that specify what constitutes morally correct action based on the desired outcome. The framework of utilitarianism aims to maximize good for the most people and is a guiding framework for the organ allocation systems in the United States.[30] Virtue ethics defines moral behavior based on the virtues and character of the individual moral actor; to make moral decisions, a person should strive to develop key virtues inherent to one's role or profession, such as honesty, integrity, and empathy.[31–36] Deontology centers on the moral duties and ethical rules of HCPs to the ailing patient in front of them, regardless of the outcome.[37] These examples are not exhaustive; rather, they serve to demonstrate how variable frameworks may guide pragmatic responses to complex issues around resuscitation. These frameworks and others are integrated into a more specific discussion of ethical topics in resuscitation in a later section.

Dignity

Resuscitation can be a traumatic experience for patients, their families, and HCPs. Within a principlist framework, dignity is encompassed in part by respect for autonomy and is also a consideration of beneficence. In the context of resuscitation, dignity is the patient's inherent worth and value as a person, even during a life-threatening event.[38] Given its importance during ECC, the value of dignity merits additional consideration. As discussed earlier, HCPs must balance the potential benefits of resuscitation with the inherent physical and psychological harms it creates, while also maintaining respect for patient dignity and privacy. The perception of patient suffering by HCPs, however, should not be used as justification for withholding or withdrawal of resuscitation without awareness of the patient's wishes or reliable input from an appropriate surrogate because this may introduce HCPs' biases into these decisions.

Many cardiac arrests occur in public settings. While the primary focus of HCPs should be on lifesaving resuscitation, it is also important that they respect patient dignity and privacy by shielding the patient to the extent possible and reasonable from those not participating in care.[39,40] When family is present during resuscitation efforts (refer to Impact on Laypersons, Families, and Caregivers), HCPs must recognize that the event is traumatic for them and, whenever possible, communicate with the family to explain procedures and provide support.[39,40]

While rare, there are reports of patient consciousness or awareness during CPR, and small observational studies have described some patients resuscitated from cardiac arrest who reported a sense of consciousness during resuscitation.[41–43] Consciousness induced by CPR can be distressing to patients, HCPs, and families and has other risks, such as potential for dislodgement of medical devices. Regardless of patient awareness, HCPs should treat every patient with dignity during resuscitation by preserving bodily integrity as much as possible, responding appropriately to any signs of distress or pain, and maintaining professional conversation and communication during resuscitation. The ethical imperative to respect patients' dignity is paramount, regardless of their level of awareness.

Striving for Equitable Health and Resuscitation

Within a principlist framework, justice demands equitable treatment of all individuals. In resuscitation, inequities arising from bias and discrimination can have deadly effects. The AHA's goal of improving cardiovascular health for all cannot be fully realized until inequities that drive health care outcome disparities are eliminated.[44,45] Health inequities arise from social determinants of health and are both entirely preventable and deeply rooted in societal structures. Discrimination and structural inequities adversely affect the cardiovascular health of numerous sociodemographic groups, and can be overt or subtle. There are many ways in which certain groups receive prioritization and privilege while others, described as marginalized, face barriers in accessing the full range of societal rights and services. Discrimination and marginalization occur along lines of race, ethnicity, gender and gender identity, sexual orientation, physical or neurocognitive disabilities, language, immigration status, cultural background, age, religion and spirituality, body shape, mental health, socioeconomic status, education, and geography. There is no exhaustive list that exists to capture all endemic and emerging biases. Inequities transcend political boundaries and impact populations from a myriad of backgrounds, making this an important issue for all peoples. Failing to acknowledge and address these disparities allows systemic inequities to remain unchallenged and healthcare disparities to persist. For this reason, HCPs and their organizations should actively address structural inequities in social determinants of health, thereby eliminating resulting disparities in cardiac arrest and emergency cardiovascular care.

Health inequities exist in disease prevention and across all links of the Chain of Survival (refer to "Part 4: Systems of Care" for discussion of the Chain of Survival).[46–48] Disparities in disease prevention among marginalized groups stem from mental, physical, and environmental health stressors as well as barriers to accessing safe living conditions, high-quality nutrition, education and work opportunities, and health care (including health insurance and accessible health care facilities).[49–51] When an emergency occurs, disparities exist in prehospital preparedness and response, including CPR training,

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recognition of cardiac arrest, delivery of layperson CPR, automated external defibrillator access and use, timely first responder and EMS arrival, use of lights and sirens, and delivery of high-quality CPR.[52–56] Disparities in advanced resuscitation include access to cardiac catheterization, critical care services, and mechanical cardiorespiratory support.[57–59] Disparities have been documented in communication that supports high-quality ECC, including shared decision-making, anticipatory counseling, advance care planning, access to palliative care, and high-quality EOL communication.[60–63] Disparities in outcomes have also been described for 1-year, 3-year, and 5-year survival following hospital discharge.[64] Use of machine learning and artificial intelligence to facilitate clinical diagnosis and decision-making is an emerging risk that can exacerbate disparities if these technologies are not intentionally designed to eliminate propagation of existing inequities.[65,66] Similarly, while protocols are often used to standardize care and reduce bias, they can unintentionally entrench inequities if they are not designed and implemented with equity in mind. These and other pervasive inequities increase morbidity and mortality of individuals from marginalized groups.[67] Despite abundant literature documenting resuscitation outcome disparities, research in this area is still relatively nascent. Societal biases and structural inequities likely affect the degree to which this research has been performed, funded, or published, which impacts the strength of evidence required by guidelines to make strong recommendations.[67a,b,c]

Many of the predominant ethical frameworks converge implicitly on the wrongness of inequity. However, interpretation of these frameworks has commonly been limited to a duty to provide equal treatment of patients who have already presented for care (ie, everyone is treated the same way, such as all similarly situated patients having the same likelihood to receive layperson CPR regardless of their personal characteristics). Treating patients equally does not address inequities that have impacted marginalized individuals long before their presentation to medical care. These factors often result in more advanced disease and worse prognosis (ie, patients who have not received layperson CPR or had less access to health care prior to cardiac arrest have more severe illness after resuscitation and are therefore less likely to receive mechanical circulatory support [refer to Advanced Therapies]). Therefore, simply treating patients equally is insufficient to resolve outcome disparities.

Instead, a growing body of scholarship supports an imperative to treat patients equitably.[68–70] To deliver equitable treatment, HCPs and health care organizations must identify and eliminate structural inequities, discrimination and address social determinants of health, as well as ensure that they provide sufficient resources to marginalized groups. Ethical education for HCPs has traditionally focused on principlism, which does not specifically address these issues.[71] A preponderance of ethics scholarship supports that emerging frameworks offered by marginalized groups deserve recognition.[71a,b] Such frameworks provide alternative lenses for understanding and addressing the health effects of social and structural inequities, and incorporating these into resuscitation education can provide HCPs perspectives complementary to principlism.

The AHA's mission, "to be a relentless force for a world of longer, healthier lives," and its vision, "advancing health and hope for everyone, everywhere," support the need for HCPs and their organizations to actively address inequities in cardiac arrest and emergency cardiovascular care.[44,45,72] Areas of focus for the resuscitation community include screening and prevention, resuscitation training, community preparedness, measurement and tracking, partnerships, advocacy, and engagement. The AHA recognizes the critical nature of partnering with and amplifying the voice of communities who are best positioned to identify disparities and solutions.

Achieving optimal resuscitation outcomes requires sustained work and commitment by HCPs and their organizations to eliminate disparities by addressing structural inequities and social determinants of health.

ETHICAL DECISION-MAKING IN RESUSCITATION

Advance Care Planning

The default approach to life-threatening illnesses such as cardiac arrest in many countries and settings is to initiate treatment. This decision must be made rapidly in patients who typically lack capacity at a time surrogate decision-makers may be overwhelmed or unavailable. Some patients wish to forgo resuscitative efforts based on their perceptions of the benefits and harms and other personal values and preferences. Timely communication of these wishes is essential to ensure that HCPs can respect these patients' autonomy, so documentation of an advance care plan (ACP) is crucial.[73–75] Because it is impossible for a written ACP to fully address every possible medical situation that might be encountered, an ACP should ideally include appointment of a health care proxy (durable power of attorney for health care) authorized to make decisions in case the patient is incapacitated.[75] Commonly encountered ACP documents include living wills, advance directives, do not attempt CPR (DNACPR) orders, and POLST. These documents should be revisited periodically because preferences can change over time.

The preferred form of ACP documentation in the setting of cardiac arrest is POLST (or a state-specific acronym, such as IPOST [Iowa Physician Order for Scope of Treatment] or MOLST [Medical Orders for Life-Sustaining Treatment]), although POLST documents have some limitations, which are discussed in this section. Living wills are

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legal documents that provide guidance on wishes specific to life-sustaining EOL treatments, but these documents can be vague, can be difficult to apply in specific clinical situations, and may require a determination of both a terminal condition and lack of decision-making capacity.[76] Advance directives are often completed as part of estate planning and typically provide broader guidance on future medical care but may be difficult to interpret during medical emergencies.[73] They are often not part of the medical record and may not be shared among care facilities and acute care settings.[73–75,77,78] General DNACPR requirements vary by state and can be less well-defined than POLST, making these ACPs difficult to honor. They are also often misunderstood by the public.[74,79] Some patients may be reluctant to complete DNACPR documents under the false assumption that comfort measures may not be provided in EOL situations. In a recent population-based study, DNACPR orders were encountered in about 10% of prehospital HCPs dispatched to out-of-hospital cardiac arrests (OHCAs); however, some patients still received full CPR due to contradictory family wishes or successful resuscitation before access to and review of the DNACPR document.[80]

A POLST is an ACP document specifically designed to communicate patient medical wishes by translating them into medical orders that can be followed in both inpatient and outpatient settings.[73–75,81,82] A version of POLST is available in all 50 US states and the District of Columbia; in many states, a POLST provides a legal DNACPR order that must be honored by first responders.[81,83] Implementation of POLST has reduced treatment intensity among patients with severe illness, reduced prehospital resuscitation efforts, and increased odds of death outside the hospital compared with in-hospital deaths.[81,84,85] A POLST document provides more specific direction over health care treatments than an advance directive and more options than a DNACPR order. A POLST is completed by a health care professional (HCP) using SDM, must be signed by both the HCP and patient or surrogate, and must provide resuscitation guidance as well as instructions for other medical interventions.[86] A POLST promotes patient autonomy, clarifies treatment preferences, and facilitates appropriate prehospital and emergency care.[82] These forms should be updated regularly as patient preferences may change over time. Ongoing issues with POLST forms include variable completeness, between-state variability, need for proper interpretation, potential for discrepancies among sections, and accessibility.[73,81,87] There is particular variation among states regarding the use of POLST in pediatric populations. Documentation should be kept easily accessible to ensure prompt availability and use during EOL situations. Accessibility issues have been addressed in some states through rapidly searchable electronic registries.

Other challenges include situations in which there is disagreement between a patient's ACP and surrogate decision-maker preferences.[88] The patient's wishes, as expressed in person or via ACP, are principal, and a surrogate's preference should be honored if the patient's wishes are uncertain.

Shared Decision-Making

Decisions around resuscitation can be challenging for HCPs, patients, and surrogate decision-makers. These include decisions to initiate, forgo, continue, or terminate resuscitation, as well as choices between different treatment options. Not all patients have ACPs, and ACPs do not provide explicit guidance on all possible medical decisions. Moreover, CPR is commonly an unanticipated event that is fraught with emotion, stress, and time pressure to make complex life-or-death decisions. When feasible, the recommended approach to real-time decisions about resuscitation or advance care planning is a collaborative process between HCPs and patients or their surrogates called *shared decision-making* (SDM).[89,90] Because full SDM is not feasible during the actual event of cardiac arrest—when CPR must be initiated immediately—the process should ideally occur in advance, such as through proactive discussions in chronic care, emergency, or inpatient settings.

Patient autonomy and informed consent are cornerstones of medical ethics. Adult patients have relatively unrestricted authority to choose between available medical options based on their goals, values, resources, and personal assessment of the balance between benefits and harms. Adults can preemptively engage in advance care planning to indicate their medical preferences should they become incapacitated.[91] If a patient is unable to make medical decisions for themselves and no preexisting ACP exists, a surrogate must make decisions on their behalf. For an adult who previously had capacity, the surrogate decision-maker should be guided to the ethical standard of substituted judgment, choosing the medical option that best aligns with their understanding of what the patient would have wanted.[92] Even when an ACP exists, patients almost always still require a surrogate to interpret and apply preferences to the current clinical situation in collaboration with clinicians. Pediatric patients do not have the authority to consent to medical procedures because of lack of capacity (with a few exceptions, eg, emancipated minors), and so they require surrogate decision-makers. Because pediatric patients are not generally considered to have the life experience or cognitive development to make medical decisions for themselves, substituted judgment does not apply. Instead, surrogates are guided by the best interest standard to make decisions intended to maximize benefit and minimize harm (refer to Pediatric Considerations and Neonatal Considerations).[93] Surrogates for adult patients who never acquired or lost capacity and for whom personal preferences are unknown also follow the best-interest standard. Patient decision aids,

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including those specific to CPR, are strongly recommended in SDM because they improve patient and surrogate understanding of risks, benefits, and trade-offs. Clinicians should consider using decision aids, where available, to support value-aligned decisions. Health care professionals have 3 roles in resuscitation decision-making: (1) determining reasonable medical options from which to choose, (2) using SDM to support patient or surrogate decision-making, and (3) making best-interest medical decisions for patients who lack capacity and for whom there is no ACP or surrogate available (Figure 2).

Major medical organizations endorse SDM as the optimal decision-making process.[94–96] In SDM, HCPs together with a patient, their surrogate, or both collaborate to make the best medical choices for that patient. This approach blends the medical expertise of HCPs with the personal values and preferences of the patient to achieve goal-concordant care and improves patient and family satisfaction. The process of SDM includes several components: (1) HCPs ensure a patient, surrogate, or both, understand the patient's current medical condition; (2) HCPs outline available medical options and discuss the likely outcomes of each option; (3) HCPs elicit the patient's goals, values, and preferences; (4) HCPs make a recommendation for the medical option most aligned with the patient's goals and values; and (5) HCPs support the patient, surrogate, or both, in choosing a medical option (Figure 2). Ideally, SDM occurs in the setting of a trusting, compassionate relationship, even if only minutes are available to build that trust. Health care professionals must strive to be honest, transparent, clear, and unbiased when discussing diagnosis, prognosis, uncertainties, and medical options. They should be aware that how decisions are framed can strongly influence patient and surrogate choices. Evidence demonstrates that defaults, word choices, and presentation order can unintentionally bias decisions, so HCPs must take care to present options in a balanced, intentional, and ethically responsible manner. Health care professionals should elicit patient's or surrogate's preferred style of decision-making and seek to make recommendations in line with that preference.[97,98] Health care professionals should incorporate additional support services as needed, such as social work, ethics, palliative care, interpreter services, cultural navigation, religious

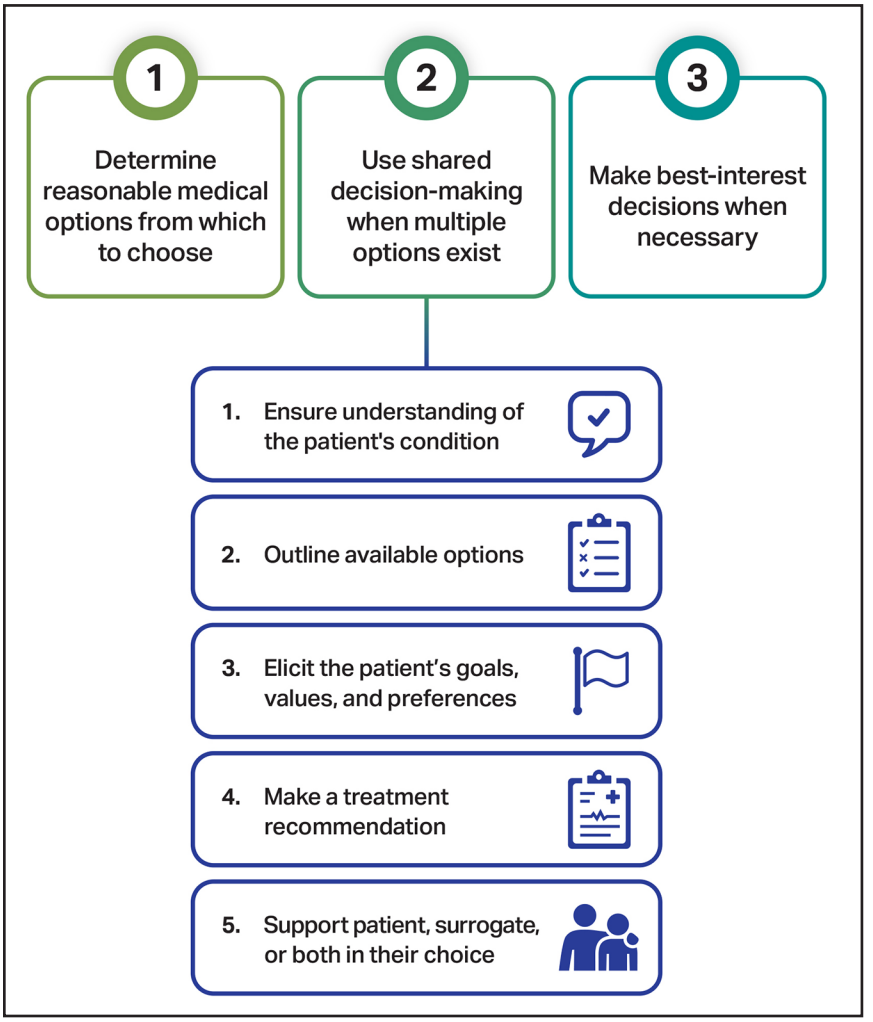

Figure 2. The role of health care professionals in shared decision-making.
Health care professionals have 3 key roles in medical decision-making, the preferred process through which patient-centered decisions are made. When only 1 reasonable medical option is available, health care professionals must ensure the surrogate's understanding of the clinical situation and provide support, but presenting a surrogate with unreasonable medical options from which to choose is confusing and counterproductive. In some situations, best-interest standards guide health care professionals and surrogates to make decisions that maximize benefit and minimize harm. Decisions based on best-interest standards are often additionally guided by federal, state, and local laws.

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services, and other family and community support when possible. Finally, HCPs should recommend community- and web-based resources to support advance care planning, including tools to facilitate conversations and clarify values. Health care professionals are strongly discouraged from simply providing the patient, surrogate, or both, with a menu of options without decisional support.

A few common situations may pose ethical challenges when complex emergency cardiovascular decisions must be made. First, a patient or surrogate may request interventions not considered medically appropriate by the HCPs. In general, medical teams are not required to provide nonbeneficial medical interventions (refer to Potentially Inappropriate Therapies). While a patient and surrogate have ethical rights to choose between reasonable medical options, they do not have a right to demand treatments that are not medically reasonable. However, perspectives about what options are medically appropriate are often value based and may differ between a patient, surrogate, or both and HCPs (eg, extending life with mechanical ventilation in the setting of a terminal illness), and even among HCPs. Disagreements about the appropriateness of medical therapies should be resolved through a process-based approach (refer to Potentially Inappropriate Therapies).[99,100] A *process-based approach* refers to a structured framework to resolve disagreements, often involving ethics consultation, engagement of clinical leadership, and adherence to institutional policies designed to ensure fairness, transparency, consensus, and an accessible appeal process.[101]

Second, bias and discrimination can affect SDM, leading to inequities in communication and decision-making. Inequities exist in how HCPs develop trusting relationships, convey prognostic information, provide resources to overcome communication barriers, and make recommendations.[102] For example, marginalized populations may face limited access to interpreter services, receive less-detailed prognostic information, or experience lower levels of trust and engagement in care planning conversations due to historical and ongoing disparities. Health care professionals should be attentive to their own biases, engage in bias reduction efforts, and actively work to provide equitable SDM for all patients and surrogates (refer to Striving for Equitable Health and Resuscitation).

Third, ethical decision-making in resuscitation may be challenging due to time pressures, limited medical information, prognostic uncertainty, and lack of a surrogate decision-maker. This may be particularly true in the prehospital setting, such as when choosing to initiate or terminate resuscitation (TOR).[103,104] Although it may be impossible to include all components of SDM in resuscitation, the process itself still has value in supporting patients, surrogates, and HCPs.

Finally, with high-stakes, emotional, and time-pressured decisions, there is risk that conflict may arise between HCPs, between a patient or surrogate and the medical team, and within a patient's family. While disagreements are a natural component of complex decision-making and unavoidable, HCPs should employ every effort to maintain a therapeutic relationship, support ongoing productive communication, and mitigate the harms of conflict to minimize distress for patients, families, and the medical team.

Decisions to Initiate/Withhold or Continue/Terminate Resuscitation

The ethical frameworks, moral principles, and approach to SDM discussed in previous sections offer HCPs structures through which they can analyze complex medical decisions and engage patients and surrogates in the decision-making process. Management of life-threatening cardiovascular emergencies has unique practical and ethical considerations. Key topics discussed below represent the most common specific circumstances encountered by HCPs.

Withholding or Terminating CPR in Adults

There are more than 350 000 OHCAs every year in the United States.[105,106] In approximately half, prehospital HCPs do not attempt resuscitation based, in part, on guidelines summarized in the 2015 AHA Guidelines Update and reaffirmed in 2020 and 2025 (refer to "Part 9: Advanced Life Support" and "Part 4: Systems of Care"). Guideline-concordant reasons to withhold CPR include situations in which attempting CPR would place the rescuer at serious risk of physical harm (refer to Impact on Health Care Professionals); presence of objective signs of irreversible death; and presence of an ACP requesting DNACPR (refer to Advance Care Planning).

Historically, HCPs have only honored written, signed advance directives to withhold CPR in OHCAs. In these instances, rescuers may initiate CPR temporarily while the documents are retrieved and reviewed.[107,108] Verbal requests from family to withhold CPR are now accepted in some communities, based on legal guidance and with medical oversight.[17,109,110] The ability to accept verbal requests allows HCPs to honor patients' autonomy and transition more rapidly to assisting families with loss and bereavement.[110]

The default position of offering resuscitation for any cardiac arrest has been challenged, with some advocating for a more selective approach wherein resuscitation is prioritized for individuals who have a higher probability of survival with preserved neurological function.[17,100] This approach upholds the ethical principle of nonmaleficence, avoiding the potential harm of CPR when it is unlikely to result in an acceptable outcome.[17] Another approach to consider when a patient is extremely unlikely to benefit from resuscitation is informed nondissent, where a clinician informs the family that unless

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they object, no resuscitation will be performed.[95] Such an approach relies on rapid assessment and excellent communication regarding the patient's condition and the reasoning behind withholding CPR. Equally important is good surrogate comprehension, mitigating power differentials, ensuring understanding of the right to dissent the recommendation, and assessing a surrogate's sense of empowerment to dissent.[95] This method respects the patient and family's need for involvement and understanding without burdening them with decisional guilt. While these methods are more traditionally discussed in the in-hospital setting,[111] it may be reasonable to discuss them outside the hospital or upon arrival to the emergency department. Concerns for CPR harm and nonbeneficial resuscitation outcomes have also led to the development of some OHCA guidelines to withhold resuscitation if the prospects of survival are estimated to be nil.[107,110,112] Given the complexity of this determination and resulting treatment decisions, variable standards exist worldwide.[113–115]

Once resuscitation has been initiated, further ethical questions exist around termination of efforts. Many prehospital care systems worldwide allow HCPs to cease resuscitation in adults—based either on standing orders or an order from online medical direction—if patients meet predefined TOR criteria (refer to "Part 9: Advanced Life Support" for clinical considerations).[108,116] From an ethical standpoint, whether in- or out-of-hospital, TOR protocols work to uphold the balance of beneficence and nonmaleficence by recommending continued CPR in patients who may recover while avoiding continuation of ineffective CPR for those extremely unlikely to benefit. Termination of resuscitation protocols limit bias and uniformly deliver emergency care across various populations. Using TOR rules can also promotes distributive justice by avoiding misuse of prehospital care systems for nonbeneficial transports, which renders them unavailable to the community they serve for the next emergency and exposes rescuers and the public to dangers of emergency transport. Termination of resuscitation rules can also exacerbate inequalities or sow public mistrust if they are not applied (or are not perceived to be applied) equitably. Another risk of applying TOR rules is that some patients meeting termination criteria might still recover with continued resuscitation, so these patients would, therefore, be harmed if CPR was stopped. Thus, TOR rules must be conservative, recommending termination only when the prospects of recovery are extremely small. Furthermore, reassessment and adjustments to TOR rules and policies must evolve with advancing therapies and outcome data. On balance, it is ethical and just for EMS systems to use TOR rules.

Within the TOR decision matrix, prehospital systems must also determine the benefit of moving patients from the scenes of their collapse to hospitals. Protocols used to guide this decision vary widely across the United States, with some recommending immediate transportation and others recommending longer on-scene resuscitation (refer to "Part 9: Advanced Life Support" and "Part 4: Systems of Care" for specific guidance). This decision must balance multiple factors, including efficacy of the resuscitation efforts during transport and its effect on the outcome. Other considerations include the availability of more advanced personnel and equipment at the hospital and potential benefits to the family from hospital-based support, particularly for pediatric OHCA.

There are also nearly 300 000 in-hospital cardiac arrests per year in the United States.[117] Decisions to withhold or terminate CPR for adult in-hospital cardiac arrest are not dissimilar to adult OHCA but often benefit from more established relationships, prognostic data, and time before the arrest to have explored patients' values and preferences more thoroughly. As in OHCA, the default approach for in-hospital cardiac arrest is to initiate CPR unless there are known prior wishes not to be resuscitated or signs of irreversible death.[11] As summarized in a recent publication by the International Liaison Committee on Resuscitation, it is key that HCPs establish treatment goals early after hospitalization, including patients' wishes to initiate or forgo CPR, and reassess these wishes frequently. These discussions can help ensure provided treatments are consistent with patients' values and preferences.

Conflicts can arise between families and HCPs around decisions to initiate or terminate resuscitation. For example, families may request initiation or continuation of CPR in cases where HCPs feel resuscitation offers no plausible benefit. Because resuscitation carries a risk of harm, the principle of nonmaleficence supports withholding these efforts when there is no potential for benefit (refer to Potentially Inappropriate Therapies). Outside the hospital, the resources and the time needed to resolve these conflicts may be limited, and the prognosis for recovery may be less certain. To ensure respect for autonomy, in some OHCA situations, it may be prudent to honor families' wishes to continue CPR and transport unless there are signs of irreversible death or an ACP documenting that a patient would not want this care (refer to Advance Care Planning). In the hospital, conflicts between families and HCPs can often be resolved through excellent communication to establish clear goals for medical care or compromises such as a time-limited trial of critical care that allows the family to feel reasonable efforts were made to provide treatment. In both the in- and out-of-hospital settings, performing deliberately low-quality CPR (for example, delivery of intentionally superficial chest compressions, sometimes termed a *slow code*[118]) confers physical risks to the patient as well as indignity and is unlikely to result in return of spontaneous circulation. These efforts may be motivated by a desire to convey to the family that aggressive treatment was attempted while avoiding what HCPs believe to be medically ineffective measures.[119] This intent is tantamount

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to deliberate deception and, therefore, is not an ethically sound approach.

Occasionally, conflicts between families and HCPs can become intractable. These situations should be resolved through a process-based approach (refer to Potentially Inappropriate Therapies). Further details about withholding or terminating resuscitative efforts in specific populations are discussed, as well as discussion of advance care planning, risk to HCPs, prognostication, and potentially inappropriate therapies.

Geriatric Considerations

Geriatric patients represent a large and growing segment of the population. Although some authors define geriatrics at a specific age (often 65–70 years), there is no set age at which all individuals meet a specific definition. Many considerations for older adults may also have implications for younger patients.[120] We have chosen to not define this population by a specific age but rather by a consideration of frailty, disability, comorbidities, and cognitive frailty, which may negatively impact survival following cardiac arrest.[121–124] Many, but not all, geriatric patients have beliefs about medical care at EOL and may not want CPR in the event of cardiac arrest.[125] However, age should not be a sole determinant for EOL decisions, development of an ACP limiting life-sustaining therapies, or resuscitative decisions.[126] A recent expert consensus concluded that many patients nearing EOL prefer a focus on palliative care, quality of life, and comfort.[127] Thus, when EOL is anticipated, it is important for HCPs to engage patients, their surrogate, or both in SDM to establish patient-centered goals for treatment.[128–132] It is equally important that HCPs document these decisions in an ACP because many patients in need of resuscitation lack capacity when emergency treatment decisions must be made. Health care professionals should discuss goals of treatment with patients and learn preferences before a crisis occurs.

Pediatric Considerations

The need for CPR and ECC for pediatric patients is less common than for adult patients, but not rare. More than 20 000 pediatric patients experience cardiac arrest in-hospital or out-of-hospital annually in the United States.[117,133] Pediatric patients present unique medical and ethical challenges for HCPs due to the need for parental/surrogate decision-making, challenges in TOR, the importance of family presence and support during and after resuscitation (refer to Family Presence During Resuscitation), and occasional need for mitigation of conflict between HCPs and family. While parental decision-making may not practically vary from surrogate decision-making for incapacitated adults, the emotional valence afforded to a parent's decisions for their child often creates a markedly different feeling and weight from these decisions. For simplicity, this discussion will refer to parents as decision-makers, acknowledging that legal guardians and agents of the state can also make surrogate decisions for children in their care.

Most pediatric patients do not have legal rights to make health decisions for themselves, and most are unable to consider or express preferences for resuscitation based on limited life experience, cognitive development, or both, thereby impairing capacity.[134] Parents, therefore, make decisions based on the best interest standard (refer to Ethical Decision-Making in Resuscitation); this may include decisions to withhold CPR or stop ongoing life-sustaining therapies.[96] Identifying what is "best" is a value judgment that can be debated and poses a significant challenge for HCPs when engaging in SDM. Parents are given significant leeway in making decisions on behalf of their children (referred to as the zone of parental discretion or constrained parental autonomy), but parental authority is not absolute.[135–137] Parental authority can be limited based on the harm principle, a threshold below which a parental decision may place the child at imminent risk of serious harm, allowing for state involvement to override parental authority.[138] Under emergency conditions like cardiac arrest, a life-threatening event requiring immediate intervention, most states have a process to allow HCPs to override parental decisional authority if the situation meets conditions of the harm principle.[139]

Under 3 sources of authority, some adolescents can make certain medical decisions on their own: (1) those seeking care for certain circumstances/conditions covered under state statutes where there is concern that failure to accept minor consent will prevent minors from seeking care for the condition (eg, sexually transmitted infections); (2) mature minors, who meet certain statutory standards are deemed by a judicial determination to meet the requisite requirements to make an informed medical decision limited to the scope of the question brought before the court; (3) emancipated minors, for whom emancipation legally confers the status of adult, granting them the autonomy to make their own medical decisions (however, this legal status is often limited to very specific circumstances and varies considerably state to state). Within these narrow constraints, minors do not generally have decision-making power over their own resuscitation preferences. However, older children and adolescents should be included in SDM (particularly those with chronic medical conditions) and HCPs should seek their assent commensurate with their developmental ability to provide it, including for decisions around resuscitation. When treatment goals established by HCPs and parents do not permit dissent (some decisions impart such an immense benefit that the child is not allowed to dissent; for example, chemotherapy for a curable cancer where nontreatment would result in death), in lieu of assent,

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HCPs and parents should disclose information about the treatment, without deception.[96]

Under most circumstances, the default in pediatrics is to initiate resuscitation, and there is rarely conflict about this decision between parents and HCPs. Exceptions to this include children who have ACPs, including DNACPR or POLST orders, or an in-the-moment shared decision to withhold resuscitation. Real-time SDM nonetheless requires accurate representations, to the extent that HCP knowledge permits, regarding risks, benefits, and outcomes expected from resuscitation to promote robust SDM with families. Even with an active POLST or DNACPR in place, implementation challenges can exist for children with life-limiting conditions in community settings such as daycares or schools, requiring careful coordination between pediatricians, staff members, EMS teams, and often local or state laws to ensure family wishes for EOL care are honored.[140]

While decisions to initiate resuscitation are generally noncontroversial in pediatrics, decisions to terminate resuscitative efforts can be much more challenging. For a variety of reasons, it is not uncommon for pediatric CPR to continue longer than in adults. Many nonpediatric emergency responders may be uncomfortable with the death of a child, choosing to continue efforts until a pediatric-trained professional is available. Pediatric specialists often practice in institutions that can also offer families more comprehensive bereavement support. With high-quality CPR, acceptable outcomes have been reported in children after prolonged CPR, particularly if extracorporeal life support (ECLS) is available and appropriate.[141,142] During in-hospital arrests, pediatric HCPs at times continue CPR until the family can arrive at the bedside, within reason.[143] Although conventional ethics suggests that decisions should focus solely on the impact on the child, in the setting of an imminent death, many HCPs may shift their duties to the surviving bereaved family members. This choice to consider a duty to the well-being of family members can be justified ethically by the cost to society of parental and family psychological outcomes following the death of a child.[144] These nuances surrounding CPR in children create challenges that require HCPs to make rapid and continuous assessments to best balance benefits and harms.

Occasionally, conflicts arise between families and HCPs around decisions to initiate or terminate resuscitation. These most often occur in the intensive care setting when a child is already receiving life support, the illness trajectory has been established, no further curative therapies are available, and death is imminent. Some families may request continuation of life support or resuscitation against the recommendation of the medical team. Every effort should be made to resolve these conflicts with strategies including maintaining the family-medical team relationship; using high-quality communication supported by specialists as available; offering family emotional support; and allowing sufficient time for the family to feel that everything has been done, which may include time-limited therapy trials.[143]

Occasionally, conflict becomes intractable. In these instances, the medical team may seek to override parental requests through an institutional process to assess the use of potentially ineffective therapies.[100] Withdrawal of life-sustaining therapies against parental wishes is rare in pediatric patients, may result in more harm than benefit for all involved, and may be regulated by state laws governing surrogate decision-making. In these circumstances, HCPs should be vigilant to ensure that potential biases or disparities in conflict management are identified and addressed. Significant distress for families and HCPs can arise around these cases and should be addressed with resources available. Health care professionals may raise the valid ethical tension between respecting parental authority within the zone of parental discretion or guidance of constrained parental autonomy, concern for ongoing suffering of the child, as well as potential scarce resource utilization. Importantly, decisions about scarce resource allocation should not be made at the bedside by the child's medical team but should be made through a fair process at the institutional level (such as development of triage protocols and use of a triage team) to avoid biases that impact outcomes.

EOL care is beyond the scope of this guideline. However, it is important to acknowledge that high-quality pediatric EOL care is crucial for dying children and their families. All HCPs who provide pediatric resuscitation should have some familiarity with basic pediatric palliative care concepts. Specialty pediatric palliative care consultation should be considered, if available, and if not, transfer to a facility where such care can be provided should be considered. Elements of high-quality EOL care can be provided concomitantly to ongoing resuscitation and may ease conflict, family trauma, and HCP distress regardless of the resuscitation outcome.

Neonatal Considerations

There are several contextual complexities surrounding resuscitative decisions for neonates that may be unique from other patient populations. Though some newborn infants die during CPR, most deaths occur in the context of withholding or withdrawing life-sustaining therapies.[145,146] Decisions about resuscitation for newborns generally occur at 2 time points: decisions to withhold resuscitative measures often happen during the perinatal period, while decisions to withdraw life-sustaining therapies tend to be made after initial stabilization. Many newborn infants who require resuscitation at birth will respond well to medical therapies. Though the need for CPR in newborn infants is a risk factor for neonatal mortality and neurodevelopmental morbidity, some infants who require CPR or other ECC will go on to survive without significant neurologic

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sequelae.[147] Resuscitation and intensive care should be provided when this is considered a likely outcome (refer to "Part 5: Neonatal Resuscitation").

Some newborns have clinical conditions that put them at very high risk of mortality or severe morbidity. In this setting, initiating or continuing life-sustaining therapies may be considered by parents and HCPs to be contrary to the infants' best interests.[148] For example, in extreme prematurity, specifically for newborn infants born at gestational ages at the borderline of viability, withholding resuscitation may be considered permissible.[149] This gestational age range is decreasing as medicine advances and varies based on local outcomes.[150] The interplay between estimated gestational age, other clinical factors, and prognosis is complicated.[151,152] Decisions about whether or not to initiate resuscitation for newborn infants in this gray zone should consider potential uncertainty in gestational age; other available clinical information; the values, views, and wishes of the parents; the availability of resources to treat the premature infant; and local legal statutes (refer to "Part 5: Neonatal Resuscitation" for specific recommendations).[153–157] A similar situation exists for newborn infants diagnosed prenatally with conditions believed to be life limiting. These have evolved over time as those once considered to be uniformly fatal early in infancy may now survive into childhood. There are deeply personal decisions attached to such situations, with existential and pragmatic considerations,[158] which may impact postnatal experiences and decision-making.

The evolving nature of available prenatal therapies may shift the timing to make decisions about neonatal resuscitation in certain clinical situations. For example, in the decade and a half since fetal repair for myelomeningocele was shown to have benefit,[159] the procedure has become more common.[160] A small proportion of fetuses undergoing in utero procedures experience significant intraoperative bradycardia, which may necessitate the consideration of in utero resuscitation measures, emergent delivery, or both, to attempt neonatal stabilization. There is marked between-hospital variability in approaches to this high-stakes decision making, and there is not general agreement on whether intraoperative delivery and resuscitation ought to be considered obligatory, permissible, or even impermissible.[161,162] Artificial womb and artificial placenta technologies at the fetus-neonate interface represents a new frontier with many unresolved ethical concerns.[163–165] Information is continually evolving and HCPs and organizations should collectively strive to review current information and decide what falls within and outside of the zone of parental discretion.

Following initial resuscitation, some newborn infants will die in the intensive care unit despite the best efforts of HCPs. Developing a prenatal or postnatal ACP may benefit newborns at high risk for death or significant morbidity because it allows advance discussions around values, goals, and care preferences outside of the context of an urgent decision.[166,167] Such ACPs not only address questions regarding the provision or withholding of resuscitative measures in the setting of an acute clinical change but also help HCPs and families collectively explore the meaning of such a change in the context of the critical illness and available prognostic information. High-quality SDM is of paramount importance. Multiple studies have examined parent and HCP preferences for neonatal decision-making[148,168] and have identified unique considerations for this population. Clinicians and parents often differ in perceptions and values about acceptability of patient outcomes, which can lead to conflicts in communication and decision-making. A key contributing factor to these differences may be ableism, specifically with regard to neurodevelopmental impairment, which may profoundly influence neonatal prognostication.[169] Conceptualization of a good death in the neonatal setting often differs between parents and HCPs, between parents, and between clinicians.[170,171] Clinicians should consider how their biases around these issues may influence what choices are offered to families and how they are framed.[172]

Time constraints may hamper perinatal decision-making. While advances in the fields of fetal imaging and prenatal genetic testing have led to more precise prenatal prognostication, some uncertainty in the postnatal condition may remain. If a baby is born with an existing prenatal ACP that indicates the family desires to limit intensive care interventions, plans can be considered provisional in most circumstances until confirmatory postnatal evaluation is performed. If uncertainty regarding the short- or long-term prognosis remains, teams typically proceed with full resuscitation and intensive care to allow for time to make informed decisions. It is important to note that full resuscitation at birth does not commit a newborn infant to continued intensive care after additional information becomes available.

Pregnancy

A pregnant patient in cardiac arrest presents unique medical, ethical, and legal challenges for responding HCPs. If the maternal condition is not rapidly reversible through resuscitation, HCPs may need to expeditiously deliver the fetus(es) when the uterine size is greater than or equal to 20 weeks' size (at or above the umbilicus). In this situation, the cesarean birth should be considered a resuscitative hysterotomy and delivery intended to provide uterine decompression to improve maternal resuscitative efforts (refer to "Part 10: Adult and Pediatric Special Circumstances of Resuscitation"). It may also be considered a perimortem delivery—an attempt to save the life of the fetus if the pregnancy is at a gestational age that will allow for postnatal stabilization.[173] Given the

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current legal landscape regarding pregnancy termination across the United States, responding HCPs may feel uncertain about how to proceed in these difficult situations. Some pregnant patients with established negative views regarding pregnancy termination may express specific wishes about how they would want HCPs to proceed in such a situation, and these should be honored. In the absence of clear documentation of a patient's wishes to the contrary, the ethical principle of beneficence obligates HCPs to provide whatever resuscitative measures they deem will best support the emergency care needs of a pregnant patient in cardiac arrest, including resuscitative delivery before or after a gestational age consistent with fetal viability.

Prognostication and Uncertainty

Understanding the likely outcomes of an illness under different treatment options informs excellent SDM. Unfortunately, outcomes of resuscitation can be difficult or impossible to predict with confidence, yet treatment decisions that both respect patients' autonomy and that are concordant with their perceptions of benefits and harms must still be made. Outcomes data and ethical frameworks are synthesized into clinical tools that range from protocolized treatment algorithms to full SDM. In unexpected cardiac arrest, clinicians are often guided by protocols to determine when to initiate, continue, or terminate CPR. By comparison, decisions about continuation of life-sustaining therapies in the intensive care unit often involve an iterative process, anticipatory guidance, and exploration of goals and values.

Likelihood and quality of recovery from any given clinical circumstance can improve with medical advances. Because clinical decision-making is both guided by historical data and can influence recovery potential, outcome prediction is exquisitely sensitive to uncertainty and self-fulfilling prophecy bias. The question of how historical data can perpetuate a self-fulfilling process is not limited to resuscitation and can be prevalent in many critically ill populations for which withdrawing life-sustaining therapies has commonly occurred in the past.[174,175] For example, advances in both available treatments and understanding of parents' perceptions of quality of life have significantly altered the prognosis of infants born at the cusp of viability and those with previously nonsurvivable chromosomal anomalies.[176–179] With evolving attitudes and treatment decisions, outcomes change.

Data that guide prediction of outcomes before a decision to initiate CPR, while CPR is ongoing, or after return of spontaneous circulation are particularly susceptible to self-fulfilling prophecies and uncertainty in individual cases. In most circumstances, clinical data cannot preclude recovery potential with absolute certainty and existing literature has serious scientific limitations. Distinguishing the nature of prognostication before, during, and after cardiac arrest may be helpful. While the likelihood of return of spontaneous circulation before or during CPR is affected primarily by premorbid disease, quality of CPR, and the circumstances of arrest, postarrest prognostication is further influenced by estimated severity of neurological injury and other organ failures. Knowledge gaps specific to post-arrest prognostication are an area of growing awareness and require careful attention in future analysis and research (refer to "Part 8: Pediatric Advanced Life Support" and "Part 11: Post–Cardiac Arrest Care.")[180] Health care professionals should share the best available knowledge regarding options and outcomes with qualifiers informed by the degree of certainty or uncertainty in any particular situation (refer to "Part 11: Post–Cardiac Arrest Care" and "Part 8: Pediatric Advanced Life Support" for a detailed discussion of these limitations as well as current prognostication data).

Further caution is needed when considering what defines a meaningful recovery. Patients and families are highly variable in what they consider to be an acceptable quality of life, and HCPs often view disability as resulting in a worse quality of life than what patients and families report.[181,182] This discrepancy raises important questions about ensuring equitable care for these populations and how estimates of functional recovery potential inform decisions to initiate, continue, or stop resuscitation.[183,184] Understanding what drives interpretation of prognosis and why patients or surrogates are reluctant to believe HCPs' prognostic estimates (particularly when the prognosis is believed to be poor) is an important element of effective communication.[185] More needs to be understood about how protocols, guidelines, communication, and elements of SDM might be adjusted to address these factors.

Ethical considerations demand caution when creating protocols or discussing realistic expectations with families to avoid decisions that may result in preventable deaths. Only by acknowledging these issues of uncertainty and potential self-fulfilling prophecy bias can HCPs and researchers begin to address the complexity of these interactions and have a clearer understanding of next steps.[186] When supporting families through SDM, clinicians must be honest with themselves about the limitations of their prognostic tools and how the range of potential recovery outcomes align with patients' values and preferences.[95,174,175]

Good ethics start with good data. Improving the quality of prognostic tools and guidelines should continue to be a priority. Additionally, more needs to be understood on how machine learning can create, perpetuate, or compound these issues and potentially offer recommendations to mitigate risks.[66] Constant reassessment of the available data and novel solutions to data interpretation will help strike the balance to guide policy and well-informed SDM. Such a balance will help mitigate the

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harms caused by decisions made based on unknown prognoses and biased by self-fulfilling prophecies.

Despite these limitations, available data and resulting guidelines inform a best estimate of which patients may benefit from initiation or continuation of CPR or continued life-sustaining therapies after initial resuscitation. Resulting decisions will always have individual and societal implications. Prolonged aggressive treatment of all individuals would deplete even resource-rich communities, let alone those with limited resources, and subject many patients to care inconsistent with their values and preferences. Conversely, no guideline or protocol can eliminate the possibility that some patients who would have benefited from aggressive treatment do not receive this care.

Potentially Inappropriate Therapies

In some circumstances, one or more medical treatments may be of no realistic benefit to a given patient.[187] All interventions have inherent risks of physical harm or indignity. Further, distributive justice supports the concept that medical treatments are limited resources that should be provided only when there is an expectation of potential benefit. Major professional societies support the ethical concept that HCPs are not obligated to provide treatments that have no plausible benefit to a patient, even when requested by surrogate decision-makers.[100,188] For example, initiating CPR when there is clear evidence of irreversible death (eg, decapitation) is neither recommended nor required. Similarly, it is ethically justifiable to discontinue treatments that are determined to be of no possible benefit.[189] Beyond examples in which there is no possibility a treatment will achieve its intended purpose, there are instances in which a treatment may achieve its proximate intent but not advance overall care toward a patient's goal. For example, initiating renal replacement therapy may effectively filter the blood but will not promote survival in the face of a nonsurvivable neurological injury. Health care professionals must be aware of and consider relevant laws and policies that require or prohibit treatment in any particular circumstance. Excellent communication with patients and surrogates about both the proximate and larger goals for medical care and their perceptions of benefit and harm is essential when considering realistic benefits.[100,189,190]

There are several challenges that can arise when considering withholding or withdrawing potentially ineffective CPR or ECC. First, determining that there is no plausible benefit to a patient can involve value-laden questions and subjective judgments. For example, living longer in a neurologically devastated state may justify continued life-sustaining therapies from the perspective of one patient (as represented by a surrogate decision-maker) but be unacceptable to another. In cardiac arrest and postarrest care, prognostication can be challenging (refer to Prognostication and Uncertainty). Once initiated, resuscitation can be discontinued, but the decision not to initiate treatment is often irrevocable. Thus, HCPs should generally err on the side of providing resuscitation when uncertainty exists. Although some professional bodies have limited consideration of potential benefit to achieving physiologic goals for a patient,[99,100] this may be insufficient to guide decision-making in resuscitation.

Requests from surrogates for resuscitation considered inappropriate by HCPs pose ethical challenges.[191] These cases are infrequent and can often be prevented or resolved through excellent communication and SDM (refer to Ethical Decision-Making in Resuscitation). However, when intractable, these disagreements can result in adverse emotional outcomes in patients, surrogates, and HCPs and suboptimal treatment decisions. In general, disagreements between a patient, surrogate, or both and HCPs about the appropriateness of treatments should be resolved through a process-based approach.[99,100] Detailed discussion of these processes is beyond the scope of this guideline, but in general, these processes are designed to avoid harm to patients and ensure procedural justice. Time constraints when considering resuscitation may limit the ability to use fully a process-based approach, but these real-world constraints do not justify a careless approach. Whenever possible, to minimize the chance an individual HCP's perspectives and biases influence determinations of benefit and to protect HCPs from moral distress, processes to resolve conflict about potentially inappropriate therapies (and resulting treatment decisions) should rely on an institutional committee or ethics consultant and be made in accordance with institutional policies.[99,100]

Cultural, Religious, and Other Considerations

In a society that is increasingly diverse and pluralistic, HCPs must understand the cultural norms, family traditions, religious beliefs, and spiritual considerations with regard to resuscitation decisions.[192] In general, the law of the land applies to most members of a society with respect to initiation of CPR and TOR.[193] More complicated are decisions related to EOL care, especially ACPs, withdrawal of life-sustaining therapies, and declaration of death by neurologic criteria. It is important to recognize that even within a particular religious tradition or culture, there is often significant variability in how individual patients and surrogates approach EOL decisions, such that HCPs cannot assume a particular response.[194,195] These decisions are also influenced by factors like socioeconomic status, education, considerations of societal costs, broken trust in the medical system, and ethical beliefs of the involved HCPs that may modify the interpretation and application of religious and cultural norms.[192,196,197]

In many cultures and religions, HCPs have been traditionally trusted with the authority to guide medical treatment.[193,198] Respecting autonomy means that it is equally

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important for HCPs to discuss with patients, surrogates, or both their wishes regarding the degree of involvement of HCPs, family, community members, or religious authorities in decisions related to EOL care. In some cultures and religious traditions, the concept of death by neurologic criteria is not well accepted and organ transplantation rates remain exceptionally low.[199] Similarly, various cultures and traditions prioritize length versus quality of life differently. Sensitivity to differing views on the definition of death may be increasingly important when discussing the transition from resuscitation to comfort measures and withdrawal of life-sustaining therapies. The treatment of suffering near EOL may also vary significantly between individuals and different cultures/religious traditions. For example, some traditions view suffering as redemptive and, therefore, patients may wish to avoid treatments that affect clarity of mind to overcome suffering.[200] There may be limits on the acceptance of religious or cultural wishes. For example, while the decision by an adult Jehovah's Witness to refuse blood transfusions is generally accepted, many institutions may seek court approval over a parent's objections to transfuse minors in elective situations or transfuse such patients in emergency situations. Lastly, there are many cultural and religious traditions that should be respected, when possible, at EOL.[201] These may include reception of sacraments near death, traditions in the way the body is handled after death, respect for bodily integrity, and the timing of funeral rites and burial or cremation.[193,198,200,202,203]

OTHER ETHICAL TOPICS

Ethical considerations in resuscitation are not limited to decisions to initiate or withhold CPR or to continue or terminate CPR or other life-sustaining therapies. Many other topics merit special consideration. These include the ethics of resuscitation research and knowledge generation, the impact of resuscitation on all involved individuals, resource limitations leading to crisis standards, advanced therapies, and organ and tissue donation; this does not represent an exhaustive list, but these topics are encountered regularly by HCPs and so are addressed in a later section.

Research and Knowledge Generation

Medical research seeks to create generalizable knowledge. During resuscitation, research poses unique challenges. Studies show that even in emergency circumstances, many research participants report being glad they were asked for prospective consent.[204] However, patients experiencing life-threatening emergencies often lack capacity and narrow therapeutic windows for intervention and acute emotional reactions of surrogates preclude usual informed consent processes, and yet, available treatments remain unsatisfactory. To address this scenario, a process for Exception From Informed Consent was developed for emergency research that meets specific regulatory requirements.[205] Exception From Informed Consent requires prospective community consultation and public disclosure, coupled with the ability for individuals to indicate to researchers that they wish to opt out of trial participation. Even under Exception From Informed Consent, when it is possible, potential research participants should be allowed to decline participation.

Some research in resuscitation (eg, all observational research) does not meet criteria for approval under Exception From Informed Consent. Other ethical pathways for regulatory approval include seeking a waiver of informed consent (eg, when the research is purely observation and determined to pose no greater than minimal risk to participants) or obtaining prospective informed consent.[206] It is the role of institutional review boards, not investigators, to determine the appropriate regulatory pathways and the responsibility of medical researchers to seek institutional review board approval for their research. It is unethical and illegal for investigators to bypass regulatory requirements for activities meeting recognized definitions of clinical research.[206] Patients who experience life-threatening emergencies including cardiac arrest are often unable to advocate for themselves and particularly susceptible to power dynamics introduced by their unexpected and precarious state. The history of medical research is fraught with examples of putatively well-intentioned investigators unethically exploiting vulnerable populations to advance medical knowledge.[207]

The AHA's Emergency Cardiovascular Care Committee believes that there is an ethical responsibility to use the utmost rigor when synthesizing available evidence into treatment guidelines (refer to "Part 2: Evidence Evaluation and Guidelines Development"). In resuscitation, there is often insufficient evidence to support a strong recommendation of benefit or harm. In these situations, HCPs and health care organizations must still develop and update protocols and make individualized treatment decisions, as appropriate. When there is a plan to investigate these sources of practice variability to create generalizable knowledge, research protections apply and should not be circumvented through use of quality improvement regulatory pathways.

Impact on Health Care Professionals

The AHA strongly advocates for HCPs who perform resuscitation to be protected from physical harm.[208] Assessing scene safety is the first step in the recommended approach to basic and advanced life support, and taking preventive measures helps to mitigate infection and electrical risks in addition to musculoskeletal injuries.[209] Health care professionals have legal and ethical duties in their professional capacities to provide treatment to patients. How far this duty extends in the face of personal risk remains hotly debated.[210] Health care

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professionals' perceptions of risk may differ significantly from evidence-based risk assessments.[211] Moreover, time-pressured judgments may be influenced by HCPs' conscious and unconscious biases. For example, historically some HCPs refused to care for patients infected with HIV despite little objective risk.[212]

To provide more objective guidance, health care, governmental, and regulatory institutions synthesize available evidence quantifying the risk to HCPs from delivering care in any particular circumstance (eg, the probability of disease exposure, the probability of resulting infection, and the severity of the consequences) and provide strategies to minimize this risk without adversely affecting patient outcomes. For example, aerosol-generating procedures during resuscitation carry some risks (refer to "Part 10: Adult and Pediatric Special Circumstances of Resuscitation"). A systematic approach to these decisions can protect HCPs, minimize adverse effects on patients, and maximize equitability of care. Evidence-based recommendations cannot fully address every clinical scenario or circumstance, so HCPs must be able to interpret and apply guidance in context. When doing so, they should be mindful of their potential biases, be deliberate in their approach to decision-making, and apply a systematic approach to weighing the available evidence.

In addition to the potential for physical harm, performing CPR is one of the most stressful and emotionally demanding experiences in health care. While many HCPs report participating in CPR is a positive experience,[213] myriad studies highlight the potential for post-traumatic stress among HCPs who perform CPR.[214–216] Health care professionals who practice in settings where CPR is common, such as the intensive care unit, experience uniquely high levels of anxiety, depression, and burnout.[217,218]

Moral distress can occur when there is disagreement about whether CPR is the 'right' thing to do and is described in this context as an individual psychological phenomenon experienced by an HCP who makes a moral judgment about the right course of action but who is unable to act on that judgment due to institutional or structural constraints.[219] The risk of moral distress here originates from disagreement about when providing CPR is the right thing to do. Studies of HCPs show that they perceive many attempts at CPR to be inappropriate,[220,221] especially when they believe from available information that prognosis is likely to be poor.[219] In some cases, moral distress is categorized more broadly to include any negative emotional response to morally challenging situations, such as those of moral constraint or conflict.[222,223] Research shows that moral distress has significant consequences to the well-being of HCPs and the provision of medical care.[224] Clinicians experiencing high levels of moral distress are more likely to seek different roles or leave the profession altogether.[225,226]

To some extent, moral distress in the setting of resuscitation is unavoidable. As resuscitation science advances, both clinical and ethical best practices must be continually redefined (refer to Prognostication and Uncertainty). During this process, there will often be a lack of moral consensus, which can lead to moral distress.[227] Institutions have opportunities and an ethical obligation to provide ethical guidelines and policies regarding resuscitation and to establish procedures for discussing controversial ethical issues and resolving refractory disputes. Managing these complex emotions and responses should not fall on the individual alone. Just as health care organizations can address stress, burnout, and clinician wellness through therapeutic and educational interventions,[228] moral distress can be mitigated using multidisciplinary resources, such as ethics and moral distress consultation services[229–231] and post-CPR debriefing.[232] These efforts provide a safe space for discussion and processing emotions and help HCPs feel heard and understood.

Impact on Survivors

Patients who survive CPR often experience lasting physical, functional, cognitive, social, emotional, and other symptoms.[233] These may cause significant and sustained harm to survivors, but when properly addressed, these harms can often be mitigated through evidence-based screening, intervention, and referral to post-acute services (refer to "Part 11: Post–Cardiac Arrest Care" and "Part 8: Pediatric Advanced Life Support"). For this reason, the AHA recognizes survivorship and recovery as integral to the Chain of Survival. Although the duty of HCPs to patients is often bound by setting and timing (for example, EMS professionals are not ethically bound to provide rehabilitation services after hospital discharge), the same is not true of health care organizations. These organizations have an ethical responsibility to develop systems of care that optimize the long-term health and well-being of the patients they serve (refer to "Part 4: Systems of Care"). Additional research that guides how best to achieve this goal is urgently needed.

Impact on Laypersons, Families, and Caregivers

Cardiac arrest and other cardiovascular emergencies can have lasting psychosocial impacts on laypersons, including responders who deliver early resuscitative intervention, families and friends, and caregivers of patients who were successfully resuscitated. Although the primary duty of HCPs is to the patient, ethical obligations extend to supporting families, caregivers, and others who surround the patient.[234] These obligations are grounded in beneficence and equity, as well as ethics of care and utilitarianism, and can minimize costs to society

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that result from adverse social and emotional outcomes of individuals adjacent to the patient.

Witnessing cardiac arrest and delivering CPR can be empowering but can also be traumatic experiences for lay responders.[235,236] In addition to direct harm to responders from emotional distress and resulting psychosocial sequelae, adverse outcomes can reduce willingness to respond in the future.[237] The ethical obligations to lay responders parallel those to HCPs, as addressed previously.

Family Presence During Resuscitation

Increasingly, family members are allowed to be present during resuscitation to (1) allow for support and dignity of the patient, (2) witness efforts by HCPs, and (3) aid the care team by providing information about the patient's condition and expressed wishes. Determining how to best support FPDR is complex and multifaceted, balancing the needs of the patient, the family, and the HCP team. Though not every patient and their supportive others will desire such accompaniment, many do favor this approach.[238,239] FPDR can have emotional benefits for family members by providing closure and a better understanding of the patient's condition and reducing complicated grief, which can lead to improved long-term psychological outcomes.[238,240] Recognizing these benefits, multiple professional guidelines recommend inclusion of patients' relatives during CPR.[241,242] For infants and children, several studies have shown that FPDR has beneficial behavioral health outcomes in the grief process (refer to "Part 8: Pediatric Advanced Life Support" for specific recommendations).[243,244] FPDR has been recommended in pediatric advanced life support for 20 years and is routinely practiced in many settings that provide high-level pediatric care. Studies have demonstrated that experienced HCPs are more likely to support the practice.[245,246]

At the same time, there are concerns associated with FPDR, including potential emotional trauma to family members,[240] interference with medical care,[247] patient confidentiality,[248] and the necessity of maintaining professional autonomy in clinical decision-making. Professional autonomy empowers HCPs to apply their clinical judgment in determining the most appropriate treatment or intervention for each patient. This is especially crucial in resuscitation, where quick and decisive action is often required. Interference is uncommon in both pediatric and adult resuscitations.[249,250]

When considering FPDR, the focus should be to prioritize patient welfare, while also factoring the psychological impact on family members and the dynamics of the medical team. Teams should respect patient and family autonomy while maintaining optimal resuscitative care, thus demonstrating beneficence and nonmaleficence. To ensure that patients and family members who desire FPDR receive just care, institutions should develop clear policies on whether there are specific circumstances or considerations that could preclude FPDR. In addition, institutions should ensure sufficient resources and training to support clear communication, robust emotional support for the family (ideally from a team member dedicated to this task, such as a social worker or chaplain), and professional training for HCPs in managing situations involving FPDR.[240,251]

Regardless of presence during initial resuscitation, cardiac arrest and cardiovascular emergencies have a lasting impact on families of both decedents and survivors. Families of decedents often develop posttraumatic stress, anxiety, and depression.[252] Early factors such as quality and clarity of communication and FPDR can help mitigate these reactions, but additional bereavement and psychiatric support may be required. Families and caregivers of patients who survive initial resuscitation also endure lasting consequences, including posttraumatic stress, anxiety, anger, and confusion.[233] To respect patient autonomy and promote beneficence and nonmaleficence, HCPs should ascertain whether patient wishes regarding the extent of caregiver involvement have been established, should monitor caregivers for distress, and should provide appropriate support and referrals for additional services following the resuscitation.[234]

Crisis Standards of Care

Crisis standards of care are guidelines that amend the standard of medical care in response to a disaster event. Qualifying events are those of sufficient size and scope to outpace the capacity of health care systems, facilities, and HCPs to meet the usual standard of care.[253–255] Crisis standards are distinct from contingency standards, in which strained systems repurpose resources and enact mitigation strategies to avoid compromising care.[256] In high-resource settings, crisis standards of care are implemented most often during mass casualty events (terrorism, natural disasters) and outbreaks (epidemics, pandemics). Crisis standards do not change or diminish HCPs' duty to patients. In a crisis, HCPs' legal and ethical responsibility is to take the same action that a reasonable and prudent HCP would take under similar circumstances. To date, there are no cases in which HCPs acting in good faith in disaster response have been found liable for the care they provided.[257,258] Crisis standards of care guide what actions may be considered reasonable and prudent without asking individual HCPs to make this judgment alone and in real time. This approach can mitigate moral distress by providing clear frameworks for decision-making and prioritization and minimize inequities when these judgments are made by individual HCPs who are susceptible to conscious and unconscious biases. This framework allows institutions and government entities

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to develop policies to provide care in a thoughtful, equitable manner and further obligates institutions to develop collaborative arrangements, share resources, and transfer patients, allowing for creative approaches and solutions.

Ethical norms of utilitarianism and fairness inform the design and implementation of crisis standards. Utilitarianism holds that the proper course of action is the one that produces the greatest good for the greatest number of people. This view dictates that in a catastrophe, care should be organized to save the most lives possible. While a principlist approach to an individual's care remains relevant,[2] crises often demand rebalancing ethical priorities. Autonomy may be deprioritized in favor of justice and beneficence reconceptualized as acting for the good of the population at large rather than the good of the individual patient.[259] The principle of solidarity, everyone acting toward a common purpose and assuming mutual responsibility, often emerges as a relevant moral consideration in crisis states.

Crisis standards of care should strive to provide a just distribution of resources and promote equitable health outcomes (refer to Striving for Equitable Health and Resuscitation). Simply dividing resources equally or using a first-come, first-served approach will not save the most lives, and relying on scoring systems that utilize comorbidities and expected life years will often result in a disproportionate impact on poor and marginalized populations.[260–263] Without a clear best solution to this challenge, focusing on the process by which crisis standards are written and implemented is essential. The moral standing of any crisis standard depends on it being recognized as fair by the people most likely to be affected by it. Stakeholders at all levels should provide input, and consideration should be given to adopting standards that reflect the values and priorities of the affected communities. For example, from 2012 to 2014, Maryland authored its crisis standards policy by conducting 15 community engagement forums across the state. The input from laypersons, ethicists, lawyers, medical personnel, and public health experts was used to generate a framework for resource allocation in case of a disaster event, which was then reviewed and approved by advocacy groups representing persons with disabilities and older adults.[264,265] During the COVID-19 pandemic, several US states, including Maryland, documented crisis standards of care and found that previous policy work aided in navigating the exceptional ethical and practical demands placed on HCPs and organizations. Many organizations found that the crisis standards of care were necessarily tailored to specific scarce resources. During surge cases, for example, organizations faced critical shortages of personal protective equipment, therapies, and vaccines.[266,267]

Advanced Therapies

A variety of advanced therapies may be considered to treat highly selected cardiac arrest patients who fail to respond to conventional resuscitation. These include extracorporeal membrane oxygenation initiated as a rescue therapy during active CPR, called extracorporeal CPR (ECPR), and other forms of mechanical circulatory support, which we consider here as a specific example of an advanced therapy with ethical implications. A summary of the evidence for ECPR and resulting treatment recommendations are discussed in "Part 9: Advanced Life Support" and "Part 8: Pediatric Advanced Life Support." These technologies require careful ethical consideration.[268] Ethical issues include limited data to guide patient selection, difficulty obtaining informed consent, high cost and resource utilization with associated questions of equitable distribution, and the role of these therapies in the possible transition from unsuccessful resuscitation to organ donation or withdrawal of life-sustaining therapies (refer to "Part 4: Systems of Care").

Few data are available to guide patient selection for ECPR in adults who experience OHCA, specifically differentiating patients who might benefit from the procedure from those who might be harmed. In addition, potentially eligible patients uniformly lack capacity during ongoing CPR and surrogate decision-makers are often unavailable or unable to engage fully in SDM or provide informed consent in the time frame within which a treatment decision must be made.[269,270] Thus, ECPR is often initiated based on implied consent rather than informed consent.

Given substantial uncertainty identifying patients who may benefit from ECPR, some patients are treated but fail to regain sufficient cardiac or neurological function to permit acceptable quality of recovery. In this situation, continuing advanced therapies can potentially become inappropriate.[271] After initiation of ECPR, it is important to reevaluate the patient's prognosis, treatment options, and values and preferences for medical care frequently and to engage in SDM with the patient or surrogate as they become available. Extracorporeal CPR programs need to have plans in place addressing how to handle (from both HCP and patient or surrogate perspectives) situations in which the patient remains dependent on extracorporeal support despite maximal therapy and options to transition to other therapies are exhausted. As costly, labor-intensive, and reliant on potentially limited resources as advanced therapies like ECPR are, there may be situations (such as a respiratory pandemic) in which allocation of advanced therapies becomes an urgent issue. Prior literature provides guidance on how hospital teams can develop ethically permissible policies allowing unilateral withdrawal of unsuccessful extracorporeal support despite patient or surrogate objections,

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although this remains an incompletely settled question in the ethics literature.[271,272]

There are significant financial, personnel, and infrastructure costs associated with ECPR. Few studies have examined the cost effectiveness of ECPR, although preliminary analysis suggests it might be cost effective in selected cases.[273,274] Policymakers do not yet have sufficient data to decide if the costs of providing routine ECPR for eligible patients is justified relative to other potential uses of resources. Complicating ethical consideration of these questions is the difficult-to-quantify potential future benefits of more widespread adoption. As discussed previously (refer to Prognostication and Uncertainty), with advances in care, patient outcomes improve over time. Greater adoption of advanced therapies today may lower future costs and improve patient outcomes as HCPs gain expertise and these tools become more widely available. Potential future medical progress must be weighed against the costs and potential harms of implementation today.

Because ECPR is a limited resource in current systems of care, it must be distributed justly. A recent study found significant racial, gender, and insurance status disparities in the use of advanced therapies.[275,276] Although there is a paucity of data to explain these observed differences, it is likely there are both systemic and individual contributions. Systemically, patients who live in poorer neighborhoods or rural areas may have longer EMS response or transport times to ECPR-capable facilities. This can substantially limit any benefit conferred by ECPR or entirely preclude access to treatment. This source of disparity can be addressed through development of systems of care (refer to "Part 4: Systems of Care"). Individual HCPs who make treatment decisions that determine ECPR eligibility (decision to initiate CPR, decision to transport with CPR ongoing, decision for ECPR after hospital arrival, etc) have both conscious and unconscious biases that affect their decision-making. High-stakes decisions under time pressure often rely on heuristics that are particularly susceptible to unconscious biases. Inequities originating from these human factors can be attenuated through use of protocols, but it is important to note that protocols can also perpetuate systemic inequities. For example, protocols that incorporate assessments of likelihood of benefit from ECPR that are influenced by social drivers of health potentially create systematic exclusion of certain patient populations for expected lack of benefit, leading to inequitable outcomes. For example, measures of organ dysfunction, such as pulse oximetry or biomarkers of renal function, can be influenced by race or ethnicity.[277,278] Thus, it is essential to consider these potential biases, in addition to disability and possibly genetic conditions, in designing any ECPR program.

Implications of advanced therapies on organ and tissue donation are discussed in a later section.

Organ and Tissue Donation

As discussed in the 2023 focused update on advanced cardiovascular life support and reaffirmed elsewhere in these guidelines, organ and tissue donation should be considered in all patients resuscitated from cardiac arrest who progress to death by neurological criteria or for whom withdrawal of life-sustaining therapies is planned (refer to "Part 4: Systems of Care," "Part 9: Advanced Life Support," and "Part 8: Pediatric Advanced Life Support").[279] Organ and tissue donation should also be considered in other clinical circumstances that permit (eg, tissue donation after circulatory death). Schiff and colleagues recommend the "implementation of protocols that aim to promote public trust and reduce conflicts of interest…proactively addressing these ethical and logistical challenges…to maximize lives saved through improved resuscitation with good neurological outcomes and increased organ donation opportunities when resuscitation is unsuccessful."[280] As in all situations, decisions for a planned transition to EOL care should be made for the patient's benefit before, and independently of, any consideration of offering organ donation to the patient or surrogate. Ethically, these measures respect the autonomy of patients who would wish to become organ donors; offer benefits to surrogates or HCPs who find solace in the donation outcome; and have clear benefits to the organ recipients, their families, and society through improved health, longevity, and quality of life after transplantation.

Extracorporeal perfusion can be initiated after failed CPR specifically to facilitate uncontrolled donation after circulatory death (uDCD) in patients deemed to have no possibility of recovery from their cardiac arrests.[281] Many European countries have an opt-out perspective in which it is assumed that a cardiac arrest patient would wish to be a donor unless they specifically decline. In the United States, the default position is an opt-in approach in which patients are presumed not to be organ donors unless they have specified a wish to do so. This poses an ethical question for HCPs treating refractory cardiac arrest as to whether extracorporeal machine perfusion should be initiated after TOR and pronouncement of death by circulatory criteria to preserve an opportunity for organ donation.[282] In opt-in systems, some argue that protocols to initiate extracorporeal perfusion for organ preservation without patient or surrogate consent may damage public trust by appearing to favor public interest over the individual patient's benefit and autonomy.[280,283] Extracorporeal perfusion raises additional questions about the irreversibility of death because cardiac activity or brain perfusion can be restored, potentially in violation of the dead donor rule.[283,284] A final ethical concern is the just distribution of expensive and labor-intensive extracorporeal support capabilities in rural or underserved urban areas. It is important to recognize that if ECLS for clinical purposes is not available, use of extracorporeal

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machine perfusion use for organ preservation alone could reinforce the appearance of favoring organ preservation over lifesaving measures.[280,283,285]

With regard to the transition of ECLS from a life-sustaining measure to a support for uDCD, Dalle Ave and colleagues[282] recommend the following:

> (1) [T]he development of internationally accepted termination of resuscitation guidelines that would have to be satisfied prior to inclusion of patients in any [uDCD] protocol, (2) the choice regarding modalities of ongoing resuscitation during transfer should be focused on the primary priority of attempting to save the life of patients, (3) only centers of excellence in life-saving resuscitation should initiate or maintain [uDCD] programs, (4) [ECLS] should be clinically considered first before the initiation of any [uDCD] protocol, and (5) there should be no discrimination in the availability of access to [ECLS].

Ethically, these recommendations minimize the risk of perceived or actual conflicts of interest, seek to maintain public trust, and ensure an equitable distribution of limited resources.

There are additional nuances in organ and tissue donation after cardiac arrest in neonatal and pediatric patients that should be considered. Fewer neonatal and pediatric patients become donors when compared with adults,[286–288] which limits available data on the frequency and outcomes of attempted donation.[288] This may contribute to variability in center-specific approaches to donation, with potential impact on whether donation is offered for clinical or research purposes,[288,289] center-specific approaches to counseling families/informed consent,[290] methods used to determine death,[290,291] premortem interventions performed to facilitate donation,[288,292] and choices offered in perimortem care.[286]

These issues need to be addressed in any program offering organ donation after cardiac arrest. As medical advances related to organ donation and transplantation evolve, there is a need for enhanced collaboration across centers to standardize approaches and provide HCP and community education.

CONCLUSION

Ethical frameworks provide a structure through which difficult decisions can be considered, including many situations frequently encountered in resuscitation and ECC. This guideline summarizes key principles that have been developed from historical frameworks as well as more contemporary expressions of these evolving principles. This document offers practical guidance on how best to implement these concepts in the often emotionally charged setting of acute care, but it is not intended to be exhaustive. HCPs, clinical ethicists who provide them guidance, as well as institutions developing policies and procedures should use this guideline as a foundation for their own critical analysis of difficult situations. They should also use this guideline to engage their patients, families, and colleagues in thoughtful discussion, debate, and SDM to make the best decision for each individual patient in a specific set of circumstances. Such complexity will never be easily translated into the algorithms often used to guide treatment throughout other chapters in these guidelines. Yet these intricacies may also provide the rewards of patient interaction and the human experience that result in moments of professional fulfillment as equitable and compassionate care is provided to patients and families in these situations.

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Disclosures

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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

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*Modest.

†Significant.

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Part 4: Systems of Care: 2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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ABSTRACT: Improving survival and quality of life after cardiac arrest requires integrated systems of people, protocols, policies, and resources along with ongoing data acquisition and review. Such systems of care, which are highly influenced by the environment in which they operate, produce efficiency and effectiveness in responding to cardiac arrest. Part 4 of the *2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care* focuses on systems of care, emphasizing elements that are relevant to a broad range of resuscitation situations. The chapter follows the Chain of Survival, beginning with prevention and preparedness to resuscitate, proceeding to early identification of cardiac arrest, and moving to effective resuscitation through to post–cardiac arrest care, survivorship, and recovery. This Part provides cardiac arrest systems of care guidelines on how to train specific personnel, protocols that have been demonstrated to be effective, as well as the incorporation of nonhuman resources to optimize cardiac arrest care with ongoing debriefing and quality improvement strategies. Specific to out-of-hospital cardiac arrest, included are recommendations about emergency medical services team composition and transport recommendations, community initiatives to promote lay rescuer response, public access defibrillation and naloxone, and an enhanced role for emergency telecommunicators. Germane to in-hospital cardiac arrest are recommendations about cardiac arrest prevention and code team composition. Specific recommendations about extracorporeal membrane oxygenation cardiopulmonary resuscitation, transport to specialized cardiac arrest centers, organ donation, survivorship systems, and performance measurement across the continuum of resuscitation situations are also included.

Key Words: AHA Scientific Statements ■ cardiopulmonary resuscitation ■ delivery of health care ■ emergency medical dispatcher ■ heart arrest ■ hospital rapid response team ■ out-of-hospital cardiac arrest ■ quality improvement

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TOP 10 TAKE-HOME MESSAGES: SYSTEMS OF CARE

1. The Chain of Survival provides a broad overview of the critical steps to care for individuals suffering cardiac arrest, which can be customized depending on the age, etiology, and location of the arrest.
2. We present a simplified Chain of Survival meant to be applied to pediatric and adult cardiac arrest. In the future, the addition of prevention and preparedness is anticipated, given the importance of avoiding cardiac arrest altogether and optimizing resuscitation once it has occurred.
3. Systems of care (SOC) comprise policies and procedures, personnel, equipment and resources, information, and quality improvement and are highly influenced by the environment of care.
4. Community initiatives to improve lay rescuer cardiopulmonary resuscitation (CPR) are inherently multimodal, incorporating mass media, directed training, publicly available resources, mobile technologies, and policies and procedures.

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5. The structure of in- and out-of-hospital resuscitation teams is variable, and adequate training, numbers of responders, and defined roles are crucial to produce good outcomes.
6. Debriefing and feedback to rescuers and analysis of data registries may be important components of a cardiac arrest quality improvement program.
7. In most cases, on-scene resuscitation aimed at achieving return of spontaneous circulation (ROSC) is preferable to patient transport with ongoing CPR, but this strategy requires that emergency medical technicians and paramedics be adequately trained on when to terminate efforts and how to provide death notifications.
8. Extracorporeal membrane oxygenation (ECMO) CPR is a promising but resource-intensive advanced resuscitation technique that requires an organized SOC to select appropriate patients and craft the optimal pathway for care delivery and optimization.
9. More research is needed to identify the optimal components of cardiac arrest centers and determine when scene or interfacility transport to such a center is beneficial.
10. An SOC that integrates inpatient and outpatient services is needed to provide elements of recovery demonstrated to be beneficial in cardiac arrest survivors.

PREAMBLE

Cardiac arrest SOC represent a comprehensive framework of personnel, resources, and policies and procedures designed to provide a coordinated, efficient, and highly effective response (Figure 1). The primary goal of cardiac arrest SOC is to resuscitate patients back to the function and quality of life that they enjoyed before the cardiac arrest. Important secondary goals include effective team function, optimizing the long-term survivor experience for the patient and those involved in the resuscitation, and improving the SOC through ongoing quality management and research. The objective of a cardiac arrest SOC is to quickly, efficiently, and effectively perform each step within the Chain of Survival (Figure 2). The SOC needed to execute the early links of the Chain of Survival differs between in-hospital cardiac arrest (IHCA) and OHCA, but assuming ROSC, these converge within the intensive care unit and continue through hospitalization and following discharge. These SOC guidelines are broadly applicable to persons of all ages, though are not geared toward neonatal resuscitation. These guidelines provide recommendations on how to create, maintain, and optimize systems intended to produce the best outcomes possible following cardiac arrest. Patient outcomes ultimately depend on some factors beyond the scope of this Part, such as the patient's comorbidities, yet a well-functioning cardiac arrest SOC can produce the best outcome achievable for any given patient by optimizing the execution of each link in the Chain of Survival.

Figure 1. Systems of care.
Graphical representation of the components of cardiac arrest systems of care.

The cardiac arrest Chain of Survival provides a progression of events beginning with the recognition that an individual is having a cardiac arrest and ideally results in the survival and recovery of that individual. There are opportunities to optimize each link in this chain with the ultimate goal of maximizing survival and function following cardiac arrest. The Chain of Survival is intended to be applied to both adult and pediatric in- and out-of-hospital cardiac arrest, though the details vary in each application. The recommendations in this Part follow the links of the Chain of Survival, beginning with prevention and preparedness, which precede the cardiac arrest event.

INTRODUCTION

Scope of the Guidelines

These guidelines are designed primarily for North American lay rescuers and health care professionals looking for up-to-date guidance to optimize clinical care through the design and operation of resuscitation systems. The emphasis in this Part of the *2025 American Heart Association* (AHA) *Guidelines for CPR and Emergency Cardiovascular Care* (ECC) is on elements of care involving coordination between different contributors to the Chain of Survival (eg, emergency telecommunicators and untrained lay rescuers), those elements common to the resuscitation of different populations (eg, community CPR training and public access to defibrillation, early

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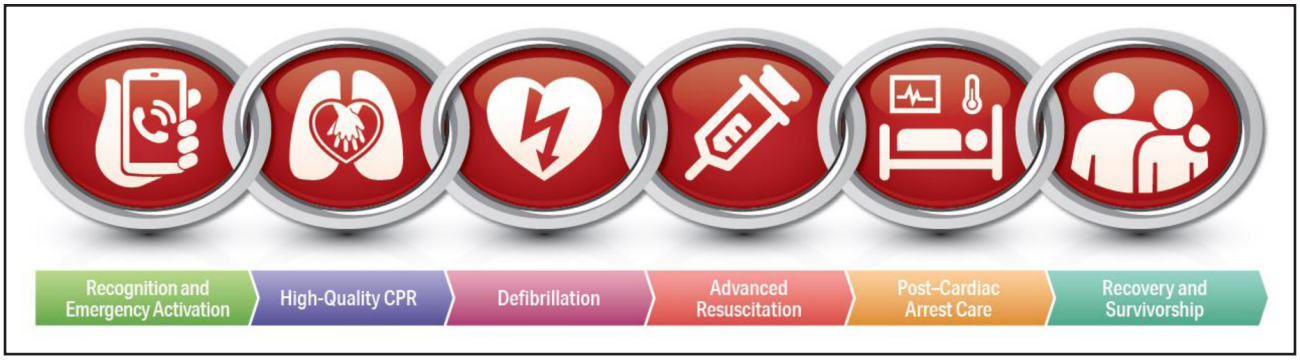

Figure 2. Updated 2025 Chain of Survival.

interventions to prevent IHCA), and means to improve the performance of resuscitation teams and systems.

Our recommendations are directly relevant to lay rescuers, health care professionals, emergency telecommunicators, and those determining policy or legislation. These individuals operate within varied settings with differing levels of training and access to resuscitation equipment, which influences what is reasonable to recommend within that SOC. Our recommendations cover a broad temporal range from before cardiac arrest occurs until after resuscitation is successful or terminated, with guidance on assessing and improving the quality of each step.

Organization of the SOC Writing Group

The SOC Writing Group included a diverse group of volunteers from the AHA with expertise in emergency medicine, emergency medical services (EMS) pediatric and adult critical care, cardiology, education, research, epidemiology, and public health. A call for candidates was distributed to the AHA ECC committee, and members with recognized expertise in pediatric and adult resuscitation were nominated by the writing group co-chairs. Writing group members were selected by the AHA Emergency Cardiovascular Care Science Subcommittee then approved by the AHA Manuscript Oversight Committee.

The AHA has rigorous conflict of interest policies and procedures to minimize the risk of bias or improper influence during the development of guidelines. Prior to appointment, writing group members disclosed all commercial relationships and other potential (including intellectual) conflicts. These procedures are described more fully in "Part 2: Evidence Evaluation and Guidelines Development."[1] Appendix 1 of this document lists the writing group members' relevant relationships with industry.

METHODOLOGY AND EVIDENCE REVIEW

These SOC guidelines are based on extensive evidence evaluation. Most of the evidence evaluation was performed in conjunction with the International Liaison Committee on Resuscitation (ILCOR) and affiliated ILCOR member councils. Three different types of ILCOR evidence reviews (systematic reviews, scoping reviews, and evidence updates) were used in the 2025 process. In most cases, the SOC writing group supplemented the evidence update reviews completed by ILCOR through a literature search of additional databases (Pubmed, EMBASE, CINAHL). For knowledge chunks lacking ILCOR reviews, the writing group worked with AHA librarians to create a relevant search strategy and conducted evidence update reviews. Each of these resulted in a summary of the literature that facilitated guideline development. A more comprehensive description of these methods is provided in "Part 2: Evidence Evaluation and Guidelines Development."[1]

Class of Recommendation and Level of Evidence

The writing group reviewed all relevant and current *AHA Guidelines for CPR and Emergency Cardiovascular Care* and all relevant *International Liaison Committee on Resuscitation Consensus on CPR and Emergency Cardiovascular Care Science With Treatment Recommendations* statements from 2020, 2021, 2022, 2023, and 2024.[2–7] Evidence and recommendations were reviewed to determine if current guidelines should be reaffirmed, revised, or retired or if new recommendations were needed. The writing group then drafted, reviewed, and approved recommendations, assigning to each a Class of Recommendation (COR; ie, strength) and Level of Evidence (LOE; ie, quality, certainty). Criteria for each COR and LOE are described in the Table.

Guideline Structure

The 2025 guidelines are organized into "knowledge chunks," grouped into discrete modules of information on specific topics or management issues.[8] Each modular knowledge chunk includes a table of recommendations that uses standard AHA nomenclature of COR and LOE. Recommendations are presented in order of COR: most potential benefit (Class 1), followed by lesser certainty

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Table. Applying Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care (Updated December 2024)*

CLASS (STRENGTH) OF RECOMMENDATION

Class 1 (STRONG) — Benefit >>> Risk

Suggested phrases for writing recommendations:
- Is recommended
- Is indicated/useful/effective/beneficial
- Should be performed/administered/other
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is recommended/indicated in preference to treatment B
  - Treatment A should be chosen over treatment B

Class 2a (MODERATE) — Benefit >> Risk

Suggested phrases for writing recommendations:
- Is reasonable
- Can be useful/effective/beneficial
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is probably recommended/indicated in preference to treatment B
  - It is reasonable to choose treatment A over treatment B

Class 2b (WEAK) — Benefit ≥ Risk

Suggested phrases for writing recommendations:
- May/might be reasonable
- May/might be considered
- Usefulness/effectiveness is unknown/unclear/uncertain or not well-established

Class 3: No Benefit (MODERATE) — Benefit = Risk
(Generally, LOE A or B use only)

Suggested phrases for writing recommendations:
- Is not recommended
- Is not indicated/useful/effective/beneficial
- Should not be performed/administered/other

Class 3: HARM (STRONG) — Risk > Benefit

Suggested phrases for writing recommendations:
- Potentially harmful
- Causes harm
- Associated with excess morbidity/mortality
- Should not be performed/administered/other

LEVEL (QUALITY) OF EVIDENCE‡

Level A
- High-quality evidence‡ from more than 1 RCT
- Meta-analyses of high-quality RCTs
- One or more RCTs corroborated by high-quality registry studies

Level B-R (Randomized)
- Moderate-quality evidence‡ from 1 or more RCTs
- Meta-analyses of moderate-quality RCTs

Level B-NR (Nonrandomized)
- Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies
- Meta-analyses of such studies

Level C-LD (Limited Data)
- Randomized or nonrandomized observational or registry studies with limitations of design or execution
- Meta-analyses of such studies
- Physiological or mechanistic studies in human subjects

Level C-EO (Expert Opinion)
- Consensus of expert opinion based on clinical experience

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consenus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR 1 and 2a; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely-used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

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of benefit (Class 2), and finally, potential for harm or no benefit (Class 3). Following the COR, recommendations are ordered by the certainty of supporting LOE: Level A (high-quality randomized controlled trials) to Level C-EO (expert opinion). This order does not reflect the order in which care should be provided.

A brief synopsis is provided to put the recommendations into context with important background information and overarching management or treatment concepts. Recommendation-specific text clarifies the rationale and key study data supporting the recommendations. When appropriate, flow diagrams or additional tables are included.

Document Review and Approval

The guideline was submitted for blinded peer review to 5 subject matter experts nominated by the AHA. Before appointment, all peer reviewers were required to disclose relationships with industry and any other potential conflicts of interest, and all disclosures were reviewed by AHA staff. All guidelines were reviewed and approved for publication by the AHA Science Advisory and Coordinating Committee and the AHA Executive Committee. Comprehensive disclosure information for peer reviewers is listed in Appendix 2.

These recommendations supersede the last full set of AHA recommendations for SOC, made in 2020.[9] The writing group members voted on and approved all guideline recommendations.

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MAJOR CONCEPTS

The Components of SOC

Any SOC (Figure 1) is shaped by the environment in which it is based. The guidelines provided in this Part apply best to the United States and Canada, which have societal values and structures distinct from other countries. Out-of-hospital cardiac arrest SOC involve personnel including laypersons who may recognize OHCA and ideally participate as rescuers in the resuscitation, property owners who maintain automated external defibrillators (AEDs), emergency service telecommunicators (also known as dispatchers or call-takers), and basic life support (BLS) and advanced life support (ALS) professionals working within EMS. In-hospital cardiac arrest SOC personnel often include physicians; nurses; respiratory therapists; pharmacists; occupational, physical, speech/language, and mental health therapists; and other professionals who participate in resuscitation and postresuscitation care. Following discharge, survivorship and recovery may require physicians, social workers, family, and friends. A major part of cardiac arrest SOC involves education and training for these individuals. Policies and procedures within cardiac arrest SOC include local and national laws as well as protocols and workflows within numerous health care organizations spanning EMS and telecommunicators, hospitals, and rehabilitation centers. The establishment and optimization of these SOC often require a local champion. The resources that are essential to cardiac arrest SOC include equipment, medications, physical facilities, and ongoing innovation within these areas.

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Finally, quality management is crucial to optimizing any SOC. This includes ongoing review of data from cardiac arrest resuscitation resulting in system modifications and, ideally, research communication of generalizable findings to permit improvement across systems.

The History of the AHA Chain of Survival

In 1991, the AHA introduced the cardiac arrest Chain of Survival, which depicted a series of sequential steps crucial to resuscitations.[1] The initial Chain of Survival depicted early access to resuscitation, CPR, defibrillation, and advanced care. In 2010, the AHA elaborated on the Chain of Survival to include early recognition of cardiac arrest and activation of the emergency response system, early high-quality CPR, rapid defibrillation, advanced life support, and post–cardiac arrest care.[2] The *2020 AHA Guidelines for CPR and ECC* depicted 4 distinct but related chains of survival for adults and infants/children experiencing IHCA and OHCA.[3] In all but the 2020 adult OHCA chains, the concept of prevention was also inserted into the initial link of the Chain of Survival. In 2020, an additional link was added to represent recovery. Recovery is unique in that it could be temporally quite distant from the earlier links, all of which occur in rapid succession in the process of resuscitation.

The neonatal chain of care concept ("Part 5: Neonatal Resuscitation") differs from the Chain of Survival presented here. Neonatal resuscitation often involves different emphasis on breathing and ventilation than pediatric and adult cardiac arrest do. The timing of transition from neonatal to pediatric guidelines and chains of survival is not strictly defined and depends on the setting, resources, team preferences, and the nature of the clinical deterioration.[4] The SOC guidelines cover pediatric and adult resuscitation, not neonatal, and likewise, the 2025 Chain of Survival is specific to pediatric and adult guidelines.

The 2025 AHA Chain of Survival

For 2025, we have elected to revert to a single Chain of Survival (Figure 2) for all forms of cardiac arrest, whether adult or pediatric, in- or out-of-hospital. This was for simplicity and because the writing groups felt each link of the chain could be applied to the different forms of cardiac arrest, although the details of this application may vary. The symbol for high-quality CPR has changed to demonstrate compressions and breaths, represented by the lungs, in recognition of the importance of breathing in resuscitation of pediatric cardiac arrest and a substantial minority of adult cardiac arrests such as those caused by drowning or opioid poisoning. The missing link from the 2025 Chain of Survival is prevention and preparedness. These actions are crucial both to avoid cardiac arrest and to equip systems to rapidly respond to it when it occurs, both of which are important steps in improving survival. The importance of prevention and preparedness is not lost on the 2025 Guidelines writing groups, but we have elected to defer the addition of this link until the concepts can be better defined and clarified in a dedicated scientific statement.

Organization of This Part Around the Chain of Survival

The SOC chapter provides recommendations across the entire Chain of Survival, and indeed the links of the Chain of Survival have been used to organize the contents of the knowledge chunks. In the following text, we review each link in further detail and discuss some of the contents of this Part, which relate to that link.

- **Prevention and preparedness:** The best outcome from a cardiac arrest is obtained by avoiding having the arrest and thus sparing the body from global ischemia and reperfusion injury. Predictive analytics using patient vital signs and other data offer the promise of providing early warning to avoid a cardiac arrest. Public access to naloxone permits reversal of opioid-induced respiratory arrest prior to progression to cardiac arrest. Preparedness for cardiac arrest includes having appropriate teams for high-acuity conditions (rapid response, shock, high-risk obstetric deliveries) and in- and out-of-hospital resuscitation, with corresponding training and quality improvement protocols in place. Individual and team training is addressed in "Part 12: Resuscitation Education Science"[5] and predelivery preparedness is the subject of "Part 5: Neonatal Resuscitation."[6]
  - **Relevant knowledge chunks:** Prevention of IHCA, Public Access Naloxone
- **Recognition and emergency activation:** Detecting the onset of cardiac arrest is increasingly possible through in-hospital monitoring and out-of-hospital wearable devices. Community initiatives to increase layperson recognition of OHCA and activation of EMS and layperson rescue are crucial first steps in resuscitation, which may be aided by telecommunicator recognition and instruction. The use of video technologies to supplement telephone communications may assist in recognition and activation.
  - **Relevant knowledge chunks:** Community Initiatives to Improve Layperson Response to OHCA, Telecommunicator Recognition of Cardiac Arrest, Telecommunicator-CPR (T-CPR) Instructions, T-CPR Quality Management, Video-Based Dispatch Systems
- **High-quality CPR** involves appropriate rate and depth of chest compressions with minimal interruptions.[7] In many cases, such as pediatric cardiac arrest or opioid-associated cardiac arrest, respiratory support through breaths or ventilation are also critical for successful resuscitation. Appropriate team composition, with defined roles and clinical debriefing

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and quality improvement, are crucial to optimize CPR efforts. Determining when to terminate OHCA resuscitation efforts or to transport patients still in cardiac arrest to the hospital is another important system question.
  - **Relevant knowledge chunks:** Clinical Debriefing, OHCA Team Composition, In-Hospital Code Team Composition, On-Scene OHCA Resuscitation
- **Defibrillation** should be provided promptly, aided by public access to AEDs whose location and delivery may be facilitated using mobile technologies or drones, all of which require appropriately designed SOC.
  - **Relevant knowledge chunks:** Community Initiatives to Improve Layperson Response to OHCA, Public Access Defibrillation
- **Advanced resuscitation interventions** including medications, advanced airway interventions, and extracorporeal CPR (ECPR) often necessitate system-level planning.
  - **Relevant knowledge chunks:** Extracorporeal CPR SOC
- **Post–cardiac arrest care**, including critical care interventions (eg, coronary angiography), targeted temperature management, and neuroprognostication, require expertise and systems that may be regionalized to centers of excellence.
  - **Relevant knowledge chunks:** Recommendation for Cardiac Arrest Centers, Extracorporeal CPR SOC
- **Recovery**, including effective support for physical, cognitive, emotional, and family needs, continues far beyond discharge from the hospital. Systems are needed to identify these needs and deliver support and, in the case of nonsurvival, to support organ donation, which may permit survival for others.
  - **Relevant knowledge chunks:** Organ Donation, Improving Cardiac Arrest Recovery

Use of Data for Continuous Improvement

Although the Chain of Survival emphasizes key elements in the care of an individual patient, it does not sufficiently emphasize steps that are necessary for improving future performance. Data collected through registries, such as AHA's Get With The Guidelines (for IHCA) and the Cardiac Arrest Registry to Enhance Survival (for OHCA) initiatives, have been critical to amassing the data needed to improve each link within the Chain of Survival. The goal is to become a learning health care system[8] that uses data to continually improve preparedness and resuscitation outcomes. Application of this concept to resuscitation SOC has been previously supported and is ongoing in many resuscitation organizations.[9,10]

- **Relevant knowledge chunks:** Data Registries to Improve System Performance

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PREVENTION OF IHCA

Recommendations for Prevention of IHCA		
COR	**LOE**	**Recommendations**
2a	**B-R**	1. Early warning score (EWS) systems can be beneficial to detect clinical deterioration, prompt an assessment, and facilitate intervention or transfer to a higher level of care.
2a	**B-NR**	2. Rapid response teams (RRTs) or medical emergency teams (METs) can be effective in reducing the incidence of cardiac arrest, particularly in general care wards.
2a	**B-NR**	3. Implementation of safety huddles to improve situational awareness of high-risk hospitalized patients and mitigate deterioration can be effective in reducing cardiac arrest rates.

Synopsis

Survival to hospital discharge after IHCA is approximately 19% for adults and 40% for children.[1] Survival

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is improved when IHCA occurs in a monitored setting, such as an intensive care unit.[2,3] Expert panels adjudicating adult IHCA and prevention initiatives in pediatric IHCA have suggested that a proportion of IHCAs are indeed preventable by recognizing and dedicating resources to the deteriorating patient.[4–6] Teams such as RRTs and METs are intended to evaluate and provide therapies to rescue and triage patients experiencing clinical decline to a higher level of care (eg, from the general hospital ward to the intensive care unit). Additionally, EWS systems incorporate patient characteristics, vital signs, and other physiologic parameters in an effort to identify patients at risk for clinical deterioration prior to IHCA; EWSs may trigger RRT/MET automated responses. The RRT, EWS, and cardiac arrest prevention quality improvement initiatives (eg, safety huddles for high-risk patients) have been adopted by hospitals in an effort to prevent IHCA. Variability in the structure and function of these systems has likely contributed to the inconsistency in reported outcomes regarding efficacy of these interventions. The potential benefits of RRTs, EWSs, or prevention bundles are unlikely to be impacted by patient age; therefore, these recommendations are intended to apply across the pediatric and adult age spectrum.

Recommendation-Specific Supportive Text

1. In a multicenter, international cluster randomized trial, implementation of the bedside pediatric EWS was associated with a decrease in clinically important deteriorations on the wards of nontertiary care hospitals but not with all-cause mortality.[7] A recent systematic review identified a statistically significant increase in unplanned code events when a pediatric EWS was not utilized. This analysis also noted trends demonstrating decreased cardiac arrest events and mortality associated with EWS use.[8] Additionally, a recent prospective multicenter cohort study in Latin America demonstrated that pediatric EWS implementation was associated with reduced rates of cardiac arrest and clinical deterioration–related mortality in pediatric patients with cancer.[9] In adults, 2 recent observational studies reported contrasting findings about the ability of EWSs to reduce IHCA,[10,11] which parallels earlier inconsistencies in adult studies.[12] Artificial intelligence and machine learning algorithms are currently being developed to predict clinical deterioration in hospitalized patients. These technologies may improve detection and prevent clinical deterioration better than current systems; however, additional validation and mitigation of bias from the algorithms is warranted.[13–16]
2. The evidence supporting the efficacy of RRT/MET systems in reducing IHCAs or hospital mortality remains mixed, but their use is widespread and recommended by multiple organizations, which limits the prospect of future randomized studies.[17–21] The RRT/MET systems have been associated with reductions in hospital mortality and cardiac arrest rates in both pediatric and adult populations.[22–24] However, 1 observational registry study of 38 pediatric hospitals found no difference in risk-adjusted mortality rates associated with RRT/MET implementation.[25] Variation in RRT structure and function may drive these observed differences in outcomes, and a better understanding of best practices is needed.[26]
3. A prospective, observational, multicenter quality improvement project demonstrated a 30% reduction in risk-adjusted IHCA rates in pediatric cardiac intensive care units of hospitals that implemented a cardiac arrest prevention bundle.[4] A similar single-center quality improvement initiative aimed at improving situational awareness and mitigating deterioration of high-risk patients admitted to the pediatric intensive care unit reduced IHCA rates by 52%.[27] Both studies incorporated care team safety huddles on high-risk patients to discuss monitoring and preparedness for deterioration to prevent progression to cardiac arrest. Neither study observed a reduction in mortality. A similar initiative in hospitalized adult patients in the intensive care unit did not reduce cardiac arrests, but the successes observed in pediatrics are likely to generalize to adults with proper intervention design and utilization.[28]

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PUBLIC ACCESS NALOXONE

Recommendations for Public Access Naloxone		
COR	**LOE**	**Recommendations**
1	B-NR	1. Public policies should allow for possession, use, and immunity from civil and criminal liability for good faith administration of naloxone by lay rescuers.
2a	B-NR	2. Naloxone distribution programs can be beneficial to increase naloxone availability among lay rescuers and decrease mortality from opioid-related overdose.

Synopsis

Opioid-related overdoses continue to represent a major public health concern in the United States.[1] An estimated 1 in 6 to 1 in 3 OHCAs are related to an overdose, most commonly involving opioids.[2–4] One common public health harm reduction strategy to decrease opioid-related overdose mortality is increasing access to naloxone in the community, also known as public access naloxone (PAN). Naloxone is an opioid antagonist that is used to reverse respiratory depression due to opioid overdose.[5] In March 2023, the first over-the-counter naloxone product was approved for use in the United States.[6] Presently, naloxone nasal spray is the only over-the-counter formulation available for public distribution in the United States. While the dosage is intended for adults, pediatric postmarketing data have not revealed adverse events when it is used in children.[7] Despite the availability of naloxone over the counter, cost remains a barrier to access and not all states have legislation

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to support and protect its use by lay rescuers,[8,9] though all states and Washington, DC, have laws increasing access to naloxone.[10] Legislation may permit coprescribing of naloxone with opioid prescriptions or decriminalization of distribution, possession, and administration of naloxone. Beyond legislation, specific PAN strategies include naloxone distribution programs, naloxone vending machines, and stationing of naloxone in public settings (similar to AED cabinets).[11–14] No evidence has been found to suggest that PAN increases opioid use or opioid-related overdoses in the community.[15,16] Secondary prevention measures include provision of naloxone by emergency departments and EMS after a nonfatal opioid-related overdose.[17]

Recommendation-Specific Supportive Text

1. Four observational studies[18–21] were found that examine the effect of naloxone access laws on opioid-related overdose mortality. Two[18,19] demonstrated that legislative changes making naloxone available without a prescription were associated with decreased opioid-related overdose mortality on a population level. One study identified an increase in opioid-related overdose deaths following implementation of naloxone access laws.[21] One study found differing changes in opioid-related overdose mortality based on US region (Northeast versus West) with the implementation of laws allowing lay rescuer distribution; however, possession laws (ie, allowing lay rescuers to carry naloxone without a prescription) were associated with decreased mortality.[20] The ecological design of these studies poses challenges in assessing causality, as the increase in deaths may reflect general increases in opioid-related overdoses and deaths in a community rather than an effect attributable to naloxone access legislation. The potential benefit at a population level of increasing access to this effective, lifesaving medication was deemed by the writing group to greatly outweigh the risks.
2. There has been inconsistent evidence of the effect of PAN on opioid-related overdose mortality, depending on mode of naloxone access (ie, law versus distribution program), region studied, and time frame. Most studies have examined individual opioid education and naloxone distribution programs or used an ecological design to estimate the population-level effect. Six observational studies[22–27] were found that examine the effect of community-based naloxone distribution programs, where naloxone was provided without a patient-specific prescription, on opioid-related overdose mortality. Four studies[22–25] found a decrease in opioid-related overdose mortality following program implementation, with evidence of a dose-dependent effect. However, 2 additional studies[26,27] found either no significant difference after program implementation or an increase in the number of opioid-related deaths per month. As these studies were ecological, causality cannot be inferred. The increase in deaths may, again, reflect secular trends of opioid-related overdose burden in the community. There also remains a lack of direct evidence regarding the effect of PAN on survival after opioid-associated OHCA.

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COMMUNITY INITIATIVES TO IMPROVE LAY RESCUER RESPONSE TO OHCA

Recommendations for Community Initiatives to Improve Lay Rescuer Response to OHCA		
COR	**LOE**	**Recommendations**
2a	**B-NR**	1. Implementing a bundle of community initiatives is a reasonable strategy to improve lay rescuer response to OHCA.
2a	**B-NR**	2. Increasing the availability of instructor-led training in communities can be effective to improve lay rescuer response to OHCA.
2a	**B-NR**	3. Mobile technologies to summon responders to nearby OHCA events is a reasonable strategy to increase timely lay rescuer CPR and AED use.
2b	**C-LD**	4. Mass media campaigns may be considered to promote learning of CPR skills in all populations.
2b	**C-LD**	5. It may be reasonable for communities to implement policies that require CPR certification in the general public.

Synopsis

Early CPR and defibrillation are staples of the Chain of Survival. Despite the recognized role of lay rescuers in improving OHCA outcomes, most communities still experience low rates of lay rescuer CPR and AED use. Community awareness of cardiac arrest and response by providing CPR play key roles in shaping survival. Interventions at the community level to improve awareness and responsiveness by lay rescuers include initiatives such as instructor-led training (eg, classes), mobile technology to summon the public, mass media campaigns (eg, social media and television advertisements), and legislative policies for CPR training. Community interventions exist at the local, state, regional, or national level and may involve collaboration between government and organizations. Interventions are most likely to be successful when taking into context the patient population, geography, and other cultural factors and when implemented with other interventions to optimize resuscitation.

Recommendation-Specific Supportive Text

1. Ten observational studies evaluated the impact of bundled interventions on lay rescuer CPR rates and survival outcomes.[1–9] Lay rescuer CPR rates were improved in 7 of these studies.[1–3,5–8] Interventions included classes taught in person in schools, workplaces, and the community; videos watched asynchronously; and public messaging through various forms of media.
2. Nine observational studies assessed the impact of instructor-led training.[10–18] Three of 5 studies found improvement in survival with good neurological outcomes after implementation of instructor-led training.[11,12,15,17,18] Two of 3 studies reported improvements in survival to hospital discharge,[11,13,18] and 1 study demonstrated an improvement in ROSC after instructor-led training.[13] Instructor-led training improved lay rescuer CPR rates by 10% to 19% in 5 studies.[10–14]
3. The 2020 AHA guidelines reviewed 6 observational studies and 1 randomized controlled trial (RCT) and found uniformly positive data supporting the use of mobile technologies to summon lay rescuers for CPR.[19] Thirteen new observational studies[20–32] and 1 new RCT[33] were identified. Twelve studies examined a period when mobile technology was in place without a comparison period. One study compared the implementation of mobile technology with a retrospective cohort. There was universal improvement in rates of bystander CPR when a mobile technology alert was accepted by a lay rescuer but inconsistent data on the incidence of ROSC and survival. Studies with improved survival (4/13) were associated with higher population

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density and high acceptance of the alert by lay rescuers.[23] The SAMBA trial randomized mobile technology to test implementation of deployment strategies for directing lay rescuers to the patient location versus nearest available AED first. The primary outcome of AED attachment was not significantly higher in the group directed to AEDs first (13.2% versus 9.5%, *P*=0.08); there were also no significant differences in rates of lay rescuer CPR or defibrillation.[30]

4. One observational study reported a 12% absolute increase in lay rescuer CPR rates during a campaign of television advertisements promoting lay rescuer CPR.[34] The durability of this improvement was not assessed. However, mass distribution (via mail) of a 10-minute CPR instructional video to 8659 households resulted in no significant improvement in lay rescuer CPR rates when compared with a community with households that did not receive a video (47% in intervention households, 53% in controls).[35]
5. Two studies looked at the effectiveness of laws requiring CPR certification either to graduate high school or to receive a driver's license. Both studies showed increases in lay rescuer CPR and survival to hospital discharge.[36,37]

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TELECOMMUNICATOR RECOGNITION OF CARDIAC ARREST

Recommendations for Telecommunicator Recognition of Cardiac Arrest

COR	LOE	Recommendations
1	C-LD	1. If the patient is unresponsive with abnormal, agonal, or absent breathing, the telecommunicator should assume that the patient is in cardiac arrest.
1	C-EO	2. Telecommunicators should determine the location of the event before questioning to identify OHCA, to allow for simultaneous dispatching of EMS response.

Synopsis

Emergency telecommunicators serve as a critical link in the OHCA Chain of Survival, improving early cardiac arrest recognition and provision of lay rescuer CPR while sending EMS resources to the scene. Telecommunicators must quickly diagnose OHCA using verbal descriptions from callers and other auditory cues, which may be vague, incomplete, and even contradictory.[1] Rates of telecommunicator cardiac arrest recognition vary substantially across systems, ranging from 46% to 98%.[1] Recognition of cardiac arrest has been linked to multiple factors related to patients, callers, and telecommunicators.[2] The most consistent challenges to telecommunicator cardiac arrest recognition are the misinterpretation of agonal breathing[2,3] and, to a lesser extent, misclassification of OHCA and seizures.[2] Cardiac arrest is unrecognized more often in children and adolescents.[4] Various algorithms have been implemented to optimize telecommunicator recognition of cardiac arrest.

Recommendation-Specific Supportive Text

1. When a caller describes an individual as unresponsive with absent or abnormal breathing, concluding that the person is experiencing OHCA maximizes sensitivity of detection and permits immediate provision of T-CPR instructions.[5,6] To address the variation in OHCA presentations, telecommunicators require training to identify OHCA across a broad range of circumstances, including agonal gasping and brief myoclonus.[7] Asking the 2 scripted questions from the No-No-Go process (Figure 3) to determine if an

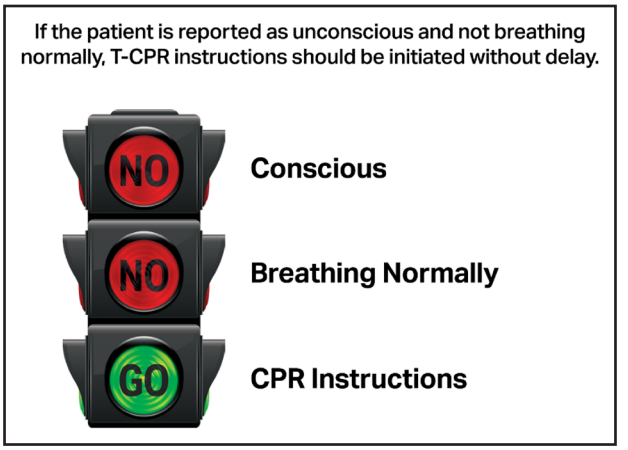

Figure 3. The No-No-Go Mnemonic for Initiation of Bystander CPR.
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individual is unresponsive with abnormal breathing positively identifies 92% of people suffering OHCA.[7] Time to first compression is strongly associated with survival from OHCA.[8] The writing group believes that the benefit of early recognition of OHCA and provision of timely chest compressions outweighs the risk of providing CPR to a person not in cardiac arrest.

2. It is critical to first obtain location information when receiving an emergency call (ie, a 911 call) to permit the dispatch of appropriate emergency medical response while additional information is being obtained and CPR instructions are being provided.[9] This permits a response to be mobilized even if the call is disconnected prematurely.

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T-CPR INSTRUCTIONS FOR PERSONS WITH SUSPECTED CARDIAC ARREST

Recommendations for T-CPR Instructions for Persons With Suspected Cardiac Arrest

COR	LOE	Recommendations
1	A	1. T-CPR instructions for adult OHCA should advise compression-only CPR consistent with adult BLS guidelines.
1	C-LD	2. Telecommunicators should instruct callers to initiate CPR for individuals with suspected OHCA.
1	C-LD	3. T-CPR instructions for infants and children experiencing OHCA should advise conventional CPR with breaths consistent with pediatric BLS guidelines.

Synopsis

Rates of lay rescuer CPR remain low for adults and children.[1] T-CPR instructions are verbal guidance given by emergency telecommunicators to callers that guide CPR. After identifying cardiac arrest by asking the caller whether the patient is responsive and breathing normally, telecommunicators can provide step-by-step instructions for initiating CPR, including how to position the patient, where to place hands for chest compressions, and coaching to maintain the correct rhythm and depth of compressions. Common types of T-CPR instructions include conventional CPR, which includes chest compressions and breathing, or compression-only CPR. T-CPR instructions are vital to increase rates of lay rescuer CPR and bridge the gap between the onset of cardiac arrest and the arrival of EMS.

Recommendation-Specific Supportive Text

1. While recent observational studies have reported improved neurologically intact survival outcomes with conventional CPR in adults,[2] these studies are vulnerable to selection bias and confounding. Three randomized trials comparing T-CPR compression-only CPR with conventional CPR instruction in adults trended toward better survival with compression-only CPR instructions.[3–5] In a pooled analysis of these data, the improvement in survival was significant (risk ratio, 1.22; 95% CI, 1.01–1.46) with a number needed to treat of 41 (95% CI, 20–1250).[6] In one of these RCTs, compression-only instructions were delivered 1.4 min faster and more likely to be delivered completely by the telecommunicator.[3] It is noteworthy that the adult OHCA RCTs largely predate the rise in overdose-associated OHCA seen in the past decade.
2. In 3 adjusted observational studies, T-CPR instructions were associated with a greater than 5 times likelihood of provision of lay rescuer CPR[7–9] and

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CPR was initiated 7 minutes sooner[8] compared with no T-CPR instructions. The delivery of lay rescuer CPR before the arrival of EMS was associated with survival and favorable neurological outcome in 6 observational studies.[7,8,10–13] In 2 studies, offering T-CPR was associated with improved favorable neurological survival 1 month after discharge, even after adjustment for multiple variables.[8,11] Based on these data, the AHA has recommended T-CPR instructions and provided resources to help implement these systems.[14]

3. Pediatric OHCAs are mostly of asphyxial etiology.[15] Large observational studies comparing compression-only CPR to CPR with breaths have consistently shown improved outcomes associated with CPR that includes breaths.[16–19] In some cases, conventional CPR was provided despite T-CPR instructions to provide compression-only CPR, which calls into question the possibility of significant selection bias.

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T-CPR QUALITY MANAGEMENT

Recommendation for T-CPR Quality Management		
COR	**LOE**	**Recommendation**
1	**B-NR**	1. Telecommunicator recognition of cardiac arrest and T-CPR instructions should be reviewed and evaluated as part of an EMS system quality management process.

Synopsis

Quality management programs are essential for ensuring that telecommunicators consistently identify cardiac arrest and deliver effective CPR instructions. Quality management encompasses both quality assurance activities where cases are retrospectively reviewed and quality improvement activities where proactive changes are made to the system to achieve meaningful improvements. Key metrics include assessing how quickly and accurately cardiac arrest is recognized, time to first instructed compression, the clarity and completeness of

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CPR instructions, appropriate coaching on compression depth, chest recoil and patient positioning, and adherence to established protocols.[1] A complete list of resuscitation variables desirable to review in OHCA quality management[2] and in evaluating CPR quality[3] is provided elsewhere. Quality management programs seek to optimize telecommunicator metrics by identifying gaps in performance and providing targeted coaching, with the ultimate goal of increasing survival rates from cardiac arrest.

Recommendation-Specific Supportive Text

1. Successful T-CPR programs incorporate a robust quality management process, including review of OHCA calls, to ensure that T-CPR is being provided as broadly, rapidly, and appropriately as possible.[4,5] Applied quality improvement initiatives have been shown to increase rates of telecommunicator cardiac arrest recognition.[6,7]

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VIDEO-BASED DISPATCH SYSTEMS

Recommendation for Video-Based Dispatch Systems		
COR	**LOE**	**Recommendation**
2b	**B-NR**	1. Video-based dispatch systems for OHCA response may be reasonable in systems with such capabilities.

Synopsis

T-CPR is currently provided in many communities through a standard telephone audio call. Mobile technology has become ubiquitous, and the use of video calling technology has become more generalized. Video-based T-CPR may allow the telecommunicator to see the caller in real time, to better assess the scene and patient's condition, to coach the caller through the response, and to provide feedback on CPR performance. Video calls are more invasive, may require more cooperation from the caller, and may need multiple rescuers on scene to be effective. Video-based dispatch systems have additional costs for implementation, which may be prohibitive in some countries, and the cost-benefit of these systems has not been fully described.

Recommendation-Specific Supportive Text

1. Simulation studies have consistently shown improved CPR quality using video-based T-CPR compared with traditional audio instruction,[1] but RCTs are lacking.[1,2] Three observational studies,[3–5] 19 randomized simulation studies,[6–24] and 4 systematic or scoping reviews[25–28] compared a video-based dispatch system for OHCA with an audio-based system or no assistance. Two observational studies reporting patient outcomes[4,5] favored video-based T-CPR over conventional T-CPR for prehospital ROSC (pooled odds ratio OR, 2.33; 95% CI, 1.87–2.88), survival to hospital discharge (pooled OR 2.33, 95% CI, 1.87–2.91), and good neurological outcome (pooled OR, 2.77; 95% CI, 2.14–3.59).[2] However, because a video-capable smartphone and at least 2 bystanders were needed, less than 20% of participants received video-based T-CPR in these studies. Among simulation studies, video-based T-CPR consistently improved CPR quality compared with audio-only T-CPR,[25] including for untrained rescuers and simulated pediatric patients. One observational study reporting on CPR quality before and after video instruction found improved hand position, rate, and depth.[3] Some studies reported delays to first compression with video calls; however, the more recent observational studies have not reproduced this concern,[4,5] potentially due to improved telecommunicator protocols and technology. Generalizability of protocols and dispatcher training to US-based systems and barriers to implementation are unclear.

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CLINICAL DEBRIEFING

Recommendations for Clinical Debriefing		
COR	**LOE**	**Recommendations**
2a	**B-NR**	1. Performance-focused debriefing of rescuers after cardiac arrest can be effective for resuscitation improvement programs.
2a	**B-NR**	2. Review of objective and quantitative resuscitation data can be effective in improving the quality of postevent debriefing for adults and children.
2a	**C-LD**	3. It is reasonable for debriefings to be facilitated by health care professionals familiar with established debriefing processes.
2a	**C-EO**	4. Incorporating immediate and delayed debriefing is reasonable and may identify different opportunities for system improvement.

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Synopsis

Postevent clinical debriefing is defined as "a reflective conversation about performance and may include processed select performance data" with the goal of improving future clinical practice.[1] Feedback is defined as "information about the performance compared with a standard" delivered in real time. During debriefing, resuscitation team members may identify systems issues that include process and quality of care (eg, algorithm adherence); review quantitative data collected during the event (eg, CPR metrics); reflect on teamwork, communication, and performance of specific roles; and address emotional responses to the event.[2–6] A facilitator, typically a health care professional, leads a discussion focused on identifying opportunities and strategies for improving performance.[2,7] Debriefings may occur either immediately after a resuscitation event (hot debriefing) or at a later time, at least a day to weeks later (cold debriefing).[3,8,9] Some debriefings take the form of personalized reflective conversations, while others involve group discussion among a larger, multidisciplinary resuscitation team.[5,7] We focused on postevent clinical debriefing excluding critical incident stress debriefing (ie, psychological debriefing). Data-informed debriefing of professionals after cardiac arrest has potential benefits for both IHCA and OHCA SOC.[6,10,11] Structured debriefing and continuous feedback play complementary roles in enhancing CPR performance and outcomes in both prehospital and hospital settings.[12,13]

Recommendation-Specific Supportive Text

1. Debriefing following cardiac arrest is a critical practice that enhances team performance, supports rescuers, and ultimately leads to improved patient outcomes.[14] A systematic review and meta-analysis compared real-time or postevent feedback with no real-time or postevent debriefing for adults with OHCA and found that feedback and postevent debriefing, when combined, improve CPR quality (compression depth, rate and fraction) and outcomes (ROSC and survival).[12] Four prospective observational studies of post-IHCA debriefing among multidisciplinary resuscitation team members showed mixed results.[6,9,10,15] A systematic review of these studies demonstrated improved ROSC and mean chest compression depth in the period after implementation of a bundle of care that included evaluation of CPR quality, feedback, and debriefing.[15,16] In a survey of hospital resuscitation practices linked to data and outcomes from hospitals within the Get With the Guidelines national registry, there was no association between debriefing frequency and adherence to CPR measures such as defibrillation and epinephrine administration.[17]
2. Because health care professional's recall of events and self-assessment of performance are often poor, the objectivity and quality of debriefings improve when supplemented with quantitative data on CPR performance. Data elements associated with improved clinical debriefing quality include chest compression rate, depth, and fraction; telemetry and defibrillator tracings; end-tidal CO_2 tracings; and resuscitation record review.[6,10,18,19]
3. In all studies reviewed, debriefings were facilitated by health care professionals familiar with the recommended debriefing process or structure, who in some cases were supported by use of a cognitive aid[5] or checklist.[5,16,20] Discussions were tailored to participant type and group size and were individualized to the nature of performance during the event. Interdisciplinary debriefing in intensive care units may improve survival outcomes and foster better teamwork.[8,13]
4. Studies have not directly compared hot versus cold debriefing. Both are recommended because each may bring out different information. Hot debriefings benefit from closer temporal proximity of the event and may foster effective teamwork. Cold debriefing provides the opportunity to review the data systematically and incorporate additional perspectives.

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OUT-OF-HOSPITAL CARDIAC ARREST TEAM COMPOSITION

Recommendations for OHCA Team Composition		
COR	**LOE**	**Recommendations**
2a	**B-NR**	1. It can be beneficial to have an advanced life support–level clinician present during the resuscitation of a person with suspected OHCA.
2a	**B-NR**	2. It is reasonable to ensure that EMS systems have a team size sufficient to achieve discretely assigned roles within the team.

Synopsis

Resuscitation in the prehospital environment is a unique and complex undertaking that requires a cross-functional, highly trained team of professionals.[1–3] The makeup of this team, from education level to experience, plays a significant role in how the team performs and the outcomes of the cardiac arrest patient.[3–5] Most studies on prehospital team composition focus on team dynamics and guideline adherence. Increasingly, there is interest in adoption of a "pit crew" model, in which team members fill defined roles in parallel to achieve an efficient and meticulous resuscitation.[6] While guideline adherence is a commonly used outcome, achieving favorable patient outcomes such as neurologically intact survival is more important and was prioritized in crafting our recommendations. First responders to OHCA may be police or fire fighters trained in BLS and AED use supplemented by BLS or advanced cardiac life support (ACLS)-trained EMS professionals. The number of responders available may be dependent on resources within the community as well as population density (urban versus rural). In systems with limited human resources, the use of mechanical chest compression devices and ventilators may assist prehospital professionals, but no data support superiority over an adequately staffed team.

Recommendation-Specific Supportive Text

1. Eighteen studies examined the effect of having an ALS-level clinician at the scene of an OHCA.[2,5–21] While there remains no consensus regarding the number of ALS clinicians (ie, paramedics or advanced emergency medical technicians) on scene that is beneficial or the specific interventions ALS clinicians performed that increased survival, the presence of an ALS clinicians was consistently associated with favorable neurologically intact survival to hospital discharge.[2,5–21]
2. Five retrospective[5,7,12,20,21] and 2 prospective observational studies[6,14] specifically examined the number and roles of prehospital professionals present at OHCA events and their correlation to neurologically intact hospital survival. These studies observed a consistent pattern of improved outcomes correlated to the inclusion of additional ALS clinicians; however, team size in general appeared most important because it permitted specific roles to be assigned like in a pit crew model. Much of the correlation with favorable outcomes was associated with better provision of BLS, such as high-quality CPR and shorter time to defibrillation. Various clinician configurations were explored within these studies and found to be successful; thus, systems have the opportunity to develop creative and

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innovative ways to obtain adequate team size using resources such as fire departments, community initiatives, and law enforcement.

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IN-HOSPITAL CODE TEAM COMPOSITION AND TRAINING

Recommendations for In-Hospital Code Team Composition and Training		
COR	**LOE**	**Recommendations**
1	B-NR	1. In-hospital code teams should comprise members with ALS training.
2a	B-NR	2. Designated or dedicated code teams with clearly defined roles, diverse expertise, and adequate training incorporating simulation can be beneficial in improving patient outcomes following IHCA.

Synopsis

For patients with IHCA, prompt initiation of CPR and early defibrillation is lifesaving.[1] Accordingly, hospitals throughout the world devote considerable resources for deploying resuscitation or code teams that can promptly initiate resuscitative efforts for patients in cardiac arrest.[2,3] Clinicians have the option to obtain ACLS training through courses like ACLS and pediatric ALS. Hospitals must determine the roles to be filled by members of the code team with recent articles comparing this model to the efficient and highly choreographed actions of a race car pit crew.[4] There is considerable variation in IHCA survival between hospitals[5] with variable adherence to ACLS and pediatric ALS. The structure, composition, training, and practices of code teams vary markedly across hospitals, including differences in how communication and leadership are incorporated.

Recommendation-Specific Supportive Text

1. Teamwork and leadership training have been incorporated in many aspects of patient care and resuscitation skills. Training in ACLS or pediatric ALS has been shown to be associated with higher-quality CPR and patient outcomes.[6,7] Advanced life support training focuses both on technical and nontechnical skills, however, there remains a lack of data on patient-specific outcomes that may reflect

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the different methods applied to behaviors and leadership skills.[6] A systematic review of 7 studies involving patient outcomes after participants took structured ALS courses that focused on leadership training found a low certainty of evidence that teamwork and leadership training improved IHCA outcomes.[8] Effective leadership is critical in resuscitation contexts, with various studies identifying specific leadership behaviors and skills that correlate with improved patient outcomes.[9,10] However, a survey of hospitals participating in a US registry found no association between adult resuscitation team leadership (physician, physician trainee, or nonphysician) with hospital's risk-standardized survival.[9,11]

2. Resuscitation teams at hospitals with high IHCA survival tend to include hospital staff with either limited (designated team) or no other clinical responsibilities (dedicated team), ensuring consistency of clinical expertise and teamwork during resuscitation events.[11] Moreover, including team members from diverse disciplines (eg, pharmacists) during resuscitation efforts can enhance compliance with ACLS guidelines, suggesting that interdisciplinary collaboration may improve resuscitation care quality.[12,13] Implementing structured simulation and training with specific role assignments (ie, the pit crew model) significantly improves CPR quality and is associated with improved survival.[4,13,14]

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ON-SCENE OHCA RESUSCITATION

Recommendations for On-Scene OHCA Resuscitation		
COR	**LOE**	**Recommendations**
1	**B-NR**	1. EMS systems should be prepared to perform termination of resuscitation (TOR) on scene, including death notification training for EMS professionals.
2a	**B-NR**	2. Prioritizing on-scene resuscitation focused on achieving sustained ROSC prior to initiation of transport for most adults and children experiencing OHCA can be beneficial in the absence of special circumstances.

Synopsis

EMS systems play a central role in OHCA SOC and emphasize delivery of high-quality resuscitation in the field. However, practices for managing OHCA vary across communities, particularly regarding decisions about when to transport patients to a medical center—whether during ongoing resuscitation efforts or after achieving sustained ROSC. Transporting patients during active resuscitation can compromise the quality of CPR provided[1,2] and introduce safety risks for both patients and EMS clinicians.[3,4]

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It is also known that EMS transport under emergency settings (ie, lights and sirens) is associated with an increased risk of motor vehicle collisions.[5] On-scene resuscitation often ends with field TOR, requiring that EMS clinicians perform death notifications. Death notification training, which teaches skills for communication and providing families with resources, improves the confidence and competence of EMS personnel.[6] The ethics of TOR in adults is discussed elsewhere (refer to "Part 3: Ethics").[7] Emerging evidence indicates that select patients with OHCA might benefit from early transport to a facility capable of providing ECMO. Specific recommendations regarding ECMO are detailed in a separate section of the guidelines. Additional examples may be found where remaining on scene is less beneficial, such as the example of circulatory arrest due to trauma. These exceptions should be made on a case-by-case basis.

Recommendation-Specific Supportive Text

1. Field TOR provides an ethical framework for resource triage, enhances clinician and community safety by reducing unnecessary lights-and-siren transports, and alleviates additional distress for grieving survivors.[8] Both pediatric and adult TOR clinical decision rules have demonstrated reliability in determining when continued resuscitation efforts are unlikely to succeed.[8,9] EMS systems implementing TOR protocols, particularly for pediatric patients, should collaborate with local government and community stakeholders to address and mitigate concerns regarding public perception. Proper training for EMS clinicians in TOR and death notification has been associated with reduced burnout and improved emotional resilience in navigating these challenging situations.[10]
2. In secondary analyses of the Resuscitation Outcomes Consortium, intra-arrest transport was not linked to improved survival in adults or children.[11–13] Survival to discharge was twice as high without intra-arrest transport in adults[12] and infants aged under 1 year old.[13] Higher agency rates of intra-arrest transport were associated with a stepwise decrease in survival.[11]

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PUBLIC ACCESS DEFIBRILLATION

Recommendation for Public Access Defibrillation		
COR	**LOE**	**Recommendation**
1	B-NR	1. We recommend that public access defibrillation (PAD) programs be implemented in communities at high risk of OHCA.

Synopsis

Early defibrillation significantly increases survival rates from OHCA.[1–4] Studies have found that lay rescuer application of an AED is associated with improved survival to hospital discharge and 30-day and 1-year survival after OHCA, including studies in children.[5–18] Public access defibrillation (PAD) programs are designed to reduce time to defibrillation by placing AEDs in public places and training community members in how to use them. Prior literature on PAD includes studies that (1) examined the effectiveness of a public AED program (ie, PAD program) in communities to improve OHCA outcomes and (2) examined

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the association of lay rescuer AED application with OHCA survival compared with defibrillation performed by EMS. The writing committee focused the current review on studies that examined the effectiveness of a PAD program in improving OHCA survival. Despite widespread implementation of AEDs in public spaces, use of public access defibrillators by lay rescuers remains low.[12,19]

Recommendation-Specific Supportive Text

1. In the PAD Trial implementation of a structured emergency response system that included training of lay volunteers in CPR and AED use led to a doubling of OHCA survival compared with CPR training alone (30 survivors in 107 arrests versus 15 survivors in 128 arrests, respectively; risk ratio, 2.0; 95% CI, 1.07–3.77; *P*=0.03).[20] These findings are also supported by multiple observational studies and systematic reviews.[21,22] Although the quality of evidence from observational studies remains low, these studies have found improved rates of survival to discharge,[5,7,10] 30 days,[6,8,9,11,13,14] and 1 year,[7] including studies in children.[11,15–17] The 2022 ILCOR scientific statement on PAD addresses key interventions (early detection, optimizing availability, signage, novel delivery methods, public awareness, device registration, mobile apps for AED retrieval, and personal access defibrillation).[23] The incremental cost-effectiveness ratio of PAD has ranged from US $37 200 to $1 152 400 per quality-adjusted life-year,[22] whereas a recent study found a high probability that public AEDs are cost effective at traditional willingness to pay thresholds of up to $150 000 per quality-adjusted life year.[24]

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RECOMMENDATION FOR CARDIAC ARREST CENTERS

Cardiac Arrest Centers		
COR	**LOE**	**Recommendation**
2b	B-R	1. Transport of resuscitated patients to specialized cardiac arrest centers when comprehensive postarrest care is not available at local facilities may be reasonable.

Synopsis

Regionalized coordination of care improves outcomes for acute critical conditions, such as ST-segment elevation myocardial infarction[1] and cerebrovascular ischemic events.[2] Expedited transfer to a center capable of providing specialized interventions, such as primary percutaneous coronary intervention, provides incremental benefit over care at the nearest hospital that cannot provide such care.[3] Analogous pathways for cardiac arrest patients have been proposed in the form of cardiac arrest centers (CACs). These CACs lack universal definitions but most commonly have been defined as those with around-the-clock temperature control and percutaneous coronary intervention capability and less consistently as centers with access to formal neuroprognostication protocols, mechanical circulatory support, and hemodynamic targeted protocols. Alternatively, CACs have been defined based on the volume of cardiac arrest cases. Studies of CACs also vary on setting (rural versus urban) and whether transport to the CAC occurs at the time of arrest or by subsequent interfacility transport. Transport of acutely resuscitated persons to a CAC must weigh the potential benefit of a higher level of care against risk of decompensation during transport and subsequent distance from loved ones.

Recommendation-Specific Supportive Text

1. We identified 1 new RCT that demonstrated no difference in 30-day all-cause mortality when patients were transported to designated CACs—defined as centers that had around-the-clock availability of interventional cardiology, cardiac surgery, and specialist intensive-care facilities—compared with the geographically closest emergency department.[4] This trial was conducted in a metropolitan area, and control hospitals were high-functioning, providing temperature control, delayed neuroprognostication, and protocolized hemodynamic management. The findings of this RCT contrast with observational studies that have demonstrated benefit associated with regionalized CACs.[5,6] Three new systematic reviews of observational studies demonstrated improved neurologically favorable survival with care provided at CACs of varying definitions.[7–9] No studies have identified specific components of a CAC associated with clinical benefit, and several components used to define CACs have not demonstrated benefit when studied in isolation. These interventions include temperature control[10] or immediate coronary angiography in patients without ST-segment elevation myocardial infarction.[11–15] The association between CAC volume and outcomes also varies.[16–18] Additional observational studies found greater benefit of direct[19] or interfacility transport[17] to CACs when the patient was coming from a smaller population center or lower-volume emergency room.

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EXTRACORPOREAL CPR SOC

Recommendations for ECPR SOC		
COR	**LOE**	**Recommendations**
2a	**C-LD**	1. It is reasonable that centers with ECPR programs develop and frequently reassess patient selection criteria to maximize cardiac arrest survival, ensure equitable access, and limit futility.
2a	**C-LD**	2. It is reasonable that clinicians performing adult peripheral ECPR cannulation be experienced in percutaneous technique.
2a	**C-LD**	3. A regionalized approach to ECPR is reasonable to optimize outcomes and resource utilization.
2b	**B-R**	4. Rapid intra-arrest transport for the purposes of ECPR may be considered for limited, highly selected adult OHCA patients.

Synopsis

The use of ECMO for refractory cardiac arrest, or ECPR, has grown substantially[1] and may benefit selected patients with IHCA or OHCA.[2] Many of the SOC needed to support ECPR are similar regardless of whether cases result from IHCA or OHCA. Present guidelines recommend the use of ECPR "in select patients when provided within an appropriately trained and equipped system of care."[3] However, RCTs of ECPR, recruiting exclusively adult OHCA patients, have shown mixed results.[4–7] This heterogeneity in outcomes may be related to differences in the SOC, patient selection, center experience, and trial design across studies. Extracorporeal CPR is a highly resource-intensive intervention that requires significant experience and expertise in both the cannulation process and specialized intensive care management and is associated with a high rate of morbidity and mortality.[2,8–11] The ethics of patient selection, equitable distribution, and resource allocation are discussed elsewhere (refer to the Advanced Therapies section in "Part 3: Ethics").[12]

Recommendation-Specific Supportive Text

1. Patient selection for ECPR affects survival and program success. Prudent patient selection with defined inclusion criteria is necessary so that all individuals with potential benefit from the therapy are considered while clear exclusion criteria ensure mindful resource utilization and avoidance of aggressive and costly therapy in futile circumstances.[13] Considerations for patient selection may differ between IHCA and OHCA. No specific criteria can be recommended with the current state of evidence, but patient characteristics that have been associated with survival include lay rescuer CPR receipt, intermittent ROSC, shockable rhythm, intermittent signs of life during CPR, and short low-flow times.[14–18] Age cutoffs and metabolic criteria suggesting futility, such as high lactate, low end-tidal carbon dioxide, and low pH, have been identified in retrospective analyses and used as selection criteria in RCTs.[6,19,20] System protocols that consider a consistent set of predefined variables in determining which patients to select for ECPR, along with routine reevaluation of these variables as additional local and external data evolve, are important components of an ECPR SOC.
2. Adult peripheral ECPR cannulation carries a risk of significant complications, including bleeding, vascular injury, limb ischemia, and cannulation failure, especially in the emergent setting with ongoing CPR.[4,5,21] Retrospective observational data suggest that percutaneous cannulation under ultrasound guidance, compared with vascular cut-down, may result in faster time to cannulation

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without significant differences in cannulation-related complications.[22–24] One of these studies, an Extracorporeal Life Support Organization registry review, also reported less brain death or diffuse cerebral ischemia with percutaneous cannulation.[24] The optimal training path to master ECPR cannulation has not been established.

3. There are no prospective randomized trials that have assessed regionalization or specialty ECPR centers. Multiple observational studies demonstrate an association between increasing ECPR volume and improved patient outcomes, although these findings are limited by confounding.[25–27] Among RCTs, the positive Advanced Reperfusion Strategies for Patients With Out-of-Hospital Cardiac Arrest and Refractory Ventricular Fibrillation (ARREST) trial was conducted at a single high-volume ECPR center,[6] which contrasts with the neutral results from the Early Initiation of Extracorporeal Life Support in Refractory OHCA (INCEPTION) trial, which spanned 10 Dutch cardiosurgical centers, 5 of which cannulated 2 or fewer patients.[5] Variation across these studies precludes a specific definition of a specialized ECPR center. However, given the relatively low frequency of ECPR events (<1% of all cardiac arrests)[28] as well as the nuanced complexities of cannulating and caring for these patients, it may be reasonable to match patients to specialized, experienced centers.
4. One single-center RCT randomized OHCA patients to rapid intra-arrest transport coupled with in-hospital ECPR compared with ongoing CPR at the scene.[4] This study did not show a statistically improved survival with good neurologic outcome at 180 days post-OHCA; however, it was stopped prematurely with a trend favoring ECPR (difference, 9.5%; 95% CI, −1.3% to 20.1%; *P*=0.09), which raises the question of whether the study was sufficiently powered. Two other OHCA ECPR RCTs randomized patients following intra-arrest transport. One was stopped early for benefit,[6] whereas the other found no difference between ECPR and standard ACLS.[5] Intra-arrest transport poses significant risks, including delays in BLS and ACLS interventions, ineffective compressions, and safety risks to EMS professionals and the public with high-speed emergency vehicle operations. Monitoring outcomes at the level of the entire community is important to account for changes in resuscitation quality that may occur with rapid transport during ongoing resuscitation. Moreover, there is no direct evidence assessing the allowable diversion distance or time past a non–ECPR-capable receiving facility.[4–7]

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ORGAN DONATION AFTER CARDIAC ARREST

Recommendations for Organ Donation After Cardiac Arrest		
COR	**LOE**	**Recommendations**
1	B-NR	1. We recommend that all patients who are resuscitated from cardiac arrest but who subsequently meet neurologic criteria for death or have planned withdrawal of life-sustaining therapies be evaluated for organ donation.
1	C-EO	2. Institutions should develop SOC focused on facilitating and evaluating organ donation after cardiac arrest consistent with local legal and regulatory requirements.
2b	B-NR	3. Patients who do not have ROSC after resuscitation efforts and who would otherwise have termination of resuscitation efforts may be considered candidates for donation in settings where such programs exist.

Synopsis

There are over 100 000 people awaiting a transplant in the United States, with dozens dying each day due to a donor shortage.[1] Nonsurvivors of cardiac arrest could represent an underrecognized source of lifesaving organs. As in other settings, donation after cardiac arrest occurs after confirmation of circulatory or brain death. Donation after circulatory death (DCD) is further divided into controlled and uncontrolled donation. Controlled DCD typically occurs following planned withdrawal of life-sustaining therapies. Uncontrolled DCD occurs immediately after cessation of resuscitative efforts. Although ethical considerations (refer to "Part 3: Ethics")[2] and local regulations dictate the circumstances and settings in which organ donation is appropriate, multiple studies across the globe reinforce that cardiac arrest nonsurvivors represent an effective donor allograft source.

Recommendation-Specific Supportive Text

1. Numerous observational studies have documented comparable allograft function and recipient outcomes when transplanted organs are recovered from donors who have suffered cardiac arrest.[3–7] This includes donation after brain death and controlled DCD, including among donors resuscitated via ECPR or otherwise supported on ECMO.[8,9]
2. A 2023 ILCOR scientific statement focused on the importance of increasing organ availability after cardiac arrest.[10] Specific interventions and SOC targeting organ donation may help facilitate its acceptance and performance following cardiac arrest, potentially expanding the donor pool.[11,12] It is vital that such programs adhere to local laws and regulations governing determination of death and organ donation.[13,14] Metrics of interest for such systems may include organ referrals and donor conversion rates or the percentage of eligible donors who go on to successful organ donation.
3. Uncontrolled DCD is less commonly performed; however, several studies have demonstrated

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acceptable kidney and liver allograft function and recipient outcomes following uncontrolled DCD among centers with established uncontrolled DCD programs.[6,15–17]

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DATA REGISTRIES TO IMPROVE SYSTEM PERFORMANCE

Recommendation for Data Registries to Improve System Performance		
COR	**LOE**	**Recommendation**
1	**B-NR**	1. Organizations that treat cardiac arrest patients should collect processes-of-care data and outcomes to guide system improvement.

Synopsis

Measurement is the cornerstone of evaluating performance and identifying opportunities for improvement. For cardiac arrest, measurement may be at the local, regional, or national level through participation in data registries that collect information on processes (CPR performance data, defibrillation times, adherence to guidelines) and outcomes (ROSC, survival) of care. Ideally, data registries are based on the Utstein template, which standardizes core and supplemental elements across participating sites.[1–3] In the United States, the AHA's Get With The Guidelines–Resuscitation registry and the Cardiac Arrest Registry to Enhance Survival are examples of initiatives that capture data related to processes and outcomes for IHCA and OHCA, respectively. More recently, an expert panel convened by ILCOR and the AHA for IHCA and the Global Resuscitation Alliance for OHCA identified participation in a registry as a key step for improving cardiac arrest survival.[4–6] Systematic collection of cardiac arrest data within registries is used to identify gaps in care quality that inform quality improvement interventions. They are also used to determine whether quality improvement initiatives are successful in improving care and outcomes.

Recommendation-Specific Supportive Text

1. Consistent with prior studies, recent observational studies demonstrate improved survival and adherence to key performance indicators (CPR process measures, defibrillator application, adherence to guidelines) over time.[7–10] In the population-based OHCA registries from Japan and Korea, survival to discharge and favorable neurological survival for OHCA patients have steadily increased since the inception of these registries, with improvements attributable to structured interventions guided by systematic data collection.[8,10] These findings are

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consistent with prior studies from established registries in other countries, highlighting the importance of registries in improving survival.[11–13] For IHCA, an observational study found notable improvement in ROSC from 61% to 73.5% (*P*=0.03) following the implementation of a quarterly CPR training program.[9] In a separate study from Singapore, the initiation of a multipronged quality improvement program that focused on CPR training and communication, improved staffing, audit and feedback was also associated with a significant improvement in ROSC (OR, 2.05; 95% CI, 1.04–4.05; *P*=0.04) but not survival to discharge.[7]

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IMPROVING CARDIAC ARREST RECOVERY

Recommendation for Improving Cardiac Arrest Recovery		
COR	**LOE**	**Recommendation**
2a	**B-R**	1. The recovery and long-term functional outcomes of cardiac arrest survivors are likely to benefit from the use of integrated systems that assess patients prior to discharge, reassess their needs after discharge, and address these needs on an ongoing basis during recovery.

Synopsis

Recovery after cardiac arrest encompasses many facets beyond the acute event and resuscitation, affects many individuals beyond the survivor, and spans long after the initial hospitalization.[1] Patients are often laden with new diagnoses and treatments for the underlying cause of their cardiac arrest. They may also deal with new neurologic, physical, or psychosocial impairments that present challenges to reintegration to work, leisure, and society.[2] Finally, friends, family, lay rescuers, and emergency personnel, appropriately recognized as cosurvivors, suffer a critical toll after experiencing a resuscitation—whether successful or not—which is increasingly being appreciated.[3] Previous guidelines and scientific statements have shed light on the importance of building SOC and science to optimize the recovery, survivorship, and cosurvivorship process.[1,3] Indeed, the creation of such SOC is considered an ethical responsibility for organizations that provide care for cardiac arrest survivors (refer to the Impact on Survivors section in "Part 3: Ethics").[4]

Recommendation-Specific Supportive Text

1. In an RCT where semistructured cognitive, medical, and psychosocial support offered to adult OHCA and IHCA survivors for 6 months after discharge was compared with no intervention, survivors had significant improvement in multiple domains of quality of life at 12 months.[5] This intervention was found to be potentially cost effective at the 1-year follow-up.[6] Other RCTs have evaluated the effectiveness of biofeedback and cognitive behavioral therapy[7] and a structured telephone follow-up[8] in cardiac arrest survivors, demonstrating improvements in long-term survival and quality of life, respectively. However, a recent systematic review of RCTs and observational studies of rehabilitation following cardiac arrest found significant heterogeneity of treatment

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effects.[9] Provision of integrated recovery services, and prevention of loss to follow-up, requires the presence of a multidisciplinary system that spans the inpatient and outpatient domains.[10–12]

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KNOWLEDGE GAPS AND PRIORITIES FOR RESEARCH

Resuscitation science continues to evolve, with a growing understanding of how integrated SOC impact clinical outcomes as new literature emerges. Although many areas still require further study, the writing group felt that the following items represented the most important knowledge gaps in SOC, therefore deserving the highest priority for future research:

1. Although the clinical effectiveness of community CPR and AED programs is well established, defining the cost effectiveness of implementation in specific populations and settings requires further study.
2. Mobile technologies hold considerable promise as a means to engage lay rescuers in CPR and AED use, however, the optimal implementation of these technologies requires further research.
3. As mobile technologies are implemented, potential risks to privacy, liability, and personal safety during lay rescuer CPR in an unknown location need to be understood.
4. Preliminary studies on drone delivery of AEDs are promising. However, the use of a drone network as part of a community cardiac arrest SOC requires cost-effectiveness analysis and research to define its application in real-world situations and its impact on patient outcomes.
5. Further research is needed to better comprehend the barriers, challenges, and benefits of integrating out-of-hospital and in-hospital datasets as part of quality improvement programs within SOC.
6. While growing evidence supports the benefits of regionalized SOC for time-sensitive emergencies (eg, stroke, ST-segment elevation myocardial infarction), CACs require better definition, including research to identify which components confer benefit and to determine whether delivery of these components justifies the requisite transport time.
7. Further studies are needed to understand how telecommunicators can better recognize cardiac arrest, particularly in pediatric patients, and how their instructions can be delivered to optimize lay rescuer participation and delivery of high-quality CPR. Research to identify age cutoffs and etiologies for which individuals in cardiac arrest benefit from full CPR with breaths, as opposed to compression-only CPR, is needed.
8. The timing, methods, and specific components of feedback or debriefing after attempted cardiac arrest resuscitation require further study.
9. Research is needed to identify which patients warrant transport to a hospital with ongoing CPR and to define the safest means to do so while maintaining high-quality CPR.
10. Further research is needed to identify the patient characteristics wherein RRT/MET programs provide the greatest outcome benefits, which interventions are most efficacious, and whether RRT/MET programs should be linked to an automated EWS.
11. Research is needed on how to apply behavior and leadership skill training to code teams and EMS systems to optimize resuscitation.

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12. Compression-only CPR is easier to implement because of its simplicity and reduced contact but may be less efficacious than CPR with breaths in some etiologies of OHCA (eg, opioid-associated OHCA). Research is needed to define whether specific etiologies of OHCA warrant distinct telecommunicator instructions.

ARTICLE INFORMATION

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Disclosures

Appendix 1. Writing Group Disclosures

Writing group member	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
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Joshua A. Worth	AmeriPro Health	None	None	None	None	None	None	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

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Appendix 2. Reviewer Disclosures

Reviewer	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
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Scott T. Youngquist	University of Utah	NINDS (PediDOSE Trial EMS Investigator)*; DoD (PAIN Clinical Trial Site PI)*; NHLBI (ICECAP Trial Site Investigator)*; AHRQ (FEED-PT Trial Site Investigator)*	None	None	None	None	Emergency Scientific*	None

This table represents the relationships of reviewers that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all reviewers are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

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Part 5: Neonatal Resuscitation: 2025 American Heart Association and American Academy of Pediatrics Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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ABSTRACT: The guidelines in this document from the American Heart Association and the American Academy of Pediatrics focus upon optimal care of the newborn infant, including those who are proceeding to a normal transition from the fluid-filled uterine environment to birth. Newborn infants who are proceeding to normal transition can benefit from deferred cord clamping for at least 60 seconds in most instances, skin-to-skin with their parent soon after birth, and appropriate assistance with thermoregulation. Some newborn infants require assistance during transition, with interventions ranging from warming and tactile stimulation to advanced airway management, assisted ventilation, oxygen therapy, intravascular access, epinephrine, and volume expansion. In this context, individuals, teams, and health care settings that care for newborn infants should be prepared and have access to appropriate training and resources for neonatal resuscitation. The newborn chain of care provides guidance on considerations that may lead to optimal outcomes for newborn infants starting from prenatal care to recovery and follow-up.

Key Words: AHA Scientific Statements ■ cardiopulmonary resuscitation ■ laryngeal mask ■ neonatal resuscitation ■ neonate ■ oxygen ■ umbilical cord management ■ ventilation

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TOP 10 TAKE-HOME MESSAGES FOR NEONATAL LIFE SUPPORT

1. The newborn chain of care starts with prenatal care and extends to recovery and appropriate follow-up in the postnatal period to ensure optimal short- and long-term health for the infant and family.
2. Newborn resuscitation requires anticipation and preparation by clinicians who train individually and as teams.
3. Most newborn infants do not require resuscitation. They can be evaluated and monitored during deferred cord clamping for 60 seconds or more and can maintain skin-to-skin contact with their parents after birth.
4. Effective ventilation of the lungs, as indicated by an increasing heart rate, is the priority in newborn infants who need resuscitation.
5. Ventilation corrective steps, including the use of an alternative airway (laryngeal mask or endotracheal intubation), may be required if the heart rate does not rise with assisted ventilation with a face mask.
6. Monitoring temperature during resuscitation helps to avoid hypothermia and hyperthermia, both of which are associated with adverse outcomes.
7. Pulse oximetry is used to guide oxygen therapy and meet oxygen saturation target ranges.

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8. Chest compressions are indicated if the heart rate remains less than 60 beats per minute after appropriate ventilation corrective steps, which preferably include endotracheal intubation.
9. If the heart rate remains less than 60 beats per minute after chest compressions, epinephrine is indicated, preferably via an intravascular route. Endotracheal epinephrine may be considered while vascular access is being obtained.
10. If all steps of resuscitation are effectively completed and there is no heart rate detected by 20 minutes, redirection of care may be discussed with the team and family.

PREAMBLE

Approximately 5% to 10% of newborn infants need help to begin breathing at birth, and approximately 1% need advanced resuscitative measures to restore cardiorespiratory function.[1–3] The neonatal mortality rate in the United States and Canada has decreased from nearly 20 per 1000 live births in the 1960s to the current rate of approximately 3.5 per 1000 live births.[4,5] Yet there remain opportunities for improvement and increasing access to quality care with disparities in neonatal mortality by region and disparities in access to care.[6–10] The inability of newborn infants to establish and sustain adequate or spontaneous respiration contributes significantly to early deaths and the burden of adverse neurodevelopmental outcomes among survivors. Effective and timely resuscitation at birth could therefore improve neonatal outcomes and reduce health disparities.

Successful neonatal resuscitation efforts depend on time-critical actions that must occur in rapid succession to maximize the chances of intact survival. The International Liaison Committee on Resuscitation (ILCOR) Formula for Survival emphasizes 3 essential components for good resuscitation outcomes: guidelines based on sound resuscitation science, effective education of health care professionals in resuscitation, and implementation of effective and timely resuscitation.[11] The 2025 neonatal resuscitation guidelines contain recommendations based on the best available resuscitation science for the most impactful steps to perform during delivery and in the neonatal period. In addition, specific recommendations regarding systems of care and training of resuscitation are provided in the respective guidelines, Parts 4[12] and 12.[13] The 2025 guidelines also introduces the Newborn Chain of Care (Figure 1), which addresses the overall context in which neonatal resuscitation occurs and how systems of care may impact newborn infant outcomes.

NEWBORN CHAIN OF CARE

The Newborn Chain of Care (Figure 1) provides a framework for considering essential elements of the health care system relating to neonatal health. A robust newborn chain of care has the potential to enhance health during the perinatal and neonatal periods and long-term outcomes. Each link in the chain is described in detail here.

Link 1: Prevention

The health of the pregnant person has a direct impact on the health of the newborn infant. Optimal care during pregnancy can help prevent or mitigate risks to the developing and growing fetus. Antenatal care includes individualized risk assessment, psychosocial support, education, and evaluation of personal and societal factors to achieve optimal health outcomes. Comprehensive care encompasses counseling on nutrition, medication, substance use, potential environmental exposures, safety, mental health, and self-care. Comprehensive care also includes early estimation of gestational age and ongoing screening, prevention measures, and interventions for conditions that may impact the health of the pregnant person or the fetus. Screening modalities include review of symptoms, measurements of blood pressure and fundal height, laboratory tests, ultrasonography, and monitoring of fetal heart rate, when indicated.[14]

Link 2: Recognition and Activation

Approximately 5% to 10% of newborn infants require assistance to breathe after birth. The need for assistance must be anticipated and recognized to reduce the

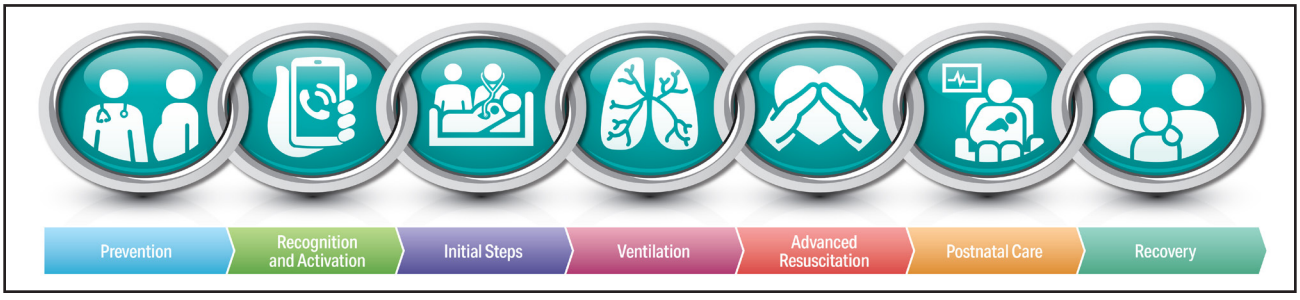

Figure 1. Newborn Chain of Care.

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risk of poor outcomes. Risk assessments evaluate factors present during pregnancy and labor that can help health care professionals identify newborn infants who are more likely to require resuscitation. When risk factors are present, an appropriate team should be mobilized to assist with resuscitation. In some cases, this may involve transferring the pregnant person to a higher level of care to a specialized hospital. When appropriate, based on anticipated risk, a qualified team with advanced resuscitation skills should be present at the time of birth. Refer to Anticipation and Preparation for Resuscitation.

Link 3: Initial Steps

Initial care at birth consists of lifesaving measures essential for all newborn infants, including those who are well and those who require respiratory support or advanced resuscitation. Steps to maintain normal temperature include maintaining a warm environment, promptly drying the infant, and skin-to-skin contact with the parent, keeping the infant's body and head covered while leaving the mouth and nose visible. Newborn infants receiving resuscitation may require alternative methods such as covering the body with plastic wrap or a bag and providing supplemental heat from a radiant warmer or thermal mattress. Umbilical cord clamping can be deferred for at least 60 seconds while performing the initial steps of drying, evaluating breathing, providing tactile stimulation if needed to support breathing, and clearing the airway if there is evidence of obstruction. Whenever possible, skin-to-skin contact is maintained with monitoring of breathing and temperature for at least 1 hour to support early initiation of breastfeeding. Refer to Umbilical Cord Management and Initial Steps.

Link 4: Ventilation

Newborn infants who do not breathe within the first 60 seconds after birth or have a heart rate less than 100 per minute despite initial steps should receive assisted ventilation. Delaying ventilatory support in newborn infants increases the risk of death. A face mask or laryngeal mask (supraglottic airway) can be used to provide initial ventilation. Leak and obstruction are common during face mask ventilation and are important to address because they prevent effective ventilation. A rise in heart rate is the primary indicator of effective ventilation. If the newborn infant's heart rate remains less than 100/min and does not increase after ventilation, inserting an alternative airway, such as a laryngeal mask or an endotracheal tube often improves effectiveness of ventilation. For spontaneously breathing preterm infants who need respiratory support, continuous positive airway pressure (CPAP) is a form of noninvasive respiratory support that helps establish and maintain functional residual capacity after birth. Refer to Ventilation and Continuous Positive Airway Pressure.

Link 5: Advanced Resuscitation

Advanced neonatal resuscitation requires a comprehensive approach to address a life-threatening situation in newborn infants. If initial steps and ventilation with an alternative airway do not improve the heart rate, then providing advanced interventions, establishing intravascular access, and administering epinephrine are crucial. Chest compressions are initiated when the newborn infant's heart rate remains less than 60/min despite adequate ventilation. Chest compressions aim to restore cardiac output. Concurrently, epinephrine is administered to augment perfusion to vital organs. Establishing intravascular access via umbilical venous catheterization or an intraosseous (IO) device is imperative for swift medication delivery and fluid resuscitation. Through the meticulous execution of these advanced interventions, health care professionals aim to optimize outcomes in newborn infants. Refer to Chest Compressions, Vascular Access During Resuscitation, Epinephrine, and Volume Expansion.

Link 6: Postnatal Care

Most healthy newborn infants can remain with their parent, prioritizing bonding, breastfeeding, and thermoregulation immediately following birth. These steps contribute to the infant's health and stability. Newborn infants who require resuscitation beyond initial steps are at risk for abnormal transition to extrauterine life and require further observation and monitoring. Transitional issues can include respiratory compromise, hypoglycemia, or hypothermia, among others. Monitoring should include assessment of respiratory effort and oxygenation, heart rate, temperature, and blood glucose. The duration of monitoring depends on the newborn infant's status and transition to postnatal stability. Some newborn infants may need interhospital transfer to a higher level of care during the postnatal period. Refer to Postresuscitation Care.

Link 7: Recovery

Ensuring appropriate primary care follow-up for all newborn infants after birth, as well as their parents, is crucial for promoting short- and long-term health. Appropriate follow-up, education, and support for families are even more critical for those infants who require specialized care in the neonatal period. Infants who are born very preterm, have congenital anomalies, require resuscitation, or experience neonatal complications will require specialized services postdischarge to effectively address their unique needs. A safe and optimal transition from hospital to home may involve medical therapies such as tube feeding, cardiorespiratory monitoring, and portable oxygen as well as arrangements for specialized services, including developmental follow-up and early intervention services. Close communication and collaboration with the outpatient health care team, including social service agencies, can promote the health of infants at risk of developmental

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difficulties, particularly for those families who may have challenges navigating the health care system.[15]

INTRODUCTION

Scope of Guideline

This guideline is designed for North American health care professionals seeking an up-to-date summary for clinical care as well as for those looking for more in-depth information on resuscitation science and gaps in current knowledge. The science of neonatal resuscitation applies to infants at birth and in the days after birth. In circumstances of altered or impaired transition, effective neonatal resuscitation reduces the risk of mortality and morbidity. Even healthy babies who breathe well after birth benefit from the facilitation of normal transition, including appropriate umbilical cord management and thermal protection with skin-to-skin care. The 2025 Neonatal Resuscitation Algorithm summarizes the sequence of assessments and actions contained in the guidelines (Figure 2).

Neonatal resuscitation science continues to advance. Although major updates to the guidelines occur every 5 years, interim updates may occur in the form of focused updates as further evidence emerges based on publications of new clinical trials and systematic reviews.[16] Gaps in knowledge relating to neonatal resuscitation remain. Some recommendations are based on weak evidence with only a few well-designed human studies. Therefore, the guidelines conclude with a summary of current gaps in neonatal resuscitation research.

These guidelines apply primarily to the newborn infant who is transitioning from a fluid-filled to an air-filled environment. The concepts in these guidelines may also apply to infants during the neonatal period (birth to 28 days of age) and potentially older infants cared for in the neonatal intensive care unit, depending on patient pathophysiology and institutional practice.[17] Institutional policies and practices should be established based on the predominant patient population profile (in terms of age and pathophysiology) and staff training. Resuscitation of infants and children is addressed in "Part 6: Pediatric Basic Life Support" and "Part 8: Pediatric Advanced Life Support."[18,19]

Evidence Evaluation and Guidelines Development

The following sections briefly describe the process of evidence review and guideline development. Refer to "Part 2: Evidence Evaluation and Guidelines Development" for more details on this process.[20]

Organization of the Writing Committee

The Neonatal Life Support Writing Group includes physicians, nurses, and scientists with backgrounds in neonatology, obstetrics, education, research, and public health. A call for candidates was distributed to the American Heart Association (AHA) Emergency Cardiovascular Care (ECC) Committee and American Academy of Pediatrics (AAP) subject matter experts, and volunteers with recognized expertise in neonatal resuscitation were nominated by the writing group co-chairs. Writing group members were selected by the AHA ECC Science Subcommittee and the AAP Executive Committee and then approved by the AHA Manuscript Oversight Committee. The AHA and AAP have rigorous conflict of interest policies and procedures to minimize the risk of bias or improper influence during development of the guidelines.[21] Before appointment, writing group members and peer reviewers disclosed all commercial relationships and other potential (including intellectual) conflicts. Comprehensive disclosure information for writing group members is listed in Appendix 1. Writing group members whose research led to changes in guidelines were required to declare those conflicts during discussions and abstain from voting on those specific recommendations. This process is described more fully in "Part 2: Evidence Evaluation and Guidelines Development."[20]

METHODOLOGY AND EVIDENCE REVIEW

These 2025 AHA and AAP neonatal resuscitation guidelines are based on the extensive evidence evaluation performed in conjunction with the ILCOR and affiliated ILCOR member councils. Three different types of evidence reviews (systematic reviews, scoping reviews, and evidence updates) were used in the 2025 process. Each of these resulted in a description of the literature that facilitated guideline development.[22] This process is described more fully in "Part 2: Evidence Evaluation and Guidelines Development."[20]

Class of Recommendation and Level of Evidence

The writing group reviewed all relevant and current AHA guidelines for cardiopulmonary resuscitation and ECC[16,23] and all relevant ILCOR consensus on science with treatment recommendations evidence and recommendations to determine if current guidelines should be reaffirmed, revised, or retired, or if new recommendations were needed.[24–28] Supplemental reviews were performed by the writing groups to develop recommendations. The writing groups then drafted, reviewed, and approved recommendations, assigning to each a Level of Evidence (LOE; ie, quality) and Class of Recommendation (COR; ie, strength) (Table). Refer to "Part 2: Evidence Evaluation and Guidelines Development."[20]

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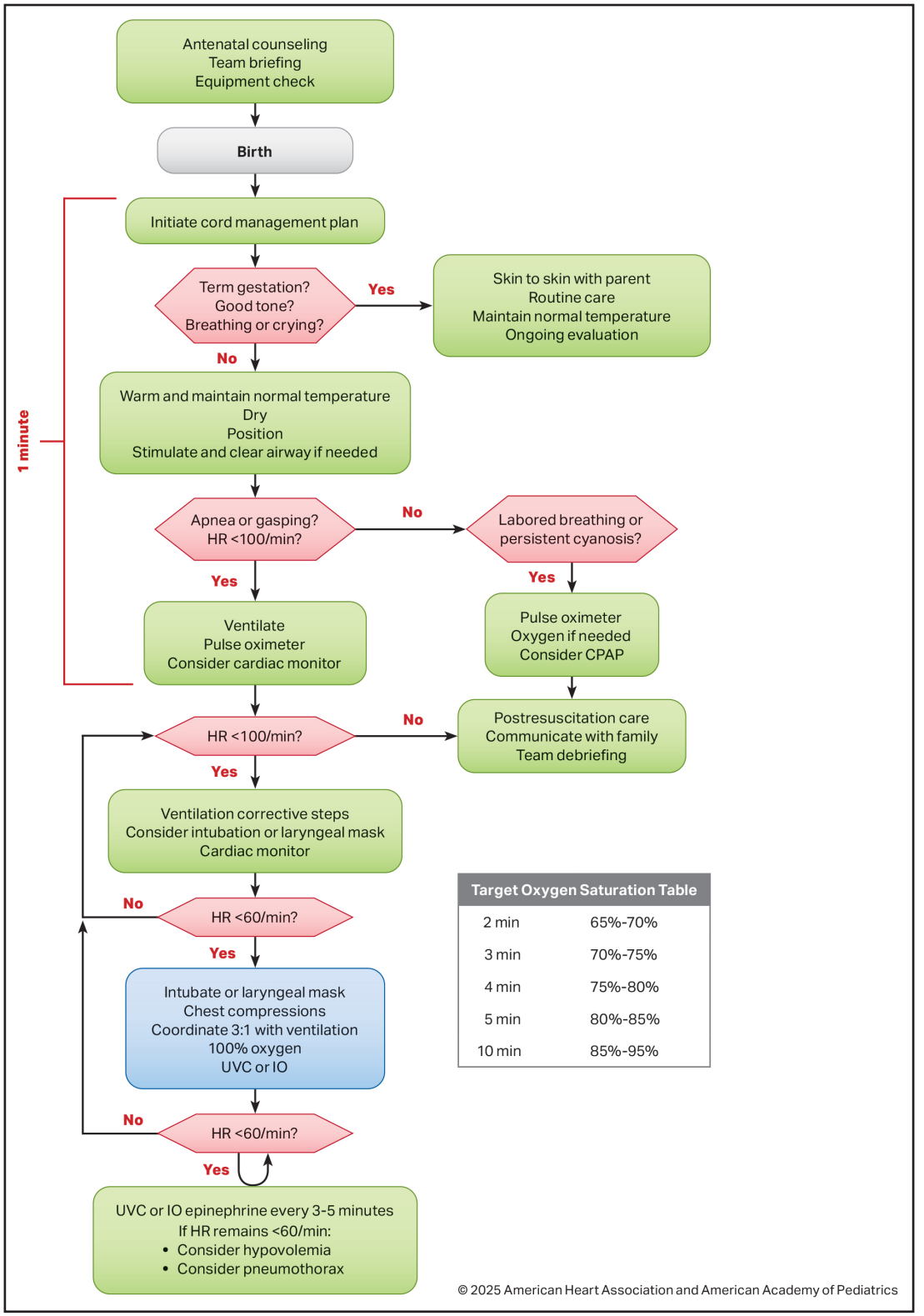

Figure 2. Neonatal Resuscitation Algorithm.

Guideline Structure

The 2025 guidelines are organized into knowledge chunks, discrete modules of information on specific topics or management issues.[29] Each modular knowledge chunk includes a table of recommendations using standard AHA nomenclature of COR and LOE. A short synopsis is provided to put the recommendations into context with important background information and overarching management or treatment concepts.

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Table. Applying Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care (Updated December 2024)*

CLASS (STRENGTH) OF RECOMMENDATION

Class 1 (STRONG) — Benefit >>> Risk

Suggested phrases for writing recommendations:
- Is recommended
- Is indicated/useful/effective/beneficial
- Should be performed/administered/other
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is recommended/indicated in preference to treatment B
  - Treatment A should be chosen over treatment B

Class 2a (MODERATE) — Benefit >> Risk

Suggested phrases for writing recommendations:
- Is reasonable
- Can be useful/effective/beneficial
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is probably recommended/indicated in preference to treatment B
  - It is reasonable to choose treatment A over treatment B

Class 2b (WEAK) — Benefit ≥ Risk

Suggested phrases for writing recommendations:
- May/might be reasonable
- May/might be considered
- Usefulness/effectiveness is unknown/unclear/uncertain or not well-established

Class 3: No Benefit (MODERATE) — Benefit = Risk
(Generally, LOE A or B use only)

Suggested phrases for writing recommendations:
- Is not recommended
- Is not indicated/useful/effective/beneficial
- Should not be performed/administered/other

Class 3: HARM (STRONG) — Risk > Benefit

Suggested phrases for writing recommendations:
- Potentially harmful
- Causes harm
- Associated with excess morbidity/mortality
- Should not be performed/administered/other

LEVEL (QUALITY) OF EVIDENCE‡

Level A
- High-quality evidence‡ from more than 1 RCT
- Meta-analyses of high-quality RCTs
- One or more RCTs corroborated by high-quality registry studies

Level B-R (Randomized)
- Moderate-quality evidence‡ from 1 or more RCTs
- Meta-analyses of moderate-quality RCTs

Level B-NR (Nonrandomized)
- Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies
- Meta-analyses of such studies

Level C-LD (Limited Data)
- Randomized or nonrandomized observational or registry studies with limitations of design or execution
- Meta-analyses of such studies
- Physiological or mechanistic studies in human subjects

Level C-EO (Expert Opinion)
- Consensus of expert opinion based on clinical experience

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consenus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR 1 and 2a; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely-used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

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Recommendation-specific text clarifies the rationale and key study data supporting the recommendations.

Document Review and Approval

Each 2025 Guidelines document was given guidance and reviewed by the AHA's ECC Science Subcommittee leadership and submitted for blinded peer review to subject matter experts nominated by the AHA and the AAP, when appropriate. Before appointment, all peer reviewers were required to disclose relationships with industry and any other potential conflicts of interest, and all disclosures were reviewed by AHA staff. Peer reviewer feedback was provided for guidelines in draft format and again in final format. All guidelines were reviewed and approved for publication by the AHA Science Advisory and Coordinating Committee, the AAP Board of Directors, and the AHA Executive Committee. Comprehensive disclosure information for peer reviewers is listed in Appendix 2. These recommendations supersede the last full set of AHA recommendations for neonatal life support, made in 2020.[23] The writing group members voted on each individual recommendation and approved all guideline recommendations.

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MAJOR CONCEPTS

The primary goal of neonatal care at birth is to facilitate transition of the fetus from the fluid-filled uterine environment and reliance on placental circulation to the newborn infant receiving oxygenation and air exchange through the lungs. The most important priority for newborn survival is the establishment of adequate lung inflation and ventilation after birth. Consequently, all births should be attended to by at least 1 person skilled and equipped to provide ventilation. Other important goals include establishment and maintenance of cardiovascular and temperature stability as well as the promotion of parent-infant bonding and breastfeeding, recognizing that simple measures can avert disruption of transition in healthy newborn infants.

The Neonatal Resuscitation Algorithm has been updated since 2020 and is the organizing framework for major concepts that support the needs of the newborn infant, the family, and the surrounding team of perinatal caregivers (Figure 2).

Anticipation and Preparation for Resuscitation

Every newborn infant should have a trained and equipped person, or team when appropriate, to facilitate transition after birth. Identification of risk factors may indicate the need for additional personnel and equipment. Team behaviors such as anticipation, communication, briefing, equipment checks, and role assignment result in improved performance and outcomes.

Umbilical Cord Management

The neonatal team can communicate and plan with the obstetric team to provide the most appropriate cord management, which in most cases will be deferring cord clamping for at least 60 seconds. This applies to both preterm and term newborn infants who do not require resuscitation.

Initial Steps

When possible, term newborn infants should be managed skin-to-skin with their parent. After birth, the newborn infant with cord intact can be placed directly skin-to-skin, with attention to warm coverings and maintenance of normal temperature, while receiving ongoing evaluation of respiratory transition. Radiant warmers and other warming adjuncts are suggested for newborn infants who require resuscitation at birth, especially those born very preterm.

Stimulation may be provided to facilitate respiratory effort. Suctioning may be considered for suspected airway obstruction but is not routinely recommended.

Assessment of Heart Rate

Heart rate is assessed initially by auscultation. Pulse oximetry and electrocardiography (ECG) are important adjuncts in babies requiring resuscitation.

Ventilation and Continuous Positive Airway Pressure

Ventilation, also referred to as *positive-pressure ventilation*, remains the primary method for providing support for newborn infants who are apneic, bradycardic, or demonstrate inadequate respiratory effort. Most newborn infants will respond to this intervention. An improvement in heart rate and establishment of breathing or crying are all signs of effective ventilation, which may be aided by corrective steps. The laryngeal mask, also known as a *supraglottic airway*, can be an effective method for providing ventilation to the newborn infant. For preterm infants who are breathing spontaneously but having increased work of breathing or hypoxia, CPAP may be beneficial.

Oxygen Supplementation

Ventilation may be initiated with air (21% oxygen) in term and late preterm newborn infants, and 21% to 30% oxygen in preterm babies 32 to 35 weeks of gestation. Very preterm infants <32 weeks' gestational age may require higher oxygen concentrations (30%–100%) to achieve target oxygen saturation goals guided by pulse oximetry.

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Chest Compressions

If the heart rate remains less than 60/min despite 30 seconds of ventilation that moves the chest, preferably through an alternative airway (endotracheal tube or laryngeal mask), chest compressions should be provided. The suggested ratio is 3 chest compressions synchronized to 1 inflation (with 30 inflations per minute and 90 compressions per minute). The preferred method is the 2 thumb–encircling hands technique, not the 2-finger or other techniques.

Intravascular Access

When intravascular access is required in the newborn infant, the umbilical venous route is preferred. When intravenous access is not possible or feasible, the IO route may be considered.

Epinephrine

If the heart rate remains less than 60/min despite 60 seconds of chest compressions and adequate ventilation, epinephrine should be administered, ideally via an intravascular route. Endotracheal epinephrine may be considered while vascular access is being obtained.

Volume Expansion

When blood loss is known or suspected based on history and examination, and there is no response to intravascular epinephrine, volume expansion is indicated.

Postresuscitation Care

If prolonged ventilation or advanced resuscitation is required, newborn infants should be closely monitored after stabilization. This monitoring may identify complications that can impact short- and long-term outcomes.

Withholding and Discontinuing Resuscitation

It may be possible to identify conditions in which withholding or discontinuing resuscitative efforts may be reasonably considered by families and health care professionals. Appropriate and timely support for collaborative decision-making should be provided to all involved.

Training and Human Performance

To optimize performance, teams and individuals who provide neonatal resuscitation should acquire necessary knowledge, technical skills, and behaviors, and also ensure ongoing maintenance of these skills. Given the low frequency of advanced resuscitation and inconsistency of resuscitation team members, institutions should be intentional in creating opportunities for individual and team training. Such training should include ongoing booster training and the use of simulation and debriefing.

Terminology

Prior neonatal guidelines have used the term *positive-pressure ventilation* to refer to providing ventilation. In this update, we generally use the term *ventilation* or *assisted ventilation* in order to simplify terminology, to align with other guidelines, and with the recognition that ventilation in neonatal resuscitation only involves positive pressure, not negative pressure.

The broad categories of gestational age can be specified as *term* to encompass infants 37+0 to 41+6/7 weeks' gestational age, while *preterm* describes infants born prior to 37 weeks' gestational age. When *term* and *preterm* are used in isolation in the guidelines, the above categorization would apply. When the evidence applies to a more specific subgroup, those gestational ages are specified in the recommendation and supportive text.

ANTICIPATION AND PREPARATION FOR RESUSCITATION

Recommendations for Anticipation and Preparation for Resuscitation

COR	LOE	Recommendations
1	B-NR	1. Every birth should be attended by at least 1 person whose only responsibility is the care of the newborn infant, including performing the initial steps of resuscitation and providing ventilation when required.
1	B-NR	2. Before every birth, a standardized risk factors assessment should be performed to determine perinatal risk and assemble a neonatal resuscitation team based on that risk.
1	C-LD	3. Before every birth, a standardized checklist should be used to ensure the presence and function of supplies and equipment necessary for a complete resuscitation.
1	C-LD	4. When anticipating a high-risk birth, a prebirth team briefing should be performed to identify potential interventions and assign roles and responsibilities.

Synopsis

Approximately 5% to 10% of newborns require assistance to breathe after birth.[1–3] Newborn resuscitation requires training, preparation, and teamwork. Delays in assisting an apneic newborn may increase risk of death.[2,4,5] Therefore, it is optimal that every birth has at least 1 person in attendance whose primary responsibility is the newborn infant and who can provide ventilation.[6–8]

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A risk assessment to evaluate factors during pregnancy and labor can identify newborn infants likely to require resuscitation; in these cases, a team with appropriate skills should be present at birth.[4,9–15] In the absence of risk stratification, up to half of babies requiring ventilation may not be identified before birth.[2,16]

A standardized checklist is a comprehensive list of critical supplies and equipment needed in the clinical setting. A standardized checklist used before every birth can ensure that supplies and equipment for a complete resuscitation are present and functional.[17,18]

A prebirth team briefing can identify the leader, assign roles and responsibilities, and plan umbilical cord management and potential interventions. Team briefings promote teamwork, communication, and safety but may delay communication with families.[17,19–22] Facilitating communication with family during resuscitation can be considered in role assignment.[21,22]

Recommendation-Specific Supportive Text

1. A large observational study found that delaying ventilation increases risk of death and prolonged hospitalization.[5] A systematic review and meta-analysis of pre-post training studies showed neonatal resuscitation training improved 7-day neonatal survival in low-resource countries.[8] A retrospective cohort study showed improved Apgar scores in the context of a statewide neonatal resuscitation training program.[23] As the need for neonatal resuscitation can be unexpected, having a dedicated and trained clinician is optimal.
2. Risk factors for low Apgar scores and receipt of assisted ventilation or advanced resuscitation procedures include prematurity, maternal conditions, delivery mode, and meconium-stained fluid.[9–15] In a prospective survey done before risk stratification, resuscitation was anticipated in less than half of births receiving ventilation.[16] In a prospective cohort study, risk stratification increased attendance of an advanced neonatal resuscitation team at high-risk births.[4]
3. Checklist use led to reduced error rates during audits in neonatal resuscitation equipment and supplies. Quality improvement and implementation work that incorporated checklist use was associated with quicker time to oxygen saturation monitoring, reduced hypothermia for preterm infants, and increased deferred cord clamping rates.[21,22,24]
4. Quality improvement initiatives have demonstrated that team briefing including role assignment, in combination with checklists, improved team communication and was associated with quicker time to oxygen saturation monitoring and normothermia for preterm infants.[21,22,24]

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UMBILICAL CORD MANAGEMENT

Recommendations for Term Newborn Umbilical Cord Management		
COR	**LOE**	**Recommendations**
2a	B-R	1. For term newborn infants who do not require immediate resuscitation, deferred cord clamping for at least 60 seconds can be beneficial when compared to immediate cord clamping.
2b	B-R	2. For nonvigorous term newborn infants and late preterm infants 35 weeks or more gestational age, intact cord milking may be reasonable when compared to immediate cord clamping.
2b	C-LD	3. For term newborn infants who do not require immediate resuscitation, the usefulness of intact umbilical cord milking compared to deferred cord clamping is uncertain.

Synopsis

Management of the umbilical cord and placental transfusion at the time of birth remains an area of robust investigation. Placental transfusion can be achieved either by delaying the clamping of the umbilical cord following delivery or by milking the umbilical cord. Milking is typically done by stripping 20 cm of cord from the placenta toward the infant 3 to 4 times, allowing the cord to refill from the placenta each time. The volume of blood transferred from the placenta to the newborn infant and the impact of this transfusion vary based on gestational age at birth, mode of delivery, the time from birth to cord clamping, any milking of the umbilical cord, and physiologic status of the newborn. Based on available literature, deferred cord clamping for at least 60 seconds can be beneficial compared to immediate cord clamping for term infants who do not require resuscitation. For term infants who require resuscitation at birth, there is limited evidence to guide timing of umbilical cord clamping. Several studies currently are underway to investigate the interaction between deferred cord clamping and resuscitation. Initial steps of resuscitation such as drying and tactile stimulation, if required, can be undertaken during deferred cord clamping.

Recommendation-Specific Supportive Text

1. For term newborns, evidence from 14 studies (n=2412)[1–14] reporting on hemoglobin and 20 studies (n=3452)[1,4–6,8,10,13,15–27] reporting on hematocrit showed that infants who received deferred umbilical cord clamping beyond 30 seconds had improved hematologic indices early in the newborn period. In 5 trials studying 1199 term newborn infants, those who received early cord clamping had lower ferritin levels at 3 to 6 months of age compared to those who received deferred cord clamping.[1,6,18,28,29] There was no difference in mortality among term infants who received deferred or early cord clamping in 3 randomized controlled trials (RCTs) including 419 infants.[16,18,30] More recent studies have evaluated deferred clamping for at least 60 seconds[3,11–13,15,18,23,25,31–34] and additional studies have evaluated longer durations of deferred umbilical cord clamping.[17,35–37] These studies have shown increases in hematological indices compared to shorter durations of deferred cord clamping.
2. One RCT including 1730 nonvigorous infants, limited to 35 to 42 weeks' gestational age, compared intact umbilical cord milking to early cord clamping (within 60 seconds of birth).[38] The primary outcome, admission to neonatal intensive care unit, was not different between groups. However, compared to early cord clamping, intact umbilical cord milking in nonvigorous infants was associated with decreases in several secondary outcomes, including rate of cardiorespiratory support in the delivery room, moderate to severe hypoxic-ischemic encephalopathy (HIE), and use of therapeutic hypothermia.
3. The currently available evidence does not support intact cord milking compared to deferred cord clamping in vigorous term newborns.[31,32,39] Two RCTs including 275 term infants showed no difference between hematologic indices when measured between 6 and 48 hours after delivery.[31,39] One study followed subjects to 4 months of age and measured hemoglobin and ferritin. No difference was noted between the cord milking and delayed cord clamping groups.[31] Two RCTs including 371

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term infants did not demonstrate a difference in hyperbilirubinemia, administration of phototherapy, or need for exchange transfusions.[32,39]

Recommendations for Preterm Newborn Umbilical Cord Management		
COR	LOE	Recommendations
1	A	1. For newborn infants born at <37 weeks of gestation who do not require immediate resuscitation, deferred cord clamping for at least 60 seconds is recommended when compared to immediate cord clamping.
2b	B-R	2. For newborn infants born at 28+0 to 36+6 weeks of gestation who do not require immediate resuscitation and in whom deferred cord clamping cannot be performed, intact cord milking may be reasonable.
3: Harm	B-R	3. For newborn infants born at less than 28+0 weeks of gestation, intact cord milking should not be performed.

Synopsis

Outcomes of interest and recommendations for cord management in preterm infants differ from term infants because of differences in the cardiovascular and cerebral vascular physiology of preterm infants. Transfer of blood from the placenta through the umbilical vein after birth has been shown to increase hemoglobin, increase circulating blood volume, improve organ perfusion, and result in greater hemodynamic stability in preterm newborns after birth.[40–42] Based on available evidence for preterm infants who do not require resuscitation, deferred cord clamping for at least 60 seconds may result in improved outcomes. While deferred cord clamping is the preferred approach, an alternative approach is intact cord milking for infants born at 28+0 to 36+6 weeks' gestational age in whom deferred cord clamping cannot be performed.[43] For infants born at less than 28 weeks' gestational age, intact cord milking is associated with increased risk of intraventricular hemorrhage.[43,44] Some studies have shown an increased incidence of hypothermia on admission to the neonatal intensive care unit for preterm infants who received deferred cord clamping when compared to those who received immediate cord clamping. Attention to maintaining normothermia is an important aspect of care during resuscitation regardless of cord management strategy.

Recommendation-Specific Supportive Text

1. A recent pairwise individual participant data meta-analysis conducted by ILCOR included 21 studies enrolling 3292 newborns with a median gestational age of 29 weeks (IQR, 27–33 weeks) and compared deferred cord clamping (30 to ≥180 seconds) to immediate cord clamping (≤15 seconds).[22,43,45–62] Twenty trials enrolling 3263 infants showed a reduction in mortality before discharge with a number needed to treat of 40 (95% CI, 143–26 infants).[22,45–63] For all preterm infants, there is an increase in hematological indices,[43] while in those infants born at <32 weeks' gestational age, there is a reduction in need for packed red blood cell transfusion during neonatal intensive care unit admission.[22,46,48–50,52,53,55,57,59,61–63] In comparing durations of deferred cord clamping, long duration (≥120 seconds) was associated with the greatest reduction in mortality, but the number of extreme preterm infants included in these studies was low (n=121) and adherence to this duration (67%) was significantly lower compared to adherence for short and medium durations (30 seconds to <120 seconds).[43] A post hoc analysis by ILCOR demonstrated that newborn infants who received deferred cord clamping for 60 seconds or more (n=1316) had a reduction in mortality compared to those who had immediate cord clamping (<15 seconds) (odds ratio [OR], 0.63 [95% CI, 0.44–0.88; *P*=0.01]).[43,64] In 8 trials including 1995 preterm infants, hypothermia (defined as <36.5 °C) was increased on admission to the neonatal intensive care unit for infants <32 weeks of gestation who received deferred cord clamping compared to immediate cord clamping (mean difference, -0.13 degrees; OR, 1.28).[43]
2. In preterm infants born at ≥28 weeks' gestational age who received intact umbilical cord milking, pairwise individual participant data meta-analysis of 12 trials including 944 infants showed that hemoglobin levels in the first 24 hours after birth were higher compared with those who received immediate cord clamping.[43] Further, data from 15 studies including 1163 infants showed a reduction in the need for red blood cell transfusion for those infants who received intact cord milking compared with immediate cord clamping.[43] For infants who received intact umbilical cord milking compared with deferred cord clamping, data from 7 studies including 860 infants showed an increased risk of severe intraventricular hemorrhage in infants born at <32 weeks' gestational age. This was primarily related to 1 RCT including 540 infants which showed an increased incidence of intraventricular hemorrhage in infants born at <28 weeks' gestational age.[44] One RCT including 1019 infants delivered at 28 to 32 weeks of gestation showed no increased rate of severe intraventricular hemorrhage in the group receiving intact umbilical cord milking when compared with those receiving deferred cord clamping.[65]
3. In a single study including 182 infants born between 23 and 27+6/7 weeks of gestation who did not require immediate resuscitation, the incidence of severe intraventricular hemorrhage was significantly higher in those who received umbilical

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cord milking compared with deferred cord clamping of 60 seconds.[44]

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INITIAL STEPS

Maintaining Normothermia at Birth

Recommendations for Maintaining Normothermia		
COR	**LOE**	**Recommendations**
1	B-NR	1. The temperature of newborn infants should be monitored and maintained between 36.5 °C and 37.5 °C after birth through admission and stabilization.
1	B-NR	2. Hypothermia (temperature less than 36 °C) should be prevented due to its association with adverse outcomes in newborn infants.
1	B-NR	3. Hyperthermia (temperature greater than 38 °C) should be prevented due to its association with adverse outcomes in newborn infants.

Synopsis

Temperature after birth is an important measure of resuscitation quality.[1,2] The ideal temperature of newborn

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infants is between 36.5 °C and 37.5 °C.[3] Hypothermia is associated with increased neonatal mortality and morbidity, especially in very preterm (less than 33 weeks' gestational age) and very low-birth-weight infants (less than 1500 g), who are at increased risk for hypothermia.[4–7] Hyperthermia is associated with increased mortality and cerebral injury in both term and preterm infants.[5,8–10] Adverse outcomes are more frequent as temperature deviation on either side of the normal range increases.[4,5]

Recommendation-Specific Supportive Text

1. There are long-standing worldwide recommendations for routine temperature management for the newborn infant.[3] Monitoring of temperature after birth shows that hypothermia is common worldwide, with a higher incidence in newborn infants of lower gestational age and birth weight.[4–7,11] Hyperthermia may occur when warming interventions are provided in the delivery room without careful monitoring.[12]
2. In observational studies, the presence and degree of hypothermia after birth is strongly associated with increased neonatal mortality and morbidity, particularly in preterm (less than 37 weeks' gestational age) and low-birth-weight infants (less than 2500 g).[4–7]
3. Two observational studies found an association between hyperthermia and increased morbidity and mortality in very preterm and very low-birth-weight newborn infants.[5,10] Two observational studies showed an association between hyperthermia in preterm infants and major abnormalities on cranial ultrasound, neurodevelopmental impairment, and necrotizing enterocolitis.[8,13] Meta-analysis of 31 observational studies of epidural analgesia showed an association between intrapartum hyperthermia and adverse neonatal neurological outcome in both term and preterm infants.[9]

Interventions to Maintain Normothermia at Birth

Recommendations for Interventions to Maintain Normothermia		
COR	**LOE**	**Recommendations**
2a	**B-R**	1. For preterm infants in the delivery room, the use of radiant warmers, plastic bags or wraps (with a cap), increased room temperature, and warmed humidified inspired gases, separately or in combination, can be effective in preventing hypothermia.
2a	**C-LD**	2. Placing newborn infants skin-to-skin after birth can be effective to maintain normothermia.
2a	**C-LD**	3. For newborn infants who require resuscitation, temperature-controlling interventions can be beneficial.
2b	**B-R**	4. For preterm infants, exothermic mattresses may be considered for the prevention of hypothermia.
2b	**B-NR**	5. For preterm infants, various combinations of warming strategies (or "bundles") may be reasonable to prevent hypothermia but may also increase the risk of hyperthermia.

Synopsis

Placing healthy newborn infants skin-to-skin after birth can be beneficial for maintaining normothermia.[14] For preterm and low-birth-weight infants or newborn infants requiring resuscitation, warming adjuncts (ambient temperature greater than 23 °C, skin-to-skin care, radiant warmers, plastic wraps or bags, hats, blankets, exothermic mattresses, and warmed humidified inspired gases)[15–17] individually or in combination may reduce the risk of hypothermia. However, exothermic mattresses have been reported to cause local heat injury and hyperthermia.[18] Warming devices, especially when used in combination with other interventions to minimize heat loss, can result in hyperthermia.

Recommendation-Specific Supportive Text

1. RCTs and observational studies of warming adjuncts, alone and in combination, demonstrate reduced rates of hypothermia in very preterm and very low-birth-weight infants.[15,16,19] However, meta-analysis of RCTs of interventions that reduce hypothermia in very preterm or very low-birth-weight infants show no impact on neonatal morbidity or mortality.[16] Two RCTs and expert opinion support ambient temperatures of 23 °C and above.[3,17,20]
2. Two meta-analyses of RCTs showed that early skin-to-skin contact promotes normothermia in healthy newborn infants.[2,14] A single-center RCT comparing immediate skin-to-skin contact during and after elective cesarean delivery with conventional management showed elimination of hypothermia and hypoglycemia in the intervention group as well as improved breastfeeding outcomes.[21] Two meta-analyses reviewed RCTs and observational studies of extended skin-to-skin care after initial resuscitation or stabilization, some in resource-limited settings, showing reduced mortality, improved breastfeeding and blood glucose stability, shortened length of stay, and improved weight gain in preterm and low-birth-weight infants.[22,23]
3. Most RCTs in well-resourced settings routinely manage at-risk babies and those requiring resuscitation under a radiant warmer.[15,16] Other warming adjuncts are utilized when resuscitation is initiated with the cord intact.[12]
4. Several RCTs suggest that exothermic mattresses (combined with other measures) prevent hypothermia in preterm infants.[19] One RCT found higher rates of hyperthermia with exothermic mattresses.[18]
5. Numerous nonrandomized quality improvement studies support the combined use of multiple warming adjuncts ("bundles").[24] The use of radiant warmers in manual mode or exothermic mattresses in combination with other interventions to conserve heat effectively maintains temperature but increases the risk of hyperthermia.[19]

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Tactile Stimulation in Newborn Infants

Recommendation for Tactile Stimulation in Newborn Infants		
COR	LOE	Recommendation
2a	C-LD	1. Tactile stimulation can be useful in newborn infants who appear to have ineffective respiratory effort after birth.

Synopsis

The immediate care of newborn infants involves an initial assessment of breathing and muscle tone. Infants who are breathing well or crying are cared for skin-to-skin with their mothers and do not need interventions such as routine tactile stimulation.[25] Tactile stimulation is defined as drying an infant and rubbing the back and soles of the feet.[25] If there is ineffective breathing effort or apnea after birth, tactile stimulation may improve or initiate breathing. There may be some benefit from repeated tactile stimulation in preterm infants during or after providing ventilation, but this requires further study.[26] Prolonged tactile stimulation should not delay the provision of ventilation.

Recommendation-Specific Supportive Text

1. Limited observational studies suggest that tactile stimulation may improve respiratory effort. In an observational study of video recordings of neonatal resuscitations among 245 infants born prior to 32 weeks of gestation, those who received tactile stimulation had lower rates of endotracheal intubation than those who did not receive stimulation.[27] One RCT found improved oxygenation after resuscitation in preterm infants who received repeated tactile stimulation.[26] This study concerned only preterm infants 27 to 32 weeks' gestational age. In an observational study of 3073 noncrying newborn infants 34 weeks or more of gestation, 83% received stimulation, of whom 81% breathed after stimulation when cord was intact, while 69% breathed after stimulation with cord clamped.[28]

Clearing the Airway in Newborn Infants

Recommendations for Clearing the Airway in Newborn Infants		
COR	LOE	Recommendations
2a	C-EO	1. Suctioning of the mouth and nose can be considered in newborn infants if ventilation is required and the airway appears obstructed.
2a	C-EO	2. Intubation and tracheal suction can be beneficial for newborn infants who have evidence of tracheal obstruction during ventilation.
3: No Benefit	B-R	3. Routine oral, nasal, oropharyngeal, or endotracheal suctioning of newborn infants is not recommended, regardless of whether the fluid is clear or meconium stained.

Synopsis

Newborn infants who are breathing well or crying are cared for skin-to-skin with their mothers and should not need interventions such as suctioning, whether the amniotic fluid is clear or meconium stained.[29] Avoiding unnecessary suctioning helps prevent the risk of induced bradycardia, apnea, desaturation, and airway injury.[29] If at initial assessment there is visible fluid obstructing the airway or a concern about obstructed breathing, the mouth and nose may be suctioned. Suctioning is reserved for when there is evidence of airway obstruction during ventilation. Direct laryngoscopy and endotracheal suctioning had been practiced in the past for newborn infants with meconium-stained amniotic fluid. However, this practice has not been shown as beneficial, whether the infant is vigorous or nonvigorous.[30] The practice of suctioning may delay assisted ventilation. When ventilation appears ineffective after corrective measures, airway obstruction may be present from blood, mucus, amniotic fluid, or meconium. In those instances, providing suction to relieve the obstruction may facilitate more effective ventilation.

Recommendation-Specific Supportive Text

1. Suctioning for suspected airway obstruction during ventilation is based on expert opinion. When ventilation is indicated and the airway appears obstructed, use of a bulb syringe or other suction device can clear the airway. There is no evidence or consensus to support the use of deep suctioning of the stomach.
2. Endotracheal suctioning for apparent airway obstruction is based on expert opinion. Regardless of the presence of meconium, when ventilation corrective steps do not lead to an increase in heart rate or to chest rise, endotracheal suctioning may help to relieve an obstruction. Obstruction may be caused by meconium, mucus plug, blood, or amniotic fluid.
3. A meta-analysis of 7 RCTs found no benefit from routine upper airway suctioning after birth in infants born through clear amniotic fluid.[29] Two RCTs and 2 prospective observational studies found lower oxygen saturations in infants who received suctioning within the first 10 minutes, while 2 RCTs did not find significant differences.[29] A meta-analysis of 4 RCTs found no benefit of endotracheal suction for infants born through meconium-stained amniotic fluid.[30] A large quality improvement trial found that avoiding suction prior to spontaneous breathing, but only wiping the mouth of nonvigorous infants with a towel, was associated with decreased exposure to oxygen in the delivery room (12.4% versus 4.4%) but no differences in Apgar scores, use of ventilation or CPAP, or neonatal intensive care unit admission.[31]

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ASSESSMENT OF HEART RATE

Recommendations for Assessment of Heart Rate in Newborn Infants		
COR	**LOE**	**Recommendations**
2a	**B-NR**	1. ECG can be useful for fast and accurate heart rate assessment in newborn infants.
2a	**C-LD**	2. Auscultation and pulse oximetry are reasonable alternatives to ECG for heart rate assessment in newborn infants.

Synopsis

After birth, the newborn infant's heart rate is used to assess the effectiveness of spontaneous respiratory effort,

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the need for interventions, and the response to interventions. Auscultation of the precordium remains the preferred physical examination method for the initial assessment of the heart rate, although assessment by auscultation (or palpation) may be unreliable and inaccurate. ECG provides the most rapid and accurate measurement of the newborn infant's heart rate at birth and during resuscitation.[1] Compared to ECG, pulse oximetry is both slower in detecting the heart rate and tends to be inaccurate during the first few minutes after birth. Several emerging technologies show potential for fast and accurate heart rate assessment, but insufficient clinical data exists for inclusion in these recommendations. Underestimation of heart rate can lead to potentially unnecessary interventions. Alternatively, overestimation of heart rate when a newborn infant is bradycardic may delay necessary interventions. Limited data are available comparing the different approaches to heart rate assessment during neonatal resuscitation on other neonatal outcomes. Use of ECG for heart rate detection does not replace the need for pulse oximetry to evaluate oxygen saturation to assess the need for supplemental oxygen. Pulse oximetry can be placed in anticipation of resuscitation or when assisted ventilation is initiated. ECG can be considered when assisted ventilation is initiated and placed by the time that an alternative airway is being considered for bradycardia (Figure 2).

Recommendation-Specific Supportive Text

1. In 1 RCT and 1 observational study including 70 infants, there were no reports of technical difficulties with ECG monitoring during neonatal resuscitation, supporting its feasibility as a tool for monitoring heart rate during neonatal resuscitation.[2,3] One observational study including 630 infants compared neonatal outcomes before (historical cohort) and after implementation of ECG monitoring in the delivery room.[4] Compared with the newborn infants in the historical cohort, newborn infants with ECG monitoring had lower rates of endotracheal intubation and higher 5-minute Apgar scores. Newborn infants in that study with ECG monitoring had higher odds of receiving chest compressions in the delivery room with appropriateness of compressions not assessed. Evidence from 11 nonrandomized studies[2,5–14] enrolling 452 newborn infants and 3 RCTs[15–17] enrolling 187 newborn infants suggest that at birth, ECG is faster and more accurate for newborn heart assessment compared with pulse oximetry. Data from 4 nonrandomized studies enrolling 156 newborns and 1 RCT enrolling 45 newborn infants show that auscultation is not as accurate as ECG for heart rate assessment during stabilization immediately after birth.[6,18–21]
2. In the absence of ECG, studies demonstrate auscultation and pulse oximetry are faster or more accurate than palpation for heart rate assessment.[1,18] When ECG is unavailable or not functional, auscultation or pulse oximetry are reasonable alternatives and adjuncts for heart rate assessment.

Recommendation for Assessment of Heart Rate in Newborn Infants Receiving Chest Compressions		
COR	**LOE**	**Recommendation**
1	C-EO	1. ECG should be used for the rapid and accurate assessment of heart rate during chest compressions in term and preterm infants.

Synopsis

When chest compressions are initiated, ECG monitoring can confirm heart rate. The placement of ECG leads can facilitate a continuous assessment of heart rate without the need for a team member auscultating the heart intermittently. During chest compressions, the ECG signal may not be reliable due to artifact. When ECG heart rate is greater than 60/min, a palpable pulse or audible heart rate rules out pulseless electrical activity.[22–26]

Recommendation-Specific Supportive Text

1. Given its reliability in heart rate assessment compared to other modalities prior to beginning chest compressions in term and preterm infants, expert opinion is that ECG should be used when providing chest compressions despite the lack of direct evidence supporting the practice during chest compressions.[1]

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VENTILATION AND CONTINUOUS POSITIVE AIRWAY PRESSURE

Ventilatory Support

Recommendations for Ventilatory Support		
COR	**LOE**	**Recommendations**
1	**B-NR**	1. Ventilation should be provided within 60 seconds after birth in newborn infants who are gasping or apneic or who are persistently bradycardic (heart rate less than 100/min) despite appropriate initial steps.
2a	**C-LD**	2. For newborn infants, initial peak inflation pressures of 20 to 30 cm H_2O are reasonable, with adjustment of peak inflation pressures to provide effective ventilation.
2b	**C-LD**	3. In newborn infants receiving ventilation, it may be reasonable to provide positive end-expiratory pressure (PEEP).
3: Harm	**C-LD**	4. Excessive peak inflation pressure can result in high tidal volume, which is potentially harmful and should be avoided.

Synopsis

Most newborn infants start breathing spontaneously within 30 to 60 seconds after birth, sometimes with the help of drying and gentle stimulation.[1] If a newborn infant does not breathe spontaneously or has a persistent heart rate below 100/min despite initial efforts including tactile stimulation, ventilation is required at a rate of 30 to 60 inflations per minute. Delay in providing ventilation can increase the risk of death.[1] The effectiveness of ventilation is assessed by increase in heart rate and, to a lesser extent, by chest movement. For newborn infants, initial peak inflation pressures of 20 to 30 cm H_2O are generally sufficient to inflate the lungs. In some cases, higher peak inflation pressures may be necessary.[2,3] However, excessive tidal volumes have been associated with lung and brain injury in preterm newborns.[4,5] As tidal volumes can be both insufficient for effective ventilation if too low, or injurious if too high, titration of peak inflation pressure can be considered during neonatal resuscitation.

Lungs of sick or preterm infants are prone to collapse due to immaturity or inflammation. PEEP improves lung function and oxygenation and maintains lung inflation during expiration. While PEEP may be advantageous, human studies in neonates are limited and the optimal level of PEEP remains undetermined.[6,7]

Recommendation-Specific Supportive Text

1. Most nonvigorous newborn infants respond to stimulation and ventilation. The risk of death or prolonged hospitalization increases by 16% for every 30-second delay in initiating ventilation.[1]

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2. An observational study in 129 term newborn infants using a T-piece resuscitator (refer to the Devices for Ventilation section) reported that during ventilation, median (IQR) peak inflation pressures of 30.6 (28.6–31.6) cm H_2O resulted in a tidal volume of 4.5 (1.6–7.8) mL/kg.[2] Similarly, an observational study in 821 term newborn infants using a self-inflating bag reported that during ventilation, median peak inflation pressure of 37.7 (32.6–40.8) cm H_2O resulted in a tidal volume of 5.2 (2.3–8.6) mL/kg.[3] Furthermore, a multicenter cluster-crossover trial randomized preterm infants greater than 26 weeks' gestational age and term infants to ventilation with either a self-inflating bag with or without a PEEP valve or a T-piece with PEEP and reported a mean (standard deviation) maximum peak inflation pressure of 26 (2) cm H_2O with the T-piece versus 28 (5) cm H_2O with the self-inflating bag.[8] Observational studies in preterm newborn infants reported that a peak inflation pressure of 20 to 25 cm H_2O delivered a median (IQR) tidal volume of 9 (3–15.7) mL/kg during ventilation, but higher initial pressures may sometimes be required.[9–14] After initiation of assisted ventilation, titrating peak inflation pressures both up and down during resuscitation may be needed to achieve effective, but not excessive, ventilation.
3. A cohort study of 1962 infants born between 23 and 33 weeks' gestational age reported lower rates of mortality and chronic lung disease during ventilation with PEEP versus ventilation with no PEEP.[6] Furthermore, using logistic regression with adjustment for maternal and neonatal characteristics, use of the T-piece resuscitator with PEEP compared with self-inflating bag without PEEP increased the chance of survival to hospital discharge without major morbidities (OR, 1.38; 95% CI, 1.06–1.80).[6]
   In preterm animal models, PEEP facilitates lung aeration and development of functional residual capacity, prevents distal airway collapse, increases lung surface area and compliance, decreases expiratory resistance, conserves surfactant, and reduces hyaline membrane formation, alveolar collapse, and the expression of proinflammatory mediators.[15–17]
4. Animal studies reported that ventilation with high volumes initiates inflammatory cascades, which result in lung and brain injury in immature animals.[18,19] The 2 pathways (cerebral blood flow instability and cerebral inflammatory cascade) increase the risk of brain injury and potential lifelong adverse neurodevelopmental outcomes.[18]
   Observational studies in preterm newborn infants have associated high tidal volume delivery during ventilation with higher rates of intraventricular hemorrhage.[4,5] When preterm newborn infants received tidal volumes >6 mL/kg, grade III and IV intraventricular hemorrhage was found in 33/124 (27%) infants compared to tidal volumes <6 mL/kg in 2/41 (6%).[4] Similarly, infants who had a greater number of inflations with a tidal volume >6 mL/kg were more likely to develop intraventricular hemorrhage.[5]

Rate and Inflation Time During Ventilation

Recommendations for Rate and Inflation Time During Ventilation		
COR	**LOE**	**Recommendations**
2a	C-LD	1. It is reasonable to provide ventilation at a rate of 30 to 60 inflations per minute in newborn infants.
2a	C-LD	2. It is reasonable to initiate ventilation with an inflation time of 0.5 to 1 seconds in newborn infants.
3: Harm	B-R	3. In preterm newborn infants less than 28 weeks of gestation, the routine use of sustained inflations (>5 seconds) to initiate ventilation is potentially harmful and should not be performed.

Synopsis

During ventilation, an inflation time of 0.5 to 1 second during ventilation aligns with the natural breathing patterns of both term and preterm newborn infants.[2,20,21] It is appropriate to provide ventilation at a rate of 30 to 60 inflations per minute for newborn infants who are not breathing effectively.[1,2] Studies that explored the effects of sustained inflations >5 seconds reported higher risks for preterm newborns.[22] The potential benefits or risks of sustained inflations lasting between 1 and 5 seconds remain unclear.

Recommendation-Specific Supportive Text

1. An observational study of 129 term newborn infants reported that ventilation using inflation time of approximately 0.5 seconds with a rate of 30 to 60/min resulted in delivered tidal volumes between 5 and 10 mL/kg.[2] An observational study of 434 late preterm and term newborns reported that an inflation rate of 30/min was associated with the highest carbon dioxide clearance and the shortest time to reach exhaled carbon dioxide >2%.[23]
2. Observational studies including 950 term newborn infants reported that median inflation time of 0.46 seconds (IQR, 0.35–0.59 seconds) was associated with adequate tidal volume delivery.[1,2] Furthermore, increased inflation times were associated with a rise in tidal volume.[2]
3. An ILCOR task force review reported no benefit in using 1 or more sustained inflations of >5 seconds for preterm infants at birth.[22] Sustained inflations may increase mortality among the subgroup of preterm newborns <28 weeks of gestation.[22] The Sustained Aeration for Infant Lungs trial included 426 newborn infants 23 to 26 weeks' gestational

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age and compared ventilation with up to 2 initial sustained inflations using a peak inflation pressure of 25 cm H_2O for 15 seconds (intervention) to standard ventilation (control) and reported significantly higher early mortality with sustained inflation compared to standard ventilation.[24]

Ventilation Corrective Maneuvers

Recommendations for Ventilation Corrective Maneuvers		
COR	**LOE**	**Recommendations**
2a	C-LD	1. Ventilation corrective maneuvers can be useful when initial positive pressure inflations are not effective for newborn infants who require ventilation.
2a	B-R	2. Video laryngoscopy can be useful for newborn infants who require endotracheal intubation.

Synopsis

Effective ventilation is difficult to perform in newborn infants due to problems such as leak around the face mask, airway obstruction, and insufficient inflating pressures.[25–28] Neonatal manikin studies have shown that large leaks around the face mask can occur during ventilation,[29–32] and these findings have been replicated in clinical studies of term and preterm infants receiving mask ventilation.[13,28,33–35] Ventilation corrective maneuvers to overcome common challenges to effective ventilation include airway repositioning, mask adjustment or use of the 2-handed mask hold, suctioning, increasing peak inflation pressure, and placement of an alternative airway.[36,37]

Direct laryngoscopy has been the traditional method of placing an endotracheal tube. As video laryngoscopes have been used both in the delivery room and in the neonatal intensive care unit, evidence has shown potential benefit, including increased rates of first attempt success and overall success.[38–43] As video laryngoscopy may not be feasible across all settings due to cost and training requirements, traditional laryngoscopy continues to be a reasonable alternative.

Recommendation-Specific Supportive Text

1. In an infant manikin study of 48 subjects and a pilot RCT of 30 preterm infants, mask leak was significantly reduced when using a 2-handed mask hold technique compared to a single operator holding the mask and providing the ventilation.[44,45] In an observational study of ventilation corrective maneuvers on the impact of tidal volume delivery during ventilation in 30 preterm infants, performing ventilation corrective steps led to improved tidal volume delivery in about one third of patients but resulted in ineffective or excessive tidal volumes in others. The number, sequence, and combination of maneuvers varied across resuscitations.[46] In an observational study of physiological response to ventilation corrective maneuvers in 28 preterm infants, mask adjustment, airway repositioning, and increasing peak inflation pressure led to improved oxygen saturation. Mask adjustment and increasing peak inflation pressure were also observed to increase expired tidal volume, although excessive tidal volumes were seen in this study.[47] An observational study of 58 term and 76 preterm infants reported a total of 427 maneuvers to improve noninvasive respiratory support. Cerebral regional tissue oxygen saturation measured by near infrared spectroscopy increased after the first ventilation corrective maneuver. There were nonsignificant improvements in heart rate, oxygen saturation, and face mask leak.[48]
2. In a meta-analysis of 6 RCTs involving 862 intubations, video laryngoscopy compared to traditional laryngoscopy led to increased endotracheal intubation success.[38–43,49] In a meta-analysis of 4 RCTs involving 610 intubations, video laryngoscopy compared to traditional laryngoscopy led to increased likelihood of endotracheal intubation on first attempt.[39,41–43] In a meta-analysis of 4 RCTs involving 555 intubations, video laryngoscopy compared to traditional laryngoscopy led to decreased number of intubation attempts.[38–40,43] Adverse outcomes such as airway trauma, bradycardia, oxygen desaturation, esophageal intubation, and pneumothorax were not increased in 5 comparative RCTs.[39–43] In 4 observational studies involving 3342 intubations, video laryngoscopy compared to traditional laryngoscopy was associated with increased likelihood of endotracheal intubation on first attempt.[50–53] While traditional laryngoscopy remains a reasonable method to achieve an alternative airway, video laryngoscopy may be preferable when resources and training allow.

Interfaces to Deliver Ventilation to Newborn Infants

Recommendations for Interfaces to Deliver Ventilation to Newborn Infants		
COR	**LOE**	**Recommendations**
2a	C-LD	1. It is reasonable to use a laryngeal mask as an alternative to endotracheal intubation for newborn infants 34+0/7 weeks' or more gestational age for whom ventilation via face mask is unsuccessful.
2b	C-LD	2. It may be reasonable to use a laryngeal mask as the primary interface to administer ventilation instead of a face mask for newborn infants 34+0/7 weeks' or more gestational age.

Synopsis

Available interfaces for delivery of ventilation during newborn resuscitation include face masks, nasal prongs, and

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laryngeal masks (also known as *supraglottic airways*). While face masks have historically been the most-used and most-studied interface in neonatal resuscitation, there is a growing body of evidence for the role of laryngeal masks as either primary or secondary interfaces for newborn ventilation.

Based on available evidence, these recommendations are limited to newborn infants ≥34+0/7 weeks of gestation as this reflects the gestational age of the infants studied. Many manufacturers of laryngeal masks also state a lower weight limit of 2 kg, but smaller devices are now being made for infants weighing less than 2 kg. There is a lack of evidence for a lower weight limit or gestational age at which these smaller devices may be safely and effectively used.

Recommendation-Specific Supportive Text

1. In 2 separate meta-analyses of the same 3 RCTs (158 infants born at ≥34+0/7 weeks' gestational age), there was no significant difference in insertion time, failure to correctly place the device, or first attempt success when a laryngeal mask was used as a secondary device instead of endotracheal intubation after face mask ventilation was unsuccessful.[54,55] In 1 RCT (68 infants born at ≥34+0/7 weeks' gestational age) that was not included in these meta-analyses, there was no significant difference in insertion time, first attempt success, or duration of ventilation.[56] In 1 observational study (86 infants born at 34+0/7 to 36+6/7 weeks' gestational age) that was not included in these meta-analyses, use of a laryngeal mask instead of an endotracheal tube was associated with decreased likelihood of admission to the neonatal intensive care unit.[57] There were insufficient subjects to determine statistical difference in important outcomes such as incidence of pneumothorax or mortality.
2. A meta-analysis of 6 RCTs (1823 infants born at ≥34+0/7 weeks' gestational age) found that use of a laryngeal mask decreased the probability of failure to improve with the assigned device and the rate of endotracheal intubation in the delivery room when compared to use of a face mask.[58] These studies had heterogeneity in regard to subjects in their resuscitation experience for face mask ventilation and tended to be conducted in low- and middle-income countries. The duration of ventilation and time until heart rate reached >100/min were also shorter with the laryngeal mask. Similarly, a quasi-randomized study of 67 infants born at >36 weeks' gestational age that was not captured in the above meta-analysis found that infants who received ventilation using a laryngeal mask required shorter duration of ventilation and were less likely to require intubation when compared to infants who were ventilated using a face mask.[59]

Devices for Ventilation

Recommendation for Devices to Deliver Ventilation to Newborn Infants		
COR	**LOE**	**Recommendation**
2a	**B-R**	1. It can be beneficial to use a T-piece resuscitator instead of a self-inflating bag, with or without a PEEP valve, for administering ventilation to newborn infants, particularly preterm infants.

Synopsis

Several devices are available to administer ventilation, including self-inflating bags, flow-inflating bags, and T-piece resuscitators. The choice of ventilation device depends upon factors reflecting the context at a birthing site: the number of births, the case mix, availability of a compressed gas source, familiarity with the different devices, amount of training required to use each device, and device cost. Because both T-piece resuscitators and flow-inflating bags require a compressed gas source to function, a self-inflating bag can serve as a backup in the event of compressed gas failure when using either of these devices.

Recommendation-Specific Supportive Text

1. A meta-analysis of 4 RCTs (1247 infants) found that resuscitation with a T-piece resuscitator compared with a self-inflating bag reduced the duration of assisted ventilation and decreased risk of bronchopulmonary dysplasia.[7] A more recent meta-analysis of 5 RCTs (1271 infants) comparing "fixed-pressure devices" (ie, T-piece resuscitators and mechanical ventilators) to "hand-pressure devices" (ie, self-inflating bags and flow-inflating bags) similarly found that fixed-pressure devices were associated with decreased bronchopulmonary dysplasia, intubation in the delivery room, requirement and duration of mechanical ventilation, and surfactant administration.[60] Neither meta-analysis showed a difference in mortality between groups. Although subgroup analyses by gestational age were not feasible[7] or not significant,[60] bronchopulmonary dysplasia is an outcome that affects preterm infants and the use of a T-piece resuscitator may provide the greatest benefit to preterm infants. Since these meta-analyses, 2 additional RCTs (92 preterm infants) comparing the use of a self-inflating bag and T-piece resuscitator have been published. Ventilation provided by a T-piece resuscitator delivered tidal volumes within goal range more consistently when compared to a self-inflating bag,[61] but there was no significant difference in duration of assisted ventilation or other outcomes.[61,62] There were no new studies identified that evaluated the use of flow-inflating bags.

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Continuous Positive Airway Pressure

Recommendations for Providing Continuous Positive Airway Pressure to Newborn Infants		
COR	**LOE**	**Recommendations**
2a	A	1. For spontaneously breathing preterm infants who require respiratory support immediately after birth, it is reasonable to use CPAP rather than intubation and mechanical ventilation.
2b	C-LD	2. For spontaneously breathing preterm infants who require respiratory support immediately after birth, the effectiveness of high-flow nasal cannula compared to CPAP is not well-established.
2b	C-LD	3. The usefulness of CPAP for spontaneously breathing term and late preterm infants 34 weeks' or more gestational age who have or are at risk of having respiratory distress immediately after birth is not well-established.

Synopsis

Newborn transition is dependent on lung inflation and establishing functional residual capacity.[63] Most spontaneously breathing term and late-preterm newborn infants will achieve this goal independently. However, some infants, particularly preterm infants, will need assistance to establish functional residual capacity even while spontaneously breathing. These infants can have signs of respiratory distress (grunting, nasal flaring, retractions) or persistent hypoxia if they have not been independently successful in adequate pulmonary recruitment. CPAP can provide noninvasive support to infants to recruit alveoli for respiration and aid in transition.

Recommendation-Specific Supportive Text

1. Four RCTs and 1 meta-analysis[64–68] showed reduction in the combined outcome of death and bronchopulmonary dysplasia when starting treatment with CPAP compared with intubation and ventilation in preterm infants less than 30 weeks of gestation with respiratory distress. The meta-analysis reported no differences in the individual outcomes of mortality, bronchopulmonary dysplasia, pneumothorax, intraventricular hemorrhage, necrotizing enterocolitis, or retinopathy of prematurity.[68]
2. One randomized trial enrolling 124 preterm infants (28–36 weeks of gestation) compared CPAP to high-flow nasal cannula as primary respiratory support in the delivery room.[69] There was no difference in "treatment failure" within 24 hours between groups. Treatment failure was defined as oxygen concentration >40%, failure of immediate extubation following surfactant administration by the Intubation-Surfactant-Extubation technique, predefined levels of acidosis or hypercarbia, apnea with predefined criteria of severity, or subsequent mechanical ventilation.
3. Two RCTs,[70,71] 2 observational studies,[72,73] and 1 meta-analysis[74] inform the use of CPAP in the delivery room. The studies included both prophylactic use of CPAP for prevention of and treatment of respiratory distress. The use of CPAP for spontaneously breathing term and late preterm infants ≥34 weeks' gestational age in the delivery room may decrease neonatal intensive care unit admission or respiratory support in the neonatal intensive care unit, though the incidence of pneumothorax may be increased.

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OXYGEN

Recommendations for Oxygen Administration During Neonatal Resuscitation

COR	LOE	Recommendations
1	C-EO	1. Oxygen supplementation should be titrated to target oxygen saturation goals in newborn infants receiving respiratory support.
1	C-LD	2. A pulse oximeter should be placed as soon as possible for newborn infants receiving respiratory support or supplemental oxygen.
2b	C-LD	3. In term and late preterm newborn infants born at 35 weeks' or more gestational age receiving respiratory support at birth, it may be reasonable to begin with 21% oxygen.
2b	C-LD	4. In preterm newborn infants born at 32 to 34+6/7 weeks' gestational age receiving respiratory support at birth, it may be reasonable to begin with 21% to 30% oxygen.
2b	C-LD	5. In preterm newborn infants born at less than 32 weeks' gestational age receiving respiratory support at birth, it may be reasonable to begin with 30% to 100% oxygen.

Synopsis

At birth, the newborn infant's blood oxygen levels rise over several minutes. For newborn infants who require resuscitation, supplemental oxygen may prevent harm from hypoxia.[1] However, hyperoxia may also be associated with harm.[2] The balance of benefit and harm of oxygen supplementation varies by gestational age and according to the individual newborn infant's physiology.

Pulse oximetry allows oxygen titration to prevent either hypoxia or hyperoxia. Placement of a pulse oximeter sensor and acquisition of a reliable signal takes time. Appropriate sensor placement is preductal, on the infant's right hand or wrist, as this reflects the blood oxygen saturation of the myocardium and brain.

In the very preterm population, failing to reach an oxygen saturation of 80% by 5 minutes has been associated with death regardless of initial oxygen concentration.[3,4] For infants less than 32 weeks' gestational age, initial oxygen concentrations of 21% to 30% may be insufficient to achieve target oxygen saturations.[5]

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Recommendation-Specific Supportive Text

1. Multiple studies have measured oxygen saturation in newborn infants at birth, but there are limited data on different oxygen saturation targets or titration strategies during newborn resuscitation. Optimal oxygen saturation targets for newborn infants receiving resuscitation at birth remain unknown. In the absence of such evidence, currently recommended preductal oxygen saturation goals remain based on ranges measured in healthy term infants after vaginal birth at sea level with the goal of avoiding the risks associated with hypoxia and hyperoxia.[6-8]
2. Placement of a pulse oximeter early in resuscitation results in earlier reading of oxygen saturation for guidance of oxygen therapy during resuscitation. In an observational study of videos of 230 resuscitated infants, median time to obtain pulse oximetry was 238 seconds.[9] In an observational study comparing asphyxiated infants to controls, the median time for oxygen saturation detection was longer (260 seconds) than in controls (100 seconds).[10] In an observational study of 428 infants, time taken to achieve an oxygen saturation reading in preterm infants was longer than in term infants.[11]
3. For term and late preterm infants 35 or more weeks of gestation requiring respiratory support at birth, initiating resuscitation with 21% oxygen (air) compared with 100% oxygen is reasonable because evidence from meta-analysis suggests that it may reduce short-term mortality.[12] The ILCOR systematic review of initial oxygen concentration for term and late preterm infants included 5 randomized and 5 quasi-randomized trials.[12] Most of the evidence came from studies with a high risk of bias and all summary estimates had serious imprecision. Meta-analysis of 7 randomized and quasi-randomized trials showed decreased short-term mortality when using 21% oxygen compared with 100% oxygen.[12] No difference was found in the risk of HIE or moderate to severe neurodevelopmental impairment among survivors at 1 to 3 years of age.[12] Although this systematic review included randomized and quasi-randomized controlled trials, the LOE has been downgraded to C-LD because of the high risk of bias in the studies included and the serious imprecision for all reported outcomes. No studies have compared initiating resuscitation with intermediate oxygen concentrations (22%–99% oxygen).
4. Evidence from meta-analysis of 10 randomized trials enrolling newborn infants less than 35 weeks' gestational age found no difference in short-term mortality when respiratory support was started with low compared with high oxygen.[13] In the included studies, low oxygen was generally 21% to 30% and high oxygen was 60% to 100%. In addition, no differences were found in multiple secondary outcomes. Most evidence came from studies with unclear risk of bias and all summary estimates had serious imprecision. In the subgroup of trials that used oxygen saturation targeting as a cointervention, all preterm infants in whom respiratory support was initiated with 21% oxygen (air) required supplemental oxygen to achieve the predetermined oxygen saturation target. The recommendation to initiate respiratory support with a lower oxygen concentration reflects a preference to avoid exposing preterm newborn infants to excess oxygen beyond that necessary to achieve the predetermined oxygen saturation target without evidence demonstrating a benefit for important outcomes.[14]
5. Analyses of the currently available data comparing initial oxygen concentration for very preterm infants have yielded conflicting conclusions, including for the critical outcome of mortality. A study-level meta-analysis of 10 RCTs enrolling preterm infants, including subanalysis of 7 trials reporting outcomes for newborn infants 28 weeks' gestational age or less, showed no difference in short-term mortality when respiratory support was started with low compared with high oxygen.[13] In these studies, low oxygen was generally 21% to 30% and high oxygen was 60% to 100%. No differences were found in long-term mortality, neurodevelopmental outcome, retinopathy of prematurity, bronchopulmonary dysplasia, necrotizing enterocolitis, or major cerebral hemorrhage.[13] In a systematic review of 8 trials that used oxygen saturation targeting as a cointervention, all preterm newborns in whom respiratory support was initiated with 21% oxygen required supplemental oxygen to achieve the predetermined oxygen saturation target.[13] A recent individual patient data meta-analysis found that in preterm infants less than 32 weeks of gestation, high initial (90%–100%) oxygen was associated with lower mortality when compared with low initial (21%–30%) oxygen concentrations.[5]

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CHEST COMPRESSIONS

Chest Compression Timing, Ventilation, and Oxygen Use

Recommendations for Initiating Chest Compressions in Newborn Infants		
COR	**LOE**	**Recommendations**
1	**C-EO**	1. In newborn infants, chest compressions are recommended if the heart rate remains less than 60/min despite 30 seconds of ventilation that inflates the lungs, as evidenced by chest movement.
1	**C-EO**	2. During chest compressions in newborn infants, ventilation with an endotracheal tube is recommended.
2b	**C-EO**	3. During chest compressions for newborn infants born at 34 weeks' or more gestational age when placement of an endotracheal tube is not possible or is unsuccessful, laryngeal mask may be a reasonable alternative.
2b	**C-EO**	4. It may be reasonable to use 100% oxygen during chest compressions in newborn infants. Once compressions are no longer needed, titrate the oxygen to meet saturation targets.

Synopsis

Most newborn infants who require resuscitation at birth respond to initial steps of resuscitation or to ventilation that inflates the lungs. Effective ventilation is indicated by a rise in heart rate. Ventilation must be optimized before starting chest compressions, including placement of an alternative airway, if possible (intubation or laryngeal mask), as chest compressions compete with delivery of effective ventilation.[1]

Oxygen is essential for organ function; however, excess inspired oxygen during resuscitation may be harmful.[2] Although current guidelines recommend using 100% oxygen during chest compressions,[3] no studies have confirmed a benefit of using 100% oxygen compared to any other concentration, including air (21%).[4] When providing chest compressions, the inspired oxygen can be increased to 100% and titrated to meet saturation targets once return of spontaneous circulation (ROSC) is achieved.

Recommendation-Specific Supportive Text

1. Initiation of chest compressions in newborn infants with a heart rate less than 60/min is based on expert opinion because there are no clinical or physiological human studies addressing this question. A review article regarding strategies to prevent progression of bradycardia and the role of chest compressions for persistent neonatal bradycardia in the delivery room included some potentially useful animal data.[5] Fetal lambs (n=14) were asphyxiated until cardiac arrest. Heart rates were continuously monitored and coronary, carotid, and pulmonary flows recorded and compared during asphyxia at different levels of bradycardia. Peak systolic carotid flows were significantly lower for heart rates <60/min compared to baseline.[5]
2. In a neonatal simulation study, once chest compressions were initiated, health care professionals (n=30) were unable to recognize changing lung compliance and thus made little effort to optimize ventilation.[1] Based on expert opinion, intubation is suggested during chest compressions in order to assure efficacy of ventilation, which is a priority for neonatal resuscitation.
3. A recent ILCOR scoping review examined the evidence for using a laryngeal mask during chest compressions in newborn infants.[6] Two animal studies suggest that ventilation via a laryngeal mask during chest compressions provides similar rates and time to ROSC compared to ventilation through an endotracheal tube.[7,8] Animal and manikin data suggest that laryngeal masks can deliver comparable ventilation to that provided through an endotracheal tube during chest compressions.[7–9]
4. A recent scoping review[4] identified that to date there are no human studies comparing air, 100% oxygen, or any other oxygen concentration during newborn infant chest compressions. Animal studies have not found any difference in rates of ROSC, mortality, markers of injury or oxidative

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stress, hemodynamics, or oxygen delivery.[4,10–12] None of the animal studies examined any longer-term outcomes. Based on expert opinion, 100% oxygen during chest compressions is suggested. Once ROSC is achieved, oxygen should be weaned to meet goal saturations, as hyperoxia following resuscitation is associated with morbidity.[13–15]

Compression-to-Ventilation Ratio and Techniques (Newborn)

Recommendations for Providing Chest Compressions		
COR	**LOE**	**Recommendations**
2b	C-LD	1. It may be reasonable to repeatedly deliver 3 compressions followed by a ventilation breath (3:1 ratio) when providing chest compressions to newborn infants.
2b	C-LD	2. It may be reasonable to use the 2 thumb–encircling hands technique compared to the 2-finger or other techniques when providing chest compressions to newborn infants.
2b	C-LD	3. It may be reasonable to compress to one third the anterior-posterior diameter of the chest when providing chest compressions to newborn infants.
2b	C-LD	4. It may be reasonable to compress over the lower one third of the sternum, taking care to be above the xiphoid process when providing chest compressions to newborn infants.
2b	C-EO	5. It may be reasonable to change the compressor role every 2 to 5 minutes when providing chest compressions to newborn infants and to switch the compressor during the heart rate assessment period.

Synopsis

The need for chest compressions is uncommon for newborn infants.[16,17] When compressions are indicated, the preferred compression to ventilation ratio is 3:1 in synchrony. The 2 thumb–encircling hands compression technique may have benefit over the 2-finger technique with respect to blood pressure generation and clinician fatigue. When providing chest compressions with the 2 thumb–encircling technique, the hands encircle the chest while the thumbs depress the sternum.[18] Performing chest compressions with this technique at the head of the bed facilitates placement of an umbilical venous catheter and has ergonomic advantages over compressing from the side of the infant.[19]

Optimal blood flow during chest compressions is achieved by compressing the chest to one third the anteroposterior diameter over the lower third of the sternum, with care to avoid the xiphoid process to avoid liver injury. Compressor fatigue may be minimized through routine role rotation among team members, preferably during heart rate assessments to limit interruptions in compressions.

Recommendation-Specific Supportive Text

1. In animal studies, the use of compression-to-ventilation ratios different from 3:1 (eg, 2:1, 4:1, 5:1, 9:3, 15:2) is associated with similar times to ROSC and mortality rates.[20–25] The use of chest compressions with asynchronous ventilations compared to a ratio of 3:1 has varied results with inconsistencies between studies with some reporting improvements in ROSC and survival, others showing no difference and some showing deteriorations in depth of compression and compressor fatigue.[4] A new technique of providing continuous compressions during a sustained inflation has been studied in animals[4,11,26,27] as well as in a small pilot trial in newborn infants.[28] The majority of studies suggest potential benefit with faster time to ROSC but inconsistent survival results. A larger clinical trial found no differences but was underpowered.[29] Providing continuous compressions during a sustained inflation remains an interesting area of research but is not ready for clinical application.
2. Animal and manikin studies frequently demonstrate greater chest compression depth, improved carotid blood flow, lower fatigue, and higher proportion of correct hand placement with the 2 thumb–encircling hands technique compared with the 2-finger and other techniques.[4,30] In 2 newborn infants with indwelling catheters, the 2 thumb–encircling hands technique generated higher systolic and mean blood pressures compared with the 2-finger technique.[31]
3. In a randomized animal trial, time to ROSC was similar with chest compression depths of 25%, 33%, and 40% of the anteroposterior chest diameter. A chest compression depth of only 12.5% did not achieve ROSC.[32] The same group also reported on hemodynamic parameters, with the highest carotid blood flow and systemic mean blood pressure being achieved with 40% chest compression depth.[32] A retrospective clinical study examined chest computed tomography scans of 54 neonates and concluded that the recommended one third anteroposterior diameter would be more effective than one fourth anteroposterior diameter compression and safer than one half anteroposterior diameter compressions.[33] No neonatal survival outcomes or long-term outcomes of newborn infants who received varying depths of compression are available.
4. One of the earliest reports of newborn infant chest compressions compared abdominal versus xiphoid versus middle sternum versus simultaneous chest/abdominal compression. Fresh cadavers of infants and young children (n=15) were used with subsequent autopsy examination. No rupture of the liver was produced when pressure was applied to the

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chest alone at midsternum. Superficial tears of the liver capsule were produced when pressure was applied to the xiphoid process, and all patients with simultaneous chest/abdominal or abdominal compressions alone had liver rupture. Compression of the middle part of the sternum (above the xiphoid) produced effective circulatory pressures.[34] Chest radiograph studies with markers at the sternal notch and xiphoid process prior to taking the film subsequently identified that for the majority of infants, the heart lies under the lower one third of the sternum.[35–37] Additional studies found that the nipple line is not a good landmark for determining compression position.[38,39] Review of infant chest computed tomography scans to evaluate the optimal chest compression site found that the left ventricle was located beneath the lower quarter of the sternum the majority of the time.[40] Due to the safety concerns from the older cadaveric studies, it is important to make sure the compression is above the xiphoid on the lower one third of the sternum.[33]

5. High-quality chest compressions encompass multiple factors, including optimal compression-to-ventilation ratio, adequate rate, depth of compression, and full recoil between compressions. If the compressor experiences fatigue, the quality of the compressions declines.[41,42] Neonatal manikin studies demonstrate that compression quality can diminish by 2 to 5 minutes when a single clinician performs compressions.[43–46]

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VASCULAR ACCESS DURING RESUSCITATION

Recommendations for Vascular Access During Resuscitation		
COR	**LOE**	**Recommendations**
1	C-LD	1. Insertion of an umbilical vein catheter is recommended for newborn infants requiring emergency vascular access.
2a	C-LD	2. Insertion of an intraosseous (IO) vascular access device can be useful for newborn infants requiring emergency vascular access if intravenous access is not successful or not feasible.

Synopsis

Newborn infants who do not respond to ventilation and chest compressions require emergency vascular access to administer epinephrine or volume expanders. Although few newborn infants receive emergency medications,[1,2] health care professionals must be prepared to obtain rapid vascular access because delayed administration of epinephrine is associated with a decreased likelihood of survival.[3] In the newborn infant, the umbilical vein is readily accessible and provides direct access to the heart and ascending aorta,[4] but many health care professionals without neonatology specialty training perceive umbilical vein catheterization to be difficult.[5] The insertion of an IO vascular access device into the medullary cavity of a long bone is an alternative route and is commonly used in prehospital and emergency department settings.[6] IO vascular access devices have been associated with serious complications, including fractures, extravasation leading to compartment syndrome, and tissue necrosis.[7]

Recommendation-Specific Supportive Text

1. Historically, umbilical vein catheterization has been the standard approach to emergency vascular access in the delivery room and has been recommended since the first international consensus guidelines for neonatal resuscitation.[8] In a registry study of 93 656 neonates in the delivery room, of the 47 neonates who received epinephrine, 32% achieved ROSC with endotracheal epinephrine while 77% achieved ROSC with intravascular epinephrine (by umbilical venous catheter) after failing endotracheal epinephrine.[1] In a single-center retrospective case series, 15/20 (75%) newborn infants who received the first dose of epinephrine through an umbilical vein catheter achieved ROSC.[9] In an animal model of neonatal asphyxia, epinephrine infused through a low-lying umbilical vein catheter achieved comparable peak plasma epinephrine concentrations and ROSC when compared with direct injection into the right atrium.[10] There are no human studies directly comparing

the safety and effectiveness of umbilical vein catheters or IO vascular access devices or describing the first attempt success and complication rate for umbilical vein catheterization during neonatal resuscitation.

2. A systematic review, including 1 case series and 12 individual case reports, described successful IO vascular access device insertion among 41 neonates during resuscitation in the delivery room or neonatal intensive care unit.[7] In total, 5 infants had serious complications, including 2 cases of limb ischemia leading to subsequent amputation and 1 tibial fracture. Subsequently, 3 case series have described IO vascular access device insertion among 12 neonates (10 newborn infants) identified by a survey from a single center,[11] 161 neonates (113 in the first day of life) identified from a multicenter pediatric emergency registry,[12] and 102 neonates (13 in the delivery room) identified from records of a pediatric emergency transfer service.[13] Successful IO vascular device insertion on the first attempt in neonates ranged from 50% to 86%, with any complication reported in 10% to 35%. In an asphyxiated lamb model of neonatal resuscitation, the peak serum epinephrine concentration and ROSC rates were similar between the umbilical vein catheter and IO vascular access device groups.[14] In simulation studies, participants inserted an IO vascular access device more quickly than an umbilical vein catheter.[15–17] However, in an anatomic cadaver study (n=16; median gestational age, 29 weeks [IQR, 27–38 weeks]) using 2 different IO vascular access devices, computed tomography imaging showed the tip of the device within the medullary cavity after only 39.7% to 61.1% of insertions.[18]

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EPINEPHRINE

Recommendations for Epinephrine Administration in Neonatal Resuscitation

COR	LOE	Recommendations
1	B-NR	1. In newborn infants whose heart rate has not increased to 60/min or more after optimizing ventilation and chest compressions, it is recommended to administer intravascular epinephrine (0.01–0.03 mg/kg).
2a	B-NR	2. In newborn infants who do not have an adequate response to an endotracheal dose of epinephrine, it is reasonable to administer intravascular epinephrine as soon as access is obtained regardless of the dosing interval.
2a	C-LD	3. In newborn infants receiving epinephrine, it is reasonable to administer endotracheal epinephrine at a larger dose (0.05–0.1 mg/kg) while vascular access is being obtained.

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Recommendations for Epinephrine Administration in Neonatal Resuscitation (Continued)		
COR	LOE	Recommendations
2b	C-LD	4. In newborn infants receiving epinephrine, it may be reasonable to administer additional doses of epinephrine every 3 to 5 minutes, preferably intravascularly, if the heart rate remains less than 60/min.

Synopsis

Medications are rarely needed in resuscitation of the newborn infant because low heart rate usually results from poor gas exchange or inadequate lung inflation after birth. Establishing ventilation is the most important step in the resuscitation of a bradycardic newborn infant. However, if heart rate remains less than 60/min after ventilating with 100% oxygen (preferably through an alternative airway, eg, endotracheal tube or laryngeal mask) and chest compressions, administration of epinephrine is indicated. Epinephrine is a cardiac and vascular stimulant that improves blood flow to the coronaries and causes vasoconstriction to the peripheral vessels. Providing epinephrine in a newborn infant who remains bradycardic despite adequate ventilation may improve the heart rate and strength of contractions.

Administration of intravascular epinephrine (through either a low-lying umbilical venous catheter or IO vascular access device) provides the most rapid and reliable medication delivery. The bioavailability of epinephrine using either method should be similar, and the choice of route may depend on the location of birth, training of health care professionals, team experience in vascular access, and available supplies. The intravascular dose of epinephrine is 0.01 to 0.03 mg/kg. This can be followed by a 3 mL normal saline flush regardless of birth weight.[1] While intravascular access is in progress, epinephrine may be given by the endotracheal route in a dose of 0.05 to 0.1 mg/kg, as a higher dose is likely needed to achieve a similar level to intravascular administration.[2–7]

Recommendation-Specific Supportive Text

1. A term piglet model of asphyxia-induced cardiac arrest demonstrated that intravenous epinephrine improved rates of ROSC compared to compressions alone.[8] Observational evidence in human infants does not demonstrate greater efficacy of endotracheal or intravenous epinephrine; however, most babies received at least 1 intravenous dose before ROSC.[2,9,10] Three studies using a term perinatal lamb model of asphyxia-induced cardiac arrest found that central venous epinephrine was associated with shorter time to ROSC and higher rates of ROSC than endotracheal epinephrine.[11–13] In a similar model, IO epinephrine was as effective as intravenous.[14] Intravenous epinephrine followed by a normal saline flush improves medication delivery.[1,15]
2. In both a single-center observational study and a multicenter registry study, most infants who received an endotracheal dose achieved ROSC after subsequent intravenous doses.[9,10] Although the more rapid response to intravenous epinephrine warrants its immediate administration once umbilical access is obtained, repetitive endotracheal doses or higher intravenous doses may result in potentially harmful plasma levels that lead to associated hypertension and tachycardia.[16–19]
3. One small observational human study demonstrated 0.01 to 0.03 mg/kg to be an inadequate endotracheal dose.[2] Both a single-center observational study and a multicenter registry study showed that although some newborn infants can achieve ROSC in response to endotracheal epinephrine while vascular access is being obtained, the majority need subsequent intravascular doses to achieve ROSC.[9,10] In a perinatal model of cardiac arrest, peak plasma epinephrine concentrations in animals were higher and were achieved sooner after central or low-lying umbilical venous administration compared with the endotracheal route, despite a lower intravascular dose (0.03 mg/kg intravascular versus 0.1 mg/kg endotracheal route).[13] Given these data, up to 0.1 mg/kg may be needed for an endotracheal dose to achieve adequate plasma concentrations.
4. In a single-center observational study and a multicenter observational registry study, many infants received multiple doses of epinephrine before ROSC.[9,10] One perinatal model of cardiac arrest documented peak plasma epinephrine concentrations at 1 minute after intravenous administration but not until 5 minutes after endotracheal administration.[13]

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VOLUME EXPANSION

Recommendations for Volume Expansion		
COR	**LOE**	**Recommendations**
2b	**C-EO**	1. It may be reasonable to administer a volume expander to newborn infants with evidence of hypovolemia, based on history and physical examination, who remain bradycardic (heart rate less than 60/min) despite ventilation, chest compressions, and epinephrine.
2b	**C-EO**	2. It may be reasonable to use normal saline (0.9% sodium chloride) or blood at 10 to 20 mL/kg for volume expansion.

Synopsis

Newborn infants who continue to have respiratory and circulatory compromise after assisted ventilation, chest compressions, and epinephrine require further assessment and interventions. Tension pneumothorax requiring thoracentesis or acute blood loss that necessitates volume infusion can be considered. Newborn infants in shock from blood loss may respond poorly to the initial resuscitative efforts of ventilation, chest compressions, or epinephrine. History and physical exam findings suggestive of blood loss include a pale appearance, weak pulses, and persistent bradycardia (heart rate less than 60/min). Blood may be lost from the placenta into the mother's circulation, from the cord, or from the infant.

When blood loss is suspected in a newborn infant who responds poorly to resuscitation, administering a volume expander without delay may improve circulation and perfusion. Normal saline (0.9% sodium chloride) is the crystalloid fluid of choice. Uncrossmatched type O, Rh negative blood (or crossmatched, if immediately available) is preferred when blood loss is substantial.[1,2] The recommended route is intravascular via an umbilical line, with the IO route being an alternative (refer to the Vascular Access During Resuscitation section).

Recommendation-Specific Supportive Text

1. The recommendation for volume resuscitation at delivery is based on the recognition that extensive blood loss can occur at the time of birth leading to cardiorespiratory compromise in the newborn infant. Conditions such as uterine rupture may be noted by the obstetric team, while conditions such as fetal-maternal hemorrhage may be unrecognized. A newborn infant with decreased intravascular volume due to blood loss may not respond to resuscitative measures fully until there is increased oxygen-carrying capacity and adequate cardiac preload provided by volume resuscitation. There is no evidence from randomized trials to support the use of routine volume resuscitation at delivery. One large retrospective review found that 0.04% of newborns received volume resuscitation in the delivery room, confirming that it is an uncommon event.[3]
2. There is insufficient clinical evidence to determine what type of volume expander (crystalloid or blood) is more beneficial during neonatal resuscitation. Extrapolation from studies in hypotensive newborns shortly after birth[4–6] and studies in animals (piglets) support the use of crystalloid over albumin solutions[2] and blood over crystalloid solutions.[1] The amount of volume expansion is based on usual practice in neonatal intensive care, 10 to 20 mL/kg initially, and repeating if inadequate

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response. In an animal study of asphyxia in the context of blood loss, providing 1 to 3 aliquots of 10 mL/kg was associated with ROSC in 33/44 animals.[1] While no clinical trials have established an optimal infusion rate, a steady infusion over 5 to 10 minutes may be reasonable.

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POSTRESUSCITATION CARE

Recommendations for Postresuscitation Care		
COR	**LOE**	**Recommendations**
1	A	1. Newborn infants born at ≥36 weeks' gestational age with moderate to severe HIE should be offered therapeutic hypothermia under clearly defined protocols.
1	B-NR	2. Newborn infants who receive prolonged ventilation or advanced resuscitation (intubation, chest compressions, or epinephrine) should be closely monitored, including checking glucose levels early in the postresuscitation period and continuing until the glucose levels are maintained in the normal range.
1	C-LD	3. For newborn infants who are unintentionally hypothermic (temperature <36 °C) after resuscitation, rewarming is indicated. The optimal rate of rewarming is unknown.

Synopsis

Therapeutic hypothermia, lowering the newborn infant's core temperature to a target temperature of 33.5 °C to 34.5 °C within 6 hours of birth for a duration of 72 hours, has the potential to improve outcomes for selected infants with neurologic injury, but careful implementation and monitoring are necessary.[1] Newborn infants who receive prolonged ventilation or advanced resuscitation (eg, intubation, chest compressions, or epinephrine) should be closely monitored after stabilization in a neonatal intensive care unit or a monitored triage area because these infants are at risk for further deterioration. Monitoring may identify and prevent subsequent complications, including neurologic, metabolic, or respiratory issues that can impact both short- and long-term outcomes for newborn infants.

Recommendation-Specific Supportive Text

1. Infants 36 weeks' or greater gestational age who receive advanced resuscitation should be examined for evidence of HIE to determine if they meet criteria for therapeutic hypothermia. Therapeutic hypothermia should be provided under defined protocols similar to those used in published clinical trials and in facilities capable of multidisciplinary care and longitudinal follow-up.[1] Therapeutic hypothermia for infants <36 weeks' gestational age with HIE has not shown benefit and may be associated with harm.[2]
   In a meta-analysis of 8 RCTs involving 1344 term and late preterm infants with moderate to severe encephalopathy and evidence of intrapartum asphyxia, therapeutic hypothermia resulted in a significant reduction in the combined outcome of mortality or major neurodevelopmental disability at 18 months of age (OR, 0.75; 95% CI, 0.68–0.83).[3]
2. Newborn infants who required advanced resuscitation, such as prolonged ventilation, chest compressions, or epinephrine, are at significant risk of developing moderate to severe HIE[4–6] and other morbidities.[7–9] Close monitoring to assess the need for interventions is warranted. This may involve care in a nursery with additional staffing, monitors, and equipment or in a neonatal intensive care unit. Hypoglycemia is common in infants who have received advanced resuscitation and is associated with poor outcomes.[10,11] These infants should be monitored for hypoglycemia and treated appropriately. Newborn infants with abnormal glucose levels (both low and high) are at increased risk for brain injury and adverse outcomes after a hypoxic-ischemic insult.[12–14] Retrospective chart review has shown risk of hypoglycemia after advanced resuscitation, especially in preterm infants born <32 weeks' gestational age.[11]
3. Infants with unintentional hypothermia (temperature <36 °C) immediately after stabilization should be rewarmed to avoid complications associated with low body temperature (including increased mortality, brain injury, hypoglycemia, sepsis, and respiratory distress). Evidence suggests that warming can be done rapidly (0.5 °C/h) or slowly (<0.5 °C/h) with no significant difference in outcomes.[15–19] Three small RCTs[15,16,20] and 6 observational studies[17–19,21–23] of infants with hypothermia after delivery room stabilization found no difference between rapid or slow rewarming for outcomes of mortality,[17–23] convulsions/seizures,[16]

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intraventricular or pulmonary hemorrhage,[16–18,20,21] hypoglycemia,[15,16,18,20] or apnea.[15,16,18,20] One observational study found less respiratory distress in infants who were slowly rewarmed,[19] while a separate study found less respiratory distress syndrome in infants who were rapidly rewarmed.[18] An RCT found no difference in respiratory distress or need for intubation.[20]

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WITHHOLDING AND DISCONTINUING RESUSCITATION

Recommendations for Withholding and Discontinuing Resuscitation

COR	LOE	Recommendations
1	C-LD	1. In newborn infants receiving resuscitation, if there is no heart rate and all the steps of resuscitation have been performed, cessation of resuscitation efforts should be discussed with the team and the family. A reasonable time frame to consider this change in goals of care is around 20 minutes after birth.
1	C-EO	2. In newborn infants, noninitiation of resuscitation and discontinuation of life-sustaining treatment during or after resuscitation should be considered ethically equivalent.
2a	C-EO	3. If a birth involves a condition likely to result in early death or severe morbidity of a newborn infant, noninitiation or limitation of resuscitation is reasonable after appropriate consultation and shared decision-making with the family.

Synopsis

Experts agree that, in certain clinical conditions, it is reasonable to not initiate or to discontinue life-sustaining efforts while continuing to provide supportive care for newborn infants and their families.[1–7] If the heart rate remains undetectable and all steps of resuscitation have been completed by around 20 minutes after birth, it may be reasonable to redirect goals of care. Case series show few intact survivors after 20 minutes of no detectable heart rate.[4] Variables to consider include whether

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resuscitation was considered optimal, availability of advanced neonatal care, circumstances before delivery, and the family's wishes.[4,7]

Some newborn infants are so sick or immature at birth that survival is unlikely, even if resuscitation and intensive care are provided. In addition, some conditions are so severe that the burden of the illness and treatment greatly outweighs the likelihood of survival or a health outcome that aligns with the family's wishes. These situations benefit from appropriate consultation and shared decision-making with families. Some of these scenarios may result in noninitiation or limitation of resuscitative efforts at birth, focusing on humane, compassionate, and culturally sensitive palliative care to ensure the newborn infant's comfort.[1,3–7]

Recommendation-Specific Supportive Text

1. An ILCOR review of RCTs and observational studies in settings where therapeutic hypothermia is available describes variable rates of survival without moderate to severe disability in newborn infants who achieve ROSC after 10 minutes or more despite continued resuscitation. None of these studies evaluate outcomes of resuscitations that extend beyond 20 minutes of age, by which time the likelihood of intact survival was very low. The studies were too heterogeneous to be amenable to meta-analysis.[4] More recent data from the Optimizing Cooling trial also demonstrated that an Apgar score of 0 at 10 minutes, in isolation, did not accurately predict death or significant neurodevelopmental impairment.[8]
2. National medical societies agree that conditions exist for which it is reasonable to not initiate resuscitation, to limit resuscitation, or to discontinue resuscitation once these conditions are identified.[1–6,9] Further aspects of medical ethics are addressed in "Part 3: Ethics."[10]
3. Conditions in which noninitiation, limitation, or discontinuation of resuscitation may be considered include extremely preterm birth and certain severe congenital anomalies. National guidelines recommend individualization of parent-informed decisions based on social, maternal, and fetal/neonatal factors.[1–3,5,6] A systematic review showed that international guidelines variably described periviability between 22 weeks' and 24 weeks' gestational age.[11]

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TRAINING AND HUMAN PERFORMANCE

There are 7 topics regarding education and training methods for resuscitation that are discussed in "Part 12: Resuscitation Education Science"[1] and are relevant to neonatal resuscitation. The recommendations for these topics are summarized as follows:

- Spaced training (training or retraining distributed over time) may be considered rather than massed training (training provided at a single time point).
- Blended training (a combination of face-to-face and online instruction) is recommended compared to a nonblended training approach (either face-to-face or online instruction only).
- Rapid-cycle deliberate practice may be considered in instructional design.
- Gamified learning (use of game-like elements in the context of training, such as point systems, group competition, leaderboards, or increasing levels of challenge) may be considered as a component of resuscitation training.
- The teaching of teamwork competencies may be considered during resuscitation training.

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- High-fidelity manikin use may be considered during resuscitation training when local resources allow. In the absence of such resources, low-fidelity manikins may be used.
- Augmented reality (hands-on experience with addition of virtual content) or traditional training may be considered for resuscitation training. The use of virtual reality alone is not recommended.

Please refer to "Part 12: Resuscitation Education Science" for the full recommendations and additional information on these topics.[1]

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KNOWLEDGE GAPS

Neonatal resuscitation science continues to advance, with contributions by many researchers in laboratories, in the delivery room, and in other clinical settings. This research has led to refinement and improvements in the Neonatal Resuscitation Algorithm. It has also led to the recognition of gaps in knowledge to further optimize neonatal resuscitation. Innovative study designs, such as cluster randomization and stepped wedge designs, along with changes in consent processes informed by families may further advance neonatal resuscitation research. Review of the knowledge chunks during this update identified questions and practices for which evidence level was low, uncertain, or absent. The following knowledge gaps would benefit from further research:

Resuscitation Preparedness

- Specific maternal and fetal factors that may warrant the need for an advanced resuscitation team
- Current rates of various interventions during neonatal resuscitation in different birth settings

During and Just After Birth

- Optimal cord management strategies for specific populations, including multiple gestations, moderately preterm infants, and those with congenital heart or lung disease
- Optimal duration of deferred cord clamping for preterm gestational age groups
- Specific clinical indications for immediate or early cord clamping

Early Resuscitation

- Adjunctive interventions that may optimize outcomes during deferred cord clamping
- Optimal interface for initial ventilation for term and preterm newborn infants
- Effectiveness of laryngeal mask for newborn infants <34 weeks' gestational age or <2 kg birth weight
- Optimal ventilation rate and whether it may depend on gestational age
- Effectiveness of new technologies for rapid heart rate measurement in regard to accuracy and clinical outcomes
- Optimal oxygen management during and after resuscitation, including titration strategies

Advanced Resuscitation

- Optimal techniques for chest compressions in newborn infants, including ratio of compressions to ventilations, asynchronous versus synchronous technique, and method of compression
- Optimal airway management during chest compressions, such as the use of a laryngeal mask and its effectiveness compared to ventilation delivered by endotracheal tube
- Whether certain populations outside of the immediate birth period may have better outcomes when resuscitated by using the neonatal or the pediatric resuscitation algorithm
- Optimal mode of intravascular access outside of the delivery room setting to administer medications or fluids
- Optimal timing, dosing, dose interval, and delivery routes for epinephrine, including earlier use in newborn infants requiring extensive advanced resuscitation
- Indications for volume expansion, as well as optimal dosing, timing, and type of volume
- The recognition and management of pulseless electrical activity
- Passive cooling during resuscitation in infants with moderate to severe HIE

Postresuscitation Care

- Optimal dose, route, and timing of surfactant in at-risk newborn infants, including less-invasive administration techniques
- Indications for and effectiveness of CPAP for various populations
- Strategies to prevent subsequent hypothermia after the immediate birth period
- Optimal rewarming strategy for newborn infants with unintentional hypothermia
- Strategy for blood glucose monitoring after neonatal resuscitation, including appropriate patient selection, method, and frequency of measurement
- Effectiveness of therapeutic hypothermia for mild HIE

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Education and Maintenance of Skills

- Optimal training strategies for individual and team performance, including methods of learning, frequency, and adjunctive tools such as virtual reality

For these gaps, when relevant and feasible, it is important to select outcomes considered critical or important by both health care professionals and families of newborn infants. The research community should seek to design studies that will lead to evidence with a high level of certainty. Internal validity is ideally addressed by clearly defined primary outcomes, appropriate sample sizes, relevant and timed interventions and controls, and time series analyses in implementation studies. ILCOR has published a guideline that should be followed for uniform reporting of neonatal resuscitation research.[1] External validity can be optimized by studying relevant health care professional populations and systems of care and by measuring the impact on critical patient outcomes.

Researchers studying these gaps will need to consider innovations in clinical trial design; examples include pragmatic study designs and novel consent processes. As mortality and severe morbidities decline with advancements and improvements in health care delivery, having adequate power for some clinical questions using traditional individual patient randomized trials declines. Another barrier is the difficulty in obtaining antenatal consent for clinical trials in the delivery room. Adaptive trials and those using cluster randomization may be suitable for some questions. When feasible, well-designed multicenter randomized clinical trials should be used to generate the highest-quality evidence.

Research should address the values and preferences of our key stakeholders, the families and teams who are involved in the process of resuscitation. Research in neonatal resuscitation has been noted to have underrepresentation of various populations. In the context of disparities in care and outcomes, researchers can make efforts to elicit input from representative families and work to ensure appropriate recruitment in trials.

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Disclosures

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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

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*Modest.

†Significant.

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This table represents the relationships of reviewers that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all reviewers are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

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Part 6: Pediatric Basic Life Support: 2025 American Heart Association and American Academy of Pediatrics Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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ABSTRACT: Codeveloped by the American Heart Association and the American Academy of Pediatrics, this publication presents the 2025 guidelines for basic life support during cardiopulmonary resuscitation and emergency cardiovascular care of the pediatric patient, excluding the newborn infant, and represents the first comprehensive update of treatment recommendations since 2020. Incorporating the results of structured evidence reviews from the International Liaison Committee on Resuscitation, these guidelines are for lay rescuers and health care professionals with recommendations designed to improve survival from sudden cardiac arrest and acute life-threatening cardiopulmonary problems. Existing guidelines remain relevant unless specifically updated in this publication. Topics reviewed include the initiation of cardiopulmonary resuscitation; pulse check; components of high-quality cardiopulmonary resuscitation; chest compression technique; support surfaces for cardiopulmonary resuscitation; opening the airway; coordination of shock and cardiopulmonary resuscitation; types of defibrillators or automated external defibrillators; defibrillator paddle or pad size, type, position; treatment of inadequate breathing with a pulse; and foreign-body airway obstruction. Key topics that are new, are substantially revised, or have significant new literature include the elimination of 2-finger chest compressions in infants due to ineffectiveness of achieving proper depth with a recommendation of 1-hand or 2 thumb–encircling hands technique; the immediate application and use of an automated external defibrillator with a pediatric attenuator if available for cardiac arrest; and in infants with severe foreign-body airway obstruction repeated cycles of 5 back blows alternating with 5 chest thrusts (no abdominal thrusts), and in children with severe foreign-body airway obstruction repeated cycles of 5 back blows alternating with 5 abdominal thrusts.

Key Words: AHA Scientific Statements ■ cardiopulmonary resuscitation ■ chest compressions ■ defibrillator ■ foreign body airway obstruction ■ heart arrest ■ shockable rhythm ■ ventilation

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TOP 10 TAKE-HOME MESSAGES

1. Respiratory conditions remain the major cause of cardiac arrest in infants and children and, as such, appropriate interventions to support ventilation and oxygenation should be initiated quickly.
2. For out-of-hospital cardiac arrest (OHCA) in infants and children, providing breaths in addition to chest compressions improves survival; thus, lay rescuers are encouraged to provide breaths if able and willing.
3. A respiratory rate of 20 to 30 breaths per minute is recommended for infants and children who are (a) receiving cardiopulmonary resuscitation (CPR) with an advanced airway in place or (b) receiving breaths and have a pulse.
4. For infants with severe foreign-body airway obstruction (FBAO), repeated cycles of 5 back

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blows alternating with 5 chest thrusts is recommended. Abdominal thrusts are not recommended in infants.
5. For children with severe FBAO, repeated cycles of 5 back blows alternating with 5 abdominal thrusts is recommended.
6. Immediate recognition of cardiac arrest is vital to improving outcomes. For infants and children who are unresponsive with abnormal breathing including gasping, rescuers should activate emergency medical services and initiate high-quality CPR beginning with chest compressions.
7. High-quality CPR is the foundation of resuscitation. The key components of high-quality CPR include providing adequate chest compression rate and depth, minimizing interruptions in CPR, allowing complete chest recoil between compressions, and avoiding excessive ventilation.
8. For infants, the recommended compression techniques include using either the 1-hand technique or the 2 thumb–encircling hands technique. If the rescuer cannot physically encircle the chest, it is recommended to compress the chest with the heel-of-1-hand technique. The use of 2 fingers along the sternum was eliminated due to ineffectiveness in achieving proper depth.
9. For infants and children in cardiac arrest, an automated external defibrillator (AED) should be attached as soon as possible using a pediatric attenuator and pediatric pads if available.
10. Prompt defibrillation for ventricular fibrillation (VF) and pulseless ventricular tachycardia (pVT) is critical, with minimization of peri-shock pauses.

PREAMBLE

More than 20 000 infants and children have an in-hospital cardiac arrest (IHCA) per year in the United States.[1–5] In 2015, emergency medical service–documented OHCA occurred in >7000 infants and children.[4] Pediatric OHCA patients' survival to hospital discharge varies by age, with survival rates of 17.3% in adolescents, 14.7% in children, and 6.6% in infants.[6] Since 2000, pediatric IHCA has had an overall increase in survival to hospital discharge improving from 18.9% to 44.2% in 2022.[5] Neurological outcomes remain difficult to assess across the pediatric age spectrum, with variability in reporting metrics and time to follow-up across studies of both OHCA and IHCA. Favorable neurological outcome has been reported in up to 47% of survivors to discharge.[7] Despite increases in survival from IHCA, there is more to be done to improve both survival and neurological outcomes.[8]

These guidelines have recommendations for pediatric basic life support (BLS)—excluding the newborn infant—and are based on the best available resuscitation science. The Chain of Survival (see Major Concepts section), including recovery from cardiac arrest, requires coordinated efforts from medical professionals in a variety of disciplines and, in the case of OHCA, from lay responders, emergency dispatchers, and first responders. In addition, specific recommendations for pediatric advanced life support are provided in "Part 8: Pediatric Advanced Life Support"[9]; recommendations for resuscitation training are provided in "Part 12: Resuscitation Education Science"[10]; recommendations about systems of care are provided in "Part 4: Systems of Care"[11]; recommendations for special circumstances are provided in "Part 10: Adult and Pediatric Special Circumstances of Resuscitation"[12]; and ethical considerations related to pediatric resuscitation are discussed in "Part 3: Ethics."[13]

INTRODUCTION

Scope of Guidelines

These guidelines are intended to be a resource for lay responders and health care professionals to identify and treat infants and children in the prearrest, intra-arrest, and postarrest states. These apply to infants and children in multiple settings: the community, prehospital, and hospital environment. Prearrest, intra-arrest, and postarrest topics are reviewed, including cardiac arrest in special circumstances such as severe FBAO.

For pediatric BLS, guidelines apply as follows:

- Infant guidelines apply to infants younger than approximately 1 year of age (excluding newborn infants).
- Child guidelines apply to children approximately 1 year of age until puberty. For teaching purposes, puberty is defined as breast development in females and the presence of axillary hair in males.
- For those with signs of puberty and beyond, adult BLS guidelines should be followed.

Neither pediatric advanced nor basic life support guidelines address the resuscitation of newborn infants, who are transitioning from a fluid-filled to an air-filled environment. Resuscitation of the newborn infant is addressed in "Part 5: Neonatal Resuscitation."[14] Although pediatric basic and advanced life support guidelines may be applied to newborn infants <28 days old based on pathophysiology and institutional practice, neonatal guidelines should be followed at birth to address unique aspects of transitional physiology.[15] Infancy is considered the first year of life.

Organization of the Pediatric Writing Committee

The Pediatric BLS Writing Group consisted of pediatric clinicians with representation from the American Heart Association (AHA) and the American Academy of Pediatrics (AAP), including intensivists, cardiac intensivists, emergency medicine physicians, respiratory therapists, nurses, and nurse practitioners. A call for candidates was distributed to the AHA Emergency

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Cardiovascular Care Committee and AAP subject matter experts, and volunteers with recognized expertise in pediatric resuscitation were nominated by the writing group co-chairs. Writing group members were selected by the AHA Emergency Cardiovascular Care Science Subcommittee and AAP Executive Committee and then

Table 1. Applying Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care (Updated December 2024)*

CLASS (STRENGTH) OF RECOMMENDATION

Class 1 (STRONG) — Benefit >>> Risk

Suggested phrases for writing recommendations:
- Is recommended
- Is indicated/useful/effective/beneficial
- Should be performed/administered/other
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is recommended/indicated in preference to treatment B
  - Treatment A should be chosen over treatment B

Class 2a (MODERATE) — Benefit >> Risk

Suggested phrases for writing recommendations:
- Is reasonable
- Can be useful/effective/beneficial
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is probably recommended/indicated in preference to treatment B
  - It is reasonable to choose treatment A over treatment B

Class 2b (WEAK) — Benefit ≥ Risk

Suggested phrases for writing recommendations:
- May/might be reasonable
- May/might be considered
- Usefulness/effectiveness is unknown/unclear/uncertain or not well-established

Class 3: No Benefit (MODERATE) — Benefit = Risk (Generally, LOE A or B use only)

Suggested phrases for writing recommendations:
- Is not recommended
- Is not indicated/useful/effective/beneficial
- Should not be performed/administered/other

Class 3: HARM (STRONG) — Risk > Benefit

Suggested phrases for writing recommendations:
- Potentially harmful
- Causes harm
- Associated with excess morbidity/mortality
- Should not be performed/administered/other

LEVEL (QUALITY) OF EVIDENCE‡

Level A
- High-quality evidence‡ from more than 1 RCT
- Meta-analyses of high-quality RCTs
- One or more RCTs corroborated by high-quality registry studies

Level B-R (Randomized)
- Moderate-quality evidence‡ from 1 or more RCTs
- Meta-analyses of moderate-quality RCTs

Level B-NR (Nonrandomized)
- Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies
- Meta-analyses of such studies

Level C-LD (Limited Data)
- Randomized or nonrandomized observational or registry studies with limitations of design or execution
- Meta-analyses of such studies
- Physiological or mechanistic studies in human subjects

Level C-EO (Expert Opinion)
- Consensus of expert opinion based on clinical experience

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR 1 and 2a; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely-used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

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approved by the AHA Manuscript Oversight Committee. The AHA and AAP have rigorous conflict of interest policies and procedures to minimize the risk of bias or improper influence during development of the guidelines.[16] Prior to appointment, writing group members and peer reviewers disclosed all commercial relationships and other potential (including intellectual) conflicts. Writing group members whose research led to changes in guidelines were required to declare those conflicts during discussions and abstain from voting on those specific recommendations. This process is described more fully in "Part 2: Evidence Evaluation and Guidelines Development."[17] Comprehensive disclosure information for writing group members and peer reviewers is listed in Appendixes 1 and 2.

METHODOLOGY AND EVIDENCE REVIEW

These pediatric guidelines are based on the extensive evidence evaluation performed in conjunction with the International Liaison Committee on Resuscitation and affiliated International Liaison Committee on Resuscitation member councils. Three types of evidence reviews (systematic reviews, scoping reviews, and evidence updates) were used in the 2025 process.[18,19] This process is described more fully in "Part 2: Evidence Evaluation and Guidelines Development."[17]

Class of Recommendation and Level of Evidence

The writing group reviewed all relevant and current *AHA Guidelines for CPR and Emergency Cardiovascular Care* and all relevant International Liaison Committee on Resuscitation Consensus on CPR and Emergency Cardiovascular Care Science With Treatment Recommendations from 2020, 2022, 2023, and 2024.[20–23] Evidence and recommendations were reviewed to determine if current guidelines should be reaffirmed, revised, or retired, or if new recommendations were needed. The writing group then drafted, reviewed, and approved recommendations, assigning a Class of Recommendation (COR; ie, strength) and Level of Evidence (LOE; ie, quality, certainty) to each. Criteria for each COR and LOE are described in Table 1.

Guidelines Structure

The 2025 guidelines are organized in discrete modules of information on specific topics or management issues.[24] Each modular knowledge chunk includes a table of recommendations using standard AHA nomenclature of COR and LOE. Recommendations are presented in order of COR: most potential benefit (Class 1), followed by lesser certainty of benefit (Class 2), and finally potential for harm or no benefit (Class 3). Following the COR, recommendations are ordered by the certainty of supporting LOE: Level A (high-quality randomized controlled trials) to Level C-EO (expert opinion). This order does not reflect the order in which care should be provided.

In addition to the table of recommendations, the knowledge chunk includes a brief synopsis to put the recommendations into context with important background information and overarching management or treatment concepts. Recommendation-specific supportive text clarifies the rationale and key study data supporting the recommendations. When appropriate, illustrations are included. Hyperlinked references are provided to facilitate quick access and review.

Document Review and Approval

The guideline was submitted for blinded peer review to 8 subject matter experts nominated by the AHA and AAP. Before appointment, all peer reviewers were required to disclose relationships with industry and any other conflicts of interest, and all disclosures were reviewed by AHA staff. The guideline was also reviewed and approved for publication by the AHA Science Advisory and Coordinating Committee, the AHA Executive Committee, and the AAP Board of Directors. Comprehensive disclosure information for peer reviewers is listed in Appendixes 1 and 2. These recommendations supersede the last full set of AHA recommendations for pediatric advanced life support, made in 2020.[25] The writing group consisting of AHA and AAP representatives voted on and approved all guideline recommendations.

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MAJOR CONCEPTS

The epidemiology, pathophysiology, and common etiologies of pediatric cardiac arrest are distinct from adult and neonatal cardiac arrest. Cardiac arrest in infants and children does not usually result from a primary cardiac cause; rather, it is the result of progressive respiratory failure or shock. In these patients, cardiac arrest is preceded by a variable period of deterioration, which eventually results in cardiopulmonary failure, bradycardia, and cardiac arrest. In children with congenital heart disease, cardiac arrest is often due to a primary cardiac cause, although the etiology is distinct from that in adults.

Outcomes for pediatric IHCA have improved over the past 20 years, in part because of early recognition, high-quality CPR, postarrest care, and extracorporeal CPR.[1–3] In a recent analysis of the AHA Get With The Guidelines-Resuscitation Registry, a large multicenter, hospital-based cardiac arrest registry, pediatric IHCA survival to hospital discharge was 19% in 2000 and 44% in 2022. Survival has improved for pediatric events requiring CPR in the United States, with a 19% absolute increase in survival for in-hospital pulseless cardiac arrests and a 9% absolute increase in survival for nonpulseless events (eg, bradycardia with hemodynamic compromise) between 2000 and 2018. However, survival from pulseless cardiac arrests has reached a plateau following 2010.[2] New directions of research and therapy may be required to improve cardiac arrest survival. More IHCA events now occur in an intensive care unit setting,

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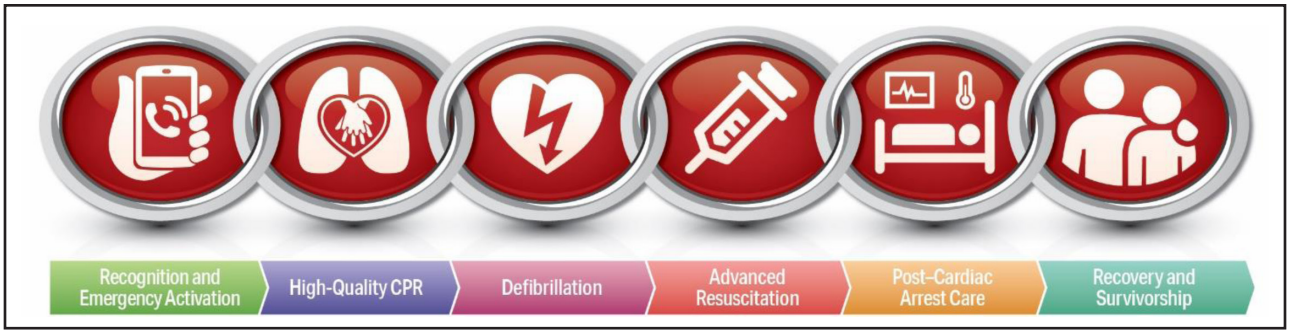

Figure 1. Cardiac arrest Chain of Survival.
CPR indicates cardiopulmonary resuscitation.

suggesting that patients at risk for cardiac arrest are being identified sooner and transferred to a higher level of care.[4,5]

Survival rates from OHCA remain less encouraging. Most pediatric OHCA are respiratory/asphyxial events leading to asystole or PEA and thus are nonshockable rhythms. While AEDs may be more prevalent in schools and sporting events over recent years, AEDs can deliver shocks only if a shockable rhythm (VF/pVT) is detected. AEDs save lives in the minority of pediatric arrests with shockable rhythms, but because those cases are rare, widespread AED deployment has not yet resulted in large overall improvements in pediatric OHCA survival at the population level.[6–8] In a recent analysis of the Cardiac Arrest Registry to Enhance Survival from 2022, a multicenter OHCA registry, annual survival to hospital discharge of pediatric OHCA ranged from 6.6% to 17.3% depending on region and patient age, demonstrating gains for some populations over the last decade.[9] There was no significant change in these rates over time, consistent with other national registries.[10,11] In the Resuscitation Outcomes Consortium Cardiac Epidemiological Registry, survival after OHCA was higher in regions with more arrests that were witnessed by emergency medical services and with higher lay responder CPR rates, stressing the importance of early recognition and treatment of these patients.[4]

As survival rates from pediatric cardiac arrest increase, there has been a shift with more focus on neurodevelopmental, physical, and emotional outcomes of survivors. Recent studies demonstrate that one quarter of patients with favorable outcomes have global cognitive impairment and that 85% of older children who were reported to have favorable outcomes have selective neuropsychological deficits.[12]

The Pediatric Chain of Survival

Historically, cardiac arrest care has focused on the management of the cardiac arrest itself, highlighting high-quality CPR, early defibrillation, and effective teamwork. However, there are aspects of prearrest and postarrest care that are critical to improve outcomes. As pediatric cardiac arrest survival rates have plateaued for pulseless cardiac arrest, the prevention of cardiac arrest becomes even more important. In the out-of-hospital environment, this includes safety initiatives (eg, bike helmet laws), sudden infant death syndrome prevention, lay rescuer CPR training, early recognition of the critically ill infant or child by the caregiver, and timely access to emergency care. When OHCA occurs, early lay responder CPR is critical in improving outcomes, as well as the availability of AEDs for shockable rhythms. In the in-hospital environment, cardiac arrest prevention focuses on the early recognition and treatment of patients at high risk, such as children undergoing cardiac surgery or children with acute fulminant myocarditis, acute decompensated heart failure, or pulmonary hypertension. Following resuscitation from cardiac arrest, management of the post–cardiac arrest syndrome (which may include brain dysfunction, myocardial dysfunction with low cardiac output, and ischemia or reperfusion injury) is important to avoid known contributors to secondary injury, such as hypotension.[13,14] Accurate neuroprognostication is important to guide caregiver discussions and decision-making. Finally, given the elevated risk of neurodevelopmental impairment in cardiac arrest survivors, early referral for rehabilitation assessment and intervention is key.

A single Chain of Survival that supports the paradigm of early recognition through recovery after cardiac arrest has now been standardized across infants, children, and adults (outside of neonatal care; Figure 1).

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TREATMENT OF RESPIRATORY FAILURE

Respiratory failure occurs when a patient's breathing becomes inadequate and results in ineffective oxygenation and ventilation. This can occur due to disordered control of breathing, upper airway obstruction, lower airway obstruction, respiratory muscle failure, or parenchymal lung disease. Providing assisted ventilation when breathing is absent or inadequate, relieving FBAO, and administering naloxone in opioid overdose can be lifesaving.

Opening the Airway

Recommendations for Opening the Airway		
COR	**LOE**	**Recommendations**
1	C-LD	1. Unless a cervical spine injury is suspected, use a head tilt–chin lift maneuver to open the airway in infants and children.
1	C-EO	2. For infants and children with suspected cervical spinal injury, use a jaw thrust without head tilt to open the airway.
1	C-EO	3. For infants and children with suspected cervical spinal injury, if the jaw thrust does not open the airway, use a head tilt–chin lift maneuver.

Figure 2. Head tilt–chin lift maneuver to open the airway in infants while providing breaths.

Synopsis

Ensuring a patent airway is crucial for effective ventilation and oxygenation. Although there is no definitive evidence favoring a particular technique related to creating/maintaining patency of the airway, it is important for rescuers to understand the benefits and limitations of each method and to remain skilled in their application. Multiple approaches may be necessary to open an airway, and continuous monitoring of the pediatric patient is essential to confirm and maintain airway patency to ensure sufficient ventilation and oxygenation. Research comparing airway management strategies in pediatric cardiac arrest patients is lacking, with most available data derived from radiographic studies obtained during elective surgeries. As observed in the 2020 Guidelines, there continues to be a lack of pediatric-specific clinical studies. Figure 2 demonstrates the head tilt–chin lift maneuver to open the airway in infants.

Recommendation-Specific Supportive Text

1. No data directly address the ideal method to achieve or maintain pediatric airway patency. One retrospective cohort study evaluated various head-tilt angles in neonates and young infants undergoing diagnostic magnetic resonance imaging and found that the highest proportion of patent airways was at a head-tilt angle of 144° to 150° based on a regression analysis.[1]
2. While no pediatric studies evaluate jaw thrust versus head tilt to open the airway, jaw thrust is widely accepted as an effective way to open the airway, and this maneuver theoretically limits cervical motion compared with the chin lift.
3. There are no pediatric studies evaluating the impact of a head tilt–chin lift maneuver to open the airway in a trauma patient with suspected cervical spine injury. However, if rescuers are unable to open the airway and deliver effective ventilations using a jaw thrust, given the importance of a

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patent airway, using a head tilt–chin lift maneuver is recommended.

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Treatment of Inadequate Breathing With a Pulse

Recommendations for Treatment of Inadequate Breathing With a Pulse		
COR	**LOE**	**Recommendations**
1	C-EO	1. For infants and children with a pulse but absent or inadequate respiratory effort, breaths should be provided.
2a	C-EO	2. For infants and children with a pulse but absent or inadequate respiratory effort, it is reasonable to give 1 breath every 2 to 3 s (20–30 breaths/min).

Synopsis

The priority in managing a seriously ill or injured child who is not in cardiac arrest is evaluating the airway and breathing. If the child demonstrates signs of inadequate or absent breathing, breaths should be initiated to restore adequate oxygenation and ventilation. Because respiratory conditions are a major cause of cardiac arrest in infants and children, it is important to begin appropriate interventions to support ventilation and oxygenation quickly.

Recommendation-Specific Supportive Text

1 and 2. Pediatric-specific clinical studies evaluating the effect of different ventilation rates on outcomes in patients who have inadequate breathing with a pulse are lacking. In 2020, the guidelines were updated to reflect new data from a multicenter observational study that found that ventilation rates of at least 30/min in infants and at least 25/min in children >1 year of age during CPR with an advanced airway in place were associated with improved return of spontaneous circulation (ROSC), survival to discharge, and survival with favorable neurological outcome. Excessive ventilation rates were associated with lower systolic blood pressures in older children, so care must be taken to avoid higher rates that could compromise hemodynamics.[1] For the ease of training, the recommended respiratory rate for the pediatric patient with inadequate breathing and a pulse continues to be 1 breath every 2 to 3 seconds.

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Foreign-Body Airway Obstruction

Recommendations for FBAO		
COR	**LOE**	**Recommendations**
1	C-LD	1. Infants or children with mild FBAO should be allowed to clear the airway by coughing while being observed for signs of severe FBAO.
1	C-LD	2. For infants with severe FBAO, repeated cycles of 5 back blows alternating with 5 chest thrusts should be performed until the object is expelled or the infant becomes unresponsive.
1	C-LD	3. For children with severe FBAO, repeated cycles of 5 back blows alternating with 5 abdominal thrusts should be performed until the object is expelled or the child becomes unresponsive.
1	C-LD	4. If infants or children with severe FBAO become unresponsive, rescuers should start CPR, beginning with chest compressions (rescuers should not perform pulse check).

Figure 3. Chest thrusts in an infant with severe foreign-body airway obstruction.

Figure 4. Back blows in an infant with severe foreign-body airway obstruction.

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Figure 5. Abdominal thrusts in a child with severe foreign-body airway obstruction.

Recommendations for FBAO (Continued)		
COR	**LOE**	**Recommendations**
1	C-LD	5. For infants or children with FBAO receiving CPR, rescuers should remove any visible foreign body when opening the airway to provide breaths.
2B	C-LD	6. Effectiveness and safety of suction-based airway clearance devices have not been established in infants and children. There is insufficient evidence to make a recommendation for infants and children.
3 Harm	C-LD	7. Blind finger sweeps should not be performed for infants and children with FBAO.

Synopsis

Suffocation (eg, FBAO) is a leading cause of death in infants and children. Balloons, certain foods (eg, hot dogs, nuts, grapes), and small household objects are the most common causes of FBAO in children,[1–3] while liquids are common among infants.[4] It is important to differentiate between mild FBAO (the patient is coughing and making sounds) and severe FBAO (the patient cannot make sounds). Patients with mild FBAO can attempt to clear the obstruction by coughing, but intervention is required in severe obstruction. There are no high-quality data to support recommendations regarding FBAO in children. Figures 3 and 4 demonstrate chest thrusts and back blows in an infant with severe FBAO, and Figure 5 demonstrates abdominal thrusts in a child with severe FBAO. Figures 6 and 7 are the algorithms for infant and child FBAO.

Recommendation-Specific Supportive Text

1 and 3. Many FBAOs are relieved by allowing the patient to cough or, if severe, are treated by bystanders using chest thrusts or abdominal thrusts.[4–8] A recent observational study of adult and pediatric FBAO suggests improved clearance of a foreign body with the use of back blows over abdominal thrusts.[8] To create consistency for instructional purposes, and in the absence of inferiority from pediatric data, management of severe FBAO in children now starts with a series of back blows instead of abdominal thrusts. Repeated cycles of

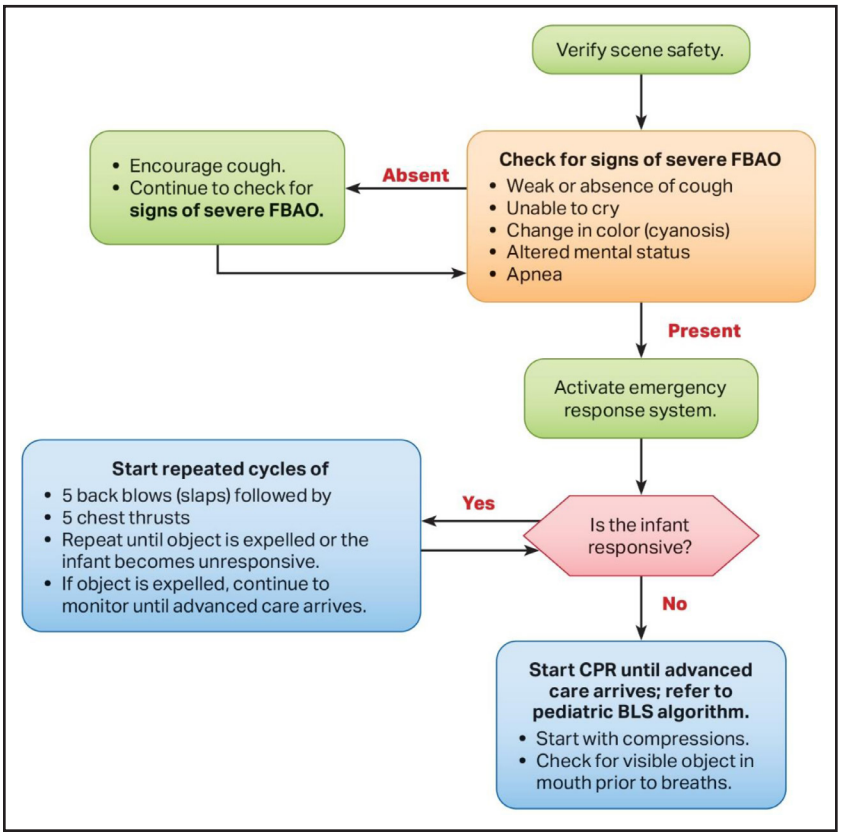

Figure 6. Infant FBAO.
BLS indicates basic life support; CPR, cardiopulmonary resuscitation; and FBAO, foreign-body airway obstruction.

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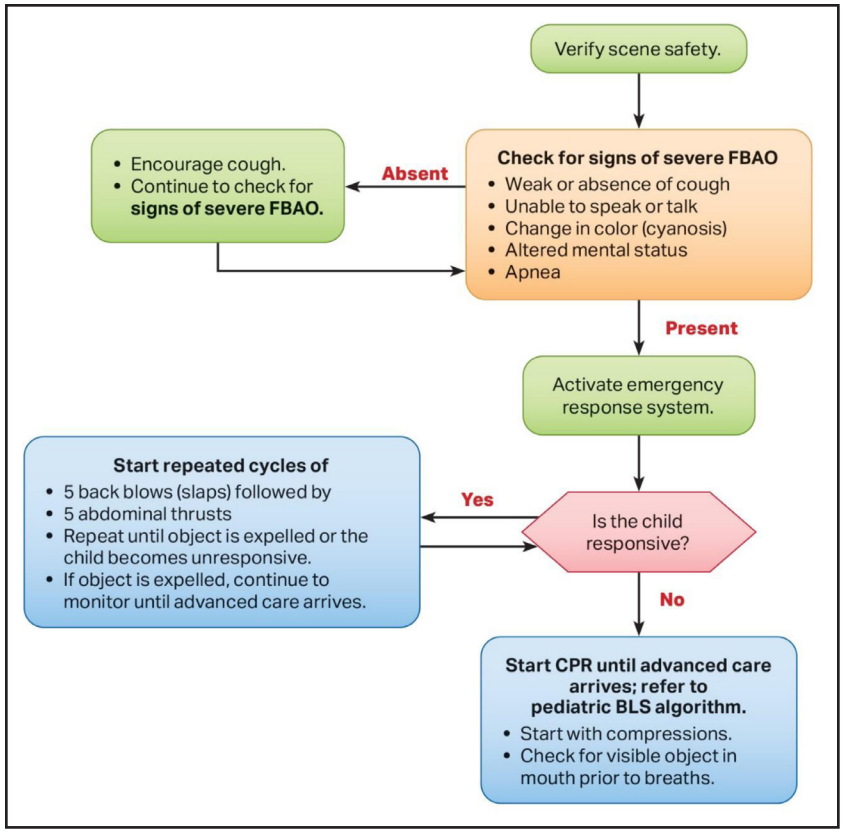

Figure 7. Child FBAO.
BLS indicates basic life support; CPR, cardiopulmonary resuscitation; and FBAO, foreign-body airway obstruction.

5 back blows followed by 5 abdominal thrusts are performed until the obstruction is cleared or the child becomes unresponsive.

2. Observational data primarily from case series support the use of back blows[4,5,9–11] or chest thrusts[7–9,12] for infants. Abdominal thrusts are not recommended for infants, given the potential to cause abdominal organ injury.[13] The heel-of-hand technique for chest thrusts is now recommended for infants with severe FBAO, as current CPR literature suggests that it generates greater compression depth than the previously recommended 2-finger technique.[14] While the heel-of-hand technique for chest thrusts resembles chest compressions that are used as part of CPR, there is no focus on the other components of high-quality CPR chest compressions (eg, rate, recoil), so the term *chest compression* is not used. If infants and children develop severe FBAO, emergency medical services should be promptly activated as they can rapidly deteriorate into cardiac arrest.
4. Once the infant or child is unconscious, observational data support immediate CPR with provision of chest compressions (do not perform a pulse check), followed by ventilations.[8,12] Note that these compressions are delivered with attention to the provision of high-quality chest compressions as part of CPR.

5 and 7. Observational data suggest that the risk of blind finger sweeps outweighs any potential benefit in the management of FBAO.[7,15–17]

6. A solitary case series describes the use of portable nonpowered suction devices for infants and children with severe FBAO.[18] As the available evidence comes from voluntary reporting to an industry-sponsored registry, there is potential for significant confounding and bias, as well as incomplete case descriptions and patient outcomes reporting. The limited reported evidence also does not suggest superiority of these devices over standard techniques such as back blows or abdominal thrusts.

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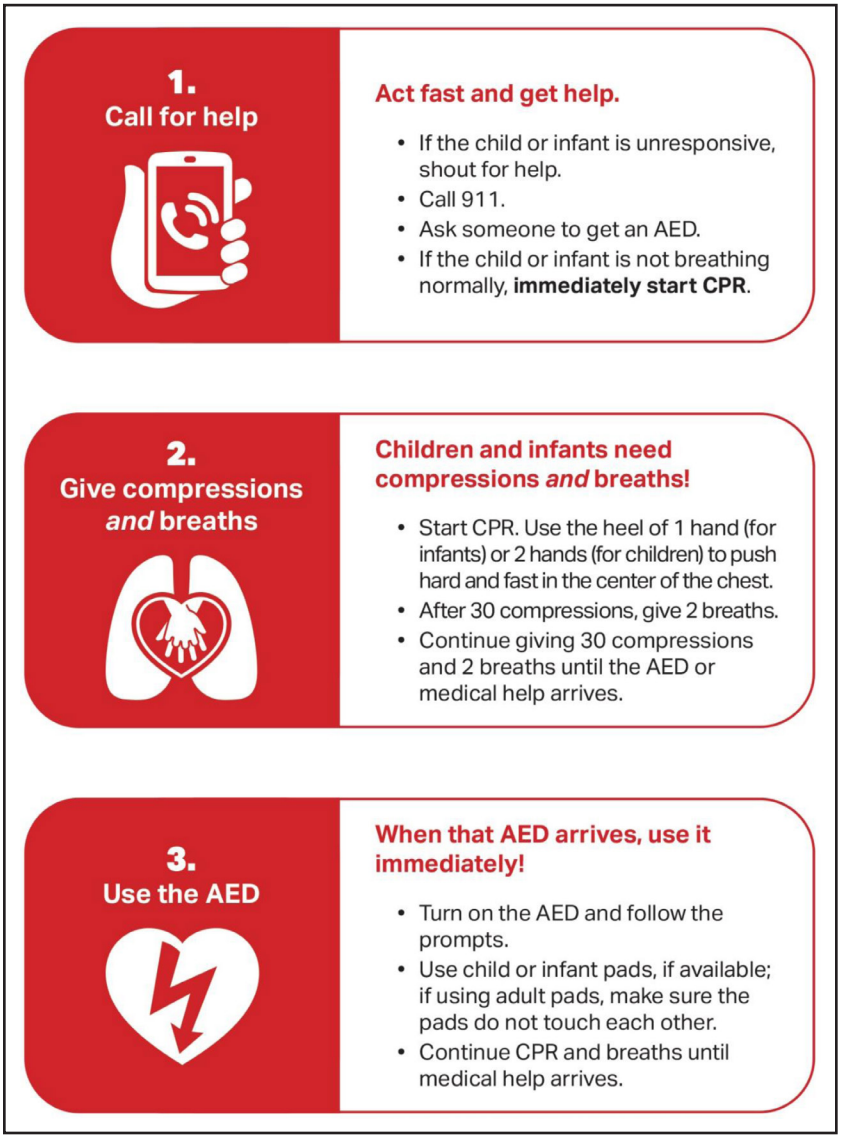

Figure 8. Pediatric BLS (Infants to Puberty) for Lay Rescuers.
AED indicates automated external defibrillator; BLS, basic life support; and CPR, cardiopulmonary resuscitation.

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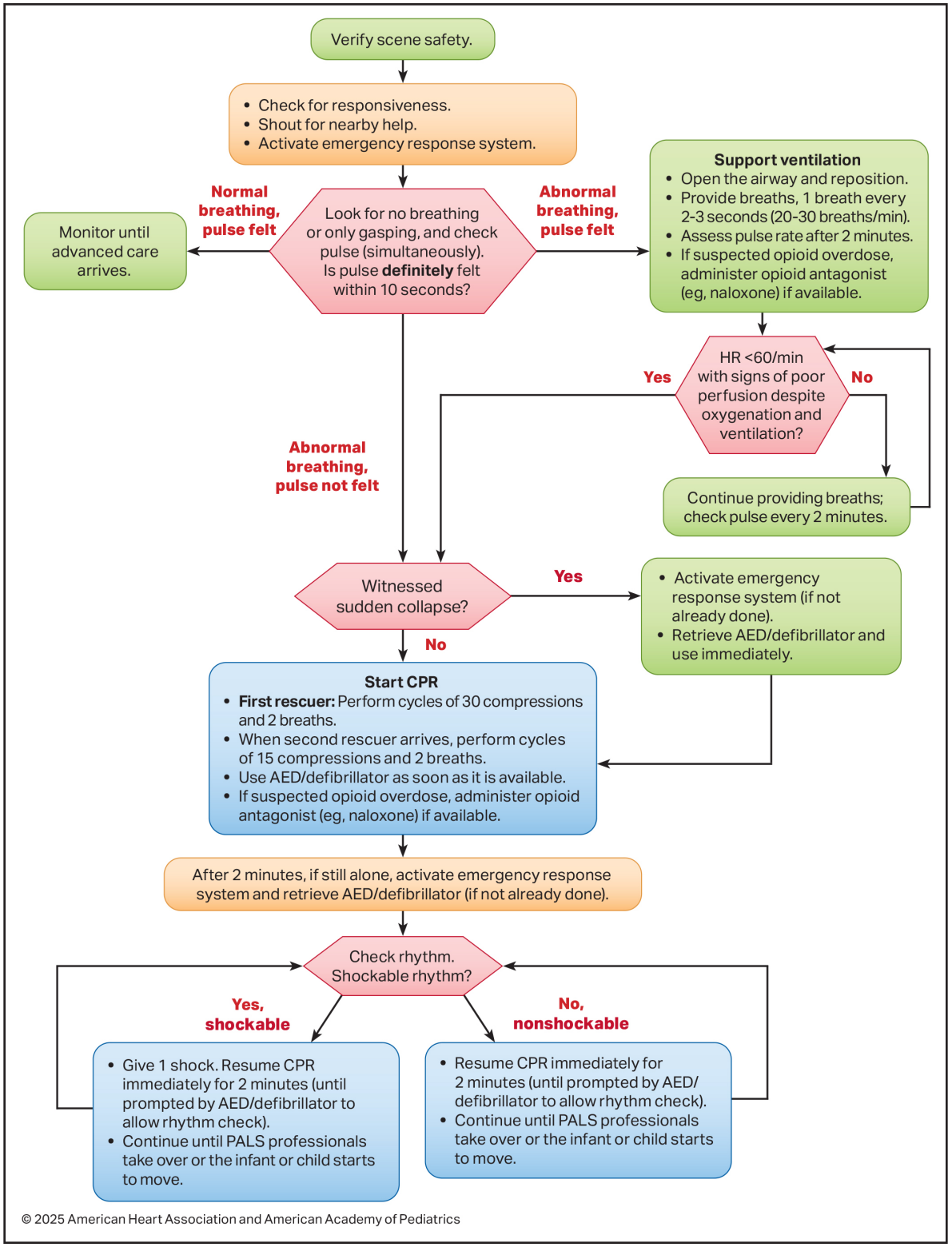

Figure 9. Pediatric BLS Algorithm (Infants to Puberty) for Health Care Professionals–Single Rescuer.
AED indicates automated external defibrillator; CPR, cardiopulmonary resuscitation; HR, heart rate; and PALS, pediatric advanced life support.

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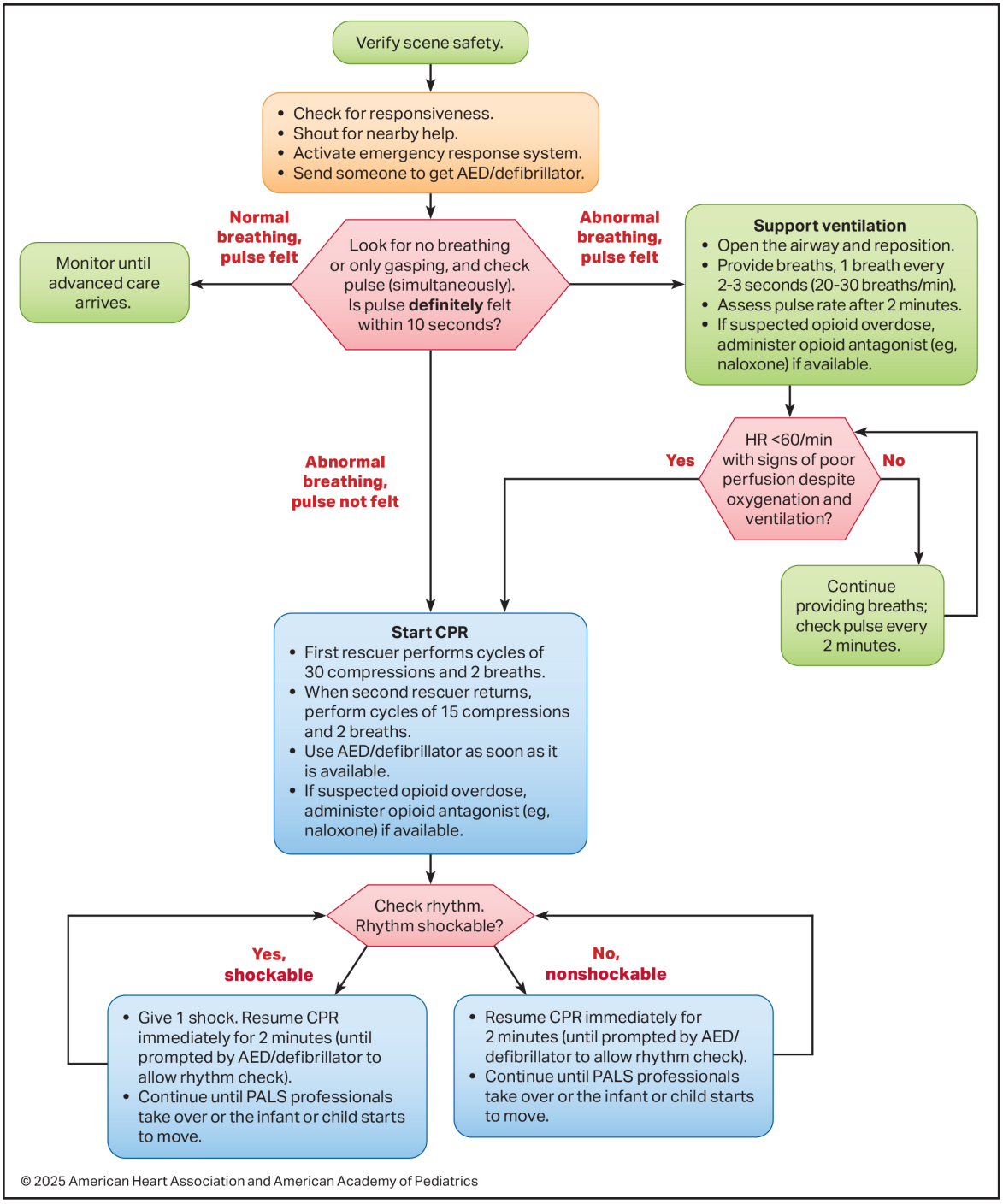

Figure 10. Pediatric BLS Algorithm (Infants to Puberty) for Health Care Professionals–2 or More Rescuers.
AED indicates automated external defibrillator; CPR, cardiopulmonary resuscitation; HR, heart rate; and PALS, pediatric advanced life support.

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SEQUENCE OF RESUSCITATION

The sequence of resuscitation events is displayed in Figures 8, 9, and 10. Figure 8 is an infographic showing the critical actions for lay rescuers (ie, without medical knowledge or experience). Figures 9 and 10 are algorithms showing the critical sequences for those with a basic level of medical knowledge and experience. The use of opioid antagonists (eg, naloxone) during respiratory or cardiac arrest is incorporated into the Pediatric BLS algorithms (Figures 9 and 10), with more detailed information provided in "Part 10: Adult and Pediatric Special Circumstances in Resuscitation."[12]

Initiation of CPR

Recommendations for Initiation of CPR		
COR	**LOE**	**Recommendations**
1	C-LD	1. Lay rescuers should begin CPR immediately for any infant or child who is unresponsive, not breathing normally, and does not have signs of life; they should not check for a pulse.
2a	C-LD	2. In infants and children with no signs of life, it is reasonable for health care professionals to check for a pulse for up to 10 s and begin compressions unless a definite pulse is felt.
2b	C-LD	3. It may be reasonable to initiate CPR with compressions-airway-breathing over airway-breathing-compressions.

Synopsis

Rapid recognition of cardiac arrest, immediate initiation of high-quality chest compressions, and delivery of effective ventilations are critical to improve outcomes from pediatric cardiac arrest. Lay rescuers should not delay starting CPR in a child with no "signs of life." Palpation for the presence or absence of a pulse is not reliable as the sole determinant of cardiac arrest and the need for chest compressions. In infants and children, asphyxial cardiac arrest is more common than cardiac arrest from a primary cardiac event; therefore, effective ventilation is paramount during resuscitation of children. When CPR is initiated, the compressions-airway-breathing sequence mirrors the adult sequence to enhance educational simplicity in training.

Recommendation-Specific Supportive Text

1. Lay rescuers are unable to reliably determine the presence or absence of a pulse and should not delay the initiation of CPR for any victim without signs of life.[1–15]
2. No clinical trials have compared manual pulse checks with observations of "signs of life." However, adult and pediatric studies have identified a high error rate, and harmful CPR pauses during manual pulse checks by health care professionals.[16–19] In one study, health care professionals' pulse palpation accuracy was 78%[16] compared with lay rescuer pulse palpation accuracy of 47% at 5 seconds and 73% at 10 seconds.[1]
3. One pediatric study demonstrated only a small delay (5.74 seconds) in commencement of breaths with compressions-airway-breathing compared with airway-breathing-compressions.[20] Although the supporting evidence is minimal, continuing to recommend compressions-airway-breathing likely results in minimal delays in giving breaths and allows for a consistent approach to cardiac arrest treatment in adults and children.

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SEQUENCE OF RESUSCITATION

Components of High-Quality CPR

Recommendations for Components of High-Quality CPR		
COR	**LOE**	**Recommendations**
1	B-NR	1. Conventional CPR (chest compressions with breaths/ventilations) should be provided to infants and children in cardiac arrest.
1	B-NR	2. For infants and children in cardiac arrest, interruptions in CPR should be minimized, and pauses in chest compressions should be <10 s.

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Recommendations for Components of High-Quality CPR (Continued)		
COR	**LOE**	**Recommendations**
1	C-EO	3. Rescuers should allow the chest to recoil completely after each compression.
2a	B-NR	4. If lay rescuers are unable or unwilling to deliver breaths to an infant or child in cardiac arrest, it is reasonable to provide compression-only CPR.
2a	C-LD	5. It is reasonable to use a chest compression rate of 100 to 120/min for infants and children.
2a	C-LD	6. For infants and children, it is reasonable for rescuers to provide chest compressions that depress the chest at least one-third the anteroposterior diameter of the chest, which equates to approximately 1.5 in (4 cm) in infants and 2 in (5 cm) in children.
2a	C-EO	7. For health care professionals, it is reasonable to perform a rhythm check, lasting no more than 10 s, approximately every 2 min.
2a	C-EO	8. It is reasonable to provide ventilations with 100% oxygen during CPR.
2a	C-EO	9. When performing CPR without an advanced airway, it is reasonable for single rescuers to provide a compression-to-ventilation ratio of 30:2 and for 2 rescuers to provide a compression-to-ventilation ratio of 15:2.

Synopsis

High-quality CPR generates blood flow to vital organs and increases the likelihood of ROSC. The 5 main components of high-quality CPR are (1) adequate chest compression depth, (2) optimal chest compression rate, (3) minimizing interruptions in CPR (ie, maximizing chest compression fraction or the proportion of time that chest compressions are provided for cardiac arrest), (4) allowing complete chest recoil between compressions, and (5) avoiding excessive ventilation. Compressions of inadequate depth and rate,[1,2] incomplete chest recoil,[3] and high ventilation rates[4,5] are common during pediatric resuscitation.

Recommendation-Specific Supportive Text

1. Despite increasing frequency of compression-only CPR in adults and children and mixed results when comparing conventional CPR (chest compressions and breaths) and compression-only CPR, large observational studies of children with OHCA show the best outcomes with conventional CPR.[1–12] A small observational study of school-aged children found similar outcomes between conventional and compression-only CPR.[12]
2. While 2 observational studies and a secondary analysis of a prospective multi-institutional randomized trial found that chest compression fraction (the percent of time during the CPR event where chest compressions were ongoing) of >70% to 90% could be achieved in a majority of resuscitations, the association between a set chest compression fraction threshold to achieve best pediatric outcomes is unclear.[13–15] There are inadequate data to recommend a goal chest compression fraction threshold for high-quality CPR in infants and children. However, two studies from a multinational, multi-institutional observational cohort registry showed that increased frequency and duration of pauses in CPR were significantly associated with lower probability of ROSC.[16,17] Additionally, longer duration of pauses at the end of CPR prior to cannulation for extracorporeal life support were associated with poor neurological outcomes and lower survival.[17]
3. Allowing complete chest re-expansion improves the flow of blood returning to the heart, and therefore by increasing preload, increases blood flow to the body during CPR. There are no pediatric studies evaluating the effect of incomplete re-expansion during CPR, although leaning during pediatric CPR is common.[18–20] In one observational study of invasively monitored and anesthetized children, leaning was associated with elevated cardiac filling pressures, leading to decreased coronary perfusion pressures during sinus rhythm.[21]
4. Large observational studies of children with OHCA show that compression-only CPR is superior to no-bystander CPR.[3,4,12,22]
5. A small observational study found that a compression rate of at least 100/min was associated with improved systolic and diastolic blood pressures during CPR for pediatric IHCA.[23] One multicenter, observational study of pediatric IHCA demonstrated increased systolic blood pressures with chest compression rates between 100 and 120/min when compared with rates exceeding 120/min.[24] Rates <100/min were associated with improved survival compared to rates of 100 to 120/min; however, the median rate in this slower category was approximately 95/min (ie, very close to 100/min).[24]
6. Three anthropometric studies have shown that the pediatric chest can be compressed to one-third of the anteroposterior chest diameter without damaging intrathoracic organs.[25–27] An observational study found an improvement in rates of ROSC and 24-hour survival, when at least 60% of 30-second epochs of CPR achieve an average chest compression depth >5 cm (about 2 inches) for pediatric IHCA in children.[28]
7. Once an AED or monitor is available, a pause in chest compressions every 2 minutes allows for a brief rhythm check as well as allowing the change of personnel performing chest compressions to avoid fatigue.
8. There are no human studies addressing the effect of varying inhaled oxygen concentrations during CPR on outcomes in infants and children. Given that the etiology of pediatric cardiac arrest is

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respiratory in nature, the use of 100% oxygen is physiologically appropriate.

9. The optimum compression-to-ventilation ratio is uncertain. Large observational studies of children with OHCA demonstrated better outcomes with compression-ventilation CPR with ratios of either 15:2 or 30:2 compared with compression-only CPR.[1,2]

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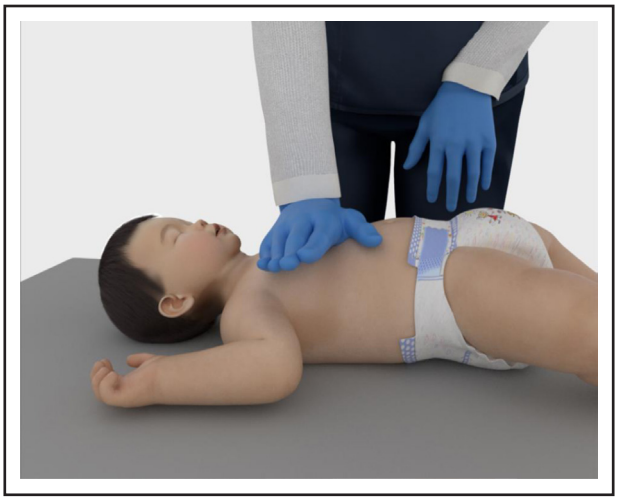

Figure 11. 1-hand technique for chest compressions in infants.

Figure 13. 2-hand technique for chest compressions in children.

SEQUENCE OF RESUSCITATION

CPR Technique

Recommendations for CPR Technique		
COR	**LOE**	**Recommendations**
1	B-NR	1. For infants, rescuers should compress the sternum using either the 1-hand technique (heel of one hand on sternum) or the 2 thumb–encircling hands technique. If the rescuer cannot physically encircle the chest, it is recommended to compress the chest with the heel-of-1-hand technique.
2b	C-LD	2. For children, it may be reasonable to use either a 1- or 2-hand technique to perform chest compressions.

Synopsis

In pediatric patients, due to the wide variation in the size of each patient, effective chest compression performance can be highly variable and depends on multiple factors, including the size and position of the rescuer as well as the hand position during CPR. Numerous studies have sought to determine optimal compression technique for each patient population.[1–4] Prior recommendations were based solely on manikin studies for the optimal compression technique in the various pediatric age groups. However, new evidence from patient registries has led to new outcome-based recommendations.[5] See Figure 11 for the 1-hand technique and Figure 12 for the 2 thumb–encircling hands technique for infants, and see Figure 13 for the 2-hand technique for children.

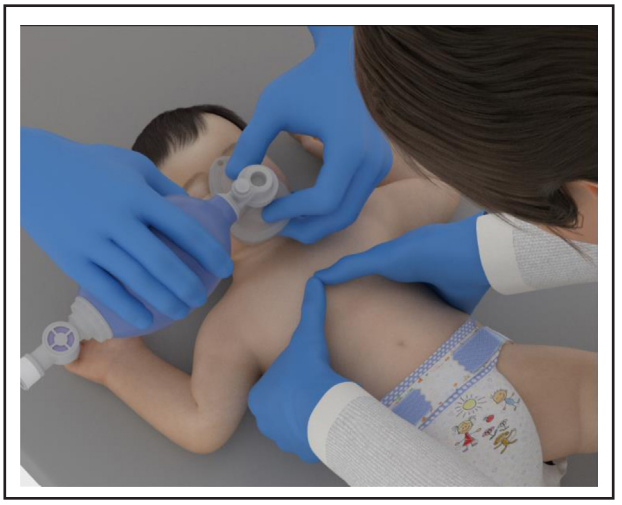

Figure 12. 2 thumb–encircling hands technique for chest compressions in infants.

Recommendation-Specific Supportive Text

1. In infants, systematic reviews and meta-analyses from simulation studies suggest that the 2 thumb–encircling hands technique is a superior technique when compared with 2-finger compressions, particularly for depth.[6–10] In a multicenter prospective observational registry study, the 1-hand technique resulted in greater compression depth than the 2 thumb–encircling hands technique in infants with no difference in chest compression rate between hand positions.[5] The 2-finger technique was utilized rarely in this study but, when used, no chest compression segments were compliant with AHA guidelines. An earlier single-center study did not show differences in chest compression depth between 1-hand and 2 thumb–encircling hands technique but noted 1-hand chest compressions were associated with an inappropriately fast rate.[11]
2. In children 1 to 8 years of age, the 2-hand compression technique resulted in greater compression depth than the 1-hand technique.[5] A secondary study from the same prospective observational registry showed that the 1-hand technique had better compliance with guideline chest compression rates than the 2-hand technique.[5] There are no clinical

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data to determine if the 1-hand or 2-hand technique is associated with better outcomes for children receiving CPR. In manikin studies, the 2-hand technique has been associated with improved compression depth[12] and compression force[13] and less rescuer fatigue.[14,15] More vertical compression angle (ie, force applied closer to 90° perpendicular to the chest) to improve depth and recoil,[16] with an "elbow-lock" technique while delivering chest compressions to maintain consistent vertical force and minimize fatigue,[17] and the use of a stepstool during CPR[5] have been studied as modifications to improve compression depth and reduce rescuer fatigue.

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SEQUENCE OF RESUSCITATION

Support Surface

Recommendations for Support Surfaces for CPR		
COR	**LOE**	**Recommendations**
2a	C-LD	1. It is reasonable to perform chest compressions on a firm surface in infants and children.
2a	C-LD	2. During IHCA, it is reasonable to use a backboard to improve chest compression depth in infants and children.

Synopsis

Chest compression depth can be optimized by placing the child in a supine position on a hard, flat surface.[1] It is challenging to perform adequate chest compressions on soft surfaces, such as a mattress, because both the chest and the surface itself can be compressed. In manikin studies, up to 57% of the compression force may be absorbed by the mattress, leading to inadequate compression depth and increased rescuer fatigue.[2–4] Backboard placement, use of the CPR mode on specially equipped hospital beds to return them to a flat position at a low height, and deflating air mattresses quickly or moving patients to the floor have been proposed to counter the impact of soft surfaces.[5]

Recommendation-Specific Supportive Text

1. Chest compression depth is overall inadequate, with few studies reaching the recommended targeted depth.[6] Use of a firm surface in meta-analyses of manikin studies and a single pediatric case series show that compression depth is increased on a firm surface.[7–9]
2. Meta-analysis of 7 studies[4,10–15] showed a 2 mm (95% CI, 0.5–4 mm) increase in chest compression depth when CPR was performed on a manikin on a hospital mattress with a backboard in place.[9]

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MANAGEMENT OF SHOCKABLE RHYTHMS

Coordination of Shock and CPR

Recommendations for Coordination of Shock and CPR		
COR	**LOE**	**Recommendations**
1	C-EO	1. In infants and children, CPR should be performed until the AED/manual defibrillator is ready to deliver a shock.
1	C-EO	2. Prompt defibrillation with a single shock followed by immediate CPR, starting with compressions, is recommended for infants and children with VF/pVT.
1	C-EO	3. Peri-shock pauses should be minimized during CPR in infants and children.

Synopsis

Shockable rhythms are rare in infants and children. The risk of shockable rhythms, VF and pVT, steadily increases throughout childhood and adolescence, but remains less frequent than in adults. Shockable rhythms may be the initial rhythm of the cardiac arrest (primary VF/pVT) or may develop during the resuscitation (secondary VF/pVT). Defibrillation is the definitive treatment for VF/pVT. The shorter the duration of VF/pVT, the more likely that the shock will result in a perfusing rhythm. Minimizing frequency and duration of pauses in CPR for shock delivery improves chances of favorable short- and long-term outcomes.

Recommendation-Specific Supportive Text

1. There are currently no pediatric data available regarding the optimal timing or duration of CPR prior to defibrillation. Adult studies show no benefit of a prolonged period of CPR before initial defibrillation.[1–4]
2. Adult studies comparing a stacked shock (1-shock protocol versus a 3-shock protocol) for treatment of VF suggest a significant survival benefit with the single-shock protocol.[5,6] The effectiveness of single compared to sequential (stacked) shocks has not been evaluated in infants and children with a shockable rhythm,[7] and therefore it is reasonable to give a single defibrillation dose of monophasic or biphasic energy followed by immediate resumption of chest compressions.[6,8]
3. Prolonged pauses in chest compressions before and after shock delivery decrease blood flow and oxygen delivery to vital organs, such as the brain and heart, and are associated with decreased survival.[9,10]

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MANAGEMENT OF SHOCKABLE RHYTHMS

Type of Defibrillator

Recommendations for Type of Defibrillator		
COR	**LOE**	**Recommendations**
1	C-LD	1. When using an AED on infants and children <8 y of age, use of a pediatric attenuator is recommended.
2a	C-LD	2. For infants and children under the care of a trained health care professional, it is reasonable to use a manual defibrillator when a shockable rhythm is identified.
2b	C-EO	3. If neither a manual defibrillator nor an AED equipped with a pediatric attenuator is available, an AED without a pediatric attenuator may be considered for infants and children.

Synopsis

Manual defibrillators and AEDs can both be used to treat VF/pVT in children. AEDs have high specificity in recognizing pediatric shockable rhythms.[1–4] Manual defibrillators, when used by health care professionals, can be used to titrate energy dose to a patient's weight. Their use also minimizes pauses for rhythm analysis. Use of monophasic defibrillators has fallen out of favor because biphasic defibrillators require less energy with fewer side effects. Many AEDs are equipped to attenuate (reduce) the energy dose to make them more suitable for infants and children.

Recommendation-Specific Supportive Text

1. Although there are no direct comparisons between pediatric attenuator and nonattenuator AED-delivered shocks, multiple studies document shock success with survival when a pediatric attenuator was used.[1–13] A retrospective cohort study in children <18 years of age with OHCA showed that return of an organized rhythm was more likely when lower energy dose was utilized.[14]
2. In adults, use of an AED in hospitals did not improve survival,[15] and the peri-shock CPR pauses needed for rhythm analysis were prolonged.[16] In children <18 years of age with IHCA, 1 well-designed retrospective multicenter cohort study, found that 30% of defibrillations were delivered for nonshockable rhythms with manual defibrillators,[17] while previous studies suggest that AEDs misclassify pediatric shockable rhythms only 2% to 4% of the time. However, the adverse impact of shocking nonshockable rhythms in IHCA is unknown, and manual defibrillators allow for titration of energy dose to a patient's weight while minimizing peri-shock CPR pauses compared to AED-associated CPR pauses.
3. AEDs without pediatric attenuation deliver 120 to 360 J, exceeding the recommended dose for children weighing <25 kg. However, there are reports of safe and effective AED use in infants and young children when the dose exceeds 2 to 4 J/kg.[7–9,11,18,19] Because defibrillation is the only effective therapy for shockable rhythms, an AED without a dose attenuator may be lifesaving.

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MANAGEMENT OF SHOCKABLE RHYTHMS

Defibrillator Paddles and Pads: Size, Type, and Position

Recommendations for Defibrillator Paddles and Pads: Size, Type, and Position

COR	LOE	Recommendations
1	C-EO	1. In infants and children, it is recommended to use the largest paddles or self-adhering pads that will fit on the chest while still maintaining good separation between the paddles or pads.
2b	C-LD	2. When using self-adhering pads in infants and children, either anteroposterior or anterolateral placement may be reasonable.
2b	C-LD	3. When delivering electric current for defibrillation in infants and children, paddles or self-adhering pads may be considered equally effective and efficient.

Synopsis

Incorrect defibrillator paddle or pad placement can lead to ineffective delivery of electric current to the heart and adversely impact return of a perfusing rhythm. The size of the defibrillator paddles or self-adhering pads depends on the age of the patient. Paddles or self-adhering pads of the largest size that can still be separated by at least 1 to 2 cm allow for appropriate current flow. When using paddles, an electrical conducting interface is needed to reduce skin and thoracic impedance. Figures 14 and 15 demonstrate placement of the pads in the anteroposterior position, and Figure 16 demonstrates placement of the pads in the anterolateral position.

Recommendation-Specific Supportive Text

1. Minimizing transthoracic impedance is important to optimize delivery of electric current. Studies comparing shocks delivered to children with pediatric to adult paddles showed that transthoracic impedance was significantly higher with pediatric paddles due to smaller size.[1–3]
2. One pediatric study demonstrated no difference in rates of ROSC with anteroposterior compared to anterolateral pad placement.[4] Among adults, a prospective cohort study showed statistically higher adjusted odds of ROSC at any time with anteroposterior pad placement while another study showed no significant difference.[5,6]
3. One simulation study demonstrated that the predominant factor to prompt defibrillation was rescuer familiarity with the defibrillator and the paddles/pads connections. There was no significant difference in median time to shock with use of paddles compared with self-adhering pads.[7]

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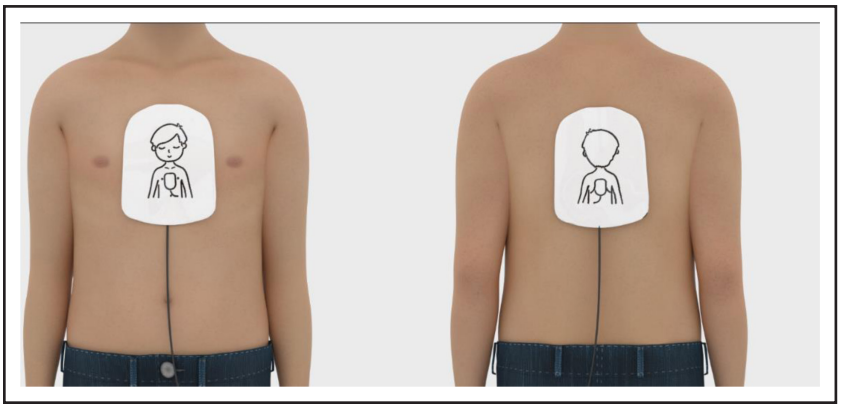

Figure 14. Placement of pediatric pads in the anteroposterior position. One pad is placed in the center of the child's bare chest (anterior) and the other pad is placed in the center of the back (posterior).

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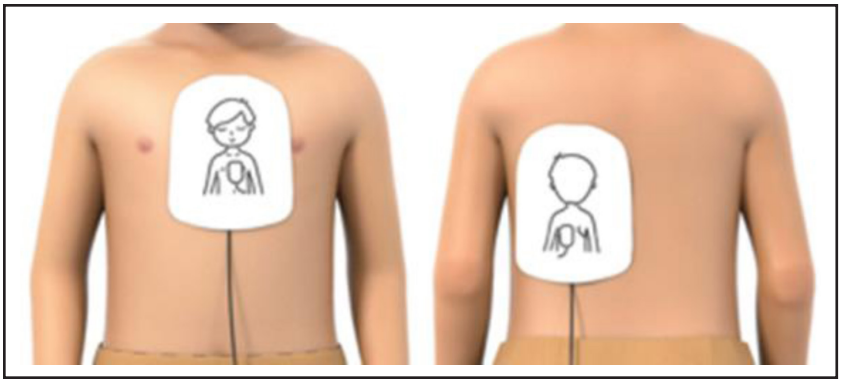

Figure 15. Placement of pediatric pads in the alternative anteroposterior position.
One pad is placed on the left side of the chest, between the left side of the child's breastbone and left nipple (anterior) and the other pad is placed on the left side of the child's back, next to the spine (posterior).

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CRITICAL KNOWLEDGE GAPS AND ONGOING RESEARCH

During the literature review process, we identified several critical knowledge gaps related to pediatric basic and advanced life support. These topics are either current areas of ongoing research or lack significant pediatric evidence to support evidence-based recommendations. In addition, we identified topics for which systematic or

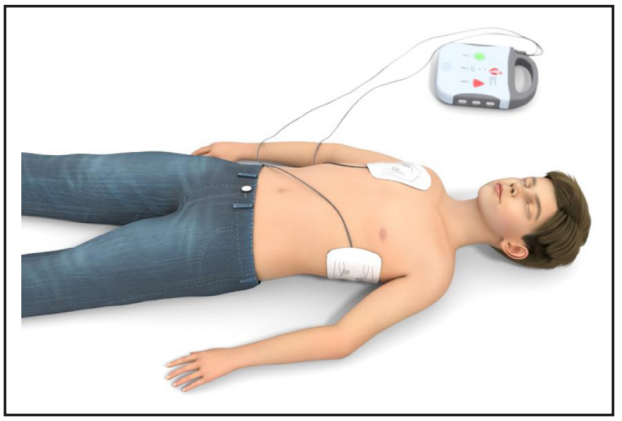

Figure 16. Placement of pediatric pads in the anterolateral position.
The right anterior pad is placed vertically on the right chest, with the top of the pad just below the clavicle. The left lateral pad is placed horizontally on the left side of the chest, centered at the midaxillary line, with the top of the pad on the lower ribcage in line with the sternal border (inferior portion of the xyphoid process). Do not place the pad on breast tissue or the abdomen.

Table 2. Critical Knowledge Gaps Due to Insufficient Pediatric Data

Critical knowledge gaps
With what frequency should the rhythm be checked during CPR?
What is the optimal ventilation rate during CPR in patients with or without an advanced airway? Is it age dependent?
What is the optimal chest compression rate during CPR? Is it age dependent?
What is the optimal CCF for optimal outcomes in pediatrics?
What is the optimal position for performing chest compressions (eg, on a stepstool, kneeling on the bed, standing)?
What is the effect of leaning on the chest and providing incomplete re-expansion of the chest in between chest compressions?
What is the ideal concentration of oxygen to deliver when performing CPR?
What is the ideal compression-to-ventilation ratio?
What is the optimal timing and dosing of defibrillation for VF/pVT?
What clinical tools can be used to help in the decision to terminate pediatric IHCA and OHCA resuscitation?
What is the optimal timing or duration of CPR prior to defibrillation?
What duration of pause in chest compressions is "prolonged" pause? Or, what is the duration of time that is considered a minimal pause in chest compressions?
What is the effectiveness of single shock compared to sequential (stacked) shocks in pediatrics?
What is the adverse impact of shocking nonshockable rhythms with a manual defibrillator in IHCA?
Is the time to shock with self-adhesive pads significantly different than with paddles?
Is there an optimal pad position for defibrillation in pediatrics? If so, is it AP or AL?
What is the ideal threshold of CCF associated with improved patient outcomes in pediatric CPR?
What is the most effective intervention for FBAO in pediatric patients, chest compressions versus abdominal thrusts?
What is the safety and efficacy of commercial devices for FBAO?
What is the role of mechanical chest compression devices in pediatric patients?
What is the role of point-of-care ultrasound (vascular or cardiac) during rhythm and pulse analysis?
What is the best method to verify effectiveness of breaths/ventilations during rescue breathing and CPR?

AL indicates anterolateral; AP, anteroposterior; CCF, chest compression fraction; CPR, cardiopulmonary resuscitation; FBAO, foreign-body airway obstruction; IHCA, in-hospital cardiac arrest; OHCA, out-of-hospital cardiac arrest; pVT, pulseless ventricular tachycardia; and VF, ventricular fibrillation.

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scoping reviews are in process by the International Liaison Committee on Resuscitation BLS or Pediatric Life Support Task Forces and elected not to make premature recommendations until these reviews are available.

As is so often the case in pediatric medicine, many recommendations are extrapolated from adult data. This is particularly true for the BLS components of pediatric resuscitation. The causes of pediatric cardiac arrest are very different from cardiac arrest in adults, and pediatric studies are critically needed. Furthermore, infants, children, and adolescents are distinct patient populations. Dedicated pediatric resuscitation research is a priority given the >20 000 infants, children, and adolescents who suffer cardiac arrest in the United States each year.

Critical knowledge gaps are summarized in Table 2.

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Disclosures

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Appendix 1. Continued

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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

Disclosures are reviewed and mitigated through a conflict-of-interest process that consists of reviewing pertinent information which is then used to decide what action is required to maintain content integrity. Disclosures may include salary, wages or other remuneration of any kind (including but not limited to consulting or advising fees, speaking fees, research funding, ownership interests, honoraria, participation in pension or benefit plans or programs or other perquisites, and reimbursement for travel, lodging, and meals) given for services rendered or other activities for which remuneration is received or expected, whether that compensation or other remuneration is paid directly to the individual or to the individual's employer or another third party.

*Modest.

†Significant.

Appendix 2. Reviewer Disclosures

Reviewer	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
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Joshua Nagler	Division of Emergency Medicine, Boston Children's Hospital	None	None	None	None	None	None	None
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Sarah Tabbutt	University of California San Francisco	None	None	None	None	None	None	None

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Part 7: Adult Basic Life Support: 2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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ABSTRACT: The American Heart Association's 2025 Adult Basic Life Support Guidelines build upon prior versions with updated recommendations for assessment and management of persons with cardiac arrest, as well as respiratory arrest and foreign-body airway obstruction. The chapter addresses the important elements of adult basic life support including initial recognition of cardiac arrest, activation of emergency response, provision of high-quality cardiopulmonary resuscitation, and use of an automated external defibrillator. In addition, there are updated recommendations on the treatment of foreign-body airway obstruction. The use of opioid antagonists (eg, naloxone) during respiratory or cardiac arrest is incorporated into the adult basic life support algorithms, with more detailed information provided in "Part 10: Adult and Pediatric Special Circumstances of Resuscitation."

Key Words: AHA Scientific Statements ■ airway obstruction ■ heart arrest ■ cardiopulmonary resuscitation ■ ventilation

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TOP 10 TAKE-HOME MESSAGES FOR ADULT BASIC LIFE SUPPORT MANAGEMENT

1. In adult cardiac arrest, resuscitation should generally be conducted where the patient is found, as long as high-quality cardiopulmonary resuscitation (CPR) can be administered safely and effectively.
2. After identifying an adult in cardiac arrest, a lone responder should activate the emergency response system first, and then immediately begin CPR.
3. In adult cardiac arrest, rescuers should perform chest compressions with the patient's torso at approximately the level of the rescuer's knees.
4. It is reasonable for health care professionals to perform chest compressions and ventilations for all adult patients in cardiac arrest from either a cardiac or noncardiac cause.
5. When ventilating adult patients in cardiac arrest, it is reasonable to give enough tidal volume to produce visible chest rise while avoiding hypo- and hyperventilation.
6. The routine use of mechanical CPR devices is not recommended for adults in cardiac arrest.
7. For adult patients who are not breathing normally but have a pulse, it is reasonable for rescuers to provide 1 breath every 6 seconds (10 breaths per minute).
8. CPR for adult cardiac arrest patients with obesity should be provided by using the same techniques as for the average weight patient.
9. For adults with severe foreign-body airway obstruction (FBAO), rescuers should perform cycles of 5 back blows followed by 5 abdominal thrusts until the object is expelled or the patient becomes unresponsive.

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10. During adult cardiac arrest, it is reasonable for rescuers to use personal protective equipment (PPE) while performing CPR.

PREAMBLE

The annual incidence of adults treated by emergency medical services (EMS) for out-of-hospital cardiac arrest (OHCA) in the United States varies considerably between states, but is estimated at 356 000, or 83 per 100 000 populations.[1,2] Despite advances in public education and awareness, as well as improvement in community-based systems of care, survival for adults after OHCA remains low and decreased during the COVID-19 pandemic.[3] The Cardiac Arrest Registry to Enhance Survival (CARES) is a voluntary OHCA database used by EMS agencies and hospitals to generate Utstein-style reports and to benchmark performance and outcomes against similar systems. Developed in 2004, CARES now has participating sites from 37 states covering approximately 56% of the US population. CARES OHCA data from 2024 showed that survival to hospital discharge was 10.5%, with favorable neurological outcome reported in approximately 8.2%.[4] The majority of adult OHCA occurred in private residences while 18% occurred in public places. Bystander CPR was provided in 47.7% of adult OHCA, and a bystander used an automated external defibrillator (AED) in 7.9% of cases. There is significant variation in rates of bystander CPR, public AED use, EMS response times, and survival from cardiac arrest between geographic regions, as well as disparities associated with race, sex, and socioeconomic status.[5,6]

The annual incidence of adult in-hospital cardiac arrest (IHCA) in the United States is estimated to be 292 000 by extrapolation from the Get With The Guidelines-Resuscitation registry.[7] Approximately 60% of adult IHCA occur in an acute care setting (eg, intensive care unit, emergency department, operating room) while 40% occur on the general inpatient units. Survival to hospital discharge decreased from 26.7% to a low of 18.8% during the COVID-19 pandemic, with improvement to 23.6% in 2023.[1] Racial and sex-related outcome disparities have also been observed in the IHCA setting.[8,9]

Early, high-quality CPR and prompt defibrillation are the most important interventions associated with improved outcomes in adult cardiac arrest. Despite this, a 2015 US prevalence report found that only 18% of people surveyed had current CPR training,[10] with lower rates in under-represented and low-income populations. More lives could be saved if a greater proportion of the public was trained in, and willing to perform, basic life support, especially chest compressions.[11]

Since 2010, the American Heart Association (AHA) Emergency Cardiovascular Care (ECC) Committee has regularly set goals aimed at increasing survival from cardiac arrest. The accompanying strategies focus on strengthening the links in the Chain of Survival to prevent, identify, treat, and support all phases of care for persons who are at risk for, or experience, cardiac arrest. The fundamental basic life support tasks of recognition of cardiac arrest, activation of emergency response, performance of chest compressions and ventilations, and use of an AED for defibrillation are critical components representing the first links of the Chain of Survival that must be optimized so persons with cardiac arrest can fully benefit from advanced cardiovascular care therapies.[12]

The 2030 Impact Goals focus on improving survival to hospital discharge with favorable neurological outcome for individuals experiencing OHCA or IHCA.[13] Not surprisingly, the first 2 goals are related to basic life support: bystander CPR and public access defibrillation. Specifically, the first goal calls for an increase in bystander adult CPR performance rates to greater than 50%, while the second goal is to increase the proportion of adults with cardiac arrest for whom an AED is applied before emergency medical response arrival to greater than 20%. To accomplish these goals, the evidence-based recommendations for performance of high-quality basic life support provided in this chapter must be coupled with strategies for awareness, advocacy, and education that improve the system of care for all persons. The accompanying chapters, "Part 12: Resuscitation Education Science" and "Part 4: Systems of Care," provide recommendations for optimizing the community and health care system approach to cardiac arrest treatment, including bystander CPR training, telecommunicator CPR, public access defibrillation, and timely activation of the emergency medical response system.[14,15] While all components of the Chain of Survival are essential, high-quality basic life support is foundational to improving outcomes.

INTRODUCTION

These recommendations supersede the last full set of AHA Guidelines for Adult Basic Life Support published in 2020[16] unless otherwise specified. The writing group reviewed all relevant and current AHA Guidelines for CPR and ECC and all relevant publications of the *International Liaison Committee on Resuscitation* (ILCOR) *Consensus on CPR and ECC Science With Treatment Recommendations* from 2020 through 2024.[17–20] Evidence and recommendations were reviewed to determine if current guidelines should be reaffirmed, revised, or retired, or if new recommendations were needed. The writing group then drafted, reviewed, and approved each recommendation. For topics that did not undergo full evidence review or updated literature search, the recommendations, recommendation-specific supportive text, and references from the 2020 Basic Life Support Guidelines were not updated and were carried over. These topics are noted within the synopsis of their respective sections and remain as the current guidelines for 2025.

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Table 1. Applying Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care (Updated December 2024)*

CLASS (STRENGTH) OF RECOMMENDATION

Class 1 (STRONG) — Benefit >>> Risk

Suggested phrases for writing recommendations:
- Is recommended
- Is indicated/useful/effective/beneficial
- Should be performed/administered/other
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is recommended/indicated in preference to treatment B
  - Treatment A should be chosen over treatment B

Class 2a (MODERATE) — Benefit >> Risk

Suggested phrases for writing recommendations:
- Is reasonable
- Can be useful/effective/beneficial
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is probably recommended/indicated in preference to treatment B
  - It is reasonable to choose treatment A over treatment B

Class 2b (WEAK) — Benefit ≥ Risk

Suggested phrases for writing recommendations:
- May/might be reasonable
- May/might be considered
- Usefulness/effectiveness is unknown/unclear/uncertain or not well-established

Class 3: No Benefit (MODERATE) — Benefit = Risk (Generally, LOE A or B use only)

Suggested phrases for writing recommendations:
- Is not recommended
- Is not indicated/useful/effective/beneficial
- Should not be performed/administered/other

Class 3: HARM (STRONG) — Risk > Benefit

Suggested phrases for writing recommendations:
- Potentially harmful
- Causes harm
- Associated with excess morbidity/mortality
- Should not be performed/administered/other

LEVEL (QUALITY) OF EVIDENCE‡

Level A
- High-quality evidence‡ from more than 1 RCT
- Meta-analyses of high-quality RCTs
- One or more RCTs corroborated by high-quality registry studies

Level B-R (Randomized)
- Moderate-quality evidence‡ from 1 or more RCTs
- Meta-analyses of moderate-quality RCTs

Level B-NR (Nonrandomized)
- Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies
- Meta-analyses of such studies

Level C-LD (Limited Data)
- Randomized or nonrandomized observational or registry studies with limitations of design or execution
- Meta-analyses of such studies
- Physiological or mechanistic studies in human subjects

Level C-EO (Expert Opinion)
- Consensus of expert opinion based on clinical experience

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consenus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR 1 and 2a; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely-used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

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Scope of the Guidelines

The 2025 Adult Basic Life Support Guidelines apply to a range of responders, including trained and untrained lay rescuers and health care professionals, with the understanding that systems of prehospital and in-hospital care vary widely across the world. They address the treatment of cardiac arrest as well as other immediately life-threatening conditions including respiratory arrest and FBAO. A person in cardiac arrest who has signs of puberty is treated by using the Adult Basic Life Support Guidelines; guidelines for pediatric patients are discussed in "Part 6: Pediatric Basic Life Support."

Organization of the Writing Group

The Adult Basic Life Support Writing Group was composed of subject matter experts and investigators with diverse backgrounds in prehospital care, emergency medicine, critical care medicine, and respiratory care in both urban and rural North American settings. Before selection for the writing group, members disclosed any conflicts of interest,

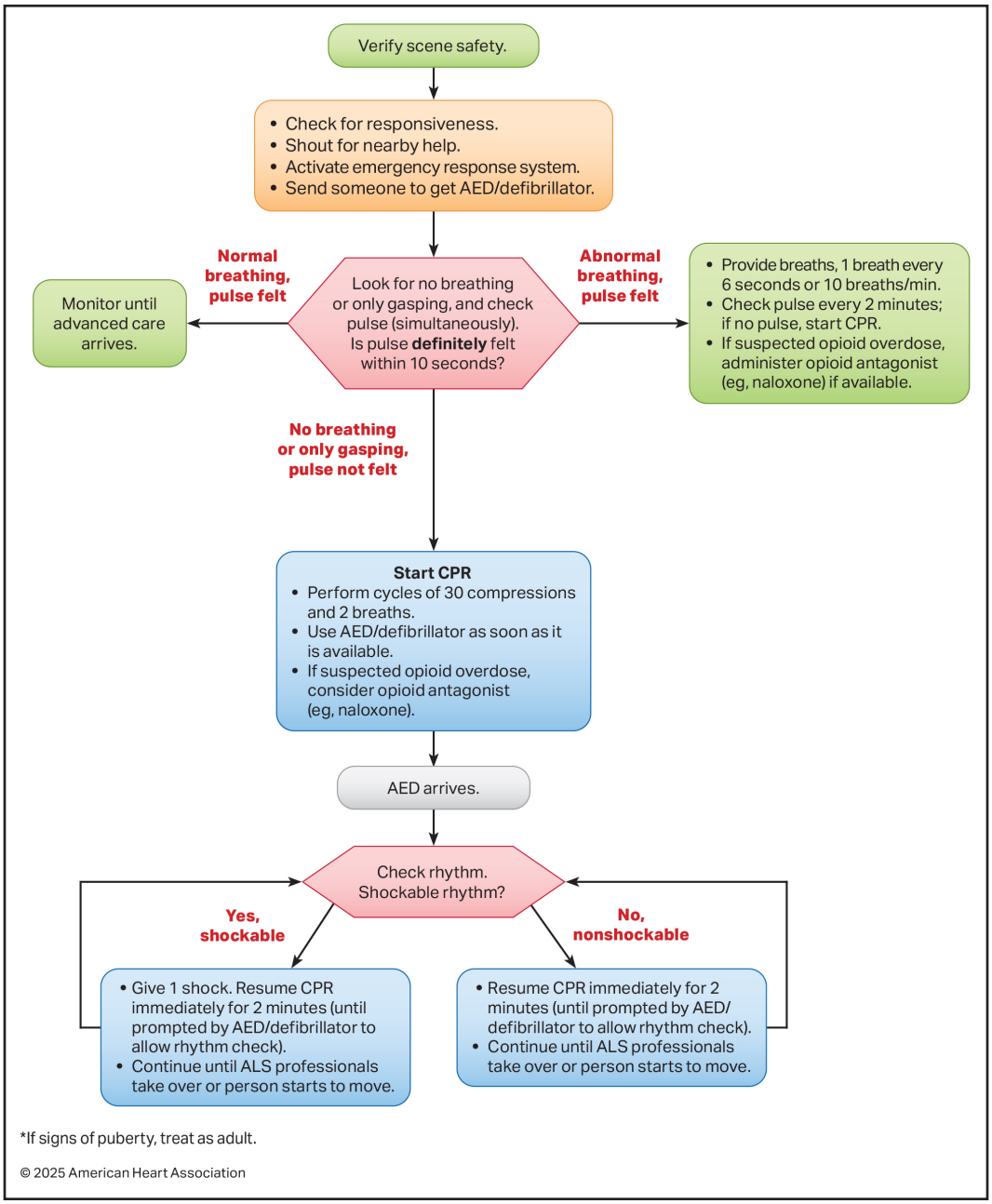

Figure 1. Adult Basic Life Support Algorithm for Health Care Professionals.
AED indicates automated external defibrillator; ALS, advanced life support; and CPR, cardiopulmonary resuscitation.

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either financial or intellectual (see Appendix), and a robust conflict of interest process was followed (see "Part 2: Evidence Evaluation and Guidelines Development").[21]

METHODOLOGY AND EVIDENCE REVIEW

The AHA is an active member of ILCOR, a consortium of 8 member councils that collaborates to review resuscitation literature and develop a consensus on science. When possible, ILCOR also provides treatment recommendations for specific aspects of ECC.

The Adult Basic Life Support Guidelines are based on the rigorous evidence evaluation process undertaken by ILCOR, which includes evidence updates, scoping reviews, and systematic reviews. When a specific topic is not concurrently addressed by ILCOR, the writing group performed updated evidence evaluations by using standardized databases to capture any additional relevant studies since the last review. More details are provided in "Part 2: Evidence Evaluation and Guidelines Development."[21]

Class of Recommendation and Level of Evidence

As in the past, all 2025 AHA Adult Basic Life Support Guideline recommendations are classified according to the AHA criteria for Class of Recommendation (COR) and Level of Evidence (LOE) (Table 1). The COR refers to the strength and consistency of the evidence and

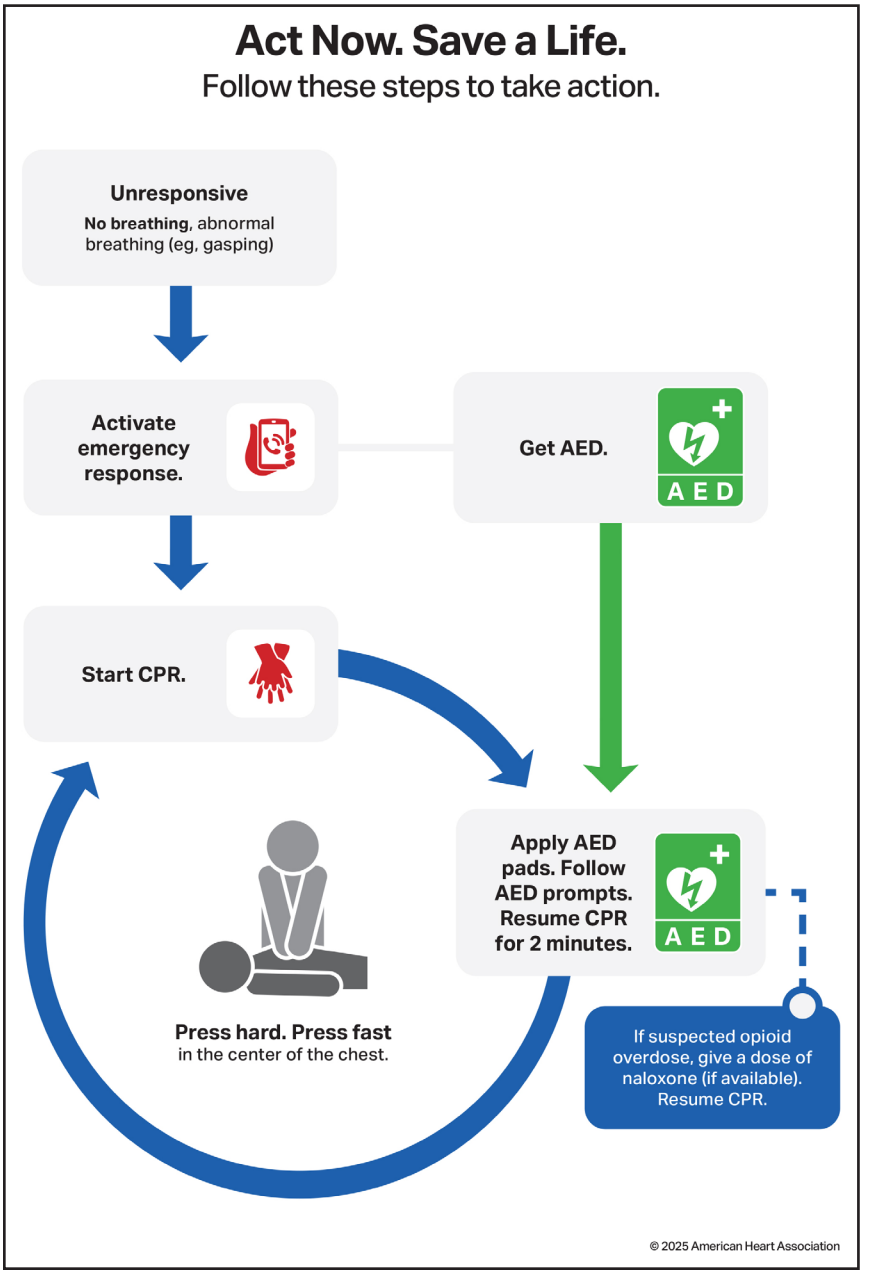

Figure 2. Adult Basic Life Support Algorithm for Lay Rescuers.
AED indicates automated external defibrillator; CPR, cardiopulmonary resuscitation.

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reflects the writing group's synthesis of the available literature, the potential impact on patient outcome, and the relevant principles of feasibility, acceptability, and equity. The specific wording is intended to reflect the risk-benefit ratio associated with the recommendation, with terms such as *is recommended* or *should* reserved for Class 1 recommendations.

The LOE reflects the quality of the evidence, with highest value (LOE A) placed on randomized controlled trials (RCTs) and meta-analyses involving RCTs. Lower-quality randomized, nonrandomized, or registry studies as well as observational studies are categorized as lower levels of evidence. Recommendations based on limited data or expert opinion are indicated as LOE C.

The use of COR and LOE for each recommendation provides transparency to the guideline user to distinguish between those recommendations that are considered clearly effective and those for which more high-quality research may result in future guideline revisions. By acknowledging the limitations of the available evidence, the guidelines are intentionally identifying knowledge gaps and areas of uncertainty to be addressed by further investigation.

Guideline Structure

The 2025 Adult Basic Life Support Guidelines are organized into knowledge chunks, which are tables of recommendations covering specific topics. Each individual

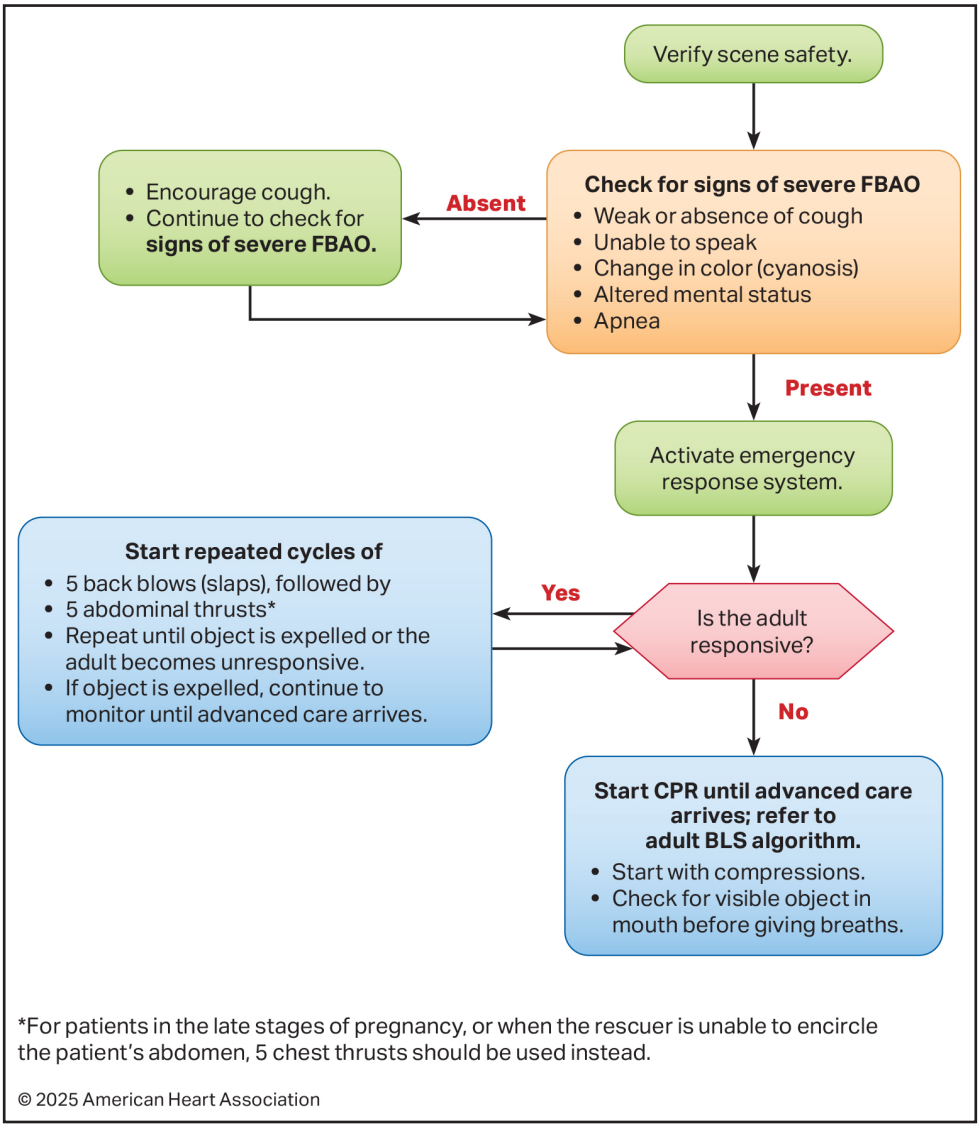

Figure 3. Adult Foreign-Body Airway Obstruction Algorithm.
BLS indicates basic life support; CPR, cardiopulmonary resuscitation; and FBAO, foreign-body airway obstruction.

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recommendation has a color-coded corresponding COR and LOE to indicate the strength of the recommendation and the type and quality of evidence supporting it. A brief synopsis follows the table to provide context and key concepts. The recommendation-specific supportive text provides background information on the topic as well as specific key studies or trials that were considered.

Of note, the order of recommendations in the tables is determined primarily by the COR, with Class 1 recommendations first, and then by LOE category. The order is not intended to reflect the sequence of resuscitation step performance, which is illustrated in the accompanying algorithms: Adult Basic Life Support for Health Care Professionals (Figure 1), Adult Basic Life Support for Lay Rescuers (Figure 2), and Adult FBAO (Figure 3).

Document Review and Approval

Each Adult Basic Life Support Writing Group member reviewed and approved each recommendation provided in the 2025 Adult Basic Life Support Guidelines. The guidelines were also reviewed by the ECC Science Oversight Committee and were submitted for blinded peer review by subject matter experts. All participants in the writing and review process were required to disclose conflicts of interest, including relationships with industry. Additional review by the AHA Science Advisory and Coordinating Committee and the AHA Executive Committee occurred before journal submission. Disclosures for writing group members and reviewers are provided in Appendixes 1 and 2.

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Updated AHA Algorithms for Adult Basic Life Support and FBAO

Three algorithms are included in the 2025 Guidelines as resources. The Adult Basic Life Support Algorithm for Health Care Professionals (Figure 1) now incorporates the use of opioid antagonists for both respiratory and cardiac arrest. A new adult basic life support algorithm (Figure 2) illustrates the approach for lay rescuers. A new algorithm for assessment and treatment of FBAO (Figure 3) is also provided.

SEQUENCE OF RESUSCITATION

Recognition of Cardiac Arrest

Recommendations for Recognition of Cardiac Arrest		
COR	**LOE**	**Recommendations**
1	C-LD	1. If an adult is unconscious/unresponsive, with absent or abnormal breathing (ie, only gasping), the lay rescuer should assume the person is in cardiac arrest.
1	C-LD	2. If an adult is unconscious/unresponsive, with absent or abnormal breathing (ie, only gasping), the health care professional should check for a pulse for no more than 10 s and, if no definite pulse is felt, should assume the person is in cardiac arrest.

Synopsis

Recognition of cardiac arrest can be difficult, especially in the out-of-hospital setting.[1] Accurate detection of a pulse is challenging for all levels of responders, increasing the risk for delays in initiation of chest compressions and activation of emergency medical response. Recognition by lay rescuers is, therefore, based primarily on level of consciousness and respiratory effort rather than using a pulse check. Health care professionals are encouraged to check for a pulse as one component of the recognition of cardiac arrest; however, the emphasis is on prompt initiation of CPR if a pulse is not definitively felt.

Recommendation-Specific Supportive Text

1. Assessment of patient unresponsiveness and absent or abnormal breathing have been shown to rapidly identify a significant proportion of patients who are in cardiac arrest.[2] Agonal breathing is characterized by slow, irregular gasping respirations that are ineffective for ventilation. Agonal breathing is described by lay rescuers with a variety of terms including *abnormal breathing*, *snoring respirations*, and *gasping*.[3] Agonal breathing is common, reported as being present in up to 40% to 60% of OHCA, and diminishes the longer a person is in cardiac arrest.[4,5] The presence of agonal breathing is cited as a common reason for lay rescuers to misdiagnose a patient as not being in cardiac arrest,[6] and may lead to delays in initiation of chest compressions. Furthermore, the risk of harm associated with providing chest compressions to an unconscious patient who is not in cardiac arrest is low.[7–11] The benefit of providing CPR for someone in cardiac arrest far outweighs any risk associated with providing chest compressions to someone who is not.
2. Protracted delays in CPR can occur when checking for a pulse at the outset of resuscitation efforts as well as between successive cycles of CPR. Health care professionals often take too long to check for a pulse and have difficulty determining if a pulse is present or absent.[12–14] There is no evidence, however, that checking for breathing, coughing, or movement is superior to a pulse check for detection of circulation.[15] Thus, health care professionals are directed to quickly check for a pulse and to promptly start compressions when a pulse is not definitively palpated within 10 seconds.

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INITIATION OF RESUSCITATION

Initiation of Resuscitation: Lay Rescuer (Untrained or Trained)

Recommendations for Initiation of Resuscitation: Lay Rescuer (Untrained or Trained)

COR	LOE	Recommendations
1	B-NR	1. All lay rescuers should provide chest compressions for adults with presumed cardiac arrest.
1	B-NR	2. After identifying an adult in cardiac arrest, a lone responder should activate the emergency response system first, then immediately begin CPR, beginning with chest compressions.
1	C-LD	3. For adults in cardiac arrest, a lone rescuer with a mobile phone should activate the emergency response system and immediately begin CPR, beginning with chest compressions.
2a	B-R	4. For lay rescuers trained in performing CPR, it is reasonable to provide ventilation (breaths) in addition to chest compressions for an adult in cardiac arrest.
2a	C-LD	5. When immediately available, it is reasonable for rescuers to use PPE during CPR for adult cardiac arrest.

Synopsis

The first link in the Chain of Survival for cardiac arrest includes prompt activation of the emergency response system.[1] Given that most lay rescuers will likely have mobile phones with hands-free options, it is possible for lay rescuers to provide CPR and activate the emergency response system at nearly the same time. Alternatively, a second lay rescuer can be instructed to call 911. Activation of the emergency response system allows for provision of telecommunicator CPR, possible notification of other lay rescuers via crowd-sourced applications, and dispatch of the designated EMS agency.

Immediate chest compressions are critical to improve patient outcomes from OHCA, and a chest compression–only approach is appropriate if lay rescuers are untrained or unwilling to provide breaths. Because CPR with breaths may lead to improved outcomes for adults in comparison with chest compression–only CPR, trained rescuers are encouraged to provide breaths along with chest compressions. PPE provides an important barrier against certain infectious diseases, but lay responders may have limited access to PPE.

Recommendation-Specific Supportive Text

1. Immediate initiation of chest compressions is one of the most impactful interventions for survival from cardiac arrest.[2–4] In Japan, nationwide dissemination of chest compression–only CPR for lay rescuers was associated with an increase in the incidence of survival with favorable neurological outcome after OHCAs, likely due to an increase in lay rescuers providing CPR.[5] Providing manual chest compressions for an unconscious patient not in cardiac arrest has not been associated with serious harm, as demonstrated in several observational studies.[6–11] The risk-to-benefit ratio remains heavily in favor of initiating CPR for presumed cardiac arrest when compared to the significant harm of withholding CPR when a patient is in cardiac arrest.
2. A previous large observational study (N=17 461) found no difference in survival to hospital discharge between patients receiving CPR before a call and patients receiving CPR after a call to the emergency response system.[8,12] Our recommendation values the practical considerations of timely emergency medical response dispatch and the availability and value of remote assistance to improve the quality of CPR.
3. Use of the “hands-free” speaker feature on most cell phones, when and where available, can help with near-simultaneous activation of emergency response and initiation of CPR. In situations where a phone is not immediately available, local circumstances will determine decisions about delaying CPR to activate the emergency medical response system; however, the importance of timely CPR must be emphasized.
4. Numerous observational studies and 1 large secondary analysis of an RCT found improved outcomes in patients with cardiac arrest who received both chest compressions and ventilations compared with those who received chest compressions only.[5,13–15] Other observational studies have reported no difference in outcome for patients receiving compressions and ventilations compared with compression-only CPR.[14,16–22] Given the potential benefit of including both compressions and ventilations during CPR, if lay rescuers are

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appropriately trained, they should be encouraged to deliver breaths with compressions.

5. The impact of PPE on CPR performance is an important consideration for responders. Although transmission of disease during CPR is uncommon, the COVID-19 pandemic heightened awareness of the importance of protection of rescuers, especially from airborne pathogens such as respiratory viruses. Because CPR is considered an aerosol-generating procedure, the use of PPE has become the norm. Safety and protection of the rescuer are of utmost importance in responding to cardiac arrest. Rescuers must be aware, however, that the process of donning PPE may delay the initiation of CPR, and use of PPE has the potential to adversely affect CPR performance and increase rescuer fatigue.[23] A 2023 systematic review and meta-analysis found no difference in survival (1 clinical study)[24] or any change in CPR performance (17 manikin studies), with donning of PPE in simulated cardiac arrest.[25] Two pooled studies from the same meta-analysis showed worse fatigue scores when rescuers performed CPR while wearing PPE.[26,27] More information is provided in "Part 10: Adult and Pediatric Special Circumstances of Resuscitation."[28]

Initiation of Resuscitation: Health Care Professional

Recommendations for Initiation of Resuscitation: Health Care Professional

COR	LOE	Recommendations
1	C-LD	1. During adult cardiac arrest, a lone health care professional should commence with chest compressions rather than with ventilation.
2a	C-LD	2. It is reasonable for health care professionals to perform chest compressions and ventilation for all adult patients in cardiac arrest from either a cardiac or noncardiac cause.

Synopsis

The 2010 Guidelines for CPR and ECC included a major change for trained rescuers, who were instructed to begin the CPR sequence with chest compressions rather than with breaths (circulation, airway, and breathing versus airway, breathing, and circulation) to minimize the time to initiation of chest compressions.[29] As health care professionals are trained to deliver compressions and ventilation, they are in a position to provide both during adult basic life support.

Recommendation-Specific Supportive Text

1. The circulation, airway, and breathing approach for adults is supported by a 2024 ILCOR systematic review.[2–4,8,30] Once chest compressions have been started, a single trained rescuer delivers breaths by mouth-to-mask or by bag-mask device to provide oxygenation and ventilation. Manikin studies demonstrate that starting with chest compressions rather than with ventilation is associated with faster times to chest compressions, breaths, and completion of the first CPR cycle.[3,4,31]
2. Numerous studies have shown improved outcomes when ventilations are provided in addition to chest compressions for adults in cardiac arrest.[5,13–15] Delivery of chest compressions without assisted ventilation for prolonged periods could be less effective than conventional CPR (compressions plus ventilation) because arterial oxygen content decreases as CPR duration increases. This concern is especially pertinent in the setting of asphyxial cardiac arrest.[13] Health care professionals, with their training and understanding, can realistically tailor the sequence of subsequent rescue actions to the most likely cause of arrest.

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OPENING THE AIRWAY

Opening the Airway in Adults in Cardiac Arrest

Recommendations for Opening the Airway in Adults in Cardiac Arrest

COR	LOE	Recommendations
1	C-EO	1. For unresponsive adult patients, health care professionals and trained lay rescuers should open the airway by using a head tilt–chin lift maneuver when no cervical spine injury is suspected.
2a	C-LD	2. When managing the airway of an adult with known or suspected basal skull fracture or severe coagulopathy, an oropharyngeal airway is preferred compared with a nasopharyngeal airway.
2b	C-EO	3. The use of an airway adjunct (eg, oropharyngeal or nasopharyngeal airway) may be reasonable in unconscious (unresponsive) adult patients with no cough or gag reflex to facilitate delivery of ventilation.
3: No Benefit	C-LD	4. The routine use of cricoid pressure in adult cardiac arrest is not recommended.

Synopsis

Opening the airway is a key component of basic life support for patients who are unresponsive with or without respiratory or cardiac arrest. Unresponsive individuals are at risk for airway obstruction primarily due to the tongue falling to the back of the oropharynx as the oropharyngeal muscles lose tone. Untreated airway obstruction can lead to hypoxia and hypercarbia, which may precipitate cardiac arrest. Alternatively, uncorrected airway obstruction may hinder resuscitation efforts. Airway adjuncts such as oropharyngeal and nasopharyngeal airways can improve airway patency by creating a passage between the tongue and the pharynx. However, these devices have contraindications with suspected facial trauma (nasopharyngeal airway) and an intact gag reflex (oropharyngeal airway). Rescuers need to consider the possibility of cervical spine injury when there is known or suspected trauma. Cricoid pressure has not been shown to have benefit and has the potential to interfere with air entry into the trachea during bag-mask ventilation.

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Recommendation-Specific Supportive Text

1. The head tilt–chin lift is an effective technique to open an airway as demonstrated in noncardiac arrest and radiological studies (Figure 4).[1–4] No studies have compared head tilt–chin lift with other airway maneuvers to establish an airway during cardiac arrest.
2. The benefit of an oropharyngeal airway compared with a nasopharyngeal airway in the presence of a known or suspected basilar skull fracture or severe coagulopathy has not been assessed in clinical trials. However, use of an oropharyngeal airway reduces the risk of intracranial passage that may occur with nasopharyngeal airway insertion. Two case reports observed intracranial placement of nasopharyngeal airways in patients with basilar skull fractures.[5,6]
3. Oropharyngeal and nasopharyngeal airway adjuncts can be used to maintain a patent airway and facilitate appropriate ventilation by preventing the tongue from occluding the airway. Incorrect placement, however, can cause an airway obstruction by displacing the tongue to the back of the oropharynx.[1–4,7,8] One retrospective study reported improved neurological outcomes during IHCA with use of airway adjuncts (eg, oropharyngeal or nasopharyngeal airway) in combination with bag-mask ventilation.[9]
4. There is no evidence that cricoid pressure facilitates ventilation or reduces the risk of aspiration in cardiac arrest patients.[10] There is some evidence that in non–cardiac arrest patients, cricoid pressure may protect against aspiration and gastric insufflation during bag-mask ventilation.[11–14] However, additional studies, including a recent systematic review, found that cricoid pressure failed to reduce aspiration and may impede the placement of an advanced airway.[15–19]

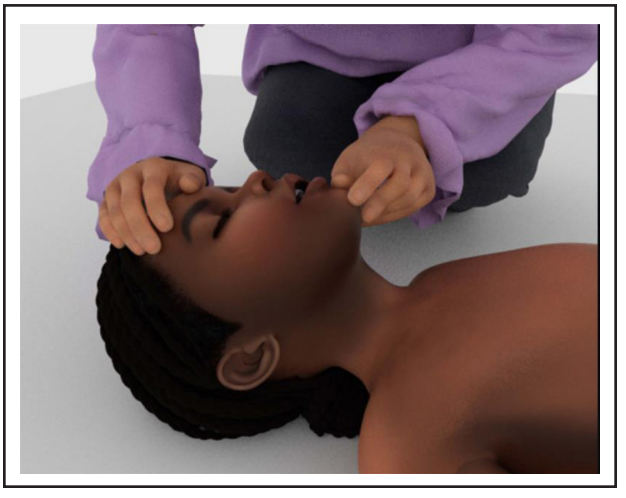

Figure 4. Opening the airway using the head tilt–chin lift technique.

Opening the Airway After Head and Neck Trauma

Recommendations for Opening the Airway After Head and Neck Trauma		
COR	**LOE**	**Recommendations**
1	C-EO	1. In cases of head and neck trauma, trained rescuers should open the airway of an adult by using a jaw thrust without head extension.
1	C-EO	2. For an adult with head and neck trauma, if the airway cannot be opened with a jaw thrust and airway adjunct insertion, trained rescuers should open the airway by using a head tilt–chin lift.
3: Harm	C-LD	3. In the setting of an adult with head and neck trauma, lay rescuers should not use rigid cervical devices for spinal motion restriction because their use by untrained rescuers may be harmful.

Synopsis

An adult with signs of head or neck trauma may have a cervical spine injury. Trained rescuers should attempt to open the airway by using the jaw thrust technique because this maneuver produces less movement of the head and neck than a head tilt–chin lift. If it is not possible to achieve an open airway with a jaw thrust and insertion of an airway adjunct, trained rescuers should open the airway by using the head tilt–chin lift given the critical importance of oxygenation and ventilation. No new evidence was identified on this topic during the 2025 evidence review.

Recommendation-Specific Supportive Text

1. If an unresponsive person has head or neck trauma, there is a possibility of cervical spinal injury. Trained rescuers should open the airway by using a jaw thrust instead of head tilt–chin lift.[1]
2. Maintaining a patent airway and providing adequate ventilation and oxygenation are priorities during CPR. If a jaw thrust and insertion of an airway adjunct are ineffective, a head tilt–chin lift may be necessary to open the airway. The importance of a patent airway outweighs the risk of further spinal damage in the cardiac arrest patient even in the setting of head and neck trauma.
3. Manual spinal motion restriction can decrease movement of the cervical spine during patient care while allowing for proper ventilation and airway control.[20,21] When head and neck injury are present, lay rescuers should maintain manual spinal motion restriction and should not use rigid cervical collar devices. Spinal immobilization devices such as rigid cervical collars may make it more difficult to maintain airway patency[22,23] and provide adequate ventilation.

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METRICS FOR HIGH-QUALITY CPR

Positioning and Location for CPR

Recommendations for Positioning and Location for CPR		
COR	**LOE**	**Recommendations**
1	B-NR	1. In adult cardiac arrest, rescuers should perform chest compressions with the patient's torso at approximately the level of the rescuer's knees whenever possible.
1	C-LD	2. When providing chest compressions for an adult, the rescuer should place the heel of one hand on the center (middle) of the person's chest (the lower half to lower third of the sternum) and the heel of the other hand on top of the first so that the hands are overlapped.
1	C-EO	3. In adult cardiac arrest, resuscitation should generally be conducted where the person is found, as long as high-quality CPR can be administered safely and effectively.
2a	C-LD	4. In adult cardiac arrest, it is preferred to perform CPR on a firm surface and with the person in the supine position, when feasible and it does not delay chest compressions.
2b	C-LD	5. In adult cardiac arrest, rescuers may consider placing their dominant hand on the sternum when performing chest compressions.
2b	C-LD	6. For adult patients who experience cardiac arrest while in the prone position, it may be reasonable to turn the patient supine before initiating chest compressions. If the patient cannot be safely turned supine, rescuers may consider performing CPR in the prone position.

Synopsis

High-quality resuscitation is vital for improved cardiac arrest outcomes including return of spontaneous circulation (ROSC) and survival. The effectiveness of chest compression delivery can be improved through optimizing rescuer hand position, rescuer body position, and patient position (Figures 5 and 6).

Recommendation-Specific Supportive Text

1. Rescuer position in relationship to the patient can affect chest compression quality. Multiple simulated crossover RCTs have shown that kneeling on the floor or in the bed next to the manikin resulted in improved chest compression depth compared to standing in adult populations.[1–6] Straddling the patient to perform CPR is similar to kneeling with improved chest compression quality in comparison to standing or walking alongside the patient while performing CPR on a moving cot.[7–9] However, kneeling and straddling, especially on a moving cot, needs to be weighed against rescuer safety and stability. One moderate-sized (n=124) RCT did not find benefit with straddling CPR compared to conventional lateral CPR while performed in a confined space.[10] Two studies specifically evaluating height found that when the manikin torso was no more than 10 cm below the rescuer's knee,

Figure 5. Rescuer position and hand location for chest compressions.

this was associated with improved chest compression depth.[11,12] Using a step stool for rescuer elevation has also shown to improve chest compression quality in comparison to standing.[1,4] Two RCTs demonstrated slightly higher chest compression quality metrics including depth and recoil with kneeling compared to step stool use.[1,4]

2. A 2020 ILCOR systematic review identified 3 studies involving 57 patients that investigated the effect of hand positioning on resuscitation process and outcomes.[13] No new studies were identified in a recent update of this review. Although no differences in resuscitation outcomes were noted, 2 studies found better physiological parameters (peak arterial pressure, mean arterial pressure, and end-tidal carbon dioxide) when compressions were performed over the lower third of the sternum compared with the middle of the sternum.[14,15] A third study found no difference.[16] Radiographic studies show the left ventricle is typically located inferior to the internipple line, corresponding with the lower half of the sternum.[17] However, hand placement inferior to the internipple line may result in compression over the xiphoid, which may be less effective.[18]
3. The ability to safely provide high-quality CPR should remain the highest priority when considering if a patient needs to be moved before initiation of CPR. If adequate chest compressions can be effectively provided while maintaining rescuer safety in the location the patient is found, immediate resuscitation can occur at this location. Importantly, delay in initiation of chest compressions is associated with worse outcomes. In a study of telephone-assisted CPR during OHCA, delays to CPR due to patient repositioning occurred in 41% of cases, most commonly due to physical limitations of the rescuer. Odds of survival to hospital discharge was significantly lower in the group with delayed chest compressions.[19] This recommendation is not intended to apply to decision-making for the timing of transportation from the scene when a patient remains in cardiac arrest.
4. A firm surface improves the likelihood of adequate chest compression depth. A recent systematic review including manikin studies recommended the use of a backboard in hospital settings to provide a firm surface for CPR.[20] Similarly, compressions on a deflated dynamic mattress or use of bed manufacturer "CPR mode" in-hospital can improve chest compression depth.[21,22] Studies have supported that optimal chest compressions are best delivered with the person on a firm surface such as the floor.[23,24]
5. Dominant hand placement on the sternum may provide improved chest compression quality. One moderate-sized (n=101) RCT and 1 (n=225) observational study showed improved chest compression quality with dominant hand placement against the sternum.[25–27] Another smaller RCT (n=59) found a nonsignificant improvement with dominant hand placement on the sternum.[28]
6. While it is preferred to perform chest compressions with the patient in the supine position, there are circumstances in which the patient is in the prone position at the time of cardiac arrest. There are multiple case reports of performing resuscitation in the prone position for patients who experience cardiac arrest during operative procedures or while in the prone position for treatment of COVID-19–associated

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Figure 6. Side view of rescuer position and hand location for chest compressions.

respiratory failure.[29–31] A 2021 systematic review by ILCOR reported 20 adult patients with cardiac arrest in the prone position in the operating room or intensive care unit. Of the 12 patients who received CPR in the prone position, all experienced ROSC and survival to discharge. Of the 8 patients who were supinated before initiation of CPR, the rate of ROSC and survival to discharge were 37.5% and 29%, respectively.[32]

Chest Compression Fraction and Pauses

Recommendations for Chest Compression Fraction and Pauses		
COR	**LOE**	**Recommendations**
1	C-LD	1. In adult cardiac arrest, preshock and postshock pauses in chest compressions should be as short as possible.
1	C-LD	2. During rhythm checks for adult cardiac arrest, the health care professional should minimize the time taken to check for a pulse (no more than 10 s), and if the rescuer does not definitely feel a pulse, chest compressions should be restarted immediately.
2a	B-R	3. In adults with cardiac arrest, it is reasonable to immediately resume chest compressions after shock administration rather than pause CPR to perform a postshock rhythm check.
2a	B-R	4. When 2 or more rescuers are available during an adult cardiac arrest, it is reasonable to switch chest compressors approximately every 2 min (or after about 5 cycles of compressions and ventilation at a ratio of 30:2).

Recommendations for Chest Compression Fraction and Pauses (Continued)		
COR	**LOE**	**Recommendations**
2a	C-LD	5. For adults in cardiac arrest receiving CPR without an advanced airway, it is reasonable to pause compressions to deliver 2 breaths, each given over 1 s.
2b	C-LD	6. During adult cardiac arrest, it may be reasonable to perform CPR with a chest compression fraction of at least 60%.
2b	C-LD	7. Outside of the advanced life support environment, where invasive monitoring is available, there are insufficient data about the value of a pulse check while performing CPR for adult cardiac arrest.

Synopsis

High-quality CPR is one of the most important interventions to improve survival from cardiac arrest. One key feature of high-quality CPR is to minimize interruptions in chest compressions, in addition to providing chest compressions of adequate rate and depth, allowing complete chest recoil between compressions, and avoiding excessive ventilations.[33,34] Chest compressions are required for forward flow during cardiac arrest, and pauses in chest compressions have been shown to result in an almost immediate drop in coronary perfusion pressure, which is associated with reduced likelihood of ROSC.[35,36] While some pauses in chest compressions, such as for ventilations and pulse checks, are necessary, ensuring that the number and duration of pauses are kept to a minimum is critical.

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The *chest compression fraction* (CCF) refers to the proportion of time a patient is receiving chest compressions during a resuscitation.

Recommendation-Specific Supportive Text

1. An increase in the overall hands-on time (CCF) during resuscitation is directly associated with improved survival from cardiac arrest.[37–39] Observational studies suggest improved outcomes with increased CCF in patients with shockable rhythms,[40,41] as well as an association between ROSC and shorter perishock pauses.[37,42–44]
2. Pulse checks and rhythm checks are common reasons for pauses in chest compressions that can reduce the CCF.[45] Patient, environmental, and logistical factors can make pulse checks difficult to perform. Observational studies have shown that pulse checks can be prolonged greater than 10 seconds, further reducing the CCF.[46]
3. Immediate resumption of chest compressions after a shock results in a shorter perishock pause and improves the overall hands-on time (CCF) during resuscitation. Two RCTs enrolling more than 1000 patients did not find any increase in survival when pausing CPR to analyze rhythm after defibrillation.[47,48] Observational studies showed decreased ROSC when chest compressions are not resumed immediately after shock.[38,49]
4. Chest compression depth begins to decrease after 90 to 120 seconds of CPR, although compression rates do not decrease significantly over that time window.[50] A randomized trial using manikins found no difference in the percentage of high-quality compressions when rotating every 1 minute compared with every 2 minutes.[51] Rotating the designated chest compressor every 2 minutes is sensible because this approach maintains chest compression quality and takes advantage of when CPR would ordinarily be paused for rhythm analysis.
5. Keeping pauses for ventilations as short as possible helps to maintain high CCF and improve resuscitation outcomes.[40,41,52] However, there is new evidence that ventilations delivered during the pause when using a 30:2 compression-to-ventilation ratio are often ineffective. In an analysis of the Resuscitation Outcomes Consortium data, investigators found that effective ventilations were delivered during fewer than half of the pauses. Importantly, when compared to the group for whom effective ventilations were provided more than 50% of the time, patients with a lower proportion of effective ventilations had worse rates of ROSC, survival to hospital discharge, and survival with favorable neurological outcome.[53]
6. Minimizing interruptions in CPR and maintaining a CCF of at least 60% has been associated with improved outcomes in a number of observational studies.[39,40,52] A 2015 systematic review reported significant heterogeneity among studies, with some studies, but not all, reporting better rates of survival to hospital discharge associated with higher CCF.[40,41,52] In 2 studies, higher CCF was associated with lower odds of survival.[54,55] A 2020 retrospective review of the Resuscitation Outcomes Consortium found an association between higher CCF and ROSC, but not survival, among patients with a nonshockable rhythm and a CCF of at least 40%.[39] Compression rate and depth and associated interventions such as defibrillation, airway management, and medications, are also important and may interact with CCF. While a CCF of 60% is considered a minimum target, high performance teams may achieve higher levels (eg, >80%).
7. Interruptions to CPR should only be done for interventions that are associated with improved outcomes. At this time, there are insufficient data and evidence to support or refute any recommendations about checking a pulse during CPR.

Chest Compression Depth and Rate in Adult Cardiac Arrest

Recommendations for Chest Compression Depth and Rate in Adult Cardiac Arrest

COR	LOE	Recommendations
1	B-NR	1. During manual CPR, rescuers should perform chest compressions to a depth of at least 2 inches, or 5 cm, for an average adult while avoiding excessive chest compression depths (>2.4 inches, or 6 cm)
2a	B-R	2. During adult cardiac arrest, it is reasonable to use audiovisual feedback devices for real-time optimization of CPR performance.
2a	B-NR	3. For adults in cardiac arrest, it is reasonable for rescuers to perform chest compressions at a rate of 100 to 120/min.
2a	C-LD	4. It can be beneficial for rescuers to allow complete chest wall recoil for adults in cardiac arrest, such as by not leaning on the chest between compressions.
2b	C-EO	5. During adult cardiac arrest, it may be reasonable to perform chest compressions so that chest compression and recoil/relaxation times are approximately equal.

Synopsis

Key components of high-quality CPR include minimizing interruptions, compressing at an optimal rate and depth, providing adequate chest recoil, and avoiding excessive ventilation.[34,56,57] Although there are numerous retrospective observational studies, there is a paucity of prospective studies or randomized trials specifically examining CPR quality targets. Further, evidence suggests interactions between CPR components (eg, rate and depth) confound studying them in isolation. These limitations do not reduce the importance

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of these elements; rather, they underscore the need for ongoing investigations into ideal CPR performance.

Recommendation-Specific Supportive Text

1. A 2020 ILCOR scoping review[56] identified 12 studies, including over 10 700 patients looking at chest compression depth. Several studies found improved survival to hospital discharge[55,58,59] when compression depth was at least 5 cm, compared to less than 4 cm.[58,59] Observational research has suggested reduced survival with chest compressions of excessive depth (>6 cm).[58,59]
2. A 2024 ILCOR scoping review[60] addressing real-time CPR audiovisual feedback for rescuers affirmed previous recommendations, however, with methodologic limitations of included studies.[13] Many studies incorporated feedback devices into multifaceted quality improvement programs. A recent systematic review and meta-analysis showed that the use of audiovisual feedback devices was associated with improved rates of ROSC and survival to discharge from cardiac arrest, although not survival with favorable neurological outcome.[61] One randomized clinical trial of IHCA demonstrated an improvement of 25.6% in survival to hospital discharge by using audible feedback on compression depth and recoil.[62]
3. A 2020 ILCOR scoping review identified 11 observational studies examining chest compression rate in adult patients in cardiac arrest.[56] Three studies of over 13 700 patients[57,63,64] suggested improved survival to hospital discharge with compression rates of 100 to 119/min, compared with lower or higher rates. One randomized trial found no difference in survival between chest compression rates of 100 and 120/min.[65] In 1 study, ROSC was improved with higher rates (121–140/min) in comparison to 100 to 120/min (n=222)[64]; however, the writing group placed higher value on survival compared with ROSC when making this recommendation.
4. Two observational studies provide mixed results for the effect of chest compression release velocity, with 1 study suggesting improved survival at rates >400 mm/s,[66,67] and the other suggesting no difference in outcomes.[66] Porcine study data suggest decreased coronary perfusion with rescuers leaning on the chest.[68]
5. The 2020 Guidelines recommended a 50% duty cycle, in which the time spent in compression and decompression was equal, mainly based on its perceived ease of being achieved in practice. In a clinical study in adults with out-of-hospital ventricular fibrillation (VF) arrest (of whom 43% survived to hospital discharge), the mean duty cycle observed during resuscitation was 39%.[69] Although many animal studies have observed higher blood flows and better outcomes when the duty cycle was less than 50%, the optimal duty cycle is not known. Currently, there is insufficient evidence to warrant a change from the existing recommendation, which remains a knowledge gap that requires further investigation.

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VENTILATION AND COMPRESSION-TO-VENTILATION RATIO

Fundamentals of Ventilation During Adult Cardiac Arrest

Recommendations for Fundamentals of Ventilation During Adult Cardiac Arrest		
COR	**LOE**	**Recommendations**
2a	**C-LD**	1. In adult patients in cardiac arrest without an advanced airway, it is reasonable to deliver breaths either by mouth-to-mouth, mouth-to-mask, or bag-mask ventilation.
2a	**C-LD**	2. When ventilating an adult patient in cardiac arrest, it is reasonable to give enough tidal volume to produce visible chest rise.
2a	**C-LD**	3. When delivering ventilations by bag-mask device for an adult in cardiac arrest, it is reasonable for 1 rescuer to use 2 hands to open the airway and seal the mask to the face while a second rescuer squeezes the bag.
2b	**C-LD**	4. When providing breaths to an adult in cardiac arrest without an advanced airway, it may be reasonable to give each breath over 1 s.
3: Harm	**C-LD**	5. When providing breaths to adult patients in cardiac arrest, rescuers should avoid hypoventilation (too few breaths or too little volume) or hyperventilation (too many breaths or too large a volume).

Synopsis

Ventilation plays a critical role during CPR and is linked to better patient outcomes.[1–3] However, providing adequate ventilation during CPR without an advanced airway can be challenging, particularly when using a bag-mask device. With bag-mask ventilation, there is a risk of an inadequate seal between the mask and the face or unintended airflow into the esophagus instead of the lungs. Because measuring ventilation volume can be difficult with the available equipment, rescuers can monitor for adequate ventilation by observing chest rise. Performing chest compressions with passive oxygen delivery does not ensure sufficient ventilation. Furthermore, chest compressions can reduce functional residual capacity, impair lung compliance due to intermittent airway collapse and atelectasis, and trigger a series of complications, including lung injury and decreased cardiac output.[4–9] Recent studies show that rescuers often fail to deliver ventilation in accordance with guidelines.[2,10,11] In contrast, CPR with both effective ventilation and chest compressions (with lung inflation in more than 50% of the pauses during 30:2 CPR) was associated with improved outcomes.[1–3] These findings highlight the importance of adequate ventilation to optimize patient outcome.

Recommendation-Specific Supportive Text

1. Both mouth-to-mouth breaths and bag-mask ventilation provide oxygen and ventilation to the person in cardiac arrest.[12] Oxygen delivery can be

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increased by adding supplemental oxygen flow to bag-mask devices or certain pocket masks. To provide mouth-to-mouth breaths, open the person's airway, pinch the person's nose, create an airtight seal around the mouth, and provide a breath. When using a barrier device, use of mouth to pocket mask provides more effective breaths than mouth to face shield.[13]

2. Ventilation during chest compressions presents a challenge, particularly because equipment to monitor tidal volumes or respiratory rates is typically unavailable in the prehospital setting. However, observing chest rise and fall remains a reliable method for assessing ventilation. One study of intubated adults found that a tidal volume of 362 to 406 mL (approximately 5–7 mL/kg for the average adult) was necessary to achieve visible chest rise.[14] While chest rise can help guide ventilation during standard 30:2 CPR, where compressions are paused for ventilation, it is not possible to monitor chest rise during continuous–chest compression CPR. With bag-mask ventilation, air leakage between the mask and the face often results in inadequate tidal volume, particularly when using a pediatric-size bag.[10] In comparison, an adult-size bag has been associated with a higher rate of ROSC in adult cardiac arrest.[11]
3. Bag-mask ventilation is a challenging skill that requires considerable practice for competency. It often fails to provide adequate ventilation, due to air leakage between the mask and the face or an incompletely opened airway.[2,15] Bag-mask ventilation is most effective when provided by 2 trained and experienced rescuers; 1 rescuer opens the airway and seals the mask to the face with both hands while the other rescuer (who might also be the chest compressor) squeezes the bag during the pauses in chest compression during 30:2 CPR. Both rescuers watch for visible chest rise and fall to confirm proper ventilation. The 2-handed mask technique with jaw thrust has been shown to be superior to a 1-handed technique that is often referred to as the *E-C clamp*.[16,17] The E-C clamp technique uses the index finger and thumb in the shape of a C to create a seal over the nose and mouth while the remaining fingers are placed along the lower edge of the jaw in an E formation to elevate the mandible and open the airway. In cases where only 1 rescuer is available, a 2-handed mouth-to-mask ventilation technique can be used during 30:2 CPR, but if a bag-mask device is used, a 1-handed technique to seal the mask and open the airway is necessary.
4. Taking a regular rather than a deep breath may help prevent the rescuer from getting dizzy or lightheaded when giving mouth-to-mouth or mouth-to-mask breaths and prevents overinflation of the person's lungs. The recommendation for using a 1-second inspiratory time is to keep the pauses in chest compressions as brief as possible during 30:2 CPR.[18]
5. Excessive ventilation can cause gastric inflation, regurgitation, aspiration, and decreased cardiac output.[1–3] Too little ventilation also is harmful and is associated with decreased survival.[1–3]

Ventilation During Adult Cardiac Arrest: Special Circumstances

Recommendations for Ventilation During Adult Cardiac Arrest: Special Circumstances		
COR	**LOE**	**Recommendations**
2a	**C-LD**	1. It is reasonable for a rescuer to use mouth-to-nose ventilation if providing breaths through the adult's mouth is impossible or impractical.
2b	**C-EO**	2. For an adult with a tracheal stoma who requires breaths, either mouth-to-stoma or face mask–to–stoma ventilation may be reasonable.

Synopsis

While pocket mask and bag-mask ventilation use both the oral and nasal passages, the performance of mouth-to-mouth breaths requires a seal between the rescuer and the mouth of the person in cardiac arrest. If certain anatomic, pathologic, and traumatic conditions prevent ventilation via the mouth, use of the nasal passage is an acceptable alternative.

Individuals who have a tracheal stoma may experience respiratory or cardiac arrest necessitating breaths. If ventilations cannot be performed via the nose or mouth, the rescuer can use the tracheal stoma to provide breaths with the mouth or a face mask. The management of a transtracheal artificial airway (eg, tracheostomy) is beyond the scope of these guidelines. No new evidence was identified on this topic during the 2025 evidence review.

Recommendation-Specific Supportive Text

1. Mouth-to-nose ventilation may be necessary if ventilation through the person's mouth is impossible because of trauma, positioning, or difficulty obtaining a seal. A case series suggests that mouth-to-nose ventilation in adults is feasible, safe, and effective.[19]
2. Effective ventilation of an adult patient with a tracheal stoma may require ventilation through the stoma, either by using mouth-to-stoma breaths or by use of a bag-mask technique that creates a tight seal over the stoma with a round, pediatric face mask. There is no published evidence on the safety, effectiveness, or feasibility of mouth-to-stoma ventilation. One study of patients with laryngectomies showed that a pediatric face mask created a better peristomal seal than a standard ventilation mask.[20]

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Ventilation of Adults With Spontaneous Circulation (Respiratory Arrest)

Recommendations for Ventilation of Adults With Spontaneous Circulation (Respiratory Arrest)		
COR	**LOE**	**Recommendations**
1	C-LD	1. For an adult with spontaneous circulation (ie, strong and easily palpable pulses) and respiratory arrest, the health care professional should provide ventilations.
2a	C-LD	2. When providing ventilations for an adult patient with respiratory arrest, it is reasonable for the health care professional to give 1 ventilation every 6 s, or 10 breaths per minute, with each ventilation creating visible chest rise.

Synopsis

Ventilation is essential for oxygen delivery and carbon dioxide elimination for a person with a pulse who is not breathing or not breathing effectively. If effective ventilations are not provided quickly to an apneic patient, high oxygen-consuming organs such as the heart and brain may sustain irreversible injury. Examples of such conditions include opioid overdose and ROSC after cardiac arrest. In people with a pulse, after only 90 seconds of apnea, oxygen saturation can drop to dangerously low levels.[21] Oxygen saturation can be restored rapidly with effective ventilation.[22]

Recommendation-Specific Supportive Text

1. A study of 14 patients who underwent general anesthesia while breathing room air found that oxygen saturation dropped to dangerously low levels within 90 seconds after onset of apnea (mean oxygen saturation, 62.1%; range, 43.9%–81.9%).[21] Respiratory arrest and hypoxia can quickly deteriorate into cardiac arrest if not effectively and aggressively managed with appropriate oxygenation and ventilation. In the 2024 guidelines for resuscitation following drowning, the use of in-water breathing support before cardiac arrest was associated with improved outcomes compared to initiation of CPR after rescue from the water.[23]
2. A randomized trial in critically ill apneic adult patients compared bag-mask ventilation with no ventilation and found that bag-mask ventilation at a rate of 10 breaths per minute compared with no ventilation decreased the incidence of severe hypoxic events before intubation.[22] The tidal volume used was enough to cause visible chest rise. While little data exist to guide the exact frequency of ventilations required to produce normocapnia (normal ventilation) during cardiac arrest, an in-hospital study examining abnormal ventilation found that any hypocapnia (too much ventilation), severe hypercapnia (too little ventilation), and swings in both hypocapnia and hypercapnia (inconsistent ventilation) were associated with a higher rate of 1-month unfavorable neurological outcome compared with mild hypercapnia.[24]

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COMPRESSION-TO-VENTILATION RATIO IN ADULT CARDIAC ARREST

Recommendations for Compression-to-Ventilation Ratio in Adult Cardiac Arrest

COR	LOE	Recommendations
2a	B-NR	1. It is reasonable for lay rescuers and health care professionals to perform CPR with cycles of 30 compressions followed by 2 breaths before placement of an advanced airway (supraglottic airway or endotracheal tube).
2b	C-LD	2. For adults in cardiac arrest without an advanced airway, health care professionals may consider the use of continuous chest compressions with asynchronous breaths.

Synopsis

Several strategies for performing adult CPR have been described in the literature. The 2 main strategies include chest compressions with interrupted ventilation pauses (eg, 30 compressions for every 2 ventilations) and continuous chest compressions with or without asynchronous ventilations.

Recommendation-Specific Supportive Text

1 and 2. The majority of studies report no difference in patient outcomes between continuous chest compressions and interrupted CPR with ventilation pauses.[1–5] A systematic review and meta-analysis of 4 RCTs of nonasphyxial cardiac arrests reported lower survival to hospital discharge when lay rescuers administered interrupted CPR compared with continuous compressions (100 compressions per minute), but the compression-to-ventilation ratio in 3 of the studies was 15:2.[6] CPR performed by prehospital health care professionals was associated with increased ROSC, survival to admission, and favorable neurological outcome with 30:2 CPR compared with continuous chest compressions with asynchronous ventilations. No difference was found in survival to hospital discharge.[6] A retrospective analysis of the Resuscitation Outcomes Consortium Continuous Chest Compressions trial analyzed 26 810 adults with nontraumatic OHCA without an advanced airway. When performed as intended (per protocol), continuous chest compressions with asynchronous ventilations by EMS were associated with lower odds of survival compared with 30:2 CPR.[7] After the imputation of missing outcomes, the overall difference in the survival rate between the treatment groups in the effectiveness population was not significant.

Importantly, the use of continuous chest compressions with asynchronous breaths does not allow the rescuer to monitor the adequacy of ventilation during CPR because chest rise cannot be observed. Recent evidence has shown that ventilations are often not provided with sufficient volume to make the chest rise during resuscitation.[8] Because it is not possible to evaluate ventilations during continuous chest compressions, value was placed on the ability to monitor chest rise during 30:2 CPR.

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DEFIBRILLATION DURING ADULT CARDIAC ARREST

Pads for Defibrillation in Adult Cardiac Arrest

Recommendations for Pads for Defibrillation in Adult Cardiac Arrest		
COR	**LOE**	**Recommendations**
2a	**C-LD**	1. It is reasonable to place defibrillation paddles or pads on the exposed chest in an anterolateral or anteroposterior position, and to use a paddle or pad electrode diameter more than 8 cm for adults in cardiac arrest.
2b	**C-EO**	2. When placing pads for defibrillation for an adult in cardiac arrest, it might be reasonable to adjust the position of a bra instead of removing it.

Synopsis

The use of paddles or pads to perform defibrillation requires direct contact with the skin, and the use of pregelled pads or electrolyte gel can further improve conduction of electricity to the myocardium. Pad placement is important to ensure that the vector of energy delivery is directed toward the myocardium, including the left ventricle where VF often originates. If using an anterolateral pad placement, it is important that the lateral pad is placed in the midaxilla and not too anteriorly (Figure 7). The size of the pad or paddle affects impedance; thus, larger paddles or pads are appropriate for adults. The need to apply pads or paddles directly to the bare chest may be a contributing factor to the observations that females experience significantly lower rates of public access defibrillation compared to males.[1,2] The option to adjust rather than remove a bra could mitigate factors such as discomfort with exposing a woman's chest or fear of accusations of inappropriate touching or sexual assault.[3]

Recommendation-Specific Supportive Text

1. Anterolateral, anteroposterior, anterior-left infrascapular, and anterior-right infrascapular electrode placements are comparably effective for treating supraventricular and ventricular arrhythmias.[4–8] A recent before-and-after study of 207 patients (1023 shocks) found no difference in shock success between anterolateral versus anteroposterior pad placement (82.1% versus 82.2%).[9] A second study found increased rates of ROSC with anteroposterior pad positioning compared to anterolateral pad positioning (odds ratio, 2.64; 95% CI, 1.50–4.65) but no difference in rates of survival to hospital discharge or favorable neurological outcome.[10] Due to the potential for significant risk of bias, the writing group felt that more research is required to confirm these findings. A larger pad/paddle size (within the limits of 8–12 cm in diameter) lowers transthoracic impedance. Self-adhesive pads have largely replaced defibrillation paddles in clinical practice.[11,12]
2. A 2024 ILCOR scoping review identified 3 studies addressing the removal of clothing, comprising 1 peer-reviewed simulation study and 2 conference abstracts. The review concluded that there was insufficient evidence to support the routine removal of a bra, and it may be possible to place pads directly on the skin by adjusting the bra's positioning rather than removing it. The single peer-reviewed simulation study[13] demonstrated a swine model, published as a conference abstract, and reported a 100% first-shock success rate

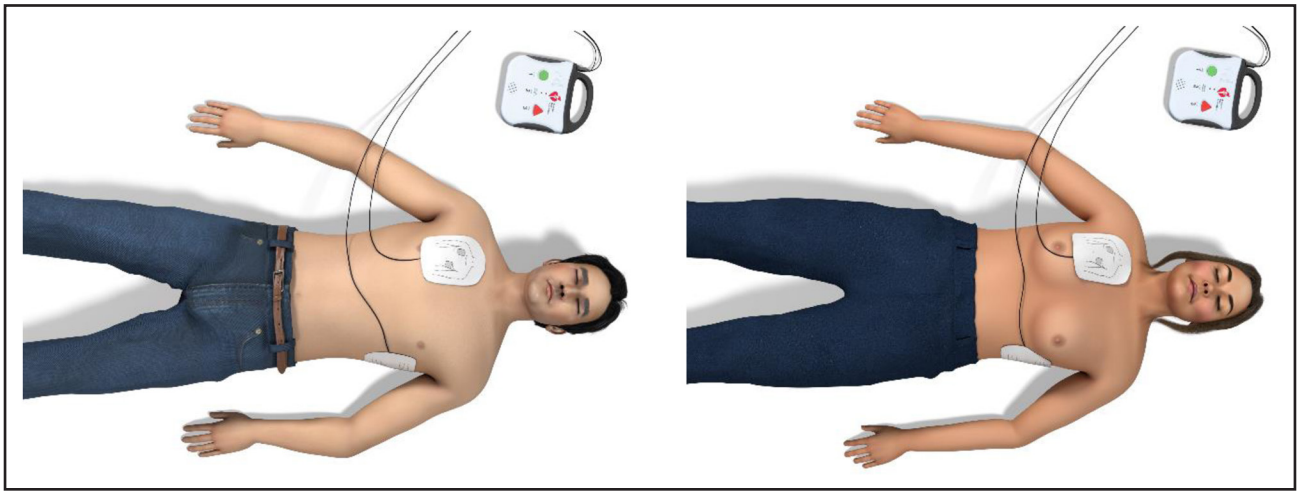

Figure 7. Electrode pad placement for defibrillation.

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even when self-adhering AED pads were applied directly over the metal underwire of a bra.[14] No adverse events such as arcing, current redirection, or burning of the bra or the pig's skin were observed in the study.

CPR Before Defibrillation in Adult Cardiac Arrest

Recommendations for CPR Before Defibrillation in Adult Cardiac Arrest		
COR	**LOE**	**Recommendations**
1	C-LD	1. For adults in cardiac arrest, CPR is recommended until a defibrillator or AED is applied.
2a	B-R	2. In unmonitored adult cardiac arrest, it is reasonable to provide a brief period of CPR while a defibrillator is being obtained and readied for use.
2a	C-LD	3. For adults in cardiac arrest, immediate defibrillation is reasonable for witnessed or monitored VF/pulseless ventricular tachycardia when a defibrillator is already applied or immediately available.

Synopsis

Early defibrillation is essential for survival when sudden cardiac arrest results from VF or pulseless ventricular tachycardia (pVT). Defibrillation is most effective when delivered promptly after the onset of VF/pVT, especially if the time to shock is minimal.[15] However, when VF/pVT persists for a longer duration, the heart's energy reserves may become depleted, reducing defibrillation effectiveness unless preceded by a period of CPR to restore these reserves before rhythm analysis. Minimizing the interruption in CPR around the time of shock delivery, or the perishock period, is also crucial to improving patient outcomes.[16] Defibrillation success refers to termination of VF/pVT, although this may not result in a perfusing rhythm.

Recommendation-Specific Supportive Text

1. High-quality CPR is the single most critical intervention for a patient in cardiac arrest. Performing CPR until a defibrillator or AED is available and applied, and ensuring minimal interruptions to chest compressions in the perishock period, is associated with improved defibrillation success and patient outcomes.[17–23] A study from the ARREST (Amsterdam Resuscitation Studies) registry of patients with witnessed out-of-hospital arrest and initial rhythm of VF showed that first-shock defibrillation success rates were 93% when first shock occurred within 6 minutes but decreased to 75% if first shock was delayed to more than 16 minutes. Every minute of delay to first shock was associated with a 6% decreased probability of survival to discharge.[24]
2. When VF/pVT has been present for more than a few minutes, myocardial reserves of oxygen and other energy substrates are rapidly depleted.[25] If replenished by a period of CPR before shock, defibrillation success improves significantly.[17–20] Studies comparing short (approximately 30 seconds) with prolonged (up to 3 minutes) periods of CPR preceding the initial rhythm analysis show no difference in defibrillation outcomes; therefore, a brief period of CPR while the defibrillator is readied for use may be sufficient in unmonitored cardiac arrest.[21–23] Even in monitored arrests, it can take time to attach defibrillator pads, power on the defibrillator, and charge the capacitor before shock delivery, during which rescuers can continue CPR.
3. Early defibrillation improves outcomes from cardiac arrest.[26–28] When VF is of short duration, myocardial reserves of oxygen and other energy substrates are likely to remain intact, and the rhythm is most responsive to defibrillation.[25,29] Thus, if the onset of VF is monitored or witnessed while a defibrillator is already applied, or there is immediate access to a defibrillator, defibrillation can be performed immediately.

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ADULT FBAO

Relief of FBAO in Conscious Adult Patients

Recommendations for Relief of FBAO in Conscious Adult Patients		
COR	**LOE**	**Recommendations**
1	B-NR	1. For adults with severe FBAO, repeated cycles of 5 back blows (slaps) followed by 5 abdominal thrusts should be performed until the object is expelled or the person becomes unresponsive.
1	C-EO	2. Rescuers should activate the emergency response system for adults with severe FBAO.
1	C-EO	3. For adults with mild FBAO, the person should be allowed to clear the airway by coughing while being observed for signs of severe airway obstruction.

Synopsis

FBAO is a common medical emergency and one of the leading causes of accidental death in the United States, with over 5000 cases in 2021.[1] Most adult FBAO cases are due to food, while FBAOs in pediatrics are commonly caused by both food and nonfood material. Cases of FBAO are often classified as mild or severe depending on the degree of obstruction. Mild, or partial, airway obstructions often present with coughing and difficulty breathing. These cases can often be relieved spontaneously with coughing, however, can progress to complete airway obstructions. Severe, or complete, airway obstructions present with weak or absent coughing, inability to speak, changes in color (cyanosis), and altered level of consciousness, which can rapidly progress to unconsciousness, apnea, and cardiac arrest if the foreign body is not removed. Longer airway obstruction time is associated with high morbidity and mortality.[2] Prompt performance of appropriate interventions to relieve the FBAO by lay rescuers has been associated with improved survival and favorable neurological outcome.[3] Additionally, activation of emergency medical services is important to provide additional techniques for FBAO removal and provide transport to a hospital for further care, regardless of removal of the foreign body.

Recommendation-Specific Supportive Text

1. There are no RCTs comparing the efficacy or safety of different interventions for FBAO, and limited evidence about the most effective sequence of FBAO interventions in both health care and non–health care settings.[3,4] A cohort study[5] of 709 persons with FBAO showed back blows were associated with improved rates of FBAO relief and fewer injuries compared to abdominal thrusts. In addition, case reports have described fatal injuries from abdominal thrusts including aortic dissection and gastric rupture.[4,6,7] The recommendation for alternating sets of 5 back blows and 5 abdominal thrusts is based on the value of consistency with

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existing infant and pediatric guidelines that use this approach.[8,9]

2. Previous observational studies have demonstrated that patients with FBAO commonly require multiple interventions before the foreign body is successfully removed. Severe FBAO cases often require intervention by prehospital care personnel or evaluation and treatment at a hospital.[3,5] Thus, promptly activating the emergency medical response system is essential for severe FBAO.
3. Coughing can produce high airway pressures,[10,11] making it effective in clearing partial obstructions. Mild FBAO can quickly progress; therefore, monitoring for signs of severe obstruction is crucial.

Relief of FBAO in Unconscious Adult Patients

Recommendations for Relief of FBAO in Unconscious Adult Patients		
COR	**LOE**	**Recommendations**
1	C-LD	1. If adults with severe FBAO become unresponsive, rescuers should start CPR, beginning with chest compressions, and activate the emergency response system if no one has done so.
1	C-EO	2. For adults with FBAO receiving CPR, rescuers should remove any visible foreign body when opening the airway to provide breaths.
3: Harm	C-LD	3. Blind finger sweeps should not be performed for adults with FBAO.

Synopsis

When a severe airway obstruction leads to unconsciousness, back blows (slaps) and abdominal thrusts become impractical, and cardiac arrest is imminent. Chest compressions can provide sufficient airway pressure to expel a foreign body.[12,13]

Recommendation-Specific Supportive Text

1. Once a patient is unconscious, observational data support immediate provision of CPR starting with chest compressions, which is associated with favorable neurological outcome, regardless of whether or not the patient has a pulse.[14] As previously noted, there is low risk of injury from performance of chest compressions for patients who are not in cardiac arrest.[8]
2. Removal of a visible foreign body will help to avoid reobstruction that could occur with ventilations. There is, however, no evidence that providing ventilations in the presence of a foreign body will make the obstruction worse, and theoretically could alleviate a complete obstruction by forcing the obstruction into a mainstem bronchi.
3. Observational data suggest that when a foreign body is not visible, the risk associated with performing a "blind" finger sweep and worsening an airway obstruction outweighs any potential benefit.[4]

Relief of FBAO in Special Circumstances

Recommendations for Relief of FBAO in Special Circumstances		
COR	**LOE**	**Recommendations**
1	C-EO	1. If the rescuer is unable to encircle the person's abdomen, repeated cycles of 5 back blows (slaps) followed by 5 chest thrusts should be used for adults with severe FBAO until the object is expelled or the person becomes unresponsive.
1	C-EO	2. For adults in the late stages of pregnancy with severe FBAO, repeated cycles of 5 back blows (slaps) followed by 5 chest thrusts should be used until the object is expelled or the person becomes unresponsive.
2b	C-LD	3. Effectiveness and safety of suction-based airway clearance devices have not been established in adults with FBAO. There is insufficient evidence to make a recommendation.

Synopsis

There are several special circumstances in which effective abdominal thrusts are either impossible to perform or inappropriate (eg, when rescuers cannot encircle the patient's abdomen, the patient is in a wheelchair, the patient is in the late stages of pregnancy). Evidence on FBAO management for these situations is limited.

Recommendation-Specific Supportive Text

1 and 2. There are no high-quality data to support recommendations about FBAO in special circumstances, such as when rescuers cannot encircle the patient's abdomen or the patient is in late-stage pregnancy. It may be impractical for rescuers to provide abdominal thrusts in these situations. Chest thrusts can be used in these situations to provide sufficient pressure to expel the foreign body.

3. Several observational studies[15,16] describe the use of portable nonpowered suction devices. However, there is a lack of evidence suggesting the superiority of these devices compared with standard techniques such as back blows or abdominal thrusts, or data establishing safety of the devices.

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CARDIAC ARREST IN ADULT PATIENTS WITH OBESITY

Recommendations for Cardiac Arrest in Adult Patients With Obesity		
COR	**LOE**	**Recommendations**
1	C-LD	1. CPR for adults with obesity who are in cardiac arrest should be provided by using the same techniques as for the nonobese patient.
2a	C-LD	2. In adults with obesity who are in cardiac arrest, it is reasonable for rescuers to consider the impact of moving the patient to a firm surface on delays in initiation of chest compressions.
2b	C-EO	3. It may be reasonable for rescuers to increase the force of compressions to achieve adequate depth for adult patients with obesity who are in cardiac arrest.
3: No Benefit	C-LD	4. For adults with obesity, the use of a partial backboard (or "CPR board") during IHCA does not provide benefit over performing chest compressions on a hospital mattress.

Synopsis

Obesity affects more than 40% of adults in the United States and is a significant risk factor for sudden cardiac arrest. In an observational study of cardiac arrest survivors with significant coronary artery disease, obesity was associated with high risk of mortality and unfavorable neurological recovery.[1] Cardiac arrest management, including performing effective chest compressions, can be difficult in patients with obesity due to increased chest wall thickness, requiring greater force to achieve the recommended depth.[2] The physical demands of performing CPR on an adult patient with obesity can lead to faster rescuer fatigue, highlighting the need for close monitoring to switch rescuers.

Recommendation-Specific Supportive Text

1. A 2024 ILCOR scoping review included 34 observational studies evaluating cardiac arrest in adult patients with obesity and found no evidence to support changes from standard CPR. One challenge to this review was that the reported patient outcomes, such as neurological outcomes, survival to hospital discharge, long-term survival, and ROSC, varied and were inconsistently measured across studies.[3] There were no differences between patients with obesity and patients without obesity in terms of shock success,[4] percentage of shocks delivered in less than 2 minutes,[5,6] or VF/pVT termination.[6]
2. Firm surfaces improve the likelihood of adequate chest compressions. Use of bed manufacturer "CPR mode" in-hospital or a firm mattress can improve chest compression depth.[2,7] During OHCA in which an adult patient with obesity is found in a bed, the time required to move the patient must be carefully considered to avoid delays in chest compression initiation.
3. Rescuers may need to increase force of compressions to achieve adequate depth of compressions when compressions are performed on inflated mattresses or for adults with obesity.[2]
4. Use of a partial backboard (or "CPR board") in obese manikins does not improve likelihood of achieving adequate chest compressions compared with the hospital mattress alone.[8] As rapid initiation of high-quality CPR improves outcomes from cardiac arrest, initiation of chest compressions for the patient with obesity while on the hospital mattress can help to minimize delays to CPR initiation.

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ALTERNATIVE TECHNIQUES FOR CPR IN ADULT CARDIAC ARREST

Recommendations for Alternative Techniques for CPR in Adult Cardiac Arrest		
COR	**LOE**	**Recommendations**
2b	**C-LD**	1. In adult cardiac arrest, the use of mechanical CPR devices may be considered in specific settings where the delivery of high-quality manual compressions may be challenging or dangerous for the health care professional, as long as rescuers strictly limit interruptions in CPR during deployment and removal of the device.
2b	**C-LD**	2. For single rescuers, performing compressions from "over-the-head" of the patient may be considered in adult cardiac arrest.
2b	**C-LD**	3. The effectiveness of heel/foot compressions is not well established in adult cardiac arrest.
3: No Benefit	**B-R**	4. The routine use of mechanical CPR devices is not recommended in adult cardiac arrest.

Synopsis

Alternatives to conventional CPR include mechanical CPR or alternative rescuer positions for use in special circumstances. Mechanical CPR can be divided into 2 types: a load-distributing compression band that compresses the thorax circumferentially or a pneumatic piston device that anteriorly to posteriorly compresses the chest. Use of these devices or techniques requires specialized equipment and additional training to minimize interruptions in CPR. Special circumstances such as during patient transport, search and rescue, or resuscitation in a confined space may support alternative methods of CPR where the rescuer is not lateral to the patient. One alternative position has been termed *over-the-head compressions*, where the rescuer kneels with the patient's head between their knees and reaches down toward the sternum to perform chest compressions, with or without ventilations. Another novel alternative method includes a rescuer performing chest compressions by using their heel or foot. These alternative CPR methods are considerations when patients are in unusual locations or when resuscitation must take place under special circumstances.

Recommendation-Specific Supportive Text

1. Individual emergency medical response agencies must weigh the potential benefits of mechanical CPR devices to logistical factors such as transport times, safety of crew, and number of personnel available for chest compressions against potential drawbacks such as interruptions in chest compressions related to application. Examples of scenarios for consideration of mechanical CPR use include the potential to improve CPR quality during patient transport, logistical constraints that may be impractical to perform manual CPR or may impact rescuer safety, prolonged resuscitations with limitations in the number of individuals for manual CPR, or a significant risk of infectious disease transmission.
2. Single rescuers may perform effective chest compressions by compressing the chest from above the shoulders of the patient, known as *over-the-head CPR*. In this scenario, rescuers are positioned such that they are kneeling with the patient's head between their knees and reaching down toward the sternum to perform chest compressions with or without ventilations. Multiple small- to moderate-sized manikin RCTs have shown no difference between chest compression quality including depth and recoil in over-the-head CPR compared to lateral CPR,[1–5] while several studies found improved chest compression quality.[6–8] Ventilation rates were improved in some of the over-the-head CPR studies while others showed no difference in ventilation quality or increased tidal volume delivery.[4,6,7] Many of these studies were designed for consideration in special circumstances such as avalanche victims or in confined spaces such as on the back of a moving boat.[2,4] Multiple studies showed that standard dual-rescuer CPR, in which 1 rescuer performed ventilations at the head of the patient and the second rescuer performed CPR lateral to the patient, had improved chest compression quality compared to a single rescuer performing over-the-head chest compressions.[7]
3. Limited observational studies showed improved duration of chest compression cycles and no difference in chest compression depth when

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compressions are delivered by using the foot or heel in comparison to conventional Hands-Only CPR.[9,10] One simulation-based randomized trial showed decreased chest compression quality when rescuers performed compressions by using their heel versus conventional CPR.[11] As data are significantly limited and show conflicting results, recommendations for or against the use of this technique cannot be provided.

4. Several large RCTs demonstrated no improvement in survival with the use of mechanical CPR devices.[12–16] This is further supported by a recent ILCOR systematic review.[17] The Prehospital Randomised Assessment of a Mechanical Compression Device in Out-of-Hospital Cardiac Arrest (PARAMEDIC) trial found no survival benefit at 30 days[13,18] and worse neurological outcome at 30 days, 3 months, and 12 months with the use of mechanical devices.[13,19,20] However, neurological outcomes at 3 months and 12 months were significantly limited by loss to follow-up in greater than 40% of patients.[20] A secondary analysis of the primary study population in the AutoPulse Assisted Prehospital International Resuscitation (ASPIRE) trial found decreased 4-hour survival with mechanical CPR, possibly associated with a delayed time to first shock, and the study was terminated due to potential harm in the mechanical group.[12] Two small observational studies showed increased rib fractures and sternal fractures with mechanical CPR use.[21,22] However, this finding has not been replicated in the published RCTs.[13,19,20]

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Disclosures

Appendix 1. Writing Group Disclosures

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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

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Appendix 2. Reviewer Disclosures

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Zachary D. Goldberger	University of Wisconsin School of Medicine and Public Health	None	None	None	None	None	None	None
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Thomas Rea	University of Washington	Philips (Grant to evaluate community response strategies. We are not evaluating proprietary technology but rather general response strategies. The grant is to my employer, the University of Washington)*; Federal government (Grant to study components of CPR and outcome of cardiac arrest)*	None	None	None	None	None	None
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This table represents the relationships of reviewers that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all reviewers are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

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Part 8: Pediatric Advanced Life Support: 2025 American Heart Association and American Academy of Pediatrics Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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ABSTRACT: The American Heart Association and the American Academy of Pediatrics provide these pediatric advanced life support guidelines focusing on resuscitation during cardiopulmonary resuscitation and emergency cardiovascular care. These guidelines are intended to be a resource for health care professionals to identify and treat infants and children up to 18 years of age (excluding newborn infants) in the prearrest, intra-arrest, and post–cardiac arrest states as well as select other emergency care situations. These guidelines apply to infants and children in various settings, including the community, prehospital environments, and hospital environments. Topics presented include ventilation and advanced airway strategies during cardiopulmonary resuscitation; drug administration and weight-based dosing of medications during cardiopulmonary resuscitation; energy doses for defibrillation; measuring cardiopulmonary resuscitation physiology and quality; extracorporeal cardiopulmonary resuscitation; post–cardiac arrest care related to management of core temperature, blood pressure, oxygenation/ventilation, neurologic monitoring, and seizures; neurological prognostication post–cardiac arrest; post–cardiac arrest survivorship; family presence during cardiopulmonary resuscitation; evaluation of sudden unexplained cardiac arrest; management of shock types; airway/intubation management; arrhythmia management including bradycardia and tachycardia (narrow and wide complex); treatment of myocarditis/cardiomyopathies; resuscitation of patients with single ventricle congenital heart disease; management of pulmonary hypertension; and management of traumatic cardiac arrest. Lastly, important gaps in resuscitation science knowledge are identified, aiming to encourage further scientific inquiry and provide additional evidence for future pediatric advanced life support guidelines.

Key Words: AHA Scientific Statements ■ cardiopulmonary resuscitation ■ child ■ epinephrine ■ heart arrest ■ pediatric ■ prognosis

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TOP 10 TAKE-HOME MESSAGES

1. High-quality cardiopulmonary resuscitation (CPR) is the foundation of pediatric advanced life support (PALS) resuscitation for health care professionals. We reaffirm the key components of high-quality CPR: providing adequate chest compression rate and depth, minimizing interruptions in CPR, allowing full chest recoil between compressions, and providing sufficient ventilation for the pediatric patient population while avoiding excessive ventilation.
2. For initial nonshockable rhythms, administering epinephrine as soon as possible is associated with favorable outcomes for infants and children in cardiac arrest.
3. Rapid defibrillation remains the priority for cardiac arrest with initial shockable rhythms. Administer epinephrine if defibrillation is not immediately possible.
4. For infants and children with continuous invasive arterial blood pressure monitoring in place during CPR, diastolic blood pressure targets of ≥25 mm Hg in infants and ≥30 mm Hg in children at

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least 1 year of age are now included as hemodynamic goals of high-quality cardiopulmonary resuscitation.
5. End-tidal carbon dioxide ($ETCO_2$) can be an indicator of CPR quality, although the use of specific $ETCO_2$ cutoff values to guide termination of resuscitation in infants and children is not advised.
6. Preventing hyperthermia is a critical component of post–cardiac arrest care. Avoiding central temperatures >37.5 °C can improve neurological outcomes in infants and children who remain comatose following cardiac arrest.
7. For infants and children, new data support maintaining post–cardiac arrest systolic and mean arterial blood pressure greater than the 10th percentile for age and sex.
8. Neuroprognostication after cardiac arrest in infants and children requires multiple modalities be assessed at various timepoints throughout the post–cardiac arrest period. Single tests conducted in isolation carry a risk of inaccurately predicting neurologic outcomes.
9. After discharge from the hospital, cardiac arrest survivors often have ongoing physical, cognitive, and behavioral challenges and require evaluation for appropriate therapies and interventions.
10. New data support the use of IV sotalol as an antiarrhythmic to treat infants and children with supraventricular tachycardia (SVT) and cardiopulmonary compromise that is unresponsive to vagal maneuvers, IV adenosine, and electrical synchronized cardioversion, when expert consultation is not available.

PREAMBLE

Every year, more than 7000 out-of-hospital cardiac arrests (OHCA) and approximately 20 000 in-hospital cardiac arrests (IHCA) occur in infants and children across the United States.[1–3] In the United States, approximately 80% of emergency medical services-treated OHCA occur in the home.[4] In contrast, the majority of IHCA arrests in infants and children occur in the intensive care unit (ICU) environment with incidence rates ranging from 1.8% for general pediatric ICU admissions (2011–2013)[5] to 3.1% in pediatric cardiac ICUs, although variability exists between centers.[6] Understanding the full spectrum of neurologic outcomes during the weeks to months after cardiac arrest across the pediatric age spectrum is limited by variability in reporting metrics and time to follow-up across studies. Survival to hospital discharge rates for OHCA range from 6% to 38%.[4,7,8] Although data on favorable neurologic outcomes among survivors of OHCA are limited, the most recent Cardiac Arrest Registry to Enhance Survival data demonstrate rates of 5.7% in infants to 12.8% in older children.[4] In contrast, survival to hospital discharge for IHCA ranges from 38% for pulseless cardiac arrest to 66% for nonpulseless cardiac arrest.[6,9] Definitions of neurologic outcome vary across studies, and neurologic outcomes are defined by different measures (eg, Vineland Adaptive Behavioral Score or Pediatric Cerebral Performance Category [PCPC]) and different thresholds. While guideline recommendations are based on review of combined data, readers should pay attention to individual study measures when looking for detailed information. Grossly favorable neurologic outcomes in survivors of IHCA based on the PCPC scoring system are much higher than OHCA neurological outcome rates at approximately 64% to 89%.[5,10]

These guidelines contain recommendations for PALS, excluding newborn infants, and are based on the best available resuscitation science. The Chain of Survival requires coordinated efforts from medical professionals in various disciplines, as well as from lay responders, emergency dispatchers, and first responders in the case of OHCA. Pediatric guidance and recommendations are provided in "Part 6: Pediatric Basic Life Support."[11] Recommendations for resuscitation training are in "Part 12: Resuscitation Education Science."[12] Recommendations about systems of care are in "Part 4: Systems of Care."[13] Recommendations for special circumstances are in "Part 10: Special Circumstances."[14] Considerations around ethics are provided in "Part 3: Ethics."[15]

INTRODUCTION

Scope of Guidelines

These guidelines are intended to be a resource for health care professionals to identify and treat infants and children in the prearrest, intra-arrest, and post–cardiac arrest states. These apply to infants and children in multiple settings: the community, prehospital, and hospital environments. Prearrest, intra-arrest, and post–cardiac arrest topics are reviewed, including cardiac arrest in special circumstances, such as infants and children with congenital heart disease.

For the purposes of the PALS guidelines, pediatric patients are infants and children up to 18 years of age. In contrast, pediatric basic life support guidelines apply to infants and children without signs of puberty. Neither pediatric advanced nor basic life support guidelines address the resuscitation of newborn infants, who are transitioning from a fluid-filled to an air-filled environment. Resuscitation of the newborn infant is addressed in "Part 5: Neonatal Resuscitation."[16] Although pediatric basic and advanced life support guidelines may be applied to newborn infants younger than 28 days of age based on pathophysiology and institutional practice, neonatal guidelines should be followed at birth to address unique aspects of transitional physiology.[17]

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Organization of the Pediatric Writing Committee

The PALS Writing Group consisted of pediatric clinicians from the American Heart Association (AHA) and the American Academy of Pediatrics (AAP) including intensivists, cardiac intensivists, cardiologists, emergency medicine physicians, and nurses. A call for candidates was distributed to the AHA Emergency Cardiovascular Care (ECC) Committee and AAP subject matter experts, and volunteers with recognized expertise in pediatric resuscitation were nominated by the writing group co-chairs. Writing group members were selected by the AHA ECC Science Subcommittee and AAP Executive Committee and then approved by the AHA Manuscript Oversight Committee. The AHA and AAP have rigorous conflict of interest policies and procedures to minimize the risk of bias or improper influence during the development of the guidelines. Before their appointment, writing group members and peer reviewers disclosed all commercial relationships and other potential (including intellectual) conflicts. Writing group members whose research informed guideline recommendations were required to declare those conflicts during discussions and abstain from voting on those specific recommendations. This process is described more fully in "Part 2: Evidence Evaluation and Guidelines Development."[18] Comprehensive disclosure information for writing group members and peer reviewers is listed in Appendixes 1 and 2.

METHODOLOGY AND EVIDENCE REVIEW

These pediatric guidelines are based on the extensive evidence evaluation performed in conjunction with the International Liaison Committee on Resuscitation (ILCOR) and affiliated ILCOR member councils. Three different types of evidence reviews (systematic reviews, scoping reviews, and evidence updates) were used in the 2025 process. This process is described more fully in "Part 2: Evidence Evaluation and Guidelines Development."[18]

Class of Recommendation and Level of Evidence

The writing group reviewed all relevant and current AHA guidelines for CPR and ECC and all relevant ILCOR consensus on CPR and ECC science with treatment recommendations from 2020, 2022, 2023, and 2024.[19–22] Evidence and recommendations were reviewed to determine if current guidelines should be reaffirmed, revised, or retired or if new recommendations were needed. The writing group then drafted, reviewed, and approved recommendations, assigning a class of recommendation (COR; ie, strength) and level of evidence (LOE; ie, quality, certainty) to each. Criteria for each COR and LOE are described in Table 1.

Guideline Structure

The 2025 Guidelines are organized in discrete modules of information on specific topics or management issues.[23] Each modular knowledge chunk includes a table of recommendations using standard AHA nomenclature of COR and LOE. Recommendations are presented in order of COR: most potential benefit (Class 1), followed by lesser certainty of benefit (Class 2), and finally no benefit or potential for harm (Class 3). Following the COR, recommendations are ordered by the certainty of supporting LOE: Level A (high-quality randomized controlled trials) to Level C-EO (expert opinion). This order does not reflect the order in which care should be provided.

A brief synopsis is provided to put the recommendations into context with important background information and overarching management or treatment concepts. Recommendation-specific supportive text clarifies the rationale and key study data supporting the recommendations. When appropriate, illustrations are included. Hyperlinked references are provided to facilitate quick access and review.

Document Review and Approval

The writing group consists of AHA and AAP representatives who voted on and approved all guideline recommendations. The guideline was submitted for blinded peer review to 10 subject matter experts nominated by the AHA and AAP. Before their appointment, all peer reviewers were required to disclose relationships with industry and any other conflicts of interest, and all disclosures were reviewed by AHA staff. The guideline was also reviewed and approved for publication by the AHA Science Advisory and Coordinating Committee, the AHA Executive Committee, and the AAP Board of Directors. Comprehensive disclosure information for peer reviewers is listed in Appendixes 1 and 2.

These recommendations supersede the last full set of AHA recommendations for PALS[24] made in 2020 unless otherwise specified. For topics that did not undergo full evidence review by the 2025 writing group, recommendations, recommendation supportive text, and references from the 2020 pediatric basic and advanced life support guidelines[24] were not updated and were carried over and remain as the current guidelines for 2025. These topics are noted within the synopsis of their respective sections.

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Table 1. Applying Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care (Updated December 2024)*

CLASS (STRENGTH) OF RECOMMENDATION

Class 1 (STRONG) — Benefit >>> Risk

Suggested phrases for writing recommendations:
- Is recommended
- Is indicated/useful/effective/beneficial
- Should be performed/administered/other
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is recommended/indicated in preference to treatment B
  - Treatment A should be chosen over treatment B

Class 2a (MODERATE) — Benefit >> Risk

Suggested phrases for writing recommendations:
- Is reasonable
- Can be useful/effective/beneficial
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is probably recommended/indicated in preference to treatment B
  - It is reasonable to choose treatment A over treatment B

Class 2b (WEAK) — Benefit ≥ Risk

Suggested phrases for writing recommendations:
- May/might be reasonable
- May/might be considered
- Usefulness/effectiveness is unknown/unclear/uncertain or not well-established

Class 3: No Benefit (MODERATE) — Benefit = Risk (Generally, LOE A or B use only)

Suggested phrases for writing recommendations:
- Is not recommended
- Is not indicated/useful/effective/beneficial
- Should not be performed/administered/other

Class 3: HARM (STRONG) — Risk > Benefit

Suggested phrases for writing recommendations:
- Potentially harmful
- Causes harm
- Associated with excess morbidity/mortality
- Should not be performed/administered/other

LEVEL (QUALITY) OF EVIDENCE‡

Level A
- High-quality evidence‡ from more than 1 RCT
- Meta-analyses of high-quality RCTs
- One or more RCTs corroborated by high-quality registry studies

Level B-R (Randomized)
- Moderate-quality evidence‡ from 1 or more RCTs
- Meta-analyses of moderate-quality RCTs

Level B-NR (Nonrandomized)
- Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies
- Meta-analyses of such studies

Level C-LD (Limited Data)
- Randomized or nonrandomized observational or registry studies with limitations of design or execution
- Meta-analyses of such studies
- Physiological or mechanistic studies in human subjects

Level C-EO (Expert Opinion)
- Consensus of expert opinion based on clinical experience

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consenus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR 1 and 2a; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely-used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

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Major Concepts

The epidemiology, pathophysiology, and common etiologies of pediatric cardiac arrest are distinct from adult and neonatal cardiac arrest. Cardiac arrest in infants and children does not usually result from a primary cardiac cause; rather, it is most frequently the result of progressive respiratory failure or shock. In these patients, a variable period of physiologic deterioration ultimately leads to cardiac arrest. Among children with congenital and acquired heart disease, cardiac arrest is more often related to underlying cardiac disease although the etiology is rarely related to coronary insufficiency or ischemia as is commonly observed in the adult population.

Outcomes for pediatric IHCA improved dramatically between 2000 and 2009.[1] Subsequent reports of temporal changes in rates of survival to hospital discharge have been variable with marginal improvements.[2] Data from the Get With the Guidelines-Resuscitation Registry, a large

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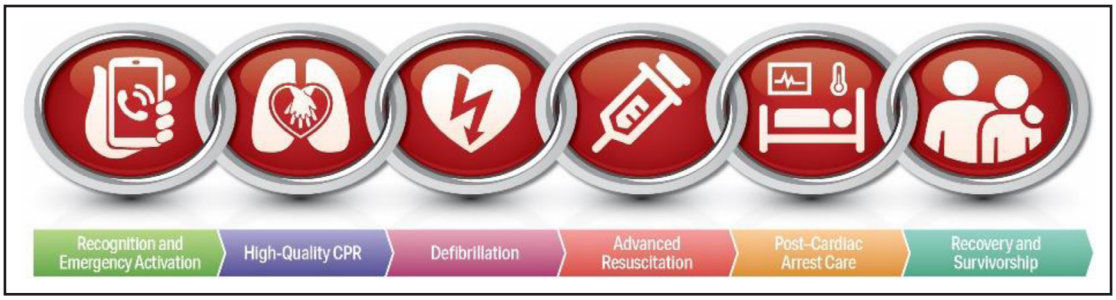

Figure 1. Cardiac Arrest Chain of Survival.

multicenter, hospital-based cardiac arrest registry, show that survival to hospital discharge from pulseless pediatric cardiac arrest increased from 19% in 2000 and 44% in 2022.[3] Survival increased on average 0.67% per year and then plateaued in 2010.[2] New directions of research and therapy may be required to improve cardiac arrest survival. In addition, more cardiac arrest events now occur in an ICU setting, which suggests that patients at risk for cardiac arrest are being identified sooner and transferred to a higher level of care before cardiac arrest.[2,4]

Survival rates from OHCA remain less encouraging. In a recent analysis of the Cardiac Arrest Registry to Enhance Survival, a multicenter OHCA registry, annual survival to hospital discharge of pediatric OHCA through 2022 ranged from 6.6% for infants younger than 1 year of age up to 17.3% for children 13 to 18 years of age.[3] Survival rates have increased since earlier data from the Resuscitation Outcomes Consortium Epidemiological Registry demonstrated survival rates from 3.3% for infants <1 year of age to 8.9% for children 13 to 18 years of age.[5] In this registry, survival from OHCA was higher in regions with more arrests that were witnessed by emergency medical services and with higher lay responder CPR rates, stressing the importance of early recognition and treatment of these patients.[6]

As survival rates from pediatric cardiac arrest have increased, there has been a shift in focus to neurodevelopmental, physical, and emotional outcomes of survivors. Studies demonstrate that a quarter of patients with favorable outcomes have global cognitive impairment and that 85% of older children who were reported to have favorable outcomes have selective neuropsychological deficits at 1-year follow-up.[7]

The Cardiac Arrest Chain of Survival

Historically, cardiac arrest care has largely focused on the management of the cardiac arrest itself, highlighting high-quality CPR, early defibrillation, and effective teamwork. However, there are aspects of prearrest and post–cardiac arrest care that are critical to improve outcomes. As pediatric IHCA survival rates have plateaued,[2] the prevention of cardiac arrest becomes even more important. IHCA prevention includes early recognition and treatment of cardiac arrest, such as children undergoing high-risk procedures (eg, infants undergoing cardiac surgery or catheterization procedures), children with high-risk diagnoses (eg, shock, pulmonary hypertension, or acute respiratory distress syndrome), and children with severely abnormal vital signs or other signs of deterioration. In the out-of-hospital environment, lay responder CPR training, sudden unexpected infant death prevention, safety initiatives (eg, bike helmet laws), and early access to emergency care are imperative. When OHCA occurs, early lay responder CPR is critical in improving outcomes.

Following resuscitation from cardiac arrest, management of the post–cardiac arrest syndrome (which may include brain dysfunction, myocardial dysfunction with low cardiac output, and ischemia/reperfusion injury) is important to avoid known contributors to secondary injury, such as hypotension.[8,9] There is recognition of growing differential use of the terms *return of spontaneous circulation* (ROSC) versus *return of circulation* (ROC) in the literature. For the purposes of these guidelines, after CPR, when ROC is achieved by native cardiac function, we use ROSC; when it has been achieved by either mechanical support (eg, extracorporeal membrane oxygenation, ECMO) or native cardiac function, we use ROC. Accurate neuroprognostication is important to guide caregiver discussions and decision-making.[10] Finally, given the high risk of neurodevelopmental impairment in cardiac arrest survivors, early referral for rehabilitation assessment and intervention is key.

A single Cardiac Arrest Chain of Survival (Figure 1) that supports the paradigm of prevention and early recognition through recovery after cardiac arrest has now been standardized across infants, children, and adults (outside of neonatal care).

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VENTILATION AND ADVANCED AIRWAY STRATEGIES DURING CPR

Recommendations for Ventilation and Advanced Airway Strategies During CPR

COR	LOE	Recommendations
2a	C-LD	1. In infants and children with out-of-hospital cardiac arrest, it is reasonable to perform bag-mask ventilation rather than advanced airway interventions (tracheal intubation or supraglottic airway [SGA] placement).
2b	C-LD	2. In infants and children with in-hospital cardiac arrest who do not have an advanced airway in place, it may be reasonable to perform bag-mask ventilation or advanced airway interventions (tracheal intubation or SGA placement).
2b	C-LD	3. When performing CPR in infants and children with an advanced airway in place, it may be reasonable to target a ventilation rate range of 20–30 breaths/min (1 breath every 2–3 s), accounting for age and clinical characteristics. Hyperventilation may compromise hemodynamics.

Synopsis

Most pediatric IHCA and OHCA are precipitated by respiratory deterioration or shock. Thus, airway management and effective ventilation are fundamental components of pediatric resuscitation. Although most patients can be successfully ventilated with bag-mask ventilation, this method requires interruptions in chest compressions and is associated with risk of aspiration and barotrauma. Advanced airway interventions, such as tracheal intubation or SGA placement, may improve ventilation, reduce the risk of aspiration, and enable uninterrupted compression delivery. However, airway placement may interrupt the delivery of compressions or result in a malpositioned device, with catastrophic consequences if unrecognized. Advanced airway placement requires specialized equipment and skilled health care professionals and may be difficult for professionals who do not routinely intubate children.

In children receiving CPR with an advanced airway in place, provision of adequate minute ventilation while avoiding hyperventilation and associated deleterious hemodynamic effects is critical. There are limited data regarding ventilation rates during pediatric CPR and determination of optimal ventilation rates deserves further study. Other components of intra-arrest ventilation, such as the appropriate peak end-expiratory pressure or tidal volume, have not been studied extensively.

Recommendation-Specific Supportive Text

1. A clinical trial showed that tracheal intubation and bag-mask ventilation achieve similar rates of survival with good neurologic function in pediatric patients with OHCA.[1] Three propensity-matched retrospective studies show similar rates of survival to discharge and survival with good neurologic function when comparing advanced airway placement (tracheal intubation or SGA) with bag-mask ventilation in pediatric OHCA.[2–4] A fourth propensity-matched study demonstrated lower 1-month survival and survival with favorable neurologic status with advanced airway placement (tracheal intubation or SGA) when compared to bag-mask ventilation.[5] No differences have been observed in outcomes between SGA and tracheal intubation in pediatric OHCA.[2,3,6]
2. There are limited data to compare outcomes between bag-mask ventilation versus tracheal intubation in the management of IHCA, and there are no studies of pediatric SGA use during in-hospital CPR. A propensity-matched retrospective cohort study found that intubation during cardiac arrest was associated with decreased survival to hospital discharge compared to no intubation.[7] Though there may be specific circumstances or populations in which early advanced airway interventions are beneficial (eg, children for whom bag-mask ventilation is technically difficult, children with severe lung disease), data supporting alternative approaches to these situations are lacking.

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3. One small, multicenter observational study of intubated pediatric patients found that ventilation rates (at least 30 breaths/min in children younger than 1 year of age, at least 25 breaths/min in older children) were associated with improved rates of ROSC and survival to discharge.[8] A ventilation rate of 20 to 30 breaths per minute was selected to account for (1) higher physiologic respiratory rates in children, (2) the preponderance of respiratory etiologies in pediatric arrest, (3) association with improved survival, and (4) avoidance of higher ventilation rates that were associated with lower systolic blood pressures during CPR.[8]

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DRUG ADMINISTRATION DURING CARDIAC ARREST

Drug Administration Methods During Cardiac Arrest

Recommendations for Drug Administration Methods During Cardiac Arrest		
COR	**LOE**	**Recommendations**
1	C-LD	1. Rapid initiation of vascular access (IV or IO) is recommended for drug administration in infants and children with cardiac arrest.

Recommendations for Drug Administration Methods During Cardiac Arrest (Continued)		
COR	**LOE**	**Recommendations**
1	C-EO	2. Health care professionals caring for infants and children with cardiac arrest should choose the initial type of vascular access route (IV or IO) based on availability, expertise, and timeliness.

Synopsis

Administration of vasoactive and antiarrhythmic medications is a key component of PALS during CPR. Medications, such as epinephrine, have historically been administered via multiple routes, including endotracheal, intravenous (IV) and intraosseous (IO). Due to limited transalveolar drug absorption and limited pulmonary blood flow during CPR, IV and IO administration of medications are preferred over the endotracheal route.[1,2] Selecting the timeliest route to deliver medication based on clinical needs and available resources is appropriate.

Recommendation-Specific Supportive Text

1. Timely provision of vasoactive and antiarrhythmic medications during cardiac arrest is dependent on rapid securement of vascular access across all pediatric age ranges. IV or IO administration of epinephrine is preferred over endotracheal administration when possible.[1,2]
2. IO access is a rapid, safe, and an effective initial vascular access route for pediatric cardiac arrest.[3–5] A recent systematic review did not identify any studies comparing IV versus IO for vascular access in pediatric cardiac arrest.[6] Two retrospective nontraumatic OHCA registry studies showed that younger, more severely ill patients with lower rates of survival were more likely to have received IO access while older patients with higher rates of survival were more likely to have received IV access.[7,8] Health care professionals should consider resource availability, expertise, and timeliness (time to confirmed vascular access) when choosing vascular access routes for drug administration.

Drug Administration During Cardiac Arrest

Recommendations for Drug Administration During Cardiac Arrest		
COR	**LOE**	**Recommendations**
2a	C-LD	1. For infants and children in cardiac arrest with initial nonshockable rhythm, it is reasonable to administer the initial dose of epinephrine as early as possible.
2b	C-LD	2. For infants and children in cardiac arrest with initial shockable rhythm, it may be reasonable to administer epinephrine after 2 attempts at defibrillation or sooner, only when rapid defibrillation is not possible.
2b	C-LD	3. For infants and children in cardiac arrest in any setting, it may be reasonable to administer epinephrine every 3–5 min until ROSC is achieved.

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Recommendations for Drug Administration During Cardiac Arrest (Continued)		
COR	**LOE**	**Recommendations**
2b	**C-LD**	4. For infants and children with shock-refractory VF/pVT, either amiodarone or lidocaine may be considered.
3: No Benefit	**B-NR**	5. Routine administration of sodium bicarbonate is not recommended for infants and children in cardiac arrest, except in special circumstances (eg, sodium channel blocker toxicity or hyperkalemia).
3: No Benefit	**B-NR**	6. Routine administration of calcium is not recommended for infants and children in cardiac arrest, except for special circumstances (eg, hypocalcemia, calcium channel blocker overdose, or hyperkalemia).

Synopsis

Administration of medications is a key component of PALS. Vasoactive agents, such as epinephrine, are used to increase coronary perfusion, primarily through alpha-1 receptor agonism. The optimal timing of initial dosing may differ in shockable cardiac arrest given the need to prioritize defibrillation. Antiarrhythmic agents are used to treat cardiac arrest with ventricular fibrillation (VF) and pulseless ventricular tachycardia (pVT). The existing literature does not support routine use of other adjunctive therapies such as sodium bicarbonate and calcium except in special circumstances.

Recommendation-Specific Supportive Text

1. A recent meta-analysis of retrospective observational studies showed that shorter time to administration of epinephrine during pediatric cardiac arrest with initial nonshockable rhythm was associated with favorable outcomes.[9–14]
2. The optimal timing of administration of epinephrine in relation to defibrillation in pediatric cardiac arrest with shockable rhythm is unknown[9] and may differ from nonshockable arrest given the need to prioritize defibrillation. Observational studies of pediatric OHCA have included patients with shockable rhythm, but none reported the relationship between initial epinephrine and timing of defibrillation.[11,13,15,16] Two observational studies in adults with shockable IHCA showed that early epinephrine, defined as before first defibrillation or within 2 minutes after first defibrillation, respectively, was associated with worse outcomes.[17,18] No studies have examined the effect of epinephrine for pediatric shockable arrest when early defibrillation is not possible.
3. The optimal interval between doses of epinephrine for pediatric cardiac arrest is unknown.[9] Observational studies for conventional CPR have shown mixed results. One study demonstrated that average intervals >5 minutes between doses were associated with increased survival compared to 1 to 5 minute intervals.[19] A second study showed that average epinephrine intervals of 3 to <5 minutes were associated with increased survival.[20] Two additional studies found that intervals of <3 minutes between epinephrine doses were associated with better outcomes.[21,22] For pediatric patients undergoing extracorporeal cardiopulmonary resuscitation (ECPR), one observational study showed that after the first 10 minutes of CPR, survivors received fewer epinephrine doses during each subsequent 10-minute interval compared to nonsurvivors. There was no difference in survival between epinephrine dosing intervals of ≤5 minutes and >5 minutes during minutes 10 to 30 of CPR on adjusted analysis.[23]
4. In an observational study of pediatric IHCA with VF/pVT, administration of lidocaine was associated with higher rates of ROSC and 24-hour survival although neither lidocaine nor amiodarone significantly affected the odds of survival to hospital discharge.[24] A subsequent propensity-matched study of pediatric IHCA with initial VF/pVT demonstrated no difference in outcomes between patients who received lidocaine compared to amiodarone.[25]
5. A meta-analysis of sodium bicarbonate administration during pediatric IHCA demonstrated lower rates of survival to hospital discharge in patients who received bicarbonate.[26–33] A subsequent propensity score-weighted cohort study found that sodium bicarbonate was associated with a lower rate of hospital survival, but no difference in rates of ROSC were observed.[34] However, these studies do not account for the fact that patients with longer durations of resuscitation, which are associated with lower survival rates, have greater exposure to medications like sodium bicarbonate. This phenomenon, known as resuscitation time bias, may falsely implicate the medication with poor survival if timing of drug administration is not accounted for in the analysis.[35] There are special circumstances in which bicarbonate is used, such as sodium channel blocker toxicity (eg, tricyclic antidepressants and cocaine)[36] and hyperkalemia. While a comprehensive list of special circumstances in which sodium bicarbonate may be beneficial has not been determined, it is important to note that sodium bicarbonate is routinely used in some of these circumstances (eg, hyperkalemia) which may significantly limit the emergence of new evidence due to lack of equipoise.[37]
6. A recent meta-analysis examining the administration of calcium during pediatric IHCA demonstrated decreased survival to hospital discharge with calcium administration.[32,38–40] Two subsequent studies in pediatric IHCA and arrests managed in the emergency department showed similar associations.[41,42] However, as noted for sodium bicarbonate, none of the studies accounted for resuscitation time bias and calcium may be falsely implicated in the decreased survival rates in patients who undergo prolonged

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resuscitation.[35] There are special circumstances in which calcium administration is used, such as hypocalcemia, calcium channel blocker overdose, and hyperkalemia. It is important to note that calcium is routinely used in some of these circumstances (eg, hyperkalemia) which may significantly limit the emergence of new evidence due to lack of equipoise.[37]

Weight-Based Dosing of Resuscitation Medications

Recommendations for Weight-Based Dosing of Resuscitation Medications		
COR	**LOE**	**Recommendations**
1	C-EO	1. For resuscitation medication dosing, it is recommended to use the infant or child's body weight to calculate resuscitation drug doses while not exceeding the recommended dose for adults.
2b	B-NR	2. It may be reasonable to use body habitus or anthropomorphic measurements to improve the accuracy of length-based estimated weight in infants or children, when possible.
2b	C-LD	3. If the infant or child's weight is unknown, a body length tape for estimating weight and other cognitive aids to calculate resuscitation drug dosing and administration may be considered.

Synopsis

Medication dosing for children is based on weight, which is often difficult to obtain in an emergency setting. There are numerous approaches to estimating weight when an actual weight cannot be obtained.[43]

This topic was last reviewed in the *2020 AHA Guidelines for CPR and ECC*. These recommendations have not been re-reviewed and updated for this edition of the Guidelines.[44]

Recommendation-Specific Supportive Text

1. There are many theoretical concerns about the use of actual body weight (especially in overweight or obese patients).[45–47] However, there are no data about the safety and efficacy of adjusting medication dosing in obese patients. Such adjustments could result in inaccurate dosing of medications.[48,49]
2. Several studies suggest that inclusion of body habitus or anthropometric measurements further refines and improves weight estimations using length-based measures.[43] However, there are considerable variations in these methods, and the training required to employ these measures may not be practical in every context.
3. Cognitive aids such as the Broselow, PAWPER XL, and Mercy tapes can assist in the accurate approximation of body weight (described as being within 10% to 20% of measured total body weight). Several studies demonstrated high variability of weight estimates, with a tendency toward underestimation of total body weight yet closely approximating ideal body weight.[47,50,51]

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ENERGY DOSES FOR DEFIBRILLATION IN CARDIAC ARREST

Recommendations for Energy Doses for Defibrillation in Cardiac Arrest		
COR	**LOE**	**Recommendations**
2a	**C-LD**	1. In infants and children experiencing cardiac arrest with VF/pVT, it is reasonable to use an initial dose of 2–4 J/kg of monophasic or biphasic energy for defibrillation; for ease of teaching, it is reasonable to use an initial dose of 2 J/kg.
2b	**C-LD**	2. In infants and children experiencing cardiac arrest with refractory VF/pVT, it may be reasonable to attempt subsequent defibrillation doses of 4 J/kg of monophasic or biphasic energy, and higher levels may be considered, though not to exceed 10 J/kg or the adult maximum dose.
2b	**C-LD**	3. In infants and children experiencing cardiac arrest with refractory VF/pVT, a single defibrillation dose of monophasic or biphasic energy may be considered over sequential (stacked) shocks, followed by resumption of chest compressions.

Synopsis

The proportion of cardiac arrests with initial VF/pVT steadily increases throughout childhood into adolescence yet remains lower than adults.[1,2] In infants and children, cardiac arrests due to an initial rhythm of VF/pVT have better outcomes than cardiac arrests due to initial nonshockable rhythms.[3] In addition, development of VF/pVT after the initiation of CPR for an initial nonshockable rhythm (subsequent VF/pVT) is associated with worse outcomes compared to patients in whom VF/pVT is the initial pulseless rhythm.[1] Timely defibrillation is the definitive treatment for VF/pVT; and the shorter the duration of VF/pVT before defibrillation, the more likely the shock will result in a perfusing rhythm.[3] Biphasic defibrillators require lower energy to terminate VF/pVT and have fewer side effects than monophasic defibrillators.[4,5] Stacked shocks (the delivery of a rapid series of sequential defibrillations for VF/pVT via one set of pads) are associated with higher rates of VF/pVT termination in some adult studies; however, this has not been well studied in pediatrics.[6–9]

Recommendation-Specific Supportive Text

1. A systematic review[10] found insufficient data to determine a relationship between optimal initial energy dose and outcomes. An IHCA case series[11] concluded that 2 J/kg was effective in terminating the majority of VF, but neither subsequent rhythm nor outcome was reported. An observational study of IHCA[12] showed a higher initial energy dose of ≥3 to 5 J/kg was less effective than 1 to 3 J/kg in achieving ROSC. One observational IHCA study[13] did not identify a specific initial energy dose associated with successful VF/pVT termination, while another observational IHCA study[14] found that 2 J/kg was an ineffective initial dose compared to higher dose ranges of 2.5 to 3 J/kg, especially for secondary VF. A registry study of pediatric IHCA with initial VF/pVT evaluated children who received energy doses <1.7 J/kg, 1.7 to 2.5 J/kg or >2.5 J/kg. They found that children ≤12 years of age who received initial energy doses of <1.7 J/kg or >2.5 J/kg had lower rates of survival to hospital discharge compared to those who received 1.7 to 2.5 J/kg. Furthermore, all children ≤18 years of age who received initial energy doses of >2.5 J/kg for initial VF had lower survival rates compared to those who received 1.7 to 2.5 J/kg.[15]
2. Two IHCA studies[13,14] suggest that defibrillation doses >2 J/kg may be needed for subsequent shocks to terminate VF. Human and animal studies demonstrate higher defibrillation doses up to 10 J/kg can be provided without significant harm to the myocardium.[14,16–21] Maximum energy doses as recommended for adults (see "Part 9: Advanced Life Support" recommendations on defibrillation[22]) may vary depending on monophasic versus biphasic defibrillators as well as specific manufacturer recommendations.[23]
3. There are limited data for the use of sequential (stacked) shocks, where a series of rapid sequential defibrillations is provided without resumption of compressions between shocks, for pediatric VF/pVT.[6,24–26] An IHCA study evaluating transthoracic impedance during defibrillation of children ≥8 years of age suggests that stacked shocks do not improve defibrillation success.[6] Notably, stacked shocks lead to longer periods where chest compressions are not being performed.

Figure 2 shows the Pediatric Cardiac Arrest Algorithm.

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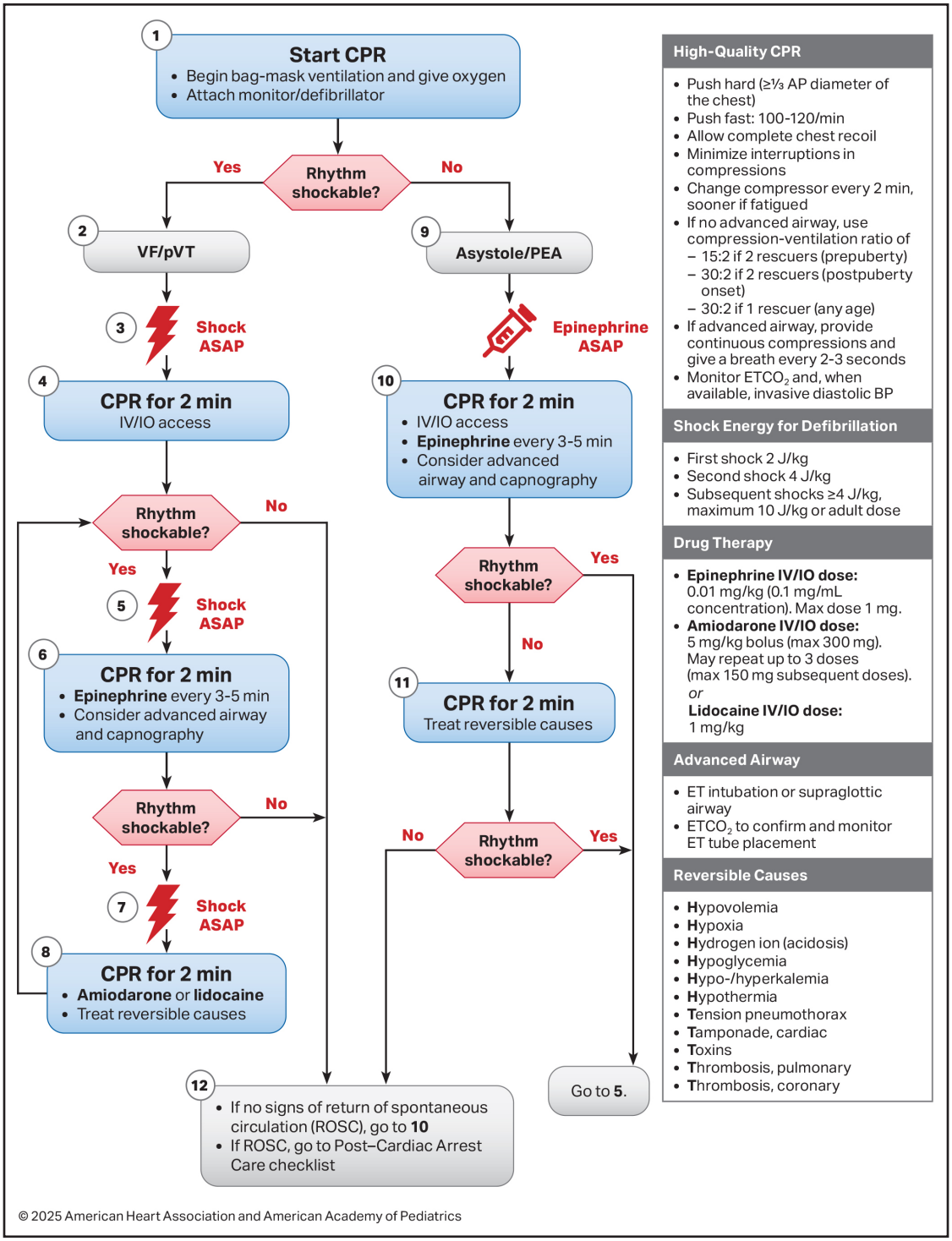

Figure 2. Pediatric Cardiac Arrest Algorithm.

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MEASURING CPR PHYSIOLOGY AND QUALITY

Recommendations for Measuring CPR Physiology and Quality		
COR	**LOE**	**Recommendations**
2a	B-NR	1. For infants and children with continuous invasive arterial blood pressure monitoring in place during CPR, it is reasonable for health care professionals to use diastolic blood pressure to assess the child's response to resuscitation efforts.
2b	B-NR	2. For infants and children with invasive airways in place during CPR, $ETCO_2$ monitoring may be considered to monitor CPR quality.
2b	C-LD	3. For infants and children with continuous invasive arterial blood pressure monitoring in place during CPR, it may be reasonable for health care professionals to target a diastolic blood pressure of ≥25 mm Hg in infants and ≥30 mm Hg in children ≥1 y of age.
2b	C-LD	4. The usefulness of noninvasive cerebral oxygenation monitoring via near-infrared spectroscopy during CPR in infants and children is not well established.
2b	C-EO	5. It may be reasonable for the rescuer to use CPR feedback devices in infants and children to optimize adequate chest compression rate and depth as part of a continuous resuscitation quality improvement system.
2b	C-EO	6. When appropriately trained personnel are available, echocardiography may be considered to identify potentially treatable causes of cardiac arrest in infants and children, such as cardiac tamponade and inadequate ventricular filling, but the potential benefits should be weighed against the known deleterious consequences of interrupting chest compressions.
3:Harm	C-LD	7. A specific $ETCO_2$ cutoff value alone should not be used as an indication to end resuscitative efforts in infants and children.

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Synopsis

Initiating and maintaining high-quality CPR are associated with improved rates of ROSC, survival to hospital discharge, and favorable neurologic outcome, yet measured CPR quality is often suboptimal.[1–3] Noninvasive and invasive monitoring techniques may be used to assess CPR quality and the patient's physiologic response to resuscitation. Invasive arterial blood pressure monitoring during CPR reveals compression and medication-generated pressures.[4,5] $ETCO_2$ reflects both the cardiac output produced and ventilation efficacy and may provide feedback on the quality of CPR.[6] A sudden rise in $ETCO_2$ may be an early sign of ROSC.[7] CPR feedback devices (ie, audio, and audiovisual devices) may improve compression rate, depth, and recoil within a system of training and quality assurance for high-quality CPR. Point-of-care ultrasound during CPR, specifically echocardiography, has been considered for the identification of reversible causes of arrest. Technologies that are under evaluation to assess resuscitation quality include noninvasive measures of cerebral oxygenation, such as near-infrared spectroscopy, which measures regional oxygen saturation and does not require pulsatile flow.

Recommendation-Specific Supportive Text

1 and 3. A multicenter observational study of children with IHCA demonstrated superior outcomes with higher diastolic blood pressure (≥25 mm Hg in infants <1 year of age and ≥30 mm Hg in older children ≥1 year of age) during the first 10 minutes of CPR.[4] In a prospective multicenter validation study in 413 children, these thresholds were associated with higher relative risk of ROSC (adjusted relative risk 1.49; 1.13–1.97) and survival to hospital discharge (adjusted relative risk 1.32; 1.01–1.74).[8,9] A secondary analysis of the same trial observed that patients who had an increase of ≥5 mm Hg in diastolic blood pressure in response to the first dose of epinephrine had higher rates of ROSC.[5] Clinical data regarding the efficacy or appropriate means of prospectively targeting diastolic blood pressure during CPR are lacking.

2. Higher $ETCO_2$ values during CPR are associated with ROSC.[10,11] A previous multicenter study of 43 children with IHCA did not identify an association between mean $ETCO_2$ and survival outcomes.[12] However, a recent prospective multicenter study in 234 children evaluated average $ETCO_2$ during the first 10 minutes of in-hospital CPR.[13] On multivariable analysis, $ETCO_2$ ≥20 mm Hg was associated with higher odds of ROSC and survival to discharge and higher intra-arrest blood pressures, but not CPR quality metrics. A single-center study found that higher median event $ETCO_2$ was associated with markers of high-quality CPR—chest compression rate less than 140 compressions per minute (P <0.0001) and chest compression fractions of 90% to 100% (P<0.0001).[11]
4. One small single-center study of cerebral near-infrared spectroscopy (n=23) monitored during pediatric cardiac arrest demonstrated that higher median regional cerebral oxygen saturation during the overall CPR event and in the last 5 minutes of CPR was associated with higher rates of ROSC, but not survival to discharge.[14] A multicenter study of 92 pediatric patients at 3 sites demonstrated an association between a higher median event regional cerebral oxygen saturation and ROSC, survival to hospital discharge, and survival with favorable neurologic outcome.[15]
5. A simulation trial of pediatric health care professionals demonstrated a significant improvement in chest compression depth and rate compliance when they received visual feedback (compared to no feedback), although overall compression quality remained poor.[16] One small observational study of 8 children with IHCA did not find an association between CPR with or without audiovisual feedback and survival to discharge, although feedback decreased excessive compression rates.[17]
6. Several case series have evaluated the use of bedside echocardiography during pediatric cardiac arrest to identify reversible causes of cardiac arrest and potentially direct management. However, data are very limited and the utility of echocardiography to direct care during pediatric CPR is unknown. Potential risks of echocardiography during CPR include prolonged interruptions in chest compressions.[18–20]
7. A single-center study found that 42% of infants and children with a median event $ETCO_2$ <20 mm Hg achieved ROSC.[11] A prospective, multicenter study of $ETCO_2$ during the first 10 minutes of CPR found that 47.5% of infants and children with $ETCO_2$ <20 mm Hg and 47.6% of those with $ETCO_2$ <10 mm Hg survived to hospital discharge.[13] Given these variable associations between low $ETCO_2$ values during CPR and survival outcomes, there is potential harm in making termination of resuscitation decisions based on $ETCO_2$ alone.[13,21]

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EXTRACORPOREAL CARDIOPULMONARY RESUSCITATION

Recommendation for the Use of Extracorporeal Cardiopulmonary Resuscitation		
COR	**LOE**	**Recommendation**
2b	**C-LD**	1. ECPR may be considered for infants and children with IHCA refractory to conventional CPR in selected populations in clinical settings with ECPR protocols and expertise.

Synopsis

ECPR is the rapid deployment of venoarterial ECMO for refractory cardiac arrest. This has been defined as the initiation of ECMO flow during active CPR or within 20 minutes of ROSC.[1] The deployment of ECPR by resourced and highly trained health care teams is associated with improved survival outcomes compared to conventional CPR in specific IHCA patient populations with reversible causes.[2,3] Pediatric patients with underlying cardiac disease continue to represent a population of patients with improved survival to hospital discharge and good neurologic outcomes following deployment of

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ECPR compared to conventional CPR for prolonged cardiac arrest.[4,5] Emerging evidence suggests that risk profiles for survival differ between cardiac subpopulations (ie, surgical cardiac versus medical cardiac populations).[3] Pediatric ECPR use is increasing beyond the pediatric cardiac population (eg, respiratory illness), with limited evidence suggesting benefit.[2,6–8]

See "Part 4: Systems of Care" for further discussion of ECPR systems of care.[9]

Recommendation-Specific Supportive Text

1. Two single-center, retrospective case series of ECPR in patients with preexisting cardiac disease showed rates of survival to hospital discharge of 43.8% to 48%, and of survivors, 68% to 75% survived with a favorable neurologic outcome.[10,11] Similar findings were reported in 5 additional single/multicenter studies among patients across illness classifications, with the majority in the cardiac illness category.[12–16] A retrospective multicenter study of cardiac ICU patients from a quality improvement registry showed higher survival to discharge of ECPR recipients with cardiac surgical disease compared to cardiac medical disease,[3] while analysis of 2 registries showed noncardiac diagnoses were associated with an increased risk of death following ECPR.[17] A retrospective analysis from an inpatient pediatric database showed no difference in mortality between patients who received conventional CPR and patients who received ECPR, the majority of whom were cardiac surgery patients.[18] Another retrospective analysis using a national registry showed higher rates of survival with ECPR in cardiac surgical patients who had a cardiac arrest.[5] For noncardiac populations experiencing IHCA, a retrospective study from a national database found no difference in survival to hospital discharge between ECPR and conventional CPR.[8] Additional data evaluating the use of ECPR in noncardiac patients or those who experience OHCA is insufficient to make a recommendation at this time.

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POST–CARDIAC ARREST CARE TREATMENT AND MONITORING

Post–Cardiac Arrest Targeted Temperature Management

Recommendations for Post–Cardiac Arrest Targeted Temperature Management		
COR	LOE	Recommendations
1	A	1. For infants and children who remain comatose following cardiac arrest, continuous central temperature monitoring is recommended.
1	B-NR	2. For infants and children who remain comatose following cardiac arrest, avoiding central temperatures >37.5 °C is recommended.
2a	B-R	3. For infants and children between 24 h and 18 y of age who remain comatose after IHCA or OHCA, it is reasonable to use a 5-d course of targeted temperature management (TTM), either 32 °C–34 °C followed by TTM of 36 °C–37.5 °C, or only TTM of 36 °C–37.5 °C.

Synopsis

Hypoxic ischemic brain injury is a leading cause of morbidity and mortality following pediatric cardiac arrest. Hypoxic ischemic brain injury leads to free radical production, cellular apoptosis and necrosis.[1] Primary and secondary brain injury can result in cerebral ischemia or hyperemia, encephalopathy, seizures, and cerebral edema. Fever is common post–cardiac arrest and is associated with worse neurologic outcomes. Fever is also associated with increased central nervous system metabolic demands which may exacerbate primary brain injury after arrest.[2,3] Targeted temperature management (TTM) refers to actively maintaining a patient's temperature within a closely prescribed temperature range while continuously monitoring central temperature. All forms of TTM actively prevent fever. Maintaining TTM between 32 °C and 34 °C attempts to treat systemic ischemic reperfusion injury.[4,5] A systematic review of pooled animal studies comparing TTM between 32 °C and 36 °C to control groups showed a strong effect of TTM on favorable neurologic outcome and reduced mortality.[6]

Recommendation-Specific Supportive Text

1. Accurate measurement of temperature is most reliably obtained at a core site (eg, rectal, esophageal, or bladder). Continuous temperature monitoring assesses temperature swings in patients at high risk for temperature instability. Continuous core temperature monitoring was used for the 5 days of TTM in Therapeutic Hypothermia After Pediatric Cardiac Arrest (THAPCA) trials.[7,8]
2. Hyperthermia in the post–cardiac arrest period is common[3] and is associated with decreased survival from both IHCA and OHCA. Avoiding hyperthermia offers a potential means to improve neurologic outcome.[9–11] Effective prevention of fever has been shown with active cooling with servo-regulated devices compared to air-cooled devices or passive cooling techniques[12] and with adoption of lower target temperature.[13]
3. The THAPCA randomized clinical trials of TTM (32 °C–34 °C for 48 hours followed by 3 days of TTM 36 °C–37.5 °C versus TTM 36 °C–37.5 °C for a total of 5 days) after IHCA or OHCA in children with coma following ROSC found no difference in 1-year survival with a favorable neurologic outcome.[7,8] Secondary analyses of the THAPCA trials showed no difference between temperature groups in any of the following subgroups: ECMO or ECPR, hypotension post-ROSC, open chest resuscitation, combined cohort of IHCA and OHCA, and acute kidney injury.[14–19] A Bayesian reanalysis of the THAPCA-OH trial found a high probability that hypothermia provides a modest benefit in neurobehavioral outcome and survival at 1 year.[20] A recent retrospective observational study found that children who received TTM 33 °C per clinician decision had higher health-related quality of life scores versus those who received TTM 36 °C evaluated at 3 years after the cardiac arrest.[21]

Post–Cardiac Arrest Blood Pressure Management

Recommendations for Post–Cardiac Arrest Blood Pressure Management		
COR	LOE	Recommendations
1	B-NR	1. After cardiac arrest in infants and children, it is recommended to maintain systolic and mean arterial blood pressure greater than the 10th percentile for age.
1	C-EO	2. After cardiac arrest in infants and children, continuous arterial pressure monitoring is recommended to identify and treat hypotension when appropriate resources are available.

Synopsis

Hypotension (<fifth percentile for age and sex) is common following ROC from cardiac arrest, occurring in 25% to 50% of infants and children.[15,22] In addition to the primary causes of cardiac arrest, hypotension can be related to myocardial dysfunction and systemic reperfusion, which is associated with inflammation and vasoplegia. Hypotension can exacerbate brain ischemia and myocardial ischemic injury, systemic hypoperfusion and resultant tissue hypoxia. Myocardial dysfunction, which is often present regardless of arrest etiology, typically occurs within hours of arrest and resolves in 48 to 72 hours.[23] Both the presence and severity of postarrest hypotension are associated with lower rates of survival to discharge.[15,22,24] whereas normal or high blood pressures are associated with survival to discharge.[14,25] When post–cardiac arrest hypotension is

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present, there is paucity of data regarding the association between interventions to treat hypotension and outcomes.

Recommendation-Specific Supportive Text

1 and 2. Blood pressure is often labile in the post–cardiac arrest period and recognition of hypotension is important. Continuous blood pressure monitoring allows for rapid identification of hypotension and can facilitate immediate treatment. Two observational studies associated systolic blood pressure below the fifth percentile for age in the first 12 hours following cardiac arrest with decreased rates of survival to discharge.[15,22] The severity and duration of systolic hypotension within the first 72 hours post–cardiac arrest care in the pediatric ICU (PICU) are associated with decreased survival to discharge,[24] whereas the combined absence of both post–cardiac arrest systolic hypotension and fever was associated with increased odds of survival to discharge.[13] A secondary analysis of the ICU-Resuscitation trial of pediatric IHCA found higher rates of survival to hospital discharge as well as survival to hospital discharge with favorable neurologic outcome when blood pressure targets were above a threshold of systolic blood pressure >10th percentile for age and diastolic blood pressure >50th percentile for age during the first 6 hours post–cardiac arrest.[26] A multicenter study of IHCA and OHCA found that mean arterial blood pressure between the fifth and 74th percentiles for age was associated with favorable neurologic outcome.[27] An additional study showed that mean arterial blood pressure <10th percentile for age in the first 24 hours after cardiac arrest, quantified as burden of hypotension (duration and magnitude), was associated with unfavorable neurologic outcomes.[28]

Post–Cardiac Arrest Oxygenation and Ventilation Management

Recommendations for Post–Cardiac Arrest Oxygenation and Ventilation Management		
COR	**LOE**	**Recommendations**
2b	**C-LD**	1. After cardiac arrest in infants and children, it may be reasonable to target normoxemia that is appropriate to the specific patient's underlying condition.
2b	**C-LD**	2. After cardiac arrest in infants and children, it may be reasonable to wean oxygen to target an oxyhemoglobin saturation between 94% and 99%.
2b	**C-LD**	3. After cardiac arrest in infants and children, it may be reasonable to target a $Paco_2$ that is appropriate to the specific patient's underlying condition and limit exposure to hypercapnia or hypocapnia.

Synopsis

Post–cardiac arrest care is a critical component of the Chain of Survival. Monitoring of gas exchange with oxygen and ventilation titration is a key component of post–cardiac arrest care with the goal of preventing secondary end-organ injury. Although current recommendations are to administer 100% oxygen during cardiac arrest to maximize oxygenation during CPR as well as to minimize hypoxic-ischemic injury,[29] target ranges for post-ROC oxygenation are less certain. Animal studies[30,31] have shown associations with hyperoxia and reactive oxygen species, inflammation and brain injury, yet observational studies in infants and children post-ROC (whether spontaneous or achieved by mechanical means) have demonstrated mixed associations for hyperoxemia with survival and neurologic outcomes.[32–36] While most studies demonstrated adverse outcomes with hypoxemia, 1 recent observational study did not find an association with hypoxemia in the post–cardiac arrest period.[37]Associations of either duration or severity of hypoxemia or hyperoxemia with adverse outcomes in the post–cardiac arrest setting are unknown.

Extremes of arterial carbon dioxide levels lead to cerebral vasoconstriction when low (hypocapnia) and vasodilation when high (hypercapnia).[38] Carbon dioxide level fluctuations and their impact on cerebral blood flow in the pediatric post–cardiac arrest population remains poorly understood, although emerging evidence suggests mild hypercapnia may be associated with survival and favorable neurologic outcome.[35,37]

Recommendation-Specific Supportive Text

1 and 2. Because an arterial oxyhemoglobin saturation of 100% may correspond to a Pao_2 between approximately 80 mm Hg and 500 mm Hg, it is reasonable to target an oxyhemoglobin saturation between 94% and 99%. Of note, pulse oximeters may overestimate oxygen saturation levels in patients with darker skin, which can lead to lower oxygen levels (hypoxemia) going undetected.[39,40] Six small observational studies of pediatric IHCA and OHCA did not show an association between hyperoxemia and outcome.[32,36,37,41–43] One larger observational study of pediatric IHCA and OHCA, as well as

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a secondary analysis of the ICU-Resuscitation trial, found associations between hyperoxemia after ROC and either decreased survival to PICU discharge[34] or decreased survival to hospital discharge with favorable neurologic outcome.[35]

3. Four observational studies found an association between hypercapnia and increased mortality and worse neurologic outcomes.[33,35,37,41] Hypercapnia and hypocapnia impact cerebral blood flow. Targeting normocapnia ($Paco_2$ 35–45 mm Hg) or the patients' baseline arterial partial pressure of carbon dioxide when chronically hypercapnic may prevent these perturbations.

Post–Cardiac Arrest Electroencephalography Monitoring and Seizure Treatment

Recommendations for Post–Cardiac Arrest Electroencephalography Monitoring and Seizure Treatment

COR	LOE	Recommendations
1	C-LD	1. When resources are available, continuous electroencephalography (EEG) monitoring is recommended for the detection of seizures after cardiac arrest in infants and children with persistent encephalopathy.
1	C-LD	2. It is recommended to treat clinical seizures after cardiac arrest in infants and children.
2a	C-EO	3. It is reasonable to treat nonconvulsive status epilepticus after cardiac arrest in infants and children in consultation with experts.

Synopsis

Post–cardiac arrest brain injury remains a leading cause of morbidity and mortality in children because the brain has limited tolerance of ischemia, hyperemia, or edema. Post–cardiac arrest seizures occur in 5% to 30% of patients and can be nonconvulsive, which can only be detected on electroencephalography.[44,45] Post–cardiac arrest status epilepticus is associated with worse outcomes, including death and neurologic injury in survivors. There are no pediatric studies assessing the efficacy of antiseizure medications for either prophylaxis or treatment of seizures and their association with outcomes such as survival to hospital discharge or survival with favorable neurologic outcome.

Recommendation-Specific Supportive Text

1. Nonconvulsive seizures and nonconvulsive status epilepticus are common after pediatric cardiac arrest and are associated with worse outcomes.[44–47] The American Clinical Neurophysiology Society recommends continuous EEG monitoring for encephalopathic patients after pediatric cardiac arrest.[48] Nonconvulsive seizures and nonconvulsive status epilepticus cannot be detected without EEG monitoring.[48]

2 and 3. There is insufficient evidence to determine whether treatment of convulsive or nonconvulsive seizures improves neurologic or functional outcomes after pediatric cardiac arrest. Both convulsive and nonconvulsive status epilepticus are associated with worse outcomes, but no study has evaluated treatment with antiseizure medications compared to no treatment.[44,45] A study comparing treatment to no treatment of rhythmic and periodic discharges following adult cardiac arrest found no difference in survival or neurologic outcomes.[49] The Neurocritical Care Society recommends treating status epilepticus with the goal of stopping convulsive and electrographic seizure activity.[50]

Figure 3 shows the checklist for post–cardiac arrest care.

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Components of Post–Cardiac Arrest Care	Check
Ensure normoxia and normocapnia.	
Monitor Spo_2 and target 94%-99% (or child's normal/appropriate oxygen saturation).	☐
Measure and target $Paco_2$ appropriate to the patient's underlying condition and limit exposure to severe hypercapnia or hypocapnia.	☐
Optimize cardiac function and end-organ perfusion.	
Monitor with cardiac telemetry.	☐
Monitor arterial blood pressure.	☐
Review hemodynamic goals daily.	☐
Monitor serum lactate and urine output to help guide therapies.	☐
Use parenteral fluid bolus with or without inotropes or vasopressors to maintain a systolic blood pressure and mean arterial blood pressure greater than the 10th percentile for age.	☐
Consider echocardiography to assess for myocardial dysfunction.	☐
Maintain electrolytes within normal ranges to avoid possible life-threatening arrhythmias.	☐
Apply targeted temperature management (TTM).	
Continuously monitor core temperature.	☐
Prevent and treat fever immediately after cardiac arrest and after rewarming.	☐
If patient is comatose, apply TTM (32 °C-34 °C) followed by (36 °C-37.5 °C) or only TTM (36 °C-37.5 °C) for up to 5 days.	☐
Prevent shivering.	☐
Remember that rewarming is a high-risk time for hypotension, electrolyte abnormalities, hypoglycemia, and seizures.	☐
Provide neuromonitoring.	
If patient is not at neurologic baseline and resources are available, monitor with continuous electroencephalography.	☐
Treat seizures.	☐
Measure glucose.	
Measure blood glucose and avoid hypoglycemia.	☐
Prevent agitation and pain.	
Treat with sedatives, anxiolytics, and analgesics to a sedation score target.	☐
Consider prognosis.	
Always consider multiple modalities (clinical and other) over any single predictive factor.	☐
Delay prognostication until at least 72 hours after cardiac arrest.	☐
Remember that prognostics assessments may be modified by TTM.	☐

Figure 3. Post–Cardiac Arrest Care Checklist.

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NEUROLOGICAL PROGNOSTICATION FOLLOWING CARDIAC ARREST

Introduction

Hypoxic ischemic brain injury is the leading cause of death and disability after cardiac arrest.[1] Early and reliable neurological prognostication after resuscitation from pediatric cardiac arrest is essential to guide treatment, enable accurate counseling, and provide family support. In addition, accurate neurological prognostication is critical to avoid inappropriate withdrawal of life-sustaining therapy in patients who may have a meaningful recovery while also avoiding potentially inappropriate life-sustaining treatments. For further discussion of ethical considerations regarding prognostication and uncertainty, refer to "Part 3: Ethics."[2]

The definitions of favorable and unfavorable neurological outcome are complex and dynamic throughout the recovery period after cardiac arrest. Recovery progresses along a temporal continuum such that a child assessed as having a favorable or unfavorable outcome at hospital discharge may be assessed differently several months to years after discharge. Gross scoring systems such as the PCPC are limited in the granularity of assessment and not standardized across ages, such that the same PCPC of a 6-month-old and 10-year-old may not be comparable. Thus, when classifying patients into favorable versus unfavorable outcome categories and combining timepoints of assessment, it is important to understand that these dichotomous outcomes may not give a complete picture of the individual patient's complex reality. However incomplete the portrait of outcomes, health care professionals must still provide guidance to families, thereby necessitating criteria to classify patient outcomes.

These 2025 recommendations are based on 2 ILCOR systematic reviews of potential prognostic modalities for neurological outcome; one for prediction of good (favorable) neurological outcome and one for prediction of poor (unfavorable) neurological outcome.[3,4] These reviews used the same data but analyzed them differently based on the outcome being assessed (good or poor). Definitions of good neurological outcome are not standardized and vary across studies, most often defined as a PCPC of 1 or 2; 1, 2, or 3; no change from baseline; or a Vineland Adaptive Behavioral Score of >70.[5,6]

Good neurological outcome was assessed as a threshold false positive rate (FPR) of less than 30% (ie, predicting a good neurological outcome but having a poor neurological outcome).[3,7] For poor neurological outcome, they used an FPR of <1% (ie, predicting a poor neurological outcome but having a good neurological outcome).[4] Sensitivity (eg, probability of a good neurological outcome in a patient who has a positive finding) was assessed for all studies but was not the primary assessment of predictive accuracy. An FPR of <1% was selected for predictors of poor neurological outcome to minimize the risk of making recommendations for limitation of care in patients who would have a good neurological outcome. Adult studies have used FPR thresholds to predict poor neurological outcome between <0% and 5%.[8,9] Standard thresholds to predict outcome from pediatric cardiac arrest have not been established.

The systematic review for predicting good (favorable) neurological outcome-assessed associations of positive test findings (eg, bilateral reactive pupils) with good neurological outcome, whereas the systematic review for poor neurological outcome-assessed associations of negative findings (eg, bilateral unreactive pupils) with poor neurological outcome. It cannot be presumed that positive findings for favorable outcome (ie, presence of reactive pupils with good neurological outcome) will have the same predictive value as negative findings for unfavorable neurological outcome (ie, absence of reactive pupils with poor neurological outcome). For the purposes of this guideline, we have chosen the terms *favorable* (good) and *unfavorable* (poor).

Neurological Prognostication Following Cardiac Arrest

Recommendation for Multimodal Prognostication Following Cardiac Arrest		
COR	**LOE**	**Recommendation**
1	**B-NR**	1. It is recommended that health care professionals consider multiple modalities when predicting neurological outcomes (favorable or unfavorable) after resuscitation from cardiac arrest in infants and children.

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Synopsis

Health care professionals use various assessments to guide neurological prognostication in the post–cardiac arrest period including neurological examination, biomarkers, EEG, and neurological imaging modalities (eg, brain computed tomography and magnetic resonance imaging). Studies reporting the predictive accuracy of individual assessments must be interpreted in the context of timing following ROC, outcome assessed (ie, survival versus survival with a good functional outcome), and unmeasured confounders (eg, sedation). Some modalities can predict favorable neurological outcome, unfavorable neurological outcome, or both. Each must be considered in conjunction with other modalities.

Recommendation-Specific Supportive Text

1. Numerous studies demonstrate associations between clinical examination findings, biomarkers, electrophysiology patterns, and neurological imaging findings with outcomes following pediatric cardiac arrest.[10–22] However, these studies are limited by their retrospective designs, lack of blinding, and unadjusted and unmeasured confounding. In addition, there are no established predictive accuracy thresholds (eg, sensitivity, specificity, Area Under the Receiver Operating Curve) for individual or combined criteria. Thus, multiple modalities are needed for neurological prognostication.

Recommendations for Prognostication Using Clinical Examination Following Cardiac Arrest

COR	LOE	Recommendations
2b	C-LD	1. The usefulness of cough or gag reflexes or response to pain to support a favorable or unfavorable neurological prognosis at any timepoint after cardiac arrest in infants and children is not well established.
2b	C-LD	2. The usefulness of motor response to any stimulus to support a favorable or unfavorable neurological prognosis at any timepoint after cardiac arrest in infants and children is not well established.
2b	C-LD	3. The usefulness of total Glasgow Coma Scale (GCS) score or GCS motor score to support a favorable neurological prognosis at any timepoint after cardiac arrest in infants and children is not well established.
2b	C-LD	4. When interpreted in the context of other prognostic criteria, it may be reasonable to use the presence of bilateral pupillary light reflexes in the first 12 h after cardiac arrest in infants and children to support a favorable neurological prognosis.
2b	C-LD	5. When interpreted in the context of other prognostic criteria, it may be reasonable to use the absence of bilateral pupillary light reflexes between 48 and 72 h after cardiac arrest in infants and children to support an unfavorable neurological prognosis.

Recommendations for Prognostication Using Clinical Examination Following Cardiac Arrest (Continued)

COR	LOE	Recommendations
3: No Benefit	B-NR	6. The absence of pupillary light reflex in the first 24 h after cardiac arrest in infants and children to support an unfavorable neurological prognosis is not recommended.
3: No Benefit	B-NR	7. The GCS score in the first 24 h after cardiac arrest in infants and children to support an unfavorable neurological prognosis is not recommended.

Synopsis

Neurologic assessments routinely include brainstem reflexes such as pupillary response, cough and gag, and motor response to stimuli. The neurologic examination evolves in the days after cardiac arrest, and a given finding (eg, pupillary reactivity) at an early timepoint may not have the same accuracy for prediction of outcome at a later timepoint. Furthermore, the predictive accuracy of an exam finding (eg, pupillary reflexes) at one timepoint for favorable neurological outcome may not have the opposite predictive accuracy when the exam finding is absent (eg, absence of pupillary reflexes for unfavorable neurological outcome). Exam findings in these studies are often obtained through retrospective chart review, thus patient condition and potential confounders may not be reported which may impact the accuracy of the assessment. Clinical examination may also be confounded by sedation administration. Therefore, caution must be used when interpreting these data and health care professionals must avoid the use of isolated exam findings to predict neurological outcome.

Recommendation-Specific Supportive Text

1. Three studies assessed the associations between cough or gag reflexes or evoked pain response and neurological outcome. The presence of cough and gag reflex at 24 hours predicted favorable neurological outcome with a low sensitivity of 40% for both and an FPR of 35% and 32% respectively.[22,23] The absence of cough and gag predicted an unfavorable neurological outcome with an FPR of 60% and a sensitivity of 65% to 69%.[23] The sensitivity for evoked pain response for favorable neurological outcome was 100%, but the FPR was as high as 67%.[22,24] The absence of an evoked pain response at 6 and 12 hours to predict unfavorable neurological outcome in 1 study had an FPR of 0% (0%–15%) with a sensitivity of 33%.[22] The FPR for these assessments did not meet predefined thresholds to predict favorable or unfavorable neurological outcome.
2. In a small study of 29 patients, any motor response at 48 and 72 hours after ROC had a sensitivity 80% to 100% and low FPR (23%–27%) for favorable neurological outcome.[25] In that same study, the absence of any motor response to predict

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unfavorable neurological outcome at <1 hour, 48 hours, and 72 hours after ROC had a sensitivity 61% to 73%. The FPR for unfavorable neurological outcome was 62% at less than 1 hour, 20% at 48 hours and 0% at 72 hours. These data are limited to 1 small single-center study and require further evaluation.[25]

3. Three studies including 296 patients assessed the association of mental status measured by the total GCS score >4, 7 or 8, or GCS motor score >4 within 24 hours of ROC with neurological outcome at ICU or hospital discharge or 6-month follow-up. They had low sensitivity (<50%), and low FPR (<14%) for favorable neurological outcome,[26–28] but only 1 study assessed each timepoint and threshold and thus data were limited.
4. Three studies evaluating the presence of bilateral pupillary reflexes within 12 hours of ROC demonstrated a sensitivity (ie, probability of patients with a favorable neurological outcome having bilateral pupillary response) of at least 82% for favorable neurological outcome (PCPC 1–2 or 1–3) and FPRs (ie, bilaterally reactive pupils with an unfavorable neurological outcome) of 16% to 31%.[22,25,27] At timepoints >24 hours from ROC, while sensitivity of bilateral pupillary reactivity was 75% to 100%, a high FPR of 68% was observed thus demonstrating its lack of reliability for prediction.[23–25,28–30] Therefore, findings of bilateral pupillary reactivity >24 hours post–cardiac arrest are less reliable and pupillary response alone is inadequate for neurological prognostication at any timepoint.
5. Three studies evaluated the absence of pupillary reflexes to predict unfavorable neurological outcome at 48 and 72 hours after ROC with an FPR <1% but with wide confidence intervals (95% CI, 0%–40%) and low sensitivity of 12% to 46%.[24,25,31] These FPRs met the prespecified FPR threshold and are moderately reliable, but should only be used in conjunction with other predictors.
6. Six of 7 studies that assessed the absence of bilateral pupillary reflexes to predict unfavorable neurological outcome between <1 hour and 24 hours after ROC had an FPR >10% up to 60% with sensitivities of 33% to 93%.[23,25,27–30] These studies show that the absence of pupillary reflex within 24 hours after ROC are not accurate to predict outcome.
7. Three studies including 296 patients assessed the association of mental status measured by the total GCS or GCS motor score within 24 hours of ROC with neurological outcome at ICU or hospital discharge or 6 month follow-up.[26–28] A GCS motor score of <4 at 1 hour after ROC to predict unfavorable neurological outcome had high FPRs of 83% and 50%, respectively, with high sensitivities of 93% to 94%.[27] A total GCS score of <4 at resuscitation or within 1 hour of ROC predicted unfavorable neurological outcome with a high FPR of 70% and a high sensitivity of 86%.[26] A total GCS score <7 to predict unfavorable neurological outcome had a high FPR of 69% and high sensitivity of 92%.[28] These data demonstrate that these GCS data are not accurate to predict outcome.

Recommendations for Prognostication Using Biomarkers Following Cardiac Arrest

COR	LOE	Recommendations
2b	B-NR	1. When interpreted in the context of other prognostic criteria, it may be reasonable to use a plasma lactate value <2 mmol/L up to 12 h after cardiac arrest in infants and children to support a favorable neurological prognosis.
2b	C-LD	2. The usefulness of neuronal biomarkers (eg, S100B, neuron-specific enolase) to support a favorable or unfavorable neurological prognosis at any timepoint after cardiac arrest in infants and children is not well established.
3: No Benefit	B-NR	3. The use of blood lactate after cardiac arrest in infants and children to support an unfavorable neurological prognosis is not recommended.
3: No Benefit	B-NR	4. The use of blood pH after cardiac arrest in infants and children to support a favorable or unfavorable neurological prognosis is not recommended.

Synopsis

Serum biomarkers are blood-based tests that measure levels of proteins that are found in the central nervous system or measure inflammation or systemic ischemic reperfusion. Central nervous system proteins are released across the blood brain barrier when the brain is injured: Neuron-specific enolase is released from injured neurons, glial fibrillary acidic protein from injured glia, neurofilament light from injured axons, and S100B from injured astrocytes. Hypoxic ischemic brain injury and reperfusion injury may cause injury to these cells differently, and release of these proteins may occur and peak at different times after injury. Studies of these neuronal biomarkers are limited by different assessment platforms, different baseline values across platforms and extracerebral sources for some proteins.

Commonly measured blood-based markers of inflammation or systemic ischemic reperfusion are pH and lactate levels. Lactate levels may reflect the severity of systemic hypoxia and ischemia before, during, or after cardiac arrest. pH is impacted by both systemic acidosis, of which lactate acidosis may be a major contributor, as well as respiratory acidosis, which may be due to inadequate ventilation. These systemic markers change over time after arrest. pH can be modified by titration of the ventilator to correct respiratory acidosis as well as administration of sodium bicarbonate to

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treat metabolic acidosis. Lactate clearance refers to the decrease in lactate over time after cardiac arrest; earlier clearance is associated with decreased mortality in adults.[32]

Recommendation-Specific Supportive Text

1. Serum lactate <2 mmol/L within 12 hours of ROC had low sensitivity of 16% to 28% for favorable neurological outcome, but a very low FPR ranging from 4% to 7%.[33–35] Lactate thresholds of <2 mmol/L at 24 and 48 hours and <5 mmol/L at 1 and 24 hours had high FPRs of 17% to 68% and were moderately sensitive (61%–89%).[33,36] Thus only timepoints before 12 hours should be considered to predict outcomes in conjunction with other findings.
2. Neuronal biomarkers S100B, neuron-specific enolase, myelin basic protein, neurofilament light, ubiquitin C-terminal hydrolase-L1, glial fibrillary acidic protein, and tau have been assessed at timepoints ranging from <1 hour through 96 hours after ROC.[20,29,37,38] Various thresholds were assessed for biomarkers to predict favorable neurological outcome at different timepoints resulting in very wide ranges of FPR (0% to 96%) and sensitivities (5% to 100%). Three studies of various thresholds for S100B had an FPR of 0% with sensitivities of 29% to 38% for unfavorable neurological outcome and for neuron-specific enolase had FPR of 0% with sensitivities of 19% to 26%.[20,29,37] While these FPRs for favorable outcome were low, there were no consistent thresholds evaluated for these markers. Further study is needed to validate specific biomarker thresholds and discrete timepoints.
3. Lactate was assessed in 6 studies.[20,34,35,39–41] Two studies had an FPR of <1% for unfavorable neurological outcome, 1 with a sensitivity of 11% with a threshold greater than 28.8 mmol/L 1 hour after ROC and 1 with a lactate clearance less than 2 mmol/L by 48 hours post-ROC.[20,39] All other studies had FPR ranging from 11% to 83% for unfavorable neurological outcome.[33–35,41]
4. pH level was assessed in 4 studies.[20,34,35,39] A pH threshold of >7.0 at 1 hour and 6 to 12 hours post–cardiac arrest had high sensitivities of 71% to 96%, but high FPRs ranging from 45% to 97% for favorable neurological outcome. A pH threshold of >7.3 at 1 hour and 24 hours post–cardiac arrest had sensitivities of 49% and 89% respectively but FPRs of 38% and 81% respectively for favorable neurological outcome.[40] For unfavorable neurological outcome, 3 studies had FPRs <5%, but sensitivities of 3% to 14%.[20,34,45] pH is not accurate enough to predict favorable or unfavorable neurological outcome.

Recommendations for Prognostication Using Electrophysiology Following Cardiac Arrest

COR	LOE	Recommendations
2a	B-NR	1. When interpreted in the context of other prognostic criteria, it is reasonable to use EEG up to 72 h after cardiac arrest in infants and children to support a favorable or unfavorable neurological prognosis.
2b	B-NR	2. When interpreted in the context of other prognostic criteria, it may be reasonable to use the presence of continuous or normal EEG background in the first 72 h after cardiac arrest in infants and children to support a favorable neurological prognosis.
2b	C-LD	3. When interpreted in the context of other prognostic criteria, it may be reasonable to use the presence of sleep spindles or stage II sleep architecture on EEG between 12 and 24 h after cardiac arrest in infants and children to support a favorable neurological prognosis.
2b	C-LD	4. When interpreted in the context of other prognostic criteria, it may be reasonable to use the presence of EEG reactivity between 6 and 24 h after cardiac arrest in infants and children to support a favorable neurological prognosis.
2b	C-LD	5. When interpreted in the context of other prognostic criteria, it may be reasonable to use the presence of status epilepticus, or the presence of burst suppression, burst attenuation or generalized periodic epileptiform discharges between 24 and 72 h after cardiac arrest in infants and children to support an unfavorable neurological prognosis.
2b	C-LD	6. The usefulness of the presence of attenuated, isoelectric or flat EEG, or presence of myoclonic status epilepticus at any timepoint after cardiac arrest in infants and children to support an unfavorable neurological prognosis is not well established.
3: No Benefit	B-NR	7. The presence of clinical or electrographic seizures, absence of sleep spindles and stage II sleep architecture, absence of continuous or normal EEG background, absence of EEG reactivity, and absence of EEG variability at any timepoint after cardiac arrest in infants and children is not recommended to support an unfavorable neurological prognosis.
3: No Benefit	B-NR	8. The absence of burst suppression, burst attenuation, generalized periodic epileptiform discharges, attenuated, isoelectric, or flat EEG at any timepoint after cardiac arrest in infants and children is not recommended to support a favorable neurological prognosis.
3: No Benefit	B-NR	9. The absence of clinical or electrographic seizures, absence of status epilepticus, or absence of myoclonic seizures at any timepoint after cardiac arrest in infants and children is not recommended to support a favorable neurological prognosis.

Synopsis

EEG is broadly used to monitor for subclinical seizures and to assess background states after brain injury. Patients who are encephalopathic after cardiac arrest may have subclinical seizures due to cortical injury which cannot be detected without EEG monitoring. Electroencephalography for neurological prognostication has

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promise as it directly assesses neurologic activity. However, studies are limited because most are single center, utilize nonstandardized terminology, lack clinician blinding to EEG data when caring for patients, and do not describe the impact of medications on EEG background. These systematic reviews assessed multiple EEG features including the presence and absence of normal and abnormal EEG features with favorable and unfavorable neurological outcomes.[5,7]

Recommendation-Specific Supportive Text

1. EEG monitoring up to 72 hours after ROC identifies EEG background features and diagnoses electrographic seizures. In patients who are encephalopathic, clinical exams can be unreliable and seizures can be subclinical. Electroencephalography is the only way to identify subclinical seizures.[21,22,30,42–46]
2. Ten studies with more than 560 patients evaluated the association of either continuous or routine (brief) EEG at either <1 hour; 6 to 12 hours; 24, 48, 72 hours; or 4 to 6 days with favorable neurological outcome at PICU or hospital discharge or 6 months following cardiac arrest. Among the studies evaluating EEG performed at 6 to 12 and 24 hours post-ROC, 6 of 7 studies had FPRs less than 29% for favorable neurological outcome with sensitivities that ranged from 7% to 100%.[23,30,42,44,45,47,48] Studies at 48 and 72 hours reported FPRs ranging from 0% to 50% for favorable neurological outcome, although 50% of the studied timepoints had FPRs less than 30%.[21,24,29,47]
3. The presence of sleep architecture at 6 to 12 hours or sleep spindles at 24 hours had an FPR of 16% and 8% for favorable neurological outcome, with sensitivities of 57% and 80%, respectively. Sleep spindles or sleep II architecture should not be used as the sole assessment to prognosticate at any timepoint.[23,30]
4. At 6 to 12 and 24 hours post-ROC, the presence of reactivity had an FPR of less than 27% with a sensitivity of 53% to 63% for favorable neurological outcome.[42,44] At 48 hours, 1 study had an FPR of 50%.[44] Thus EEG reactivity, based on these data, is accurate only at 6 to 24 hours, not 48 hours for favorable neurological outcome.
5. The presence of status epilepticus predicted unfavorable neurological outcomes with a low FPR of 0% at 24 to 72 hours after ROC in 3 studies,[21,24,48] but an FPR of 4% to 5% at 4 to 6 hours and 6 to 12 hours, all with low sensitivity.[42,45] Thus, the presence of status epilepticus at 24 to 72 hours is moderately predictive for unfavorable neurological outcome. The presence of burst suppression, burst attenuation or generalized periodic epileptiform discharges within 24 hours of ROC had an FPR that ranged from 0% to 19% and sensitivity of 9% to 30% for unfavorable neurological outcome.[23,44,45,49] From 48 to 72 hours after ROC, 3 studies had FPRs <1% (95% CI, upper limit range 16%–54%) with sensitivities of 0% to 67% for unfavorable neurological outcome.[21,22,24] The prediction of unfavorable neurological outcome was moderately reliable from 24 to 72 hours.
6. Two studies of 61 patients, of which 8 had myoclonic status epilepticus, had an FPR of 0% (95% CI, 0%–34%) and sensitivity of 17% to 21% at PICU/hospital discharge.[22,44] The presence of attenuated, isoelectric, or flat EEG before 24 hours in 5 studies had FPRs ranging from 6% to 95%,[23,42,45,47,49] except for 2 studies that had and FPR of 0% with upper limit confidence intervals of 4% to 31%.[30,50] In 6 studies from 48 hours to 7 days, 2 had FPRs <1% with 95% CI up to 34% to 52%[22,44]; while other studies had FPRs that ranged from 3% to 71%.[21,29,47,51] There are conflicted data and further study is needed.
7. Of 10 studies, the presence of seizures between 4 to 6 hours and 24 hours post-ROC had an FPR of 0% to 20%, of which only 1 had an FPR of <1% with wide confidence intervals[44,45,50] and a sensitivity of 2% to 38% for predicting unfavorable neurological outcome.[27,30,34,42,44,45,48–50] At 48 hours and onward only 2 studies reported an FPR for predicting unfavorable outcome of <1%[41,44]; others had FPRs up to 58%. The presence of seizures is accurate to predict unfavorable neurologic outcome at any of these timepoints. The absence of a normal/continuous EEG background patterns (defined as normal, continuous, and reactive; continuous and unreactive; and nearly continuous) by ACNS definitions[52] had variability and high FPRs ranging from 0% to 90%[21–24,29,30,42,44,45,47–50]; only 2 studies had an FPR <1%.[48,51] The absence of a normal/continuous EEG background pattern is not accurate to predict unfavorable neurological outcome. The absence of EEG reactivity had an FPR of 0% to 93% and sensitivity of 36% to 100%[21,42,44]; absence of sleep II architecture had an FPR of 0% to 43% and sensitivity of 84% to 92%[23,30,42]; and absence of variability on EEG[42,44] had an FPR of 0% to 80% and sensitivity of 21% to 82% for unfavorable neurological outcome prediction. These were unreliable tests for unfavorable outcome prediction.
8. Absence of attenuated, isoelectric or flat EEG to predict favorable neurological outcome was assessed in 10 studies.[21–23,29,30,42,44,45,47,51] The FPR was greater than 40% in most studies and the sensitivity was high in most studies at all timepoints (71%–100%).[23,30,42,44,45,47,51] While the absence of burst suppression, burst attenuation, or generalized periodic epileptiform discharges had

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a sensitivity for favorable neurological outcome of >81% at all timepoints, the FPR was >67% at all timepoints.[21–23,42,44,45] These EEG features should not be used to predict favorable neurological outcome.

9. The absence of seizures had FPRs of 58% to 100% and sensitivities that ranged from 50% to 100% for favorable neurological outcome at PICU or hospital discharge, or 6 or 12 months post–cardiac arrest.[21,22,27,30,34,35,42,44,45,51] Absence of status epilepticus at 6 to 12 or 72 hours had a high sensitivity (>96%) for favorable neurological outcome, but very high FPRs (75% to 91%).[21,24,42,45] The absence of myoclonus in the 48 hours post–cardiac arrest was 100% sensitive for favorable neurological outcome but had high FPRs (79% to 83%).[22,44] Thus these EEG features should not be used to predict favorable neurological outcome at any timepoint.

Recommendations for Prognostication Using Neuroimaging Following Cardiac Arrest		
COR	**LOE**	**Recommendations**
2b	**B-NR**	1. When interpreted in the context of other prognostic criteria, it may be reasonable to use normal brain magnetic resonance imaging (MRI) between 72 h and 2 wk after cardiac arrest in infants and children to support a favorable neurological prognosis.
2b	**C-LD**	2. When interpreted in the context of other prognostic criteria, it may be reasonable to use an abnormal brain MRI showing high ischemic burden at 72 h or later after cardiac arrest in infants and children to support an unfavorable neurological prognosis.
2b	**C-LD**	3. When interpreted in the context of other prognostic criteria, it may be reasonable to use a CT with loss of gray-white matter differentiation within 24 h after cardiac arrest in infants and children to support an unfavorable neurological prognosis.
3: No Benefit	**C-LD**	4. A normal brain CT scan within the first 48 h after cardiac arrest in infants and children is not recommended to support a favorable neurological prognosis.

Synopsis

Early neuroimaging after cardiac arrest is useful to detect structural brain injury and potential etiologies of cardiac arrest that may be amenable to intervention such as evacuation of intracranial hemorrhage. MRI can assess the severity of cytotoxic injury through diffusion weighted imaging. Ischemic injury on diffusion weighted imaging peaks at days 3 to 7 after cardiac arrest and may have the appearance of normalizing, or "pseudonormalization," 2 weeks after injury. Both computed tomography (CT) and MRI findings evolve over the days after cardiac arrest and must be interpreted in the context of other findings and based on time from injury. Studies assessing neuroimaging for the prediction of neurological outcome require careful interpretation as they are limited by retrospective designs where health care professionals have likely used imaging results to guide treatment decisions.

Recommendation-Specific Supportive Text

1. In 3 studies, absence of diffusion restriction or absence of any abnormality on MRI had a sensitivity of 42% to 88% with FPRs of 0% to 2% for favorable neurological outcome.[24,51,53] Apparent diffusion coefficient thresholds of $>600\times10^{-6}$ mm^2/s in >93% and $>650\times10^{-6}mm^2/s$ in >89% of brain volume, at a median of 4 days after ROC, predicted favorable neurological outcome with a sensitivity of 100% and low FPR of 20%.[54] While the absence of specific regional abnormalities on MRIs were highly sensitive for favorable neurological outcome, they had very high FPRs.[31,55]
2. In 3 studies, the presence of high burden of ischemia defined as apparent diffusion coefficient threshold $<650\times10^{-6}$ mm^2/s in ≥10% of brain volume at a median of 4 days after ROC, predicted unfavorable neurological outcome with a sensitivity of 49% to 52% and an FPR of 0% to 6% (95% CI, 1%–21%)[49,54,56] but only 1 had an FPR <1% with a sensitivity of 80%.[54] The presence of diffusion restriction based in any brain region based on nonstandardized definitions at a median of 4 days and up to 14 days had high FPR (12%–58%) for unfavorable neurological outcome.[24,56] The studies found that the abnormalities in diffusion weighted imaging, T1-, and T2-weighted imaging in individual regions of the brain, at 4 to 6 days post-ROC, predicted unfavorable outcome with FPR of 0% to 10% but wide confidence intervals up to 50%.[24,31,55]
3. One study of 78 children had an FPR 0% (CI 0%–12%) and sensitivity of 65% for the loss of gray-white matter differentiation on CT within 24 hours of arrest to predict unfavorable neurological outcome (PCPC >3) at hospital discharge.[16] Clinicians were not blinded to the CT results in any study.
4. In 2 studies, the absence of grey-white matter differentiation on CT within 24 hours from ROC had a sensitivity of 64% to 100% with an FPR between 35% and 75% for favorable neurological outcomes at hospital discharge.[16,57] Absence of a reversal sign and cistern or sulcal effacement had high FPRs that ranged from 14% to 80% sensitivities despite sensitivities that ranged from 93% to 100%.[16,57] Normal CT early after cardiac arrest is not accurate to predict favorable neurologic outcome.

Figure 4 provides a timeline summary of recommendations for prognosticating good or bad neurologic outcomes.

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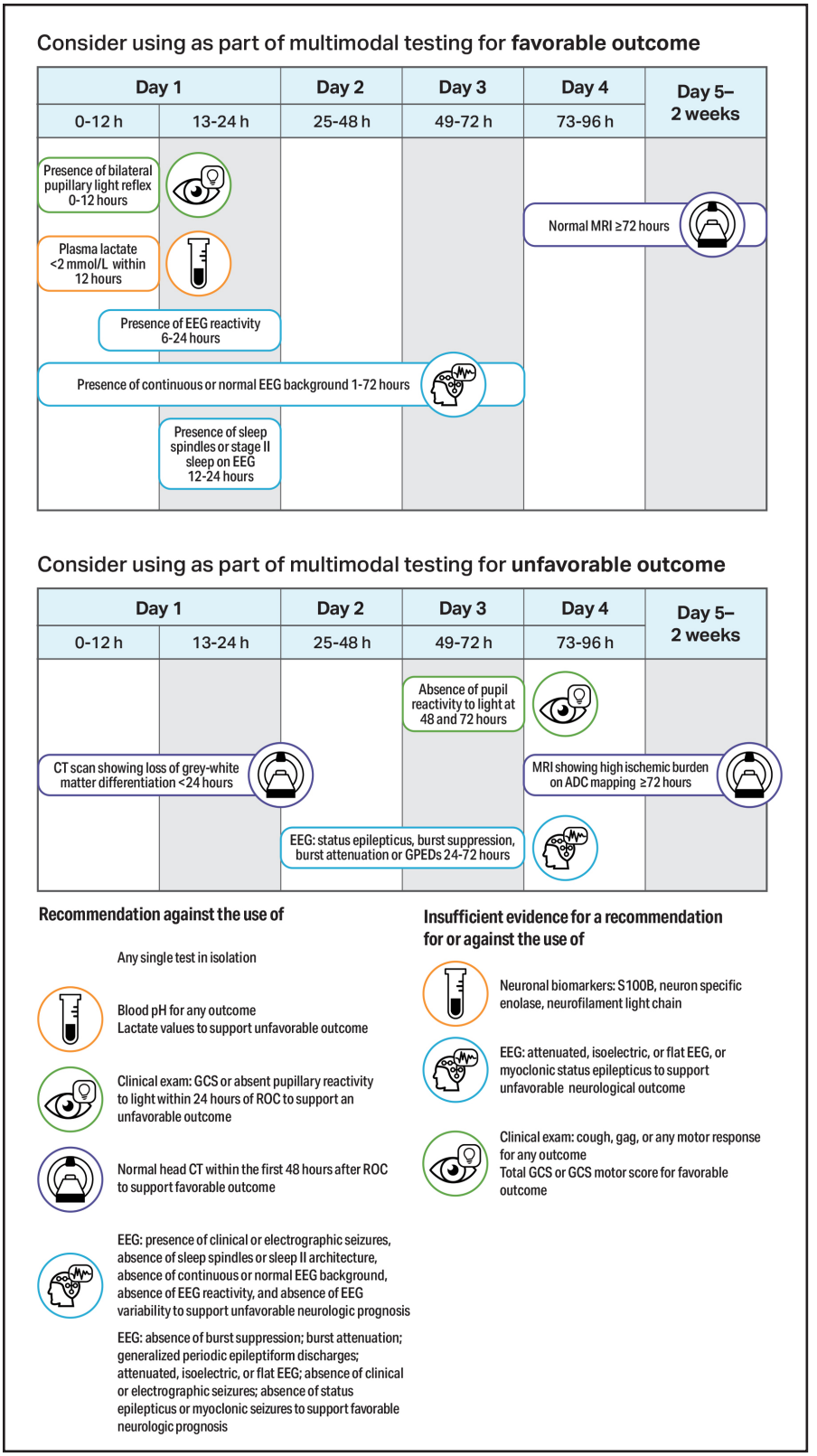

Figure 4. Recommendations for neuroprognostication testing modalities and timing.

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POST–CARDIAC ARREST RECOVERY AND SURVIVORSHIP

Recommendations for Post–Cardiac Arrest Recovery and Survivorship		
COR	**LOE**	**Recommendations**
1	C-LD	1. It is recommended that infants and children who survive cardiac arrest be evaluated for rehabilitation services.
2a	B-NR	2. It is reasonable that infants and children who survive cardiac arrest be evaluated for physical, cognitive, and emotional needs to guide follow-up care within the first year following cardiac arrest.

Synopsis

Survivors of both in-hospital and out-of-hospital cardiac arrest are at significant risk for both short-term and long-term physical, neurological, cognitive, emotional, and social morbidities.[1–3] Children who survive a cardiac arrest with a grossly favorable outcome on the PCPC scale may have more subtle and sustained neuropsychological impairment.[4] The full impact of brain injury on children's development may not be fully appreciated until months to years after the cardiac arrest and discharge outcome does not necessarily predict long-term outcome, as some survivors with unfavorable outcome improve and others with favorable outcome at discharge worsen over time.[5] Recovery and Survivorship is the sixth ring in the Chain of Survival and acknowledges that survivors of cardiac arrest may require ongoing integrated medical, rehabilitative, caregiver, and community support in the months to years after their cardiac arrest (see Figure 5).[6] The overall societal burden of pediatric OHCA was assessed from

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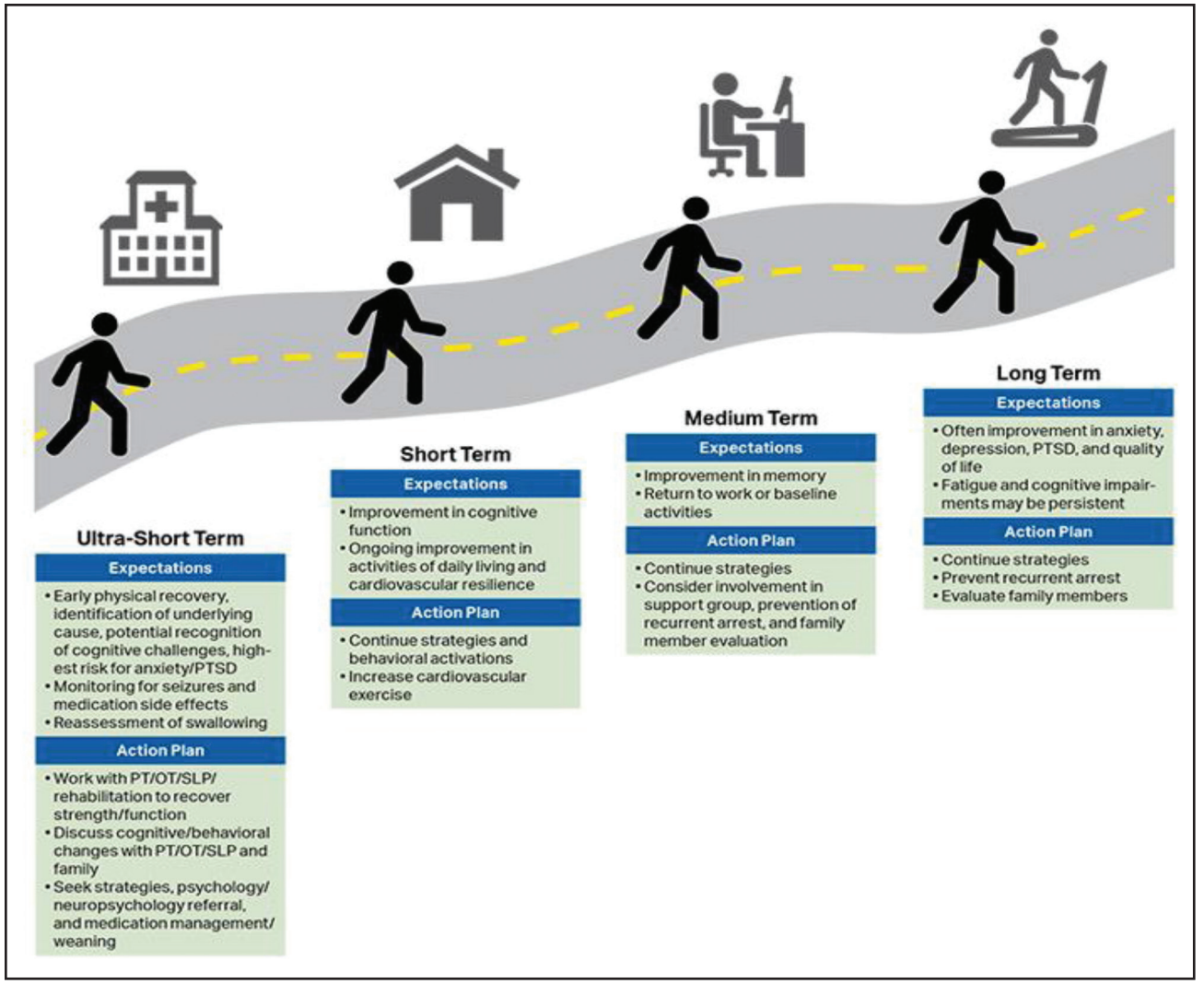

Figure 5. Roadmap to recovery.

2016 to 2020, in terms of disability-adjusted life years as a common public health metric to estimate burden of disease, placing nontraumatic OHCA as 1 of the top 10 leading causes of annual disability-adjusted life years.[7]

Recommendation-Specific Supportive Text

1. Two randomized controlled trials of TTM for comatose children after IHCA or OHCA, with a primary outcome of favorable neurobehavioral function defined by the Vineland Adaptive Behavioral Score at 1 year post–cardiac arrest, showed that new morbidity in survivors is common.[8,9] Many children who survived to 1 year with a favorable neurobehavioral outcome on Vineland Adaptive Behavior Scales-II had global cognitive impairment or selective neuropsychological deficits.[10]
2. Recent statements from the AHA highlight the importance of follow-up after discharge.[1,11] Several case series of pediatric cardiac arrest outcomes at greater than 1 year post–cardiac arrest demonstrate ongoing cognitive, physical, and neuropsychological impairments.[2–5] Longitudinal follow-up studies up to 5 years after cardiac arrest identified cognitive and behavioral deficits in pediatric survivors who had absent or minimal neurologic change from prearrest baseline at hospital discharge.[5,10] Compared to healthy controls, survivors of cardiac arrest have specific cognitive deficits correlated with structural brain abnormalities demonstrated on MRI.[12] Patients discharged with functional impairments often face years of impaired function and significant health care needs. The impact of ongoing childhood development on recovery following pediatric cardiac arrest is unknown.

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FAMILY PRESENCE DURING RESUSCITATION

Recommendations for Family Presence During Resuscitation		
COR	**LOE**	**Recommendations**
1	B-NR	1. Family members should be provided the option of being present during the resuscitation of their infant or child.
1	B-NR	2. When family members are present during resuscitation of their infant or child, it is recommended for a designated team member to provide comfort, answer questions, and support the family.
1	C-LD	3. If the presence of family members is considered detrimental to the resuscitation of the infant or child, family members should be respectfully asked to leave.

Synopsis

The practice of allowing family presence during resuscitation has become more common over the last 25 years.[1] Parents may desire to be present during their child's resuscitation to provide emotional support, share information with the care team,[2] and observe resuscitation measures. Parental presence may offer a sense of involvement, reduce helplessness, and provide closure.[3] Presence at their child's death can lead to lower rates of anxiety and depression as well as improved grieving behaviors such as social withdrawal and changes in activity levels.[4,5]

Health care professionals' perspectives on family presence differ significantly, but acceptance generally rises with prior experience and among senior professionals.[3] Parental presence can be encouraged by providing parents with adequate support and consistent updates throughout the resuscitation process, benefiting both the family and the health care team. While health care professionals often worry about the potential negative psychological effects on families, evidence suggests benefit for families to be present during resuscitation of their child.

Recommendation-Specific Supportive Text

1. A systematic review of qualitative survey-based studies reported that 85% of parents surveyed expressed a desire to be present during their child's resuscitation.[6] Additionally, parents of 272 children who underwent resuscitation perceived benefits from their presence, such as reduced anxiety and improved understanding and processing of the event.[6] The presence of family members can enhance parental satisfaction with the care provided, provide families with a greater sense of control,[7] and improve self-reported adjustment to the loss of their child.[3,8] Additionally, parent surveys indicated a strong desire to be present to understand what was happening, ensure that all possible measures were being taken, and maintain physical contact with their child.[3,9,10] Not all parents who have witnessed their child's resuscitation would choose to do so again.[11] While concerns have been raised regarding family presence during resuscitation including potential trauma for the family, interference with procedures, effects on technical performance, and challenges for teaching and clinical decision-making, these concerns have not been substantiated by current evidence.[7,12–14]

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2. The presence of a facilitator to support families is beneficial and helps reduce stress.[15–19] One study reported that 72% of health care professionals support the use of a dedicated staff member for this role during resuscitation.[20] A systematic review emphasized the significance of family facilitators in providing emotional support and reducing parental anxiety during resuscitation.[21] Team members serving as communication liaisons have been reported to update families in real-time, explain medical terminology, and ensure effective two-way communication. Both parents and health care professionals emphasized the importance of training personnel to support family presence.[22,23] A qualitative study highlighted essential competencies for facilitators, such as the ability to provide active listening, foster partnership, and facilitate communication between the family and resuscitation team leader.[20] In addition, 2 systematic reviews showed that parents often seek spiritual and cultural comfort during pediatric resuscitations.[19,21] Including spiritual health care professionals/chaplains can help align clinical care with families' needs, enhance the emotional safety of resuscitations, and support long-term healing.[24] While having a dedicated team member to support families during resuscitations can help in the processing of traumatic events, this may not always be feasible, and the absence of such a team member does not preclude family presence during resuscitation.
3. Most surveys suggest that family presence during resuscitation is not disruptive, although some health care professionals report increased stress.[25] Health care professionals with extensive experience in family presence recognize that occasional negative experiences may occur.[26] Concerns have been raised by both health care professionals and family members that parental presence during resuscitation may be distracting and could impact the resuscitation. Health care professionals, in particular, often worry about the risk of litigation and the potential negative psychological effects on families.[3,7] One randomized trial found that witnessed resuscitation increased health care professionals' anxiety yet reduced anxiety in family members.[27] In randomized controlled simulation studies, family presence did not affect hands-on time or CPR quality, but led to increased frustration, perceived temporal demands, and mental demands on health care professionals.[28,29]

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EVALUATION OF SUDDEN UNEXPLAINED CARDIAC ARREST

Recommendations for the Evaluation of Sudden Unexplained Cardiac Arrest		
COR	**LOE**	**Recommendations**
1	B-NR	1. A complete unrestricted autopsy of infants and children with sudden unexplained death is recommended, preferably performed by a pathologist with training and experience in cardiovascular pathology with preservation of biological material for further genetic analysis to determine the presence of inherited cardiac disease.
1	B-NR	2. When conventional autopsy does not identify a cause of death or diagnosis in infants and children with sudden unexplained death, a postmortem genetic evaluation is recommended, when resources allow, especially if clinical evidence suggests the diagnosis of an inherited cardiac disease.
1	B-NR	3. When autopsy does not identify a cause of death or is not performed in infants and children with sudden unexplained death, it is recommended that first-degree family members be referred to a health care professional or center with expertise in inherited cardiac disease and cardiac genetic counseling.
1	C-EO	4. For infants and children who survive sudden unexplained cardiac arrest, obtain a complete past medical and family history (including a history of syncopal episodes, seizures, unexplained accidents or drowning, or sudden unexpected death before 50 y of age), review previous electrocardiograms, and refer to a cardiologist with expertise in inherited cardiac disease.

Synopsis

Inherited cardiac diseases (ie, cardiomyopathies, channelopathies), and coronary artery anomalies are common causes of sudden unexplained cardiac arrest in infants and children. In patients who do not survive, autopsy plays an essential role to correctly identify the etiology of the cardiac arrest. Up to one third of young patients who do not survive sudden unexplained cardiac arrest have no abnormalities found on gross and microscopic autopsies.[1–4] Postmortem genetic evaluation ("molecular autopsy") is increasingly used as an important tool to evaluate potential causes of sudden unexplained death and identify inheritable cardiac diseases.[5] In addition to providing an explanation, genetic diagnosis can enable necessary screening and preventive measures for relatives and survivors.

Recommendation-Specific Supportive Text

1. Previous reviews and consensus guidelines state the importance of an autopsy following sudden unexplained cardiac death to aid in determining the cause of death and to identify possible inherited cardiac conditions.[6–9] An autopsy can identify several causes of death in infants and children with sudden unexplained cardiac death, including cardiomyopathy (ie, hypertrophic, dilated, or arrhythmogenic) and anomalous coronary arteries. When no cause of death is identified on gross examination, microscopic evaluation and preservation of biological tissue is paramount to be able to perform a molecular autopsy if resources allow.
2. Previous systematic reviews and consensus guidelines emphasize the use of postmortem genetic testing for inherited cardiac causes of sudden death (ie, cardiomyopathies, channelopathies). A review reported up to 50% of sudden cardiac death cases in infants and children had a potential genetic disease identified.[7] In multiple studies, genetic mutations causing channelopathies were identified in 2% to 10% of infants with sudden infant death syndrome.[10–16] Among children with sudden unexplained death and a normal autopsy, 9 cohort studies report identification of genetic mutations associated with channelopathy or cardiomyopathy.[14,17–24]
3. In multiple studies, 13% to 53% of first- and second-degree relatives of patients with unexplained cardiac arrest were diagnosed with inherited cardiac disease after screening using medical and family history, clinical exam, and laboratory evaluation.[7,17–20,25–32] A small case series suggested that genetic screening of family members should be directed by clinical history.[17]
4. A retrospective study of 155 adult survivors of nonischemic sudden cardiac arrest reported 49% of survivors were diagnosed with an inherited cardiac condition.[27] Several cohort studies report the utility of obtaining a complete past

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medical and family history, including multigenerational pedigree, after sudden unexplained cardiac arrest as well as review of prior electrocardiograms. Three small cohort studies and 1 population-based study reported relevant clinical symptoms or medical comorbidities before cardiac arrest, such as seizure, syncope, palpitations, chest pain, left arm pain, and shortness of breath, among patients who had a sudden unexplained cardiac arrest.[18,19,21,22]

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MANAGEMENT OF SHOCK

Fluid Resuscitation and Management of Septic Shock

Recommendations for Fluid Resuscitation and Management of Septic Shock		
COR	LOE	Recommendations
1	C-LD	1. Health care professionals should reassess infants and children after every fluid bolus to assess for fluid responsiveness and signs of volume overload.
2a	B-R	2. Either isotonic crystalloids or colloids can be effective as the initial fluid choice for resuscitation in infants and children.
2a	B-NR	3. Either balanced or unbalanced solutions can be effective as the fluid choice for resuscitation in infants and children.
2a	C-LD	4. In infants and children with septic shock, it is reasonable to administer fluid in 10-mL/kg or 20-mL/kg aliquots with frequent reassessment.
2a	C-LD	5. In infants and children with fluid-refractory septic shock, it is reasonable to use either epinephrine or norepinephrine as an initial vasoactive infusion.
2a	C-EO	6. For infants and children with cardiac arrest and sepsis, it is reasonable to apply the standard PALS algorithm compared with any unique approach for sepsis-associated cardiac arrest.
2b	B-NR	7. For infants and children with septic shock unresponsive to fluids and requiring vasoactive support, it may be reasonable to consider stress-dose corticosteroids.
2b	C-LD	8. In infants and children with fluid-refractory septic shock, if epinephrine or norepinephrine are unavailable, dopamine may be considered.

Synopsis

Shock is the failure of oxygen delivery to meet tissue metabolic demands and can be life threatening. The most common type of pediatric shock is hypovolemic, including hemorrhagic shock, with distributive, cardiogenic, and obstructive shock occurring less frequently. Multiple types of shock can occur simultaneously, and early presentations can be subtle; health care professionals must be vigilant.

Shock progresses over a continuum of severity, from a compensated to a decompensated (hypotensive) state. Compensatory mechanisms include tachycardia and increased systemic vascular resistance to maintain cardiac output and end-organ perfusion. As compensatory mechanisms fail, hypotension and signs of inadequate end-organ perfusion develop, such as depressed mental status, decreased urine output, acidosis, and weak central pulses.

Sepsis is a life-threatening response to infection, where the body's immune system overreacts, leading to widespread inflammation and organ dysfunction. Septic shock is characterized as sepsis with cardiovascular dysfunction including hypotension. Early recognition and prompt treatment (eg, antibiotics, fluids) are critical for improving outcomes in infants and children. Mortality from pediatric sepsis has declined, concurrent with implementation of guidelines emphasizing early antibiotic and fluid administration.[1] Controversies in septic shock management include volume and type of fluid administration, vasopressor timing and choice, and use of corticosteroids. Previous AHA guidelines[2] had considered large studies of patients with malaria, sickle cell anemia, and dengue shock syndrome; however, generalization of results from these studies is problematic.

This topic was last reviewed in the *2020 AHA Guidelines for CPR and ECC*. These recommendations have not been updated for this edition of the Guidelines, with the exception of No. 6, which was reviewed and updated.[3]

Recommendation-Specific Supportive Text

1. Although fluids remain the mainstay initial therapy for infants and children in shock, especially in hypovolemic and septic shock, fluid overload can lead to increased morbidity.[4] In 2 randomized trials of patients with septic shock, those who received higher fluid volumes[5] or faster fluid resuscitation[6] were more likely to develop clinically significant fluid overload characterized by increased rates of mechanical ventilation and worsening oxygenation.
2. In a systematic review, 12 relevant studies were identified, though 11 assessed colloid or crystalloid fluid resuscitation in patients with malaria, dengue shock syndrome, or "febrile illness" in sub-Saharan Africa.[7] There was no clear benefit to crystalloid or colloid solutions as first-line fluid therapy in any of the identified studies.
3. One randomized controlled trial compared the use of balanced (lactated Ringer's solution) to unbalanced (0.9% saline) crystalloid solutions as the initial resuscitation fluid and showed no difference in relevant clinical outcomes.[8] A matched retrospective cohort study of pediatric patients with septic shock showed no difference in outcomes,[9] though a propensity-matched database study showed an association with increased 72-hour mortality and vasoactive infusion days with unbalanced crystalloid fluid resuscitation.[10]
4. In a small, randomized controlled study, there were no significant differences in outcomes with the use of 20 mL/kg as the initial fluid bolus volume in septic shock, compared to 10 mL/kg; however, the study was limited by a small sample size.[5]
5. Two pediatric randomized controlled trials comparing escalating doses of dopamine or epinephrine demonstrated improvement in timing of resolution of septic shock[11] and 28-day mortality[12] with the use of epinephrine over dopamine. Both studies were conducted in resource-limited settings, and the doses of inotropes used may not have been directly comparable, limiting conclusions from the

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studies. Medications that increase systemic vascular resistance, such as norepinephrine, may also be a reasonable initial vasopressor therapy in septic shock patients.[1,13–15] International sepsis guidelines recommend the choice of medications to be guided by patient physiology and clinician preferences.[1]

6. No studies support deviations from standard life-support algorithms to improve outcomes in patients with sepsis-associated cardiac arrest. Sepsis-associated cardiac arrest is associated with worse outcomes than other causes of cardiac arrest.[16]
7. A meta-analysis[17] showed no change in survival with corticosteroid use in pediatric septic shock, though a subsequent randomized controlled trial suggested a shorter time to reversal of shock with steroid use.[18] Two observational studies[19,20] suggested there may be specific subpopulations, based on genomics, that would either benefit or experience harm from steroid administration, though these subpopulations are difficult to identify clinically. Patients at risk for adrenal insufficiency (eg, those on chronic steroids, patients with purpura fulminans) are more likely to benefit from steroid therapy.[14]
8. In situations when epinephrine or norepinephrine are not available, dopamine is a reasonable alternative initial vasoactive infusion in patients with fluid-refractory septic shock.[11,12] Patients with vasodilatory shock may require a higher dose of dopamine.[13]

Management of Cardiogenic Shock

Recommendations for Management of Cardiogenic Shock		
COR	**LOE**	**Recommendations**
1	**C-EO**	1. For infants and children with cardiogenic shock, early expert consultation is recommended.
2b	**C-EO**	2. For infants and children with cardiogenic shock, it may be reasonable to use epinephrine, dopamine, dobutamine, or milrinone as an inotropic infusion.

Synopsis

Cardiogenic shock occurs when the heart is unable to pump blood efficiently, resulting in decreased cardiac output and inadequate oxygen delivery to tissues. While it is relatively rare in children compared to other forms of shock, it is associated with high rates of mortality.[21] Causes of cardiogenic shock include congenital heart disease, myocarditis, cardiomyopathies, and arrythmias. Clinical manifestations vary by severity and underlying cause. Initial compensatory mechanisms include tachycardia, tachypnea, and increased systemic vascular resistance. As compensatory mechanisms fail, hypotension and signs of inadequate end-organ perfusion develop, such as depressed mental status, decreased urine output, lactic acidosis, and weak central pulses. Initial treatment is focused on improving oxygen delivery, minimizing oxygen consumption, and restoring cardiac function through administration of vasoactive medications. It is important to note that cardiogenic shock can occur with other forms of shock simultaneously. In its early stages, it can be difficult to diagnose, so a high index of suspicion is warranted. This topic was last reviewed in the *2020 AHA Guidelines for CPR and ECC*. These recommendations have not been updated for this edition of the Guidelines.[3]

Recommendation-Specific Supportive Text

1 and 2. Cardiogenic shock in infants and children is uncommon and associated with high mortality rates. No studies were identified comparing outcomes between vasoactive medications. For patients with hypotension, vasoactive medications such as epinephrine may be more appropriate as an initial inotropic therapy. Because of the rarity and complexity of these presentations, expert consultation is recommended when managing infants and children in cardiogenic shock.

Management of Traumatic Hemorrhagic Shock

Recommendation for Management of Traumatic Hemorrhagic Shock		
COR	**LOE**	**Recommendation**
2a	**C-EO**	1. Among infants and children with hypotensive hemorrhagic shock following trauma, it is reasonable to administer blood products, when available, instead of crystalloid for ongoing volume resuscitation.

Synopsis

Resuscitation guidance for children with hemorrhagic shock is evolving, as crystalloid-then-blood paradigms are being challenged by resuscitation protocols using blood products early in resuscitation. However, the ideal resuscitation strategy for a given type of injury is often unknown.

This topic was last reviewed in the *2020 AHA Guidelines for CPR and ECC*. These recommendations have not been updated for this edition of the Guidelines.[3]

Recommendation-Specific Supportive Text

1. There are no prospective pediatric data comparing the administration of early blood products versus early crystalloid for traumatic hemorrhagic shock. A scoping review identified 6 retrospective studies that compared patient outcomes with the total volume of crystalloid resuscitation received in the first 24 to 48 hours among children with hemorrhagic shock.[22–27] Four studies reported no differences in survival to 24 hours, survival at 30 days with good neurological outcome, or survival to discharge.[22,24–26,28] Large-volume resuscitation was associated with increased hospital/ICU length of stay in 5 of the

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6 studies.[23–28] One study reported lower survival to hospital discharge among children who received more than 60 mL/kg crystalloid compared to lower volume groups.[27] Despite limited pediatric data, guidelines for adults from the Eastern Association for the Surgery of Trauma,[29] the American College of Surgeons, and the National Institute for Health and Care Excellence[30] suggest the early use of balanced ratios of packed red blood cells, fresh frozen plasma, and platelets for trauma-related hemorrhagic shock.[29] The American College of Surgeons and the National Institute for Health and Care Excellence[30] suggest the early use of balanced ratios of packed red blood cells, fresh frozen plasma, and platelets for trauma-related hemorrhagic shock.

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INTUBATION

Use of Cuffed Endotracheal Tubes for Intubation

Recommendations for the Use of Cuffed Endotracheal Tubes for Intubation		
COR	**LOE**	**Recommendations**
1	**C-EO**	1. When a cuffed endotracheal tube (ETT) is used in infants and children, attention should be paid to ETT size, position, and cuff inflation pressure (usually <20–25 cm H_2O).
2a	**B-NR**	2. It is reasonable to choose cuffed ETTs over uncuffed ETTs for intubating infants and children.

Synopsis

Cuffed and uncuffed ETTs have been studied in the perioperative period and up to 48 hours postintubation. These studies have shown that cuffed ETTs are safe in infants and children and are not associated with significant differences in postextubation airway complications.[1–6] The primary advantage of cuffed ETTs over uncuffed tubes is a reduction in the need for ETT changes, which reduces high-risk reintubations and interruptions in chest compressions during CPR that may occur during reintubation. Additional potential benefits include improved capnography accuracy and a lower risk of atelectasis.[2,5–13] Although several studies have identified that cuffed tubes may decrease airway trauma by decreasing tube exchanges, attention must be directed to selecting the correct tube size[3] and cuff inflation pressure.[14] ETT cuff pressures are dynamic during transport at altitude,[15] and with increasing airway edema or pressure, make it necessary to monitor the cuff pressure to avoid damage to the airway mucosa.

Recommendation-Specific Supportive Text

1. A retrospective study of 155 neonates and children under 12 years of age undergoing cardiac surgery with cardiopulmonary bypass and intubated for at least 4 hours postoperatively found larger ETT size as the only significant factor associated with airway complications.[3] A retrospective study of 2953 children found that applying 25 cm H_2O of cuff pressure with a slight leak around the ETT resulted in no cases of clinically significant subglottic stenosis and the incidence of reintubation for stridor was less than 1%.[1]
2. Three systematic reviews, 5 randomized controlled trials, and 3 retrospective reviews support the safety of cuffed ETTs in infants and children.[2–5,7–13] While these studies were almost entirely performed in the perioperative patient population, 2 studies included patients who remained intubated for 4 hours[3] or over 12 hours postoperatively.[5] An additional retrospective review evaluating the use of perioperative cuffed ETTs in 1162 infants weighing 2 to 5 kg demonstrated no increase in postoperative airway complications.[6] The use of cuffed ETTs is associated with lower reintubation rates, more successful ventilation, and improved accuracy of capnography without increasing the risk of complications.[2,5–9,11–13,16–18] Cuffed ETTs may also decrease the risk of aspiration and atelectasis.[5,19,20]

The Use of Cricoid Pressure During Intubation

Recommendations for the Use of Cricoid Pressure During Intubation		
COR	**LOE**	**Recommendations**
3: No Benefit	**C-LD**	1. Routine use of cricoid pressure to reduce the risk of regurgitation is not recommended during bag-mask ventilation of infants and children.
3: No Benefit	**C-LD**	2. Routine use of cricoid pressure is not recommended during tracheal intubation of infants and children.
3: Harm	**C-LD**	3. If cricoid pressure is used, discontinue if it interferes with ventilation or the speed or ease of tracheal intubation in infants and children.

Synopsis

Cricoid pressure during bag-mask ventilation and during intubation has historically been utilized to minimize the risk of regurgitation of gastric contents into the airway while potentially aiding in visualization of laryngeal structures.[21,22] However, uniform application of cricoid pressure may impede bag-mask ventilation or obscure visualization of the airway during laryngoscopy.[23–25] Cricoid pressure should be distinguished from external laryngeal manipulation where pressure is applied to the larger thyroid cartilage to facilitate airway visualization.[26]

Recommendation-Specific Supportive Text

1. A retrospective study from a large international pediatric ICU intubation registry showed that cricoid pressure during bag-mask ventilation before tracheal intubation was not associated with lower rates of regurgitation.[26]

2 and 3. A bronchoscopic study of 30 children revealed distortion of the airway with the application of cricoid pressure at forces below those recommended by usual intubation guidelines.[27] Acknowledging anatomic differences in the airway from infancy through adulthood, relevant adult data was considered, given limited pediatric data for the use of cricoid pressure in pediatric patients. A systematic review of cricoid pressure during rapid sequence intubation in adult emergency department patients found insufficient evidence to conclude if

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cricoid pressure affected the rate of first pass intubation success or the incidence of complications such as aspiration.[25] In a study of 60 adult patients undergoing elective anesthesia, cricoid pressure interfered with bag-mask ventilation in over 50% of patients.[24]

Atropine Use for Emergency Intubation

Recommendations for Atropine Use for Emergency Intubation		
COR	LOE	Recommendations
2b	C-LD	1. It may be reasonable to use atropine as a premedication to prevent bradycardia in infants and children during emergency intubation.
2b	C-LD	2. When atropine is used as a premedication for emergency intubation of infants and children, a dose of 0.02 mg/kg with no minimum dose may be considered.

Synopsis

Pediatric emergency intubation is a lifesaving, high-risk procedure that can be complicated by hypoxemia, bradycardia, hypotension, and cardiac arrest. Peri-intubation bradycardia may occur in response to (1) the underlying disease process that led to respiratory failure, (2) hypoxemia, (3) medications given for rapid sequence intubation, (4) the transition from negative to positive pressure ventilation, and (5) vagus nerve stimulation during laryngoscopy and endotracheal intubation, particularly in infants.[28,29] Previous guidelines have discouraged the routine administration of atropine before intubation but state that atropine pretreatment may be reasonable to prevent vagally mediated bradycardia in select populations.[30] Observational studies demonstrate an association between atropine pretreatment and decreased bradycardia, higher heart rates without ventricular arrhythmias, and increased ICU survival.[31,32] However, there is little evidence to support the use of atropine as a pretreatment for the prevention of peri-intubation cardiopulmonary compromise or cardiac arrest.

Recommendation-Specific Supportive Text

1. Two prospective, observational studies conducted between 2007 and 2009 in patients <8 years of age intubated in the PICU or by critical care transport teams showed associations between atropine pretreatment and (1) decreased ICU mortality after propensity score adjustment and (2) significant acceleration in heart rate without provoking arrhythmias and a decrease in bradycardia.[31,32] Conversely, 4 retrospective, observational studies did not demonstrate an association between atropine use and occurrence of bradycardia during the peri-intubation period.[33–36]
2. Historically, a minimum dose of atropine (0.1 mg) was recommended to prevent paradoxical bradycardia based on a 1971 study of 79 patients undergoing elective surgery, of which 5 participants were between 6 weeks and 3 years of age. These infants and children had a small and statistically insignificant decrease in heart rate after receiving doses of atropine ranging from 0.0018 to 0.0036 mg/kg, approximately 10% to 20% of the recommended dose for atropine pretreatment for intubation.[37] In 2015, in a prospective, observational study of 60 infants less than 15 kg undergoing elective surgery all of whom received <0.1 mg of atropine before intubation, no patient experienced paradoxical bradycardia or arrhythmias.[38]

Monitoring Exhaled CO_2 in Patients With Advanced Airways

Recommendations for Monitoring Exhaled CO_2 in Patients With Advanced Airways		
COR	LOE	Recommendations
1	C-LD	1. In all settings, for infants and children with a perfusing rhythm, exhaled CO_2 detection (colorimetric detector or capnography) should be used for confirmation of ETT placement.
2a	C-LD	2. In infants and children with a perfusing rhythm and ETT in place, it is beneficial to monitor exhaled CO_2 (colorimetric detector or capnography) during out-of-hospital and intra-hospital transport.

Synopsis

Confirmation of ETT placement in patients with a perfusing rhythm is not reliably achieved by auscultation of breath sounds, mist in the tube, or chest rise. Either colorimetric exhaled CO_2 detection or capnography is a more reliable method to assess initial ETT placement. In patients with decreased pulmonary blood flow from low cardiac output or cardiac arrest, exhaled CO_2 may not be reliable.

Recommendation-Specific Supportive Text

1. Although there are no randomized controlled trials linking use of exhaled CO_2 detection with clinical outcomes, the Fourth National Audit Project of the Royal College of Anesthetists and the Difficult Airway Society concluded that the failure to use capnography contributed to adverse events, including death and persistent neurological injury, in a study of adults and children in the ICU and emergency department settings.[39] One small, randomized study showed that capnography was faster than clinical assessment in premature newborns intubated in the delivery room.[40] There has been no difference in patient outcomes in pediatric studies comparing qualitative (colorimetric) and quantitative (capnography or numeric display) exhaled CO_2 detectors in the delivery room, ICU, or emergency department.[41–43]
2. Adult literature suggests monitoring and correctly interpreting capnography in intubated patients may prevent adverse events.[39,44,45] This has

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been demonstrated in pediatric simulation studies, in which capnography improved health care professional recognition and response to ETT dislodgement.[46,47]

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MANAGEMENT OF BRADYCARDIA

Recommendations for the Management of Bradycardia With Cardiopulmonary Compromise

COR	LOE	Recommendations
1	C-LD	1. In infants and children with bradycardia and cardiopulmonary compromise due to increased vagal tone or atrioventricular conduction block not due to factors such as hypoxia, atropine is recommended.
1	C-EO	2. In infants and children with heart rate <60 beats/min and cardiopulmonary compromise despite effective ventilation with oxygen, start CPR.
1	C-EO	3. In infants and children with bradycardia and cardiopulmonary compromise that persists after correction of other factors (eg, hypoxia), give epinephrine IV/IO.
2b	C-EO	4. Emergency transcutaneous pacing may be considered for infants and children with bradycardia and cardiopulmonary compromise due to complete heart block or sinus node dysfunction unresponsive to CPR.

Synopsis

Bradycardia associated with cardiopulmonary compromise, even with a palpable pulse, may be a harbinger of impending pulseless cardiac arrest. As such, bradycardia with a heart rate of less than 60 beats per minute in infants and children should prompt an evaluation for cardiopulmonary compromise, including acutely altered mental status, hypotension or other signs of shock. Correctable factors that contribute to bradycardia include hypoxia, hypotension, hypoglycemia, hypothermia, acidosis, and toxic ingestions.

Recommendation-Specific Supportive Text

1. Atropine increases heart rate in both children and adults.[1–4] As atropine is a vagolytic agent, use is limited to bradycardia with cardiopulmonary compromise due to increased vagal tone or atrioventricular conduction block, but not due to other factors such as hypoxia.
2. Retrospective studies have shown that children who received CPR for bradycardia with cardiopulmonary compromise have better outcomes than children who receive CPR for pulseless cardiac arrest.[5–8] No studies compared outcomes between children with bradycardia and cardiopulmonary compromise who did or did not receive CPR, though 1 study reported 8 patients who received drug therapy without CPR, and all survived to hospital discharge.[9]
3. A retrospective, time-dependent propensity–score matched study of pediatric patients with bradycardia and cardiopulmonary compromise found that patients who received epinephrine had worse outcomes than patients who did not receive epinephrine.[10] A subsequent retrospective study did not show differences in outcomes for patients who did or did not receive "early" epinephrine within the first 2 minutes of CPR for bradycardia and cardiopulmonary compromise.[11] Due to limitations of these studies, further research on the impact of epinephrine on patients with bradycardia and cardiopulmonary compromise is required.
4. There are limited data about transcutaneous pacing for refractory bradycardia in children with or without congenital/acquired heart disease.[12–14] In patients with complete heart block or sinus node dysfunction who have not responded to oxygenation, ventilation, medications, or CPR, emergency transcutaneous pacing may be considered.

Figure 6 shows the algorithm for pediatric bradycardia with a pulse.

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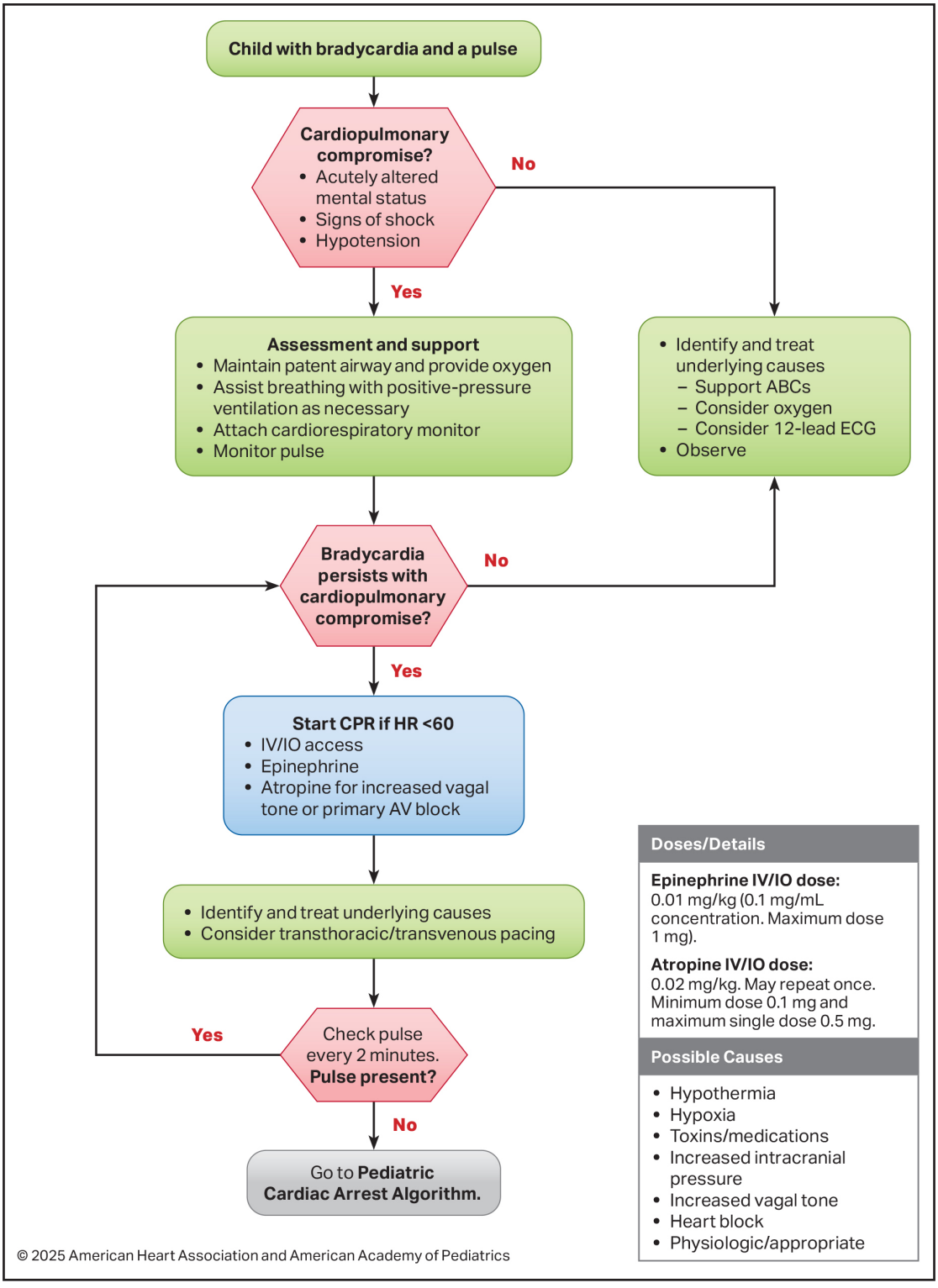

Figure 6. Pediatric Bradycardia With a Pulse Algorithm.

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TACHYARRHYTHMIAS

Treatment of Supraventricular Tachycardia With a Pulse

Recommendations for Treatment of Supraventricular Tachycardia With a Pulse		
COR	**LOE**	**Recommendations**
1	**C-LD**	1. In infants and children with SVT without cardiopulmonary compromise, it is useful to attempt vagal stimulation first.
1	**C-LD**	2. If IV/IO access is readily available, adenosine is recommended for the treatment of SVT in infants and children.
1	**C-EO**	3. For infants and children without cardiopulmonary compromise whose SVT is unresponsive to vagal maneuvers and IV adenosine, expert consultation is recommended.
2a	**C-LD**	4. In infants and children with SVT and cardiopulmonary compromise, it is reasonable to perform electrical synchronized cardioversion starting with a dose of 0.5 to 1 J/kg. If unsuccessful, increase the dose to 2 J/kg.
2b	**C-LD**	5. For infants and children with SVT and cardiopulmonary compromise unresponsive to vagal maneuvers, adenosine, and electrical synchronized cardioversion and for whom expert consultation is not available, it may be reasonable to consider either IV procainamide, amiodarone, or sotalol.

Synopsis

Regular, narrow-complex tachyarrhythmias (QRS duration 0.09 second or less) are most commonly caused by re-entrant circuits, although other mechanisms such as ectopic atrial tachycardia or junctional tachycardia may occur. Regular, wide-complex tachyarrhythmias (WCT; QRS >0.09 second) can have multiple mechanisms, including SVT with aberrant conduction, antidromic SVT, or VT. SVT with aberrant conduction is the most common cause of WCT in infants and children.[1]

The hemodynamic impact of SVT in the pediatric patient can be variable, with signs of cardiopulmonary compromise such as altered mental status, signs of shock, or hypotension occurring in a minority of patients. In infants and children without cardiopulmonary compromise, re-entrant SVT can often be terminated with vagal maneuvers.[2–5] Adenosine remains the preferred medication initially unresponsive to vagal maneuvers.[3,6–14] For patients with hemodynamically stable SVT that recurs after initial successful treatment, expert consultation is important to diagnose etiology and customize treatment. The use of other IV antiarrhythmics including procainamide, amiodarone, and sotalol have been studied with varying levels of success.[15–20] When cardioversion is provided, the administration of sedation before synchronized cardioversion can minimize the pain associated with the shock. However, extreme caution is warranted in the selection and dosage of sedatives in a patient with cardiopulmonary compromise.

Recommendation-Specific Supportive Text

1. Vagal maneuvers are noninvasive, have few adverse effects, and effectively terminate SVT in many cases; exact success rates for each type of maneuver (ie, ice water to face, postural modification) are unknown.[3] Although improved success rates have been reported with a postural modification to the standard Valsalva maneuver in adults,[2] published pediatric experience with this technique is very limited. Upside-down positioning may be an additional form of a vagal maneuver that is effective in children.[4]
2. IV adenosine remains generally effective for terminating re-entrant SVT within the first 2 doses. In retrospective observational studies on the management of tachyarrhythmias, none directly compared adenosine to other drugs.[6,7,9–14] A Cochrane review that included mostly adult studies and 1 pediatric study showed that either adenosine or calcium channel blockers can be used for quick termination of SVT.[8] Given the fast onset of action, short half-life, and favorable side effect profile, adenosine is preferred for infants and children.[21]
3. For infants and children with SVT without cardiopulmonary compromise that is refractory to vagal

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maneuvers or adenosine, expert consultation can guide the choice of alternative second-line agents. The risk for proarrhythmic and life-threatening hemodynamic collapse increases with the administration of multiple antiarrhythmic agents. Multiple medications have been used as second-line agents for the management of adenosine-refractory SVT, including IV verapamil, β-blockers, amiodarone, procainamide, and sotalol.[3,6,7,10,11,15,16,18–20,22,23] Few comparative studies exist.

4. Direct current transcutaneous synchronized cardioversion remains the treatment of choice for infants and children with SVT and cardiopulmonary compromise (characterized by altered mental status, signs of shock, or hypotension). However, these cases are uncommon, and there are few studies that report outcomes from cardioversion of SVT.[7,13,24] The administration of sedation before synchronized cardioversion can minimize the pain associated with the shock. However, extreme caution is warranted in the selection and dosage of sedatives in a patient with cardiopulmonary compromise.
5. Procainamide and amiodarone are moderately effective treatments for adenosine-resistant SVT.[16] Procainamide may be slightly more efficacious; adverse effects are frequent with both therapies. IV sotalol was approved for the treatment of SVT in 2009. Since its approval, several single-center and 1 multicenter registry have shown that IV sotalol is effective in acute conversion of SVT, with a 60% to 100% termination rate of SVT and atrial tachyarrhythmias.[15,17,18–20] In these studies, IV sotalol was administered under the guidance of pediatric electrophysiologists in acute care settings and no significant adverse events were reported.

Treatment of Wide-Complex Tachycardia With a Pulse

Recommendations for Treatment of Wide-Complex Tachycardia With a Pulse		
COR	**LOE**	**Recommendations**
1	**C-LD**	1. In infants and children with wide-complex tachycardia without cardiopulmonary compromise, expert consultation is recommended prior to administration of antiarrhythmic agents.
2a	**C-EO**	2. In infants and children with wide-complex tachycardia with regular and monomorphic QRS without cardiopulmonary compromise, adenosine administration can be useful in conjunction with expert consultation.
2a	**C-EO**	3. In infants and children with wide-complex tachycardia and cardiopulmonary compromise, it is reasonable to perform electrical synchronized cardioversion starting with a dose of 0.5–1 J/kg. If unsuccessful, increase the dose to 2 J/kg.

Synopsis

The occurrence of WCT (QRS duration >0.9 second) with a pulse is rare in children and may originate from either the ventricles or the atria.[25] SVT with aberrant conduction is the most common cause of WCT in infants and children; however, other etiologies can include antidromic SVT or VT.[1] For patients with WCT and no cardiopulmonary compromise, expert consultation is important to diagnose etiology and customize treatment. The administration of sedation before synchronized cardioversion can minimize the pain associated with the shock. However, extreme caution is warranted in the selection and dosage of sedatives in a patient with cardiopulmonary compromise.

Recommendation-Specific Supportive Text

1. Both pediatric and adult studies have identified potential populations at risk of proarrhythmic complications from antiarrhythmic therapies, including patients with underlying cardiomyopathies, long-QT syndrome, Brugada syndrome, and Wolff-Parkinson-White syndrome.[26–30] Given this potential risk, expert consultation can help provide a tailored antiarrhythmic choice to minimize the chances of arrhythmia.
2. Given that the most common cause of WCT in infants and children is SVT with aberrancy,[1] the use of adenosine can be either therapeutic or diagnostic. If the cause of the WCT is SVT with aberrancy, administration of adenosine is likely to terminate the arrhythmia. If the cause of the WCT is VT, the administration of adenosine can be diagnostic if it demonstrates ventriculo-atrial dissociation. Adenosine should only be administered in WCT if the tachycardia is monomorphic and regular. If WCT is irregular, it can represent pre-excited atrial fibrillation, and the administration of adenosine can lead to VF. When possible, the administration of adenosine should be done with a running rhythm strip or multilead electrocardiogram to help with interpretation of the adenosine response.[1,31]
3. Cardiopulmonary compromise is a key factor in determining the use of electrical therapy over primary pharmacologic management in children with WCT and a pulse. In patients with cardiopulmonary compromise, electrical direct current synchronized cardioversion should be provided urgently, regardless of suspected atrial or ventricular origin. There is insufficient evidence describing the incidence of WCT without cardiopulmonary compromise, and there is no support for or against the use of specific antiarrhythmic drugs in the management of children with wide-complex tachycardia with a pulse.

Figure 7 shows the algorithm for pediatric tachyarrhythmia with a pulse.

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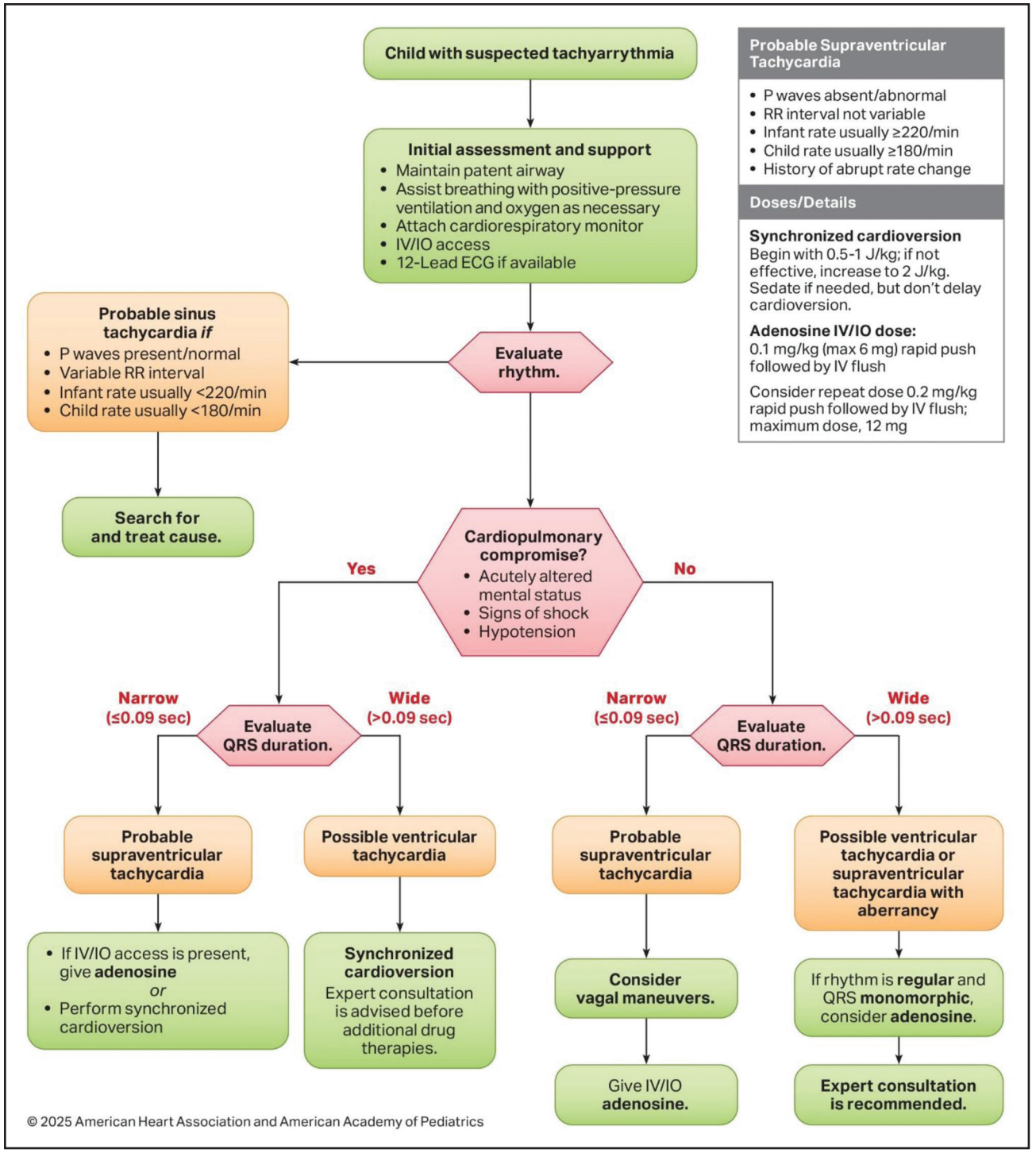

Figure 7. Pediatric Tachyarrhythmia With a Pulse Algorithm.

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TREATMENT OF MYOCARDITIS AND CARDIOMYOPATHY

Recommendations for Treatment of Myocarditis and Cardiomyopathy

COR	LOE	Recommendations
1	B-NR	1. Given the high risk of cardiac arrest in infants and children with myocarditis who demonstrate arrhythmias, heart block, ST-segment changes, or low cardiac output, early consideration of transfer to an ICU for monitoring and therapy is recommended.
2a	B-NR	2. For infants and children with myocarditis or cardiomyopathy with refractory low cardiac output, ECMO/mechanical cardiac support (MCS) can be beneficial to provide end-organ support and to prevent cardiac arrest.
2a	B-NR	3. In infants and children with myocarditis or cardiomyopathy experiencing cardiac arrest, early deployment of ECPR is reasonable.
2a	C-LD	4. For infants and children with myocarditis or cardiomyopathy and refractory low cardiac output, when feasible, early transfer to a center with ECMO/MCS capability is reasonable.

Synopsis

Acute decompensated heart failure can result in end-organ compromise and rapid progression to cardiac arrest.[1] Fulminant myocarditis and cardiomyopathy are common causes of acute decompensated heart failure in children.[1–6] Outcomes can be optimized by early diagnosis and prompt intervention, including ICU monitoring and therapy. Heart block, ventricular arrythmias, requirement for invasive mechanical ventilation, or signs of organ failure in the patient with fulminant myocarditis are considered a prearrest state.[2–5,7,8]

Early consideration of transfer to a center capable of providing mechanical circulatory support (MCS) in the form of a ventricular assist device is important.[3,4,9–11] Centers with more experience in the management of these patients may have better outcomes.[3] Early ECMO cannulation of patients requiring invasive ventilation may be associated with survival.[3,9] The use of ECMO and MCS have improved outcomes of patients with acute

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myocarditis, with a high possibility of partial or complete recovery of myocardial function.[3–6,9,11–15]

Recommendation-Specific Supportive Text

1. Multiple retrospective studies have evaluated predictors of worse outcome in patients with acute decompensated heart failure with most studies in patients with fulminant myocarditis. There is an increased incidence of cardiac arrest and need for ECMO/MCS in this high-risk population.[1–3,5,7,8,10,11] Incidence of cardiac arrest in fulminant myocarditis ranges from 25% to 75%.[3,5,7,8,10] Signs of organ failure, a requirement for invasive mechanical ventilation, and even modest decreases in left ventricular fraction are associated with the need for ECMO/MCS.[3–5,8,9,11] In 1 registry study, ventricular arrythmias that required treatment were strongly associated with mortality (OR, 8.47; 95% CI, 7.16–10.04; $P<0.001$).[3]
2. The prognosis for patients with fulminant myocarditis who receive ECMO or MCS can be good and is generally better than for patients who require ECMO due to other causes, especially those with congenital heart disease.[1,12] In 4 observational studies, transplant-free survival to hospital discharge in myocarditis patients without congenital heart disease requiring ECMO or MCS ranged from 72% to 80%.[4,5,9,10]
3. In a cohort of 847 myocarditis patients, 60/847 (7.1%) had a cardiac arrest with 43/60 (72%) of these patients receiving ECPR. Among ECPR patients, 31/43 (72.1%) survived to hospital discharge compared to 11/17 (64.7%) of non-ECPR cardiac arrest patients.[4] In 1 study, 95% of children with myocarditis who were placed on ECMO (n=15) or MCS (n=1) after cardiac arrest were alive 6 months later compared to 85% in nonmyocarditis patients.[14]
4. In a retrospective study, shorter time to ECMO cannulation after intubation was associated with survival in patients with fulminant myocarditis (3 h in survivors, 6 h in nonsurvivors).[9] A registry analysis from Japan noted improved outcomes if pediatric patients with myocarditis were managed in higher-volume centers.[3]

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RESUSCITATION OF PATIENTS WITH SINGLE VENTRICLE CONGENITAL HEART DISEASE

Recommendations for the Resuscitation of Patients With Single Ventricle Congenital Heart Disease

COR	LOE	Recommendations
1	C-EO	1. For infants and children with aortopulmonary shunt-dependent congenital heart disease with known or suspected shunt obstruction, early consideration for transfer to a center with advanced cardiac therapy capabilities (ie, cardiac catheterization, cardiac surgery, ECMO) is recommended if these services are not available.

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Recommendations for the Resuscitation of Patients With Single Ventricle Congenital Heart Disease (Continued)		
COR	**LOE**	**Recommendations**
2a	**C-LD**	2. In infants and children with single ventricle congenital heart disease following initial palliative procedures (eg, Stage I Norwood, Hybrid procedure, Blalock-Thomas-Taussig shunt), timely ECMO deployment can be useful to treat low cardiac output syndrome.
2a	**C-EO**	3. For infants and children with aortopulmonary shunt-dependent congenital heart disease with known or suspected shunt obstruction, it is reasonable to administer oxygen, vasoactive agents, and heparin while preparing for catheter-based or surgical intervention.
2b	**C-LD**	4. In infants and children with single ventricle congenital heart disease following initial palliative procedures (eg, Stage I Norwood, Hybrid procedure, Blalock-Thomas-Taussig shunt) experiencing cardiac arrest, timely ECPR deployment may be a useful rescue strategy to achieve ROC.
2b	**C-LD**	5. In infants and children with single ventricle congenital heart disease following Stage II (bidirectional Glenn, hemi-Fontan) or Stage III (Fontan) palliation, timely ECMO deployment may be considered to treat low cardiac output syndrome.

Synopsis

The complexity and variability in pediatric congenital heart disease (CHD) pose unique challenges during resuscitation. Children with single-ventricle CHD typically undergo 3 staged palliative operations. The first procedure, typically performed during the neonatal period, creates unobstructed systemic blood flow, an atrial communication to allow for atrial level mixing, and regulated pulmonary blood flow to prevent pulmonary overcirculation and to decrease the volume load on the systemic ventricle[1,2] (Figure 8). During the second stage, a superior cavopulmonary anastomosis (ie, bidirectional Glenn/hemi-Fontan operation) is created to aid in the redistribution of systemic venous return directly to the pulmonary circulation (Figure 9). The Fontan procedure is the final palliation where inferior vena cava blood flow is baffled directly to the pulmonary circulation, thereby making the single (systemic) ventricle preload-dependent on passive flow across the pulmonary vascular bed (Figure 10).

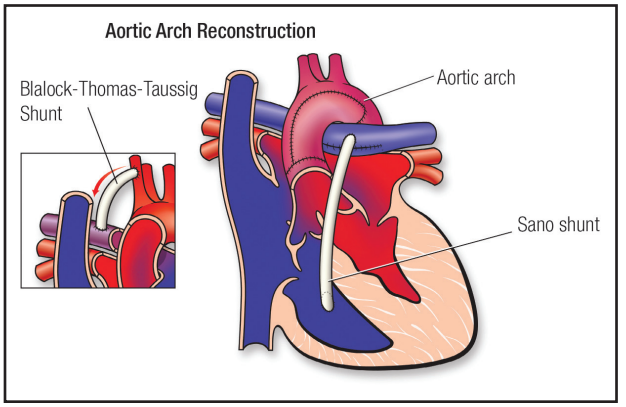

Figure 8. Stage I palliation for single ventricle with a Norwood repair and either a Blalock-Thomas-Taussig shunt from the right subclavian artery to the right pulmonary artery or a Sano shunt from the right ventricle to pulmonary artery.

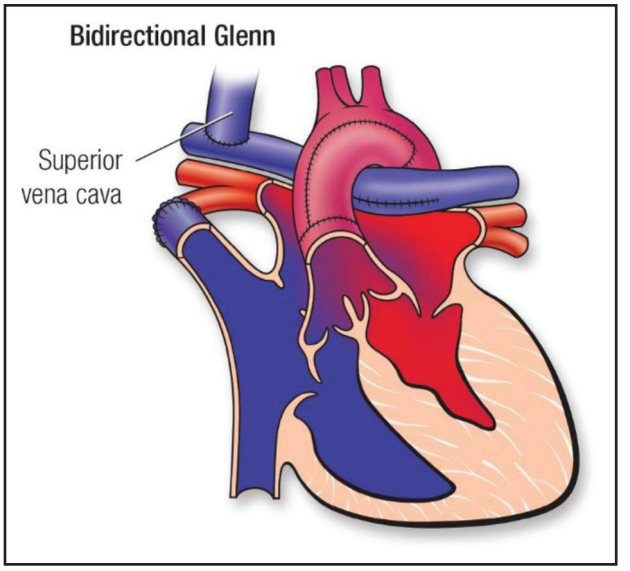

Figure 9. Stage II palliation for single ventricle with a bidirectional Glenn shunt connecting the superior vena cava to the right pulmonary artery.

Neonates and infants with single-ventricle physiology have an increased risk of cardiac arrest because of increased myocardial work from ventricular volume loading, imbalances in relative systemic (Qs) and pulmonary (Qp) blood flow, and potential shunt occlusion.[1–3] Depending on the stage of repair, resuscitation may require control of pulmonary and systemic vascular resistance, administration of supplemental oxygen, intervention for shunt obstruction, or the use of ECMO.

Recommendation-Specific Supportive Text

1. In aortopulmonary shunt-dependent CHD patients with suspected shunt obstruction, either cardiac catheterization or cardiothoracic surgery can be performed to restore patency of an obstructed shunt. Although observational single-center reports have not compared outcomes between procedural interventions (catheter-based or surgical) versus no procedural intervention for treatment of aortopulmonary shunt obstruction, lack of pulmonary blood flow can lead to severe cardiopulmonary compromise and cardiac arrest.[1–4] ECMO can be deployed to rescue the shunt-dependent patient with cardiopulmonary compromise related to shunt obstruction before performing interventions to restore shunt patency.[1–5]

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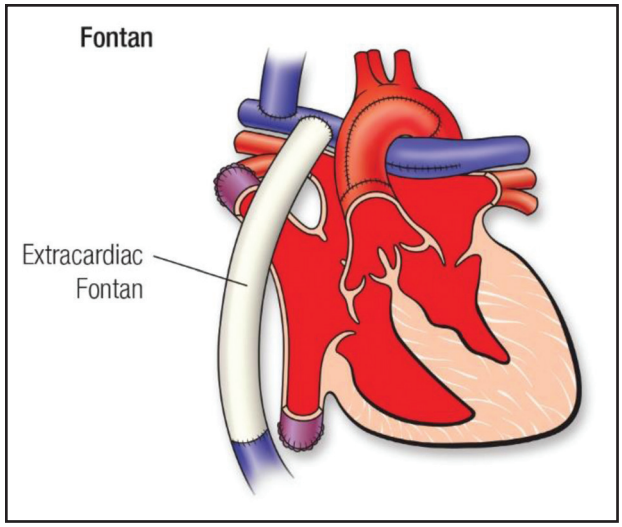

Figure 10. Stage III Fontan single ventricle palliation with an extracardiac conduit connecting the inferior vena cava to the right pulmonary artery.

2. For children with single ventricle CHD after initial surgical palliation (eg, Blalock-Thomas-Taussig shunt, Stage I Norwood) needing postoperative ECMO for management of low cardiac output state, reported survival rates range from 31% to 53%.[3,5,7–9] In 1 small observational study of patients undergoing staged palliation, survival rates were statistically unchanged in patients who received elective ECMO (n=15) compared to ECPR (n=10) (55% versus 36%, *P*=0.17).[7] In another study, neonates with hypoplastic left heart syndrome status post–Stage I palliation supported with ECMO had a survival rate of 31%, compared to 51% survival for neonates placed on ECMO for cardiac indications as reported to Extracorporeal Life Support Organization registry database.[5] Though reported survival rates for ECPR in this cohort (32%–57%) after initial surgical palliation are similar to survival rates for elective ECMO (31%–53%), clinical practice standards advocate for earlier recognition of the postoperative low cardiac output state and deployment of elective ECMO before cardiac arrest, as this may be associated with improved long-term functional outcomes.[5,7,10,11] There are no studies which directly compare children with single ventricle CHD after initial surgical palliation experiencing impending hemodynamic collapse receiving postoperative elective ECMO to cohorts not receiving ECMO under similar hemodynamic conditions.
3. Medical treatment for acute aortopulmonary shunt obstruction in peri-arrest and cardiac arrest states can include administration of supplemental oxygen, vasoactive agents (eg, epinephrine, phenylephrine, norepinephrine) to maximize shunt perfusion pressure, and anticoagulation with heparin (50–100 units/kg bolus) to mitigate clot propagation.[1,3,6]
4. In children with single ventricle CHD after initial surgical palliation (eg, Blalock-Thomas-Taussig shunt, Stage I Norwood) experiencing cardiac arrest, observational and registry studies identify rates of survival to hospital discharge ranging from 32% to 57%.[3,5,7,9,11–16] One observational and 1 registry study of neonates with hypoplastic left heart syndrome undergoing ECPR after Stage I palliation noted survival rates of 32% to 36%, similar to the survival rate of patients undergoing elective ECMO (30%).[5,16] There are no studies of single ventricle populations after initial stage palliation receiving ECPR for cardiac arrest that provide comparisons to conventional CPR. There are limited data on ECPR outcomes in children after Stage II and Stage III surgical palliation. Observational studies of ECMO support after Stage II palliation showed an overall survival rate of 41%, with subanalysis of ECPR in Stage II cohorts noting a survival rate of 44% to 45%[17,18] and rates of neurological injury as high as 57% in Stage II ECPR survivors (Pediatric Overall Performance Category/PCPC score ≥3).[18] One observational study of children receiving postoperative ECMO after Stage III surgical palliation identified a survival rate of 27% for the subgroup of Stage III cohorts receiving ECPR.[19] Due to a lack of significant literature supporting ECPR use after Stage II and III surgical palliations,[17–19] specific recommendations for ECPR in these cohorts are not provided.
5. In a retrospective analysis of the Extracorporeal Life Support Organization database, among infants undergoing Stage II palliation receiving postoperative ECMO support, survival rates for those undergoing elective ECMO were similar to those patients undergoing ECPR (41% versus 45%, respectively), with a higher rate of neurological injury for the cohort who received ECMO versus ECPR (23% versus 0%).[17] An Extracorporeal Life Support Organization database study evaluating children after Stage III palliation (Fontan) who received postoperative ECMO noted a survival rate of 35%.[19] There are no studies which directly compare children with single ventricle CHD after Stage II or III surgical palliation experiencing impending hemodynamic collapse receiving postoperative elective ECMO to analogous cohorts not receiving ECMO under similar hemodynamic conditions.

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MANAGEMENT OF PULMONARY HYPERTENSION

Management of Infants and Children at Risk for Pulmonary Hypertensive Crises

Recommendations for the Management of Infants and Children at Risk for Pulmonary Hypertensive Crises

COR	LOE	Recommendations
1	B-NR	1. For infants and children who are at risk for pulmonary hypertensive crises, provide careful respiratory management and monitoring to avoid hypoxia and acidosis.
1	C-EO	2. For infants and children who are mechanically ventilated and at risk for pulmonary hypertensive crises, provide adequate analgesics, sedatives, and neuromuscular blocking agents.
1	C-EO	3. For infants and children who are at risk for pulmonary hypertensive crises, avoid dehydration, fluid overload, and anemia.

Synopsis

Pulmonary hypertensive crises are acute rapid increases in pulmonary artery pressure that can lead to systemic hypotension, myocardial ischemia, cardiac arrest, and death. Optimization of physiologic conditions and avoidance of potential triggers of pulmonary hypertensive crises can potentially avoid these events. Acidosis and hypoxemia are both potent pulmonary vasoconstrictors.[1–4] Inadequate sedation or uncontrolled pain can lead to increased sympathetic activity, which raises pulmonary vascular resistance and can exacerbate pulmonary hypertension.[1,5–7] Hypovolemia in children with pulmonary hypertension decreases preload and potentially compromises cardiac output, worsening the condition and increasing hypoxia risk. Conversely, fluid overload causes venous congestion and impairs heart function in the setting of right ventricular dysfunction.[8] Anemia can be problematic in patients with pulmonary hypertension due to reduced oxygen-carrying capacity.[8]

Recommendation-Specific Supportive Text

1. One review, 1 consensus statement, and 1 scientific statement highlight the importance of identifying and treating environmental factors that contribute

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to pediatric pulmonary hypertensive crises, such as hypoxia and acidosis, especially in high-risk populations with preexisting idiopathic pulmonary arterial hypertension or with congenital heart disease and pulmonary arterial hypertension.[7,9,10] Two physiologic reviews, 1 randomized clinical trial, and 2 retrospective observational studies demonstrated that hypercarbia, hypoxemia, acidosis, atelectasis, and ventilation-perfusion mismatch can lead to increases in pulmonary vascular resistance and, hence, elevation of pulmonary artery pressures in the immediate postoperative period.[1–4,11]

2. Two observational studies in select high-risk postoperative cardiac patients found an attenuation in the stress response in those patients receiving fentanyl in the postoperative period.[5,6] Three studies indicate that triggering factors, such as pain and anxiety, can precipitate pulmonary hypertension crises both during the perioperative period and outside of it, particularly in the presence of acute lung injury, infection, or noncardiac interventions. Managing and preventing these aggravating factors with sedatives and analgesics can help prevent recurrent, more severe, and prolonged pulmonary hypertension crises.[7,10,12] Neuromuscular blockade can be used in addition to sedation and analgesia in critically ill, mechanically ventilated children with pulmonary hypertension.[7,12]
3. Hypovolemia and hypervolemia can be deleterious to the cardiac function. Right ventricular decompensation may result from conditions leading to increases in cardiac demand or increases in ventricular afterload. Two consensus statements on the treatment of pediatric pulmonary hypertension emphasize the importance of managing triggering factors such as volume overload, dehydration, and anemia in critically ill children with acute pulmonary hypertension.[8,10]

Treatment of Infants and Children With Pulmonary Hypertensive Crises

Recommendations for the Treatment of Infants and Children With Pulmonary Hypertensive Crises

COR	LOE	Recommendations
1	B-R	1. In infants and children with pulmonary hypertensive crises or acute right-sided heart failure secondary to increased pulmonary vascular resistance, inhaled nitric oxide or prostacyclin should be used as the initial pulmonary vasodilator therapy.
2a	C-LD	2. For the initial treatment of infants and children with pulmonary hypertensive crises, oxygen administration and induction of alkalosis through hyperventilation or alkali administration can be useful while pulmonary vasodilators are administered.
2b	C-LD	3. For infants and children with refractory pulmonary hypertension, including signs of low cardiac output or profound respiratory failure despite optimal medical therapy, ECMO may be considered.

Synopsis

During a pulmonary hypertensive crisis, elevated pulmonary vascular resistance reduces pulmonary blood flow, impairing left-heart (or single ventricle) preload and ultimately leading to a fall in cardiac output. Hypoxia and hypercarbia can significantly increase pulmonary vascular resistance and trigger pulmonary hypertension crises.[1,8,10] Supplemental oxygen helps maintain oxygen levels and lowers pulmonary artery pressures, as does inducing alkalosis. Pulmonary vasodilators, including inhaled nitric oxide, inhaled prostacyclin and IV prostacyclin analogs have been used to treat acute pulmonary hypertensive crises while IV and oral phosphodiesterase type-5 inhibitors, oral endothelin receptor antagonists and oral soluble guanylate cyclase stimulators are used as long-term therapies to lower pulmonary vascular resistance and prevent pulmonary hypertensive crises.[13–16] ECMO may stabilize infants with severe pulmonary hypertension, low cardiac output, or severe respiratory failure when other treatments fail,[12] or during high-risk cardiac interventions.[17] Children with pulmonary hypertension who require ECMO have higher mortality rates compared to those without pulmonary hypertension.[18,19]

Recommendation-Specific Supportive Text

1 and 2. Treatment with inhaled nitric oxide reduces the frequency of pulmonary hypertensive crises and shortens time to extubation.[20] In patients with atrioventricular septal defect repair and severe postoperative pulmonary hypertension, inhaled nitric oxide administration is associated with reduced mortality.[15,21] Inhaled prostacyclin transiently produces pulmonary vasodilation and improves oxygenation, but the alkalinity of the drug can irritate airways, and precise dosing can be complicated by drug loss in the nebulization circuit.[12,22] Two physiologic reviews and 1 randomized clinical trial demonstrated that hypercarbia, hypoxemia, acidosis, atelectasis, and ventilation-perfusion mismatch can lead to increases in pulmonary vascular resistance and elevation of pulmonary artery pressures in the immediate postoperative period after cardiac surgery.[2–4] One prospective study on the right ventricular response to hypercarbia following cardiac surgery showed that hypercarbia significantly increased pulmonary vascular resistance by 54% and mean pulmonary arterial pressure by 34%.[23] In addition, a prospective

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study in infants after cardiopulmonary bypass demonstrated that increasing the arterial pH by the administration of sodium bicarbonate resulted in significant reduction of pulmonary vascular resistance with both a decrease in mean pulmonary arterial pressure and a concomitant increase in cardiac index.[24]

3. Extracorporeal membrane oxygenation has been used in children with pulmonary vascular disease in refractory low cardiac output states and cardiac arrest.[25,26] Although outcomes remain poor in certain populations,[27] advances in technology of extracorporeal devices may allow for bridging to durable MCS or to transplantation.[17,28] Although patients with pulmonary hypertension who require ECMO have a high mortality rate, provision of ECMO can be lifesaving.[12,29,30]

Pulmonary Hypertension–Specific Therapies and Interventions for the Treatment of Infants and Children in Cardiac Arrest

Recommendation for Pulmonary Hypertension–Specific Therapies and Interventions for the Treatment of Infants and Children in Cardiac Arrest		
COR	**LOE**	**Recommendation**
2b	**C-EO**	1. In infants and children with pulmonary hypertension experiencing cardiac arrest, it is unknown whether the addition of pulmonary hypertension–specific therapies improves CPR outcomes compared to standard CPR.

Synopsis

Among children with in-hospital cardiac arrest, pulmonary hypertension is a common preexisting condition, and several observational studies have found an association between pulmonary hypertension and lower cardiac arrest survival rates.[19,31–34] Despite inhaled nitric oxide showing efficacy in preclinical large animal models of cardiac arrest associated with pulmonary hypertension,[35,36] studies on optimal management for children with pulmonary hypertension-associated cardiac arrest are scarce, and the efficacy of specific intra-arrest therapies is unknown.

Recommendation-Specific Supportive Text

1. No intra-arrest therapies have been prospectively compared to standard resuscitation therapies for pulmonary hypertension-associated cardiac arrest. One observational study reported that 55% of children with pulmonary hypertension and in-hospital cardiac arrest were receiving inhaled nitric oxide at the time of arrest, but did not identify associations with survival.[32] No studies have prospectively investigated pulmonary vasodilator therapy during pediatric cardiac arrest.

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MANAGEMENT OF TRAUMATIC CARDIAC ARREST

Recommendations for the Management of Traumatic Cardiac Arrest		
COR	**LOE**	**Recommendations**
1	C-EO	1. In infants and children with traumatic cardiac arrest, evaluation and treatment for potentially reversible causes such as hemorrhage, tension pneumothorax, and pericardial tamponade are recommended.
2b	C-LD	2. In infants and children with traumatic cardiac arrest secondary to penetrating thoracic injury with a short transport time, it may be reasonable to perform resuscitative thoracotomy.

Synopsis

Unintentional injuries are the most common cause of death among children and adolescents.[1] Although many organizations have established trauma care guidelines,[2–4] the management of traumatic cardiac arrest is often inconsistent. Cardiac arrest due to major blunt or penetrating injury in children has a very high mortality rate.[5–8] Suspect thoracic injury in all thoraco-abdominal trauma because tension pneumothorax, hemothorax, pulmonary contusion, or pericardial tamponade may impair hemodynamics, oxygenation, and ventilation.

This topic was last reviewed in the *2020 AHA Guidelines for CPR and ECC*. These recommendations have not been updated for this edition of the Guidelines.[9]

Recommendation-Specific Supportive Text

1. Early correction of reversible causes by reducing delays in the delivery of trauma-specific interventions may increase survival following penetrating traumatic cardiac arrest.[10,11] Guidelines for cardiac arrest due to trauma recommend opening the airway, relieving tension pneumothorax hemorrhage control, restoring circulating blood volume, and relieving tension pneumothorax. Perform these measures simultaneously with conventional resuscitation.
2. Systematic reviews,[12–15] multicenter retrospective studies,[16,17] and single-center retrospective studies[18] recommend emergent thoracotomy for pediatric patients who present pulseless after penetrating thoracic injury. However, there is no evidence to support emergent thoracotomy for infants and children with blunt injury presenting in cardiac arrest.[13,19]

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Table 2. Critical Knowledge Gaps Due to Insufficient Pediatric Data

Topic	Knowledge gap
Guidelines development	What is the appropriate age and setting to transition from (1) neonatal resuscitation protocols to pediatric resuscitation protocols and (2) from pediatric resuscitation protocols to adult resuscitation protocols?
Drug administration	What is the optimal method (ie, age, weight, or physiology) to estimate body weight for medication administration?
	What is the optimal method to transition from weight-based dosing to fixed-dose medication administration during cardiac arrest in adolescents or children with high BMI?
	With what frequency should subsequent doses of epinephrine be administered?
	Should epinephrine dosing strategies be individualized to patients based on hemodynamic response, blood pressure targets, or both?
	With what frequency should epinephrine be administered in infants and children during CPR who are undergoing ECMO cannulation?
	What are special circumstances in which sodium bicarbonate and calcium are beneficial to administer during pediatric cardiac arrest? Are there circumstances where these medications are harmful?
CPR techniques	Are alternative compression techniques (cough CPR, precordial thump, fist pacing, interposed abdominal compression CPR, mechanical CPR devices) equally or more effective than conventional CPR?
	What are the optimal chest compression techniques for patients immediately poststernotomy?
	Is double sequential defibrillation, vector change, or stacked shocks more effective to achieve ROSC than traditional single defibrillation? When are these strategies appropriate in defibrillation sequences when single shocks have failed?
	What is the optimal timing and dosing of initial defibrillation for VF/pVT or subsequent defibrillation for refractory VF/pVT?
Airway management, ventilation, oxygenation during cardiac arrest	Are there specific situations in which advanced airway placement is beneficial or harmful in OHCA?
	What is the appropriate timing of advanced airway placement in IHCA?
	What is the optimal FIO_2 to administer during CPR?
	What is the optimal ventilation rate during CPR in patients with or without an advanced airway? Is it age dependent?
	What is the optimal PEEP, PIP, and tidal volume to administer during CPR?
	For mechanically ventilated infants and children with IHCA, does manual ventilation versus remaining on the ventilator impact the efficacy of ventilation or outcomes?
	Is there an $ETCO_2$ value that health care professionals should target during CPR?
Monitoring during cardiac arrest	What are the optimal blood pressure targets during CPR? Is it age dependent?
	Can transthoracic or transesophageal echocardiography diagnose reversible causes/contributors to cardiac arrest?
	Can transesophageal echocardiography during cardiac arrest guide and improve CPR quality?
	Can NIRS or other cerebral perfusion monitoring technologies improve CPR quality or outcomes when used during cardiac arrest?
	Should specific heart rate, blood pressure or other factors be used as the threshold for performing CPR in children with poor perfusion?
Mechanical circulatory support (ECPR/VAD)	What is the role of ECPR for patients with OHCA and IHCA due to noncardiac causes?
	What other patient/arrest factors should be considered in determining ECPR candidacy?
	Should the optimal dosing frequency of vasoactive medications be modified for ECPR?
	What approach to minimizing chest compression pauses during cannulation is optimal during ECPR?
	What is the role of ECPR deployment in patients with single ventricle heart disease at each stage of palliation (Stage I, II, III)?
	Should post–cardiac arrest care hemodynamic, oxygenation, ventilation targets be similar for ECPR patients when compared to conventional CPR patients?
	What are optimal CPR practices for patients with intra- or extracorporeal ventricular assist devices (continuous flow or pulsatile) experiencing low-flow alarm, absent pulse, hypotension, with or without evidence of VAD malfunction?
Termination of resuscitation	What clinical tools can be used to help in the decision to terminate pediatric IHCA and OHCA resuscitation?
Family presence	What is the long-term emotional and psychological impact on family members who witness resuscitation, including potential trauma, grief processing, or closure?
	What is the impact on health care professionals' emotional well-being when families are present during resuscitation?
	How do cultural, religious, or individual family beliefs influence the perception of FPDR and how should we tailor practices to respect these differences?

(*Continued*)

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Table 2. Continued

Topic	Knowledge gap
Post–cardiac arrest care, neuroprognostication	What are the blood pressure targets during post–cardiac arrest period and for what time period post–cardiac arrest should they serve as hemodynamic targets?
	Should seizure prophylaxis be administered post-cardiac arrest?
	Does the treatment of post–cardiac arrest convulsive and nonconvulsive seizure improve outcomes?
	What is the optimal temperature and duration of TTM for post–cardiac arrest care?
	Does TTM benefit subpopulations of cardiac arrest patients?
	What are the reliable methods and optimal timing for post–cardiac arrest prognostication?
	What are the modalities and timing of physical, cognitive, and psychological assessments that should be provided in the year following cardiac arrest?
	Which modalities and their respective timing should be used to predict good and poor neurological outcomes after cardiac arrest?
Arrhythmia management	What are the most effective and safest medications for adenosine-refractory SVT?
Specific disease etiologies presenting in cardiac arrest–myocarditis/ cardiomyopathy	Are there specific modifications to the cardiac arrest algorithm that should be used when treating a patient with myocarditis/ cardiomyopathy and cardiac arrest?
Specific disease etiologies presenting in cardiac arrest–pulmonary hypertension	What intra-arrest therapies are effective to treat pulmonary hypertension-associated cardiac arrest compared to standard resuscitation therapies?
	What is the optimal approach to ventilation during the resuscitation of infants and children with pulmonary hypertension?

BMI indicates body mass index; CPR, cardiopulmonary resuscitation; ECMO, extracorporeal membrane oxygenation; ECPR, extracorporeal cardiopulmonary resuscitation; $ETCO_2$, end-tidal carbon dioxide; FIO_2, fraction of inspired oxygen; FPDR, family presence during resuscitation; IHCA, in-hospital cardiac arrest; IO, intraosseous; IV, intravenous; NIRS, near-infrared spectroscopy; OHCA, out-of-hospital cardiac arrest; PEEP, positive end-expiratory pressure; PIP, peak inspiratory pressure; pVT, pulseless ventricular tachycardia; ROSC, return of spontaneous circulation; SVT, supraventricular tachycardia; TTM, targeted temperature management; VF, ventricular fibrillation; and VAD, ventricular assist device.

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CRITICAL KNOWLEDGE GAPS AND ONGOING RESEARCH

During the literature review process, we identified several critical knowledge gaps related to PALS. These topics are either current areas of ongoing research or lack significant pediatric evidence to support evidence-based recommendations.

The causes of pediatric cardiac arrest are very different from cardiac arrest in adults, and pediatric studies are critically needed. As often occurs in the development of pediatric medical guidelines, some recommendations are extrapolated from adult data. However, infants and children are distinct patient populations and dedicated pediatric resuscitation research is a priority given the more than 20 000 cardiac arrests that occur in infants and children in the United States each year. These critical knowledge gaps are identified areas that, when addressed, will be the foundational future knowledge to advance how we care for patients.

Critical knowledge gaps are summarized in Table 2.

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Melissa Mahgoub	American Heart Association	None	None	None	None	None	None	None
Ryan W. Morgan	The Children's Hospital of Philadelphia	NIH†	None	None	None	None	None	None
Taylor McCormick	Denver Health	AHRQ†	None	None	None	None	None	None
Joan S. Roberts	University of Washington	PEDICA study*; SAMURAI study†	None	None	None	None	None	Seattle Children's Hospital†
Catherine E. Ross	Boston Children's Hospital	NHLBI†	None	None	None	None	None	Abbvie*

(*Continued*)

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Appendix 1. Continued

Writing group member	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
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Todd Sweberg	Northwell Health/ Cohen Children's Medical Center	None	None	None	None	None	None	Nonin Medical*; Abbott Laboratories*
Santiago O. Valdés	Texas Children's Hospital - Baylor College of Medicine	Milestone Pharmaceuticals*	None	None	None	None	None	Abbott Laboratories*; AltaThera Pharmaceuticals*; Medtronic*

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

Disclosures are reviewed and mitigated through a conflict-of-interest process that consists of reviewing pertinent information which is then used to decide what action is required to maintain content integrity. Disclosures may include salary, wages or other remuneration of any kind (including but not limited to consulting or advising fees, speaking fees, research funding, ownership interests, honoraria, participation in pension or benefit plans or programs or other perquisites, and reimbursement for travel, lodging, and meals) given for services rendered or other activities for which remuneration is received or expected, whether that compensation or other remuneration is paid directly to the individual or to the individual's employer or another third party.

*Modest.

†Significant.

Appendix 2. Reviewer Disclosures

Reviewer	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
Erica Andrist	University of Michigan, Mott Children's Hospital	NHLBI (Administrative supplemental award to R01HL153519)†; SCCM (Research support to fund an SCCM-endorsed project about brain death/death by neurologic criteria)*	None	None	None	None	None	None
Andrew Cheng	USC	None	None	None	None	None	None	None
Anne-Marie Guerguerian	The Hospital for Sick Children (Canada)	None	None	None	None	None	None	None
Rudy Kink	Le Bonheur Children's Hospital	None	None	None	None	None	None	None
Alan Leonard Nager	Division of Emergency and Transport Medicine, Keck School of Medicine	None	None	None	None	None	None	None
Gene Yong-Kwang Ong	KK Women's and Children's Hospital (Singapore)	None	None	None	None	None	None	None
Sylvia Owusu-Ansah	University of Pittsburgh	None	None	None	None	None	Prodigy EMS*; "The Pitt" medical drama series*	None
Alyssa Smith	Washington University School of Medicine	None	None	None	None	None	None	None
Vijay Srinivasan	Critical Care Medicine, Children's Hospital of Atlanta	None	None	None	None	None	None	None
Muhammad Waseem	Lincoln Medical Center	None	None	None	None	None	None	None

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†Significant.

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Circulation

Part 9: Adult Advanced Life Support: 2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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ABSTRACT: In these 2025 Advanced Life Support Guidelines, the American Heart Association provides comprehensive recommendations for the resuscitation and management of adults experiencing cardiac arrest, respiratory arrest, and life-threatening cardiovascular emergencies. Based on structured evidence reviews and the latest clinical research, these guidelines offer evidence-based strategies to optimize survival and patient outcomes. The 2025 guidelines provide guidance for the treatment of cardiac arrest, including ventricular fibrillation, pulseless ventricular tachycardia, asystole, and pulseless electrical activity, as well as peri-arrest conditions such as atrial fibrillation and flutter with rapid ventricular response. Recommendations are made for defibrillation, electrical cardioversion, advanced airway management, drug therapies, and intravenous access. Additionally, guidelines are provided for the use of double sequential defibrillation, head-up cardiopulmonary resuscitation, and point-of-care ultrasound in the advanced life support setting. Termination of resuscitation rules have been refined to guide decision-making based on the emergency medical services professional's scope of practice. Finally, these guidelines also underscore the importance of identifying causative versus secondary arrhythmias to inform the appropriate timing of therapeutic strategies.

Key Words: AHA Scientific Statements ■ advanced cardiac life support ■ airway management ■ arrhythmias, cardiac ■ cardiopulmonary resuscitation ■ drug therapy ■ electric countershock ■ emergency medical services

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TOP 10 TAKE-HOME MESSAGES FOR ADULT ADVANCED LIFE SUPPORT

1. A rapid assessment of clinical stability is essential to direct the appropriate advanced life support (ALS) treatment, and these guidelines go into greater depth to describe how poor organ perfusion manifests as instability.
2. Higher first-shock energy settings (≥200 J) are preferable to lower settings for cardioversion of atrial fibrillation and atrial flutter.
3. Updated termination of resuscitation (TOR) guidelines emphasize rule application based on emergency medical services (EMS) scope of practice (basic life support [BLS], ALS, or universal TOR rule [UTOR]), and that end-tidal carbon dioxide ($ETCO_2$) should not be used in isolation to end resuscitative efforts.
4. The usefulness of vector change (VC) and double sequential defibrillation (DSD) has not been established as therapies for shock-refractory ventricular fibrillation (VF); however, further investigation of these techniques, patient candidacy, and the development of new technology to optimize shock delivery are necessary.
5. Head-up cardiopulmonary resuscitation (CPR) use is discouraged outside of the setting of rigorous clinical trials with appropriate subject protections.
6. Recommendations regarding outdated or extraordinary procedures that have been replaced by

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modern equivalents with better efficacy (eg, administration of intra-arrest medications via an in-place endotracheal tube) have been removed.
7. Use of point of care ultrasonography (POCUS) by experienced professionals during cardiac arrest may be considered to diagnose reversible causes if it can be done without interrupting resuscitative efforts (ie, CPR).
8. Polymorphic ventricular tachycardia is always unstable and should be treated immediately with defibrillation, because delays in shock delivery worsen outcomes.
9. Intravenous (IV) access remains the first-line choice for drug administration during cardiac arrest; however, intraosseous (IO) access is a reasonable alternative if IV access is not feasible or delayed.
10. Arrythmias can be both the cause of and a manifestation of clinical instability. Evaluating the proximal cause of that instability will direct professionals to the most judicious use of these guidelines.

PREAMBLE

In the United States, cardiac arrest remains a significant public health challenge. The incidence of EMS-treated OHCA is 83.4 individuals per 100 000 population annually.[1] Despite advancements in resuscitation science, training, and systems of care, survival to hospital discharge after EMS-treated OHCA remains low, at approximately 10%. Immediate interventions, such as high-quality CPR and timely defibrillation, are crucial for improving outcomes.

In-hospital cardiac arrest (IHCA) occurs in approximately 1 in 100 hospitalized adults. Data indicates that about 72.2% of these patients achieve return of spontaneous circulation (ROSC), with survival to hospital discharge rates around 24.2%. Among those who survive to discharge, approximately 85% have favorable neurological outcomes. These statistics underscore the importance of ALS interventions, including advanced airway management, pharmacologic therapies, and coordinated postresuscitation care, in both prehospital and in-hospital settings.

The International Liaison Committee on Resuscitation (ILCOR) emphasizes the "Formula for Survival," which identifies 3 critical components for improved outcomes: guidelines based on sound science, effective education of resuscitation professionals, and well-functioning systems of care.[2] The 2025 ALS guidelines build upon these principles by incorporating the latest evidence, promoting high-quality education for ALS professionals, and describing the critical decisions required to provide life-saving emergency cardiovascular care.

This document outlines the American Heart Association (AHA) recommendations for ALS interventions, drawing from rigorous evidence evaluation and expert consensus. Recommendations are tailored to the scope and practice of ALS professionals, focusing on enhancing survival and functional recovery. The 2025 ALS guidelines aim to provide a framework for continued advancements in resuscitation science while highlighting areas for future research and innovation.[1]

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INTRODUCTION TO THE 2025 ALS GUIDELINES

Scope of the Guidelines

The 2025 ALS guidelines provide evidence-based recommendations for health care professionals managing adult cardiac arrest and life-threatening cardiovascular emergencies. These guidelines are tailored to professionals with advanced training in resuscitation techniques, incorporating a wide range of pharmacologic and device-based therapies and critical interventions to optimize survival and neurological outcomes.

This document complements the separately published 2025 BLS guidelines, which address foundational resuscitation practices for lay rescuers and BLS- and ALS-trained health care professionals. Importantly, the ALS guidelines address prehospital resuscitation, in-hospital resuscitation, and TOR recommendations when resuscitation has been unsuccessful. There is a recognition that in the literature there is differential use of the terms *return of spontaneous circulation* (ROSC) versus *return of circulation*. For the purposes of these guidelines, after CPR, when return of circulation is achieved by mechanical means (eg, extracorporeal membrane oxygenation), we use return of circulation; when due to cardiac function, we use ROSC. Specific recommendations about the training of ALS resuscitation professionals are provided in Part 12: Resuscitation Education Science,[1] recommendations about incorporating ALS professionals or procedures into systems of care are provided in Part 4: Systems of Care,[2] recommendations about caring for the adult patient following ROSC are provided in Part 11: Post–Cardiac Arrest Care,[3] and recommendations about ethical considerations in delivering or withholding ALS care are provided in Part 3: Ethical Considerations of Resuscitation.[4]

Organization of the Writing Group

The ALS Writing Group included experts in emergency medicine, EMS, cardiology, critical care, public health, nurs-

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ing, and education, along with AHA staff and science editors. Members disclosed potential conflicts of interest before and every 90 days during appointment, aligning with the AHA's policies to ensure unbiased guideline development. Disclosure information for writing group members is in Appendix 1.

METHODOLOGY AND EVIDENCE REVIEW

These guidelines are based on evidence evaluation conducted by the ALS Writing Group.[5] Evidence review processes included systematic reviews, scoping reviews, and annual focused evidence updates, composed by ILCOR, affiliates, and individual Writing Group Members, to support robust and transparent guideline development. Each of these resulted in a description of the literature and exhaustive discussion among Writing Group members that facilitated guideline development. Details of evidence evaluation can be found in Part 2: Evidence Evaluation and Guidelines Development.[6]

Class of Recommendation and Level of Evidence

Each recommendation in the 2025 ALS guidelines is assigned a Class of Recommendation (COR) to reflect its strength and a Level of Evidence (LOE). The LOE is based on the quality, quantity, relevance, and consistency of the available evidence. In determining the COR, the writing group considered the LOE and other factors, including systems issues, economic factors, and ethical factors such as equity, acceptability, and feasibility. Criteria for each COR and LOE are described in Table 1. For further explanation, refer to Part 2: Evidence Evaluation and Guidelines Development.[6]

Guideline Structure

The 2025 ALS guidelines are organized into knowledge chunks, which are modular, and organized into sections addressing specific clinical topics.[7] Each module includes a table of recommendations, a brief synopsis, supporting rationale, and references. Flow diagrams and tables clarify the cascade of clinical decision-making, and hyperlinked references provide access to studies and resources.

Document Review and Approval

Each section of the 2025 ALS guidelines underwent rigorous review by subject matter experts and independent peer reviewers. All guidelines were reviewed and approved for publication by the AHA Science Advisory and Coordinating Committee and the AHA Executive Committee. Disclosure information for peer reviewers is listed in Appendix 2.

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DEFIBRILLATION

Recommendations for Defibrillation Indication, Type, and Energy		
COR	**LOE**	**Recommendations**
1	B-NR	1. In adult patients with cardiac arrest, defibrillators (using biphasic or monophasic waveforms) are recommended to treat tachyarrhythmias requiring a shock such as ventricular fibrillation or pulseless ventricular tachycardia.
2a	B-R	2. Biphasic waveform defibrillation is preferred over monophasic waveform defibrillation for treatment of tachyarrhythmias in adult patients with cardiac arrest.
2a	B-NR	3. A single shock strategy is preferred to stacked shocks for defibrillation in adult patients with cardiac arrest.
2a	C-LD	4. It is reasonable that selection of fixed versus escalating energy levels for subsequent shocks for adults in cardiac arrest with presumed shock-refractory arrhythmias be based on the specific manufacturer's instructions for that waveform.
2b	B-R	5. If using a defibrillator capable of escalating energies, higher energy for second and subsequent shocks may be considered if the initial shock fails to restore a perfusing rhythm in adult patients with cardiac arrest.
2b	C-LD	6. In the absence of conclusive evidence that one biphasic waveform is superior to another in termination of ventricular fibrillation, it may be reasonable to use the manufacturer's recommended energy dose for the first shock in adult patients with cardiac arrest. If this is not known, defibrillation at the maximal dose may be considered.

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Table 1. Applying Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care (updated December 2024)*

CLASS (STRENGTH) OF RECOMMENDATION

Class 1 (STRONG) — Benefit >>> Risk

Suggested phrases for writing recommendations:
- Is recommended
- Is indicated/useful/effective/beneficial
- Should be performed/administered/other
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is recommended/indicated in preference to treatment B
  - Treatment A should be chosen over treatment B

Class 2a (MODERATE) — Benefit >> Risk

Suggested phrases for writing recommendations:
- Is reasonable
- Can be useful/effective/beneficial
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is probably recommended/indicated in preference to treatment B
  - It is reasonable to choose treatment A over treatment B

Class 2b (WEAK) — Benefit ≥ Risk

Suggested phrases for writing recommendations:
- May/might be reasonable
- May/might be considered
- Usefulness/effectiveness is unknown/unclear/uncertain or not well-established

Class 3: No Benefit (MODERATE) — Benefit = Risk (Generally, LOE A or B use only)

Suggested phrases for writing recommendations:
- Is not recommended
- Is not indicated/useful/effective/beneficial
- Should not be performed/administered/other

Class 3: HARM (STRONG) — Risk > Benefit

Suggested phrases for writing recommendations:
- Potentially harmful
- Causes harm
- Associated with excess morbidity/mortality
- Should not be performed/administered/other

LEVEL (QUALITY) OF EVIDENCE‡

Level A
- High-quality evidence‡ from more than 1 RCT
- Meta-analyses of high-quality RCTs
- One or more RCTs corroborated by high-quality registry studies

Level B-R (Randomized)
- Moderate-quality evidence‡ from 1 or more RCTs
- Meta-analyses of moderate-quality RCTs

Level B-NR (Nonrandomized)
- Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies
- Meta-analyses of such studies

Level C-LD (Limited Data)
- Randomized or nonrandomized observational or registry studies with limitations of design or execution
- Meta-analyses of such studies
- Physiological or mechanistic studies in human subjects

Level C-EO (Expert Opinion)
- Consensus of expert opinion based on clinical experience

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consenus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR 1 and 2a; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely-used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

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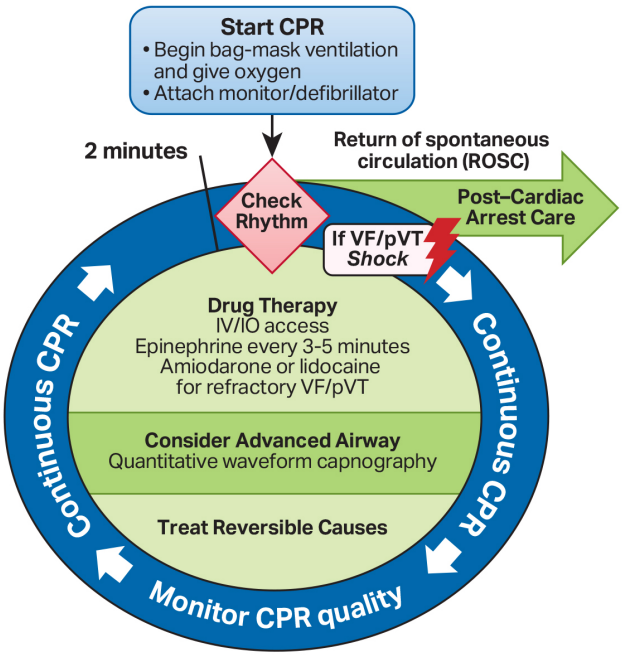
Synopsis

Along with CPR, early defibrillation is critical to survival when sudden cardiac arrest is caused by ventricular fibrillation or pulseless ventricular tachycardia (VF/pVT).[1,2] Defibrillation is most successful when administered as soon as possible after the onset of VF/pVT. Conversely, when VF/pVT is prolonged, depletion of the heart's energy reserves can compromise the efficacy of defibrillation unless replenished by a prescribed period of CPR before rhythm analysis. Figure 1 describes the algorithm for performing shocks and other ALS interventions. Minimizing disruptions in CPR surrounding shock administration is a high priority. Currently marketed defibrillators use proprietary shock waveforms that differ in their electrical characteristics. These deliver different peak currents even at the same programmed energy setting, making comparisons of shock efficacy between devices challenging. Technologies have been developed to diagnose the underlying cardiac rhythm during CPR and to derive prognostic information from the ventricular waveform that may guide patient management. These technologies require further validation before routine use.

While investigations continue to evaluate the optimal waveform and current, escalating energy may also be effective in termination of VF or pVT. Furthermore, optimized pad placement for defibrillation is an important factor in shock success (see Recommendation-Specific Supportive Text, items 4 and 5, and the section Vector Change and Double Sequential Defibrillation).

Recommendation-Specific Supportive Text

1. Emergent electric defibrillation is highly effective at terminating VF/pVT and other hemodynamic destabilizing tachyarrhythmias (please



High-Quality CPR

- Push hard (at least 2 inches [5 cm]).
- Push fast (100-120/min) and allow complete chest recoil.
- Minimize interruptions in compressions.
- Avoid excessive ventilation.
- Change compressor every 2 minutes, or sooner if fatigued.
- If no advanced airway, 30:2 compression-ventilation ratio.
- If advanced airway in place, give 1 breath every 6 seconds (10 breaths/min) with continuous chest compressions.
- Continuous waveform capnography
  - If $ETCO_2$ is low or decreasing, reassess CPR quality.

Shock Energy for Defibrillation

- **Biphasic:** Manufacturer recommendation (eg, initial dose of 120-200 J); if unknown, use maximum available. Second and subsequent doses should be equivalent, and higher doses may be considered.
- **Monophasic:** 360 J

Drug Therapy

- **Epinephrine IV/IO dose:** 1 mg every 3-5 minutes
- **Amiodarone IV/IO dose:** First dose: 300 mg bolus. Second dose: 150 mg.
  or
- **Lidocaine IV/IO dose:** First dose: 1-1.5 mg/kg. Second dose: 0.5-0.75 mg/kg.

Advanced Airway

- ET intubation or supraglottic advanced airway
- Continuous waveform capnography or capnometry to confirm and monitor ET tube placement
- Once advanced airway in place, give 1 breath every 6 seconds (10 breaths/min) with continuous chest compressions

Reversible Causes

- **H**ypovolemia
- **H**ypoxia
- **H**ydrogen ion (acidosis)
- **H**ypo-/hyperkalemia
- **H**ypothermia
- **T**ension pneumothorax
- **T**amponade, cardiac
- **T**oxins
- **T**hrombosis, pulmonary
- **T**hrombosis, coronary

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Figure 1. Adult Cardiac Arrest Circular Algorithm.
CPR indicates cardiopulmonary resuscitation; ET, endotracheal; IO, intraosseous; IV, intravenous; pVT, pulseless ventricular tachycardia; and VF, ventricular fibrillation.

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see sections on wide-complex and narrow-complex tachycardias or atrial fibrillation/flutter as appropriate).

2. Biphasic waveform defibrillators (which deliver pulses of opposite polarity) expose patients to a much lower peak electric current with equivalent or greater efficacy for terminating atrial[3] and ventricular tachyarrhythmias than monophasic (single polarity) defibrillators.[4–10] These potential differences in safety and efficacy favor preferential use of a biphasic defibrillator, when available. Biphasic defibrillators have largely replaced monophasic shock defibrillators which were last commercially manufactured in the late 1990s, however, some may still be in use.
3. The rationale for a single shock strategy, in which CPR is immediately resumed after the first shock rather than after serial "stacked" shocks (if required) is based upon several considerations. These include the high success rate of the first shock with biphasic waveforms (lessening the need for successive shocks), the declining success of immediate second and third serial shocks when the first shock has failed,[11] and the protracted interruption in CPR required for a series of stacked shocks. A single shock strategy results in shorter interruptions in CPR and a significantly improved survival to hospital admission and discharge (although not 1-year survival) compared with serial "stacked" shocks.[12–14] It is unknown whether stacked shocks or single shocks are more effective in settings of a monitored witnessed arrest, specifically, an in-patient cardiac arrest or cardiac arrest after cardiac surgery where the rhythm change is monitored in real time. (See the section on cardiac arrest after cardiac surgery in Part 10.[15])

4 and 5. Commercially available defibrillators either provide fixed energy settings or allow for escalating energy settings; both approaches are highly effective in terminating VF/pVT.[16] An optimal energy setting for initial or subsequent biphasic defibrillation, whether fixed or escalating, has not been identified and is best deferred to the defibrillator's manufacturer. When a manufacturer's specified setting is unknown, another approach is to apply the maximum dose setting for that device. A randomized trial comparing fixed 150 J biphasic defibrillation with escalating higher shock energies (200–300–360 J) observed similar rates of successful defibrillation and conversion to an organized rhythm after the first shock. However, among patients who required multiple shocks, escalating shock energy resulted in a significantly higher rate of conversion to an organized rhythm, although overall survival did not differ between the 2 treatment groups.[17] An observational study comparing fixed 200 J biphasic defibrillation against escalating (200-300-360 J) shocks had similar findings.[18] Different strategies to increase current delivery from biphasic waveform shock have been described, including optimizing pad-skin contact, applying manual pressure to pads during shock delivery (with appropriate self-protective insulation precautions), or vector change of pads. Vector change and double sequential defibrillation are described below.[19]

6. There is no conclusive evidence of superiority of one biphasic shock waveform over another for defibrillation.[20] Given the variability in electric characteristics between proprietary biphasic waveforms, energy settings are prespecified by the manufacturer for each specific device.

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ANCILLARY WAVEFORM TECHNOLOGY

Recommendations for Ancillary Waveform Technology		
COR	**LOE**	**Recommendations**
2b	**C-LD**	1. The effectiveness of artifact-filtering algorithms for analysis of electrocardiogram rhythms during chest compressions for adults in cardiac arrest has not been established.
2b	**C-LD**	2. The effectiveness of VF waveform analysis to guide the acute management of adults with cardiac arrest has not been established.

Synopsis

CPR obscures interpretation of the underlying rhythm because of the artifact created by chest compressions on the electrocardiogram. This makes it difficult to plan the next step of care and can potentially delay or even misdirect drug therapies if given empirically (blindly) on the basis of the patient's presumed, but not actual, underlying rhythm. Time taken for rhythm analysis also disrupts CPR. Artifact-filtering and other innovative techniques to identify the underlying rhythm beneath ongoing CPR can surmount these challenges and minimize interruptions in chest compressions while offering a diagnostic advantage to better direct therapies.[1–6] These still require further testing and validation before routine use.

Recommendation-Specific Supportive Text

1. Despite the theoretical advantages, no study has evaluated artifact-filtering technologies in a real-time clinical setting or validated their clinical effectiveness compared to current resuscitation strategies. At present, filtering algorithms are strictly used for visual (manual) rhythm interpretation and not for automated VF/VT rhythm detection in automated external defibrillators during ongoing CPR. Further investigation and clinical validation are necessary before these technologies are adopted into routine clinical practice.[7]
2. The electric characteristics of the VF waveform are known to change over time.[8] VF waveform analysis may be of value in predicting the success of defibrillation or other therapies during the course of resuscitation.[9–11] The prospect of basing therapies on a prognostic analysis of the VF waveform in real time is an exciting and developing avenue of new research. However, the validity, reliability, and clinical effectiveness of an approach that prompts or withholds shock or other therapies on the basis of predictive analyses is currently uncertain. The only prospective clinical trial comparing a standard shock-first protocol with a waveform analysis–guided shock algorithm was underpowered, however, observed no difference in ROSC.[12] The consensus of the writing group is that there is currently insufficient evidence to support the routine use of waveform analysis to guide resuscitation care, but it is an area in which further research with clinical validation is needed and encouraged.

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VECTOR CHANGE AND DOUBLE SEQUENTIAL DEFIBRILLATION

Recommendations for Vector Change and Double Sequential Defibrillation		
COR	**LOE**	**Recommendations**
2b	**B-R**	1. The usefulness of vector change for adults in cardiac arrest with persisting VF/pVT after ≥3 consecutive shocks has not been established.
2b	**B-R**	2. The usefulness of double sequential defibrillation for adults in cardiac arrest with persisting VF/pVT after ≥3 consecutive shocks has not been established.

Synopsis

Combined with CPR, successful defibrillation is essential to survival from cardiac arrest caused by VF/VT.[1,2] Defibrillation delivers shock energy (joules), creating a current across the thorax from pad-to-pad.[3] Its success is influenced by a variety of factors independent of energy setting, including the electrical resistance of tissues encountered (typically highest at the skin-pad interface) that can dramatically reduce current delivery,[4–7] pad positions (and resulting shock "vector") that encompass the heart anatomically[8–11] and concomitant high quality CPR. When these are all properly managed, biphasic shock can be highly effective (>75% success) in terminating VF/pVT.[12,13]

"Shock-resistant" and "shock-refractory" are commonly used to describe VF/pVT that continues to be seen on rhythm checks after repeated shocks. In some cases this is due to true failure of shock to terminate VF/pVT, resulting in ongoing, incessant VF/pVT. Causes of such shock failure can be related to correctable deficiencies in defibrillation technique that are best addressed before employing alternate shock strategies such as pad repositioning (vector change) or double sequential defibrillation (DSD). Conversely, evidence indicates a far more common mechanism for VF/pVT that continues to be seen on post-shock rhythm checks (≈80% of instances) is not due to shock failure, but rather to VF/pVT's recurrence following successful termination by shock, an event that is obscured by the ensuing period of CPR. When CPR is later paused for rhythm/pulse checks, VF/pVT then seen is attributed to shock failure rather than to its recurrence after successful termination, which is more often the actual case.[12,14,15] This distinction is important since recurrent VF/pVT may be better remedied by post-shock rhythm stabilization therapy rather than altering an already successful defibrillation technique. Thus labels like "shock-refractory" can be misleading when they conflate different mechanisms for post-shock VF/pVT, for which different treatment strategies may be required. Accordingly, we propose using "persisting VF/pVT" in these guidelines for patients who remain in VF/pVT arrest after ≥3 consecutive shocks, when its actual mechanism (incessant VF/pVT due to true shock failure vs recurrent VF/pVT following successful termination by shock) is not known with certainty.

Recommendation-Specific Supportive Text

1 and 2. Prior systematic reviews of low-quality evidence have not reported benefit from DSD for persisting VF.[16–20] Defibrillator pad relocation, called vector change (VC), an inherent feature of DSD, was evaluated in only one trial as a stand-alone measure. That trial (DOSE-VF), compared standard defibrillation, VC, and DSD in patients with cardiac arrest in whom VF continued to be seen on rhythm checks after 3 standard shocks. It found significant improvement in survival at hospital discharge with VC and DSD compared to standard defibrillation by intention-to-treat, but notably not when trial findings were analyzed by the treatment strategy patients actually received.[21] Furthermore, in a secondary exploratory analysis a significant survival benefit from DSD was only observed in the 17% of study patients in whom VF was incessant, and not in the vast majority (83%) of patients in whom VF recurred after a successful shock.[22] The interval between each sequential "double" shock required for successfully terminating VF has also been shown experimentally[23,24] and demonstrated in DOSE-VF itself[25] to require a level of precision (separated by milliseconds) unlikely to be consistently achievable by manual activation of two defibrillators. Based on its review, ILCOR's 2023 International Consensus on CPR and Emergency Cardiovascular Care Science With Treatment Recommendations (CoSTR) judged the overall supportive evidence as relatively weak when issuing "may be considered" recommendations for VC and DSD.[26] The adoption of VC or DSD into routine clinical practice for persisting VF/pVT (by whatever mechanism) thus requires further investigation, given its diagnostic and technological requirements.[27] These include technologies that can reliably distinguish recurrent from incessant

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post-shock VF during ongoing CPR,[28] provide the precise timing interval needed between shocks, and best direct if, how, when, and in whom such a strategy may be applicable.

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NONDEFIBRILLATION ELECTRICAL THERAPIES FOR CARDIAC ARREST

Nondefibrillation Electrical Therapies for Cardiac Arrest		
COR	**LOE**	**Recommendation**
3: No Benefit	**B-R**	1. Routine use of electrical pacing is not recommended during the resuscitation of an established adult cardiac arrest.

Synopsis

In addition to defibrillation, alternative electrical therapies have been explored as possible treatment options during cardiac arrest. Transcutaneous pacing has been studied during cardiac arrest with bradyasystolic cardiac rhythm. In theory, the heart will respond to electrical stimuli by producing myocardial contraction and generating forward movement of blood, but clinical trials have not shown pacing to improve patient outcomes.

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Other pseudo-electrical therapies, such as cough CPR, fist or percussion pacing, and precordial thump have all been described as temporizing measures in select patients who are either peri-arrest or in the initial seconds of witnessed cardiac arrest (before losing consciousness in the case of cough CPR) when definitive therapy is not readily available.[1] These therapies are described elsewhere (see Part 10. Special Circumstances[2] for more on precordial thump, fist pacing, and cough CPR).

Recommendation-Specific Supportive Text

1. Existing evidence, including observational and quasi–randomized controlled trial (RCT) data, suggests that pacing by a transcutaneous, transvenous, or transmyocardial approach during cardiac arrest does not improve the likelihood of ROSC or survival, regardless of the timing of pacing administration in established asystole, location of arrest (in-hospital or out-of-hospital), or primary cardiac rhythm (asystole, pulseless electrical activity).[3–7] Protracted interruptions in chest compressions while the success of pacing is assessed can be detrimental to survival. Specifically, attempts at electrical pacing may delay evidence-based resuscitative measures, such as CPR. It is not known whether the timing of pacing initiation may influence pacing success such that pacing may be useful in the initial minute of select cases of witnessed, monitored cardiac arrest (see Part 10. Special Circumstances, Cardiac Arrest After Cardiac Surgery[2]). If pacing is attempted during cardiac arrest related to the special circumstances described above, professionals are cautioned that its performance could be at the expense of high-quality CPR. Of note, this recommendation addressing electrical pacing is specifically focused upon patients in cardiac arrest and does not address prevention of cardiac arrest nor does it address the utility of overdrive pacing for arrhythmia.

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VASCULAR ACCESS IN CARDIAC ARREST MANAGEMENT

Recommendations for Vascular Access in Cardiac Arrest Management

COR	LOE	Recommendations
1	A	1. It is recommended that professionals first attempt establishing intravenous access for drug administration in adult patients in cardiac arrest.
2a	A	2. Intraosseous access is reasonable if initial attempts at intravenous access are unsuccessful or not feasible for adult patients in cardiac arrest.
2b	C-LD	3. For appropriately trained professionals, central venous access may be considered for adult patients in cardiac arrest if attempts to establish intravenous and intraosseous access are unsuccessful or not feasible.

Synopsis

Traditionally, peripheral IV access has been used to administer medication during cardiac arrest. However, obtaining IV access under emergent conditions can be challenging because of patient characteristics and operator experience leading to delay in pharmacological treatments. Alternatives to IV access for drug administration include IO, central venous, intracardiac, and endotracheal routes. Intracardiac drug administration was discouraged in the "2000 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care" due to its specialized skill set requirements, potential for morbidity, and the availability of other access options.[1] Similarly, drug administration via secured endotracheal tube results in low blood concentrations and unpredictable pharmacological effects and has also been removed from the guidelines.[2] Central venous access is primarily used in a hospital setting because it requires specialized training to acquire and maintain proficiency.

Recommendation-Specific Supportive Text

1 and 2. The peripheral IV route for vascular access has traditionally been preferred for emergency drug and fluid administration during adult resuscitation. The pharmacokinetic properties, acute effects, and clinical efficacy of emergency drugs have primarily been described for IV administration.[3–6] However, observational studies have noted a significant increase in the use of IO access in adult OHCA, despite the absence of high-quality evidence.[7,8] Three recent large RCTs evaluated the clinical effectiveness of initial IO access compared with

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initial IV access in adult OHCA and found no differences in clinical outcomes.[9–11] Each RCT used a superiority design; therefore, the absence of outcome differences between the two groups does not indicate equivalence. An ILCOR systematic review, including data from these RCTs, found that the use of IO access compared with IV access did not result in a statistically significant improvement in outcomes, including survival to discharge, survival with favorable neurological outcome, or health-related quality of life.[12] This systematic review noted lower odds of achieving sustained ROSC for the IO route compared with the IV route (odds ratio [OR] 0.89; 95% CI, 0.80–0.99).[12] Patient, EMS professional, or circumstantial characteristics may limit successful IV access or make IV access infeasible. In these cases, the available evidence supports IO access as an alternative. The optimal anatomical location for IO access (ie, tibial or humeral) remains a knowledge gap.

3. Drug administration through central venous access can achieve faster circulation times and higher plasma concentrations in adults in cardiac arrest when compared with peripheral IV administration.[13–15] However, data comparing clinical outcomes from cardiac arrest based on different access routes, including central venous access, remain limited. A small, single- center study reported higher rates of ROSC among participants who were randomized to femoral or internal jugular vein access compared to those with peripheral IV access, although with a high risk of bias.[16] If central venous access is attempted by appropriately trained professionals, special attention is required to avoid delays in chest compressions or defibrillation.

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RECOMMENDATIONS FOR VASOPRESSOR MEDICATIONS IN ADULT CARDIAC ARREST

Recommendations for Vasopressor Management in Cardiac Arrest		
COR	**LOE**	**Recommendations**
1	B-R	1. Administration of epinephrine is recommended for adult patients in cardiac arrest.
2a	B-R	2. It is reasonable to administer epinephrine (1 mg) every 3 to 5 min for adult patients in cardiac arrest.
2a	B-NR	3. With respect to timing, for adult patients in cardiac arrest with a nonshockable rhythm, it is reasonable to administer epinephrine as soon as feasible.
2a	B-NR	4. With respect to timing, for adult patients in cardiac arrest with a shockable rhythm, it is reasonable to administer epinephrine after initial defibrillation attempts have failed.
3: No Benefit	B-R	5. Vasopressin alone or vasopressin in combination with epinephrine offers no advantage as a substitute for epinephrine for adult patients in cardiac arrest.
3: No Benefit	B-R	6. High-dose epinephrine is not recommended for routine use for adult patients in cardiac arrest.

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Synopsis

The potent vasopressor effects of epinephrine have been recognized for nearly 150 years. Vasopressors increase coronary perfusion pressure and increase the likelihood of ROSC. Epinephrine has been shown to increase ROSC and survival to hospital admission in placebo-controlled RCTs, cohort studies, and registry studies, but there is limited evidence to support improvement in survival to hospital discharge or functional neurologic outcome. Studies comparing different dosing intervals, high-dose epinephrine, and low-dose epinephrine against standard-dose epinephrine (1 mg every 3–5 minutes) have not demonstrated an advantage in survival outcomes. Defining the optimal number of doses or maximum dose of epinephrine is a critical knowledge gap and more research is needed.

Vasopressin, a naturally occurring antidiuretic hormone, has been studied as an alternative to epinephrine during cardiac resuscitation. In high doses, vasopressin acts as a potent vasoconstrictor and, like epinephrine, increases systemic vascular resistance and raises coronary perfusion pressure. However, there have been no clinical trials demonstrating an advantage to using vasopressin alone or vasopressin in addition epinephrine over standard-dose epinephrine alone.

Recommendation-Specific Supportive Text

1. There have been no new RCTs comparing epinephrine to placebo since the publication of the 2020 ALS guidelines. There is consistent and compelling evidence from previous RCTs, cohort, and registry studies to support a potent effect of epinephrine on ROSC, survival to hospital admission, and survival to hospital discharge.[1,2] However, studies have failed to show an increase in survival with functional neurologic outcome.[2–5] A secondary analysis of the PARAMEDIC2 (Prehospital Assessment of the Role of Adrenaline: Measuring the Effectiveness of Drug Administration in Cardiac Arrest) trial found 12-month survival favored epinephrine, whereas there was no significance difference in 6-month survival with functional neurologic outcome between arms.[6] While there is no evidence supporting improvement in neurologic outcome, epinephrine does improve short- term survival, a prerequisite to meaningful recovery. In the absence of a feasible, intra-arrest method of determining the likelihood of favorable neurological outcome, epinephrine remains standard therapy to treat cardiac arrest.
2. Existing clinical trials have used a protocol of 1 mg of epinephrine administered every 3 to 5 minutes.[3–6] Operationally, administering epinephrine every second cycle of CPR, after the initial dose, meets this recommendation.
3. Multiple observational studies have demonstrated an association between earlier epinephrine administration and ROSC.[2] A post-hoc analysis of the PARAMEDIC2 trial found that the effectiveness of epinephrine, compared to placebo, converges at approximately 20 minutes of pulselessness where there is no difference in survival to hospital discharge, 30-day survival, or functional neurologic outcome with longer times to initial epinephrine administration.[7]
4. Systematic reviews and meta-analyses of RCTs and cohort studies have found that epinephrine is associated with improved ROSC in all rhythms, but the benefit in shockable rhythms is less than in nonshockable rhythms.[2–4,8] One observational study of IHCA demonstrated 10% lower risk-adjusted survival in hospitals with the highest rates of epinephrine administration prior to initial defibrillation when compared with those hospitals with the lowest rates.[9] The optimal timing for epinephrine in relation to defibrillation is unknown. In patients with shockable rhythms, this literature supports prioritizing rapid defibrillation and administering epinephrine after initial attempts with CPR and defibrillation are not successful.
5. When compared to placebo, administration of vasopressin improves ROSC regardless of presenting rhythms and increases survival to hospital admission and discharge in nonshockable rhythms.[10] However, multiple systematic reviews and meta-analyses of RCTs and observational studies have found no difference in survival outcomes when comparing vasopressin alone or vasopressin combined with epinephrine versus epinephrine alone.[2,10–12]
6. Multiple RCTs have compared administration of high-dose epinephrine with standard-dose, but the definition of high-dose epinephrine varies widely by study. There were no new RCTs published since the 2020 Guidelines comparing standard-dose epinephrine to any high-dose epinephrine. Systematic reviews and meta-analysis of RCTs have yielded mixed results.[10,12] One registry-based study found dosing epinephrine more frequently than the standard interval may be potentially harmful.[13] High-dose intramuscular (IM) epinephrine for the treatment of OHCA, with a different pharmacokinetic profile than traditional IV administration, has also been evaluated. One single-center, before-after study of 1405 OHCA patients receiving an initial IM dose of epinephrine followed by standard IV/IO administration shortened time to epinephrine administration and improved survival to hospital admission, hospital survival, and favorable neurologic status at hospital discharge. However, the study design could not account for multiple

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confounders, such as temporal trends, misclassification, and resuscitation characteristics.[14] Further study is needed to evaluate the potential benefit of high-dose IM epinephrine in cardiac arrest.

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NONVASOPRESSOR MEDICATIONS DURING CARDIAC ARREST

Recommendations for Nonvasopressor Medications in Adult Cardiac Arrest		
COR	**LOE**	**Recommendations**
2b	B-R	1. For adults in cardiac arrest amiodarone or lidocaine may be considered for ventricular fibrillation (VF) or pulseless ventricular tachycardia (pVT) that is unresponsive to defibrillation.
2b	C-LD	2. For adults in cardiac arrest, the use of β-blockers, bretylium, procainamide, or sotalol for VF/pVT unresponsive to defibrillation is of uncertain benefit.
2b	C-LD	3. For adults in cardiac arrest, the use of steroids is of uncertain benefit.
3: No Benefit	B-R	4. For adults in cardiac arrest, routine administration of calcium is not recommended.
3: No Benefit	B-R	5. For adults in cardiac arrest, routine administration of sodium bicarbonate is not recommended.
3: No Benefit	B-R	6. For adults in cardiac arrest, routine administration of magnesium is not recommended.

Synopsis

Pharmacological treatment of cardiac arrest is provided (if indicated) when ROSC is not achieved by CPR and defibrillation.[1] Treatments include vasopressor agents such as epinephrine (discussed in Recommendations for Vasopressor Medications During Cardiac Arrest) as well as drugs without direct hemodynamic effects (nonvasopressors) and their administration is delineated in Figure 2. The latter group includes antiarrhythmic medications (which include β- blockers), magnesium, sodium bicarbonate, calcium, and steroids, many of which are commonly administered by health care professionals, including EMS, during cardiac arrest. Although theoretically attractive and of modest benefit in animal studies, none of these therapies have definitively demonstrated improvement in survival after cardiac arrest. Some, however, offer potential benefit in selected populations and circumstances.

Guidance for the treatment of cardiac arrest due to hyperkalemia, including the use of calcium and sodium bicarbonate for this indication, is presented in Electrolyte Abnormalities within Part 10. Special Circumstances.[2] In addition, Part 10 offers guidance for the management of cardiac arrest due to toxic ingestion that discusses the administration of these medications in these specific circumstances. Guidance for management of torsades de pointes is presented in Recommendations for Polymorphic VT later in these guidelines.

Recommendation-Specific Supportive Text

1. The 2023 AHA focused update on adult advanced cardiovascular life support[3] and ILCOR's 2024 CoSTR summary[4] addressed administration of parenteral antiarrhythmic medications to patients with cardiac arrest unresponsive to defibrillation.

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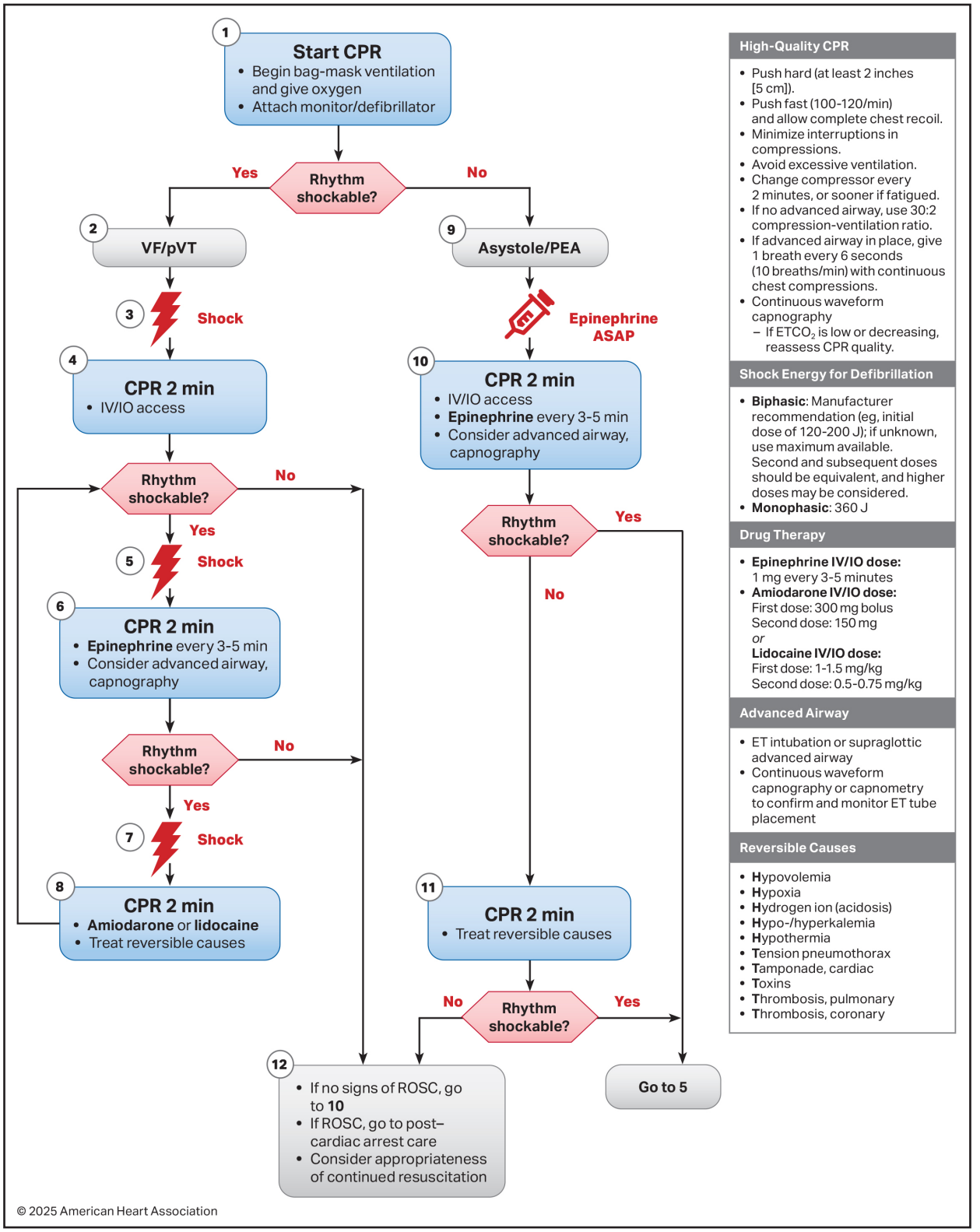

Figure 2. Adult Cardiac Arrest Algorithm.
CPR indicates cardiopulmonary resuscitation; ET, endotracheal; IO, intraosseous; IV, intravenous; PEA, pulseless electrical activity; pVT, pulseless ventricular tachycardia; and VF, ventricular fibrillation.

A large, randomized, placebo-controlled prehospital trial found amiodarone and lidocaine each improved survival to hospital admission over placebo, however, there was no difference in survival to hospital discharge.[5] Secondary analyses of both drugs found improved survival to hospital

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discharge in bystander-witnessed arrest, with a significant interaction between active drug effect and witnessed arrest status, as did amiodarone in EMS-witnessed arrest. When administered within 8 minutes of ALS-capable EMS arrival, amiodarone also improved survival to hospital admission, discharge, and functional survival at hospital discharge.[6] This suggests the potential for a small, time-dependent therapeutic window in patients with rapidly recognized and treated cardiac arrest. Data are insufficient to definitively distinguish between the effectiveness of lidocaine and amiodarone, nor their benefit when given in combination.

2. No new evidence emerged from a 2025 ILCOR evidence update[7] regarding the use of other parenteral antiarrhythmic agents in cardiac arrest. These include bretylium tosylate (which was recently reintroduced in the United States market with no new evidence on its effectiveness or safety); sotalol (which requires a slow infusion and has unknown benefit when given as a bolus in cardiac arrest[8]), procainamide (also requiring slow infusion, and of uncertain benefit when given by rapid infusion as a second-line agent in cardiac arrest[9]), and beta blockers (for which the ILCOR update found insufficient evidence to recommend for or against use).[10] The effectiveness of these drugs administered in combination for cardiac arrest has not been systematically addressed and remains a knowledge gap. Nifekalant is currently unavailable in the United States and is therefore excluded from this recommendation.
3. Both the 2023 AHA focused update and ILCOR's 2023 CoSTR summary identified no new compelling data to alter previous recommendations regarding the use of steroids bundled with a vasopressor agent in cardiac arrest.[3,11] A large multicenter, blinded, placebo-controlled randomized trial of IHCA deploying this drug combination found an improved rate of ROSC but not survival to hospital discharge or neurological outcome, failing to confirm results of 2 previous single center trials.[12] Observational studies combining intra-arrest corticosteroids with standard resuscitation have demonstrated mixed outcomes.[13–15] An ongoing registered clinical trial (NCT06203847) may provide further clarity.
4. The 2023 AHA focused update,[3] ILCOR's 2023 CoSTR summary,[11] and a systematic review including 3 RCTs,[16] found routine calcium administration during cardiac arrest, including cases of refractory asystole and pulseless electrical activity, did not improve survival to hospital discharge or neurological outcome, with a cautionary trend toward potential harm. A Get With the Guidelines registry report also found no evidence of benefit from calcium administration, independent of rhythm presentation, during IHCA.[17] Although the findings of registry data are confounded by temporal bias (ie, calcium administered as a last resort during prolonged resuscitations, where outcomes are already likely poor), the randomized trial data, designed to mitigate that bias, found no evidence of benefit when calcium was administered immediately after the first dose of epinephrine.[18] Administration of calcium in special circumstances such as hyperkalemia and toxic ingestion is discussed elsewhere as noted above.
5. The 2023 AHA focused update found routine administration of sodium bicarbonate in cardiac arrest was of no benefit.[3] However, recent observational data examining prehospital administration of sodium bicarbonate in pulseless electrical activity and asystole suggests a potential association with improved survival.[19] As observed with calcium, issues of resuscitation time bias may also apply to bicarbonate, resulting in difficulty interpreting the findings.[20,21] Although contemporary evidence is insufficient to change the recommendation, there may be clinical equipoise to warrant further clinical trials to assess its utility in nonshockable presenting rhythms. Use of sodium bicarbonate in special circumstances such as hyperkalemia is discussed elsewhere as noted above.
6. The 2024 ILCOR CoSTR found intra-arrest magnesium administration did not improve ROSC, survival, or neurological outcome regardless of the presenting cardiac arrest rhythm,[22–25] nor was it useful for monomorphic VT.[26] Magnesium's efficacy in the treatment of torsade de pointes is addressed later in this Part (see Treatment of Adults With Polymorphic Ventricular Tachycardia).

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ADJUNCTS FOR PERFORMANCE OF CPR

Recommendations for Adjuncts to CPR		
COR	**LOE**	**Recommendations**
2b	**B-NR**	1. An abrupt increase in end-tidal CO_2 may be used to detect ROSC during chest compressions in adults in cardiac arrest or when a rhythm check reveals an organized rhythm.
2b	**C-LD**	2. Use of point-of-care ultrasonography during adult cardiac arrest resuscitation to diagnose reversible causes is not well established.
2b	**C-LD**	3. Use of point-of-care echocardiography to assess cardiac function for prognostication during adult cardiac arrest resuscitation is not well established.
2b	**C-LD**	4. When supplemental oxygen is available, it may be reasonable to use the maximal feasible inspired oxygen concentration during CPR for adults with cardiac arrest.
2b	**C-LD**	5. Measurement of arterial blood gases during CPR has uncertain benefit in adults with cardiac arrest.
2b	**C-LD**	6. In adult patients with cardiac arrest, it may be reasonable to use physiological parameters such as arterial blood pressure or end-tidal CO_2 when feasible to monitor and optimize CPR quality.
2b	**C-EO**	7. Arterial pressure monitoring by arterial line may be used to detect ROSC during chest compressions or when a rhythm check reveals an organized rhythm in adults with cardiac arrest.
3: No Benefit	**C-LD**	8. Head-up cardiopulmonary resuscitation in adults with cardiac arrest is not recommended except in setting of clinical trials.

Synopsis

The foundation of cardiac arrest resuscitation focuses on high-quality CPR, early defibrillation when indicated, and guideline-directed pharmacologic therapies and airway

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management strategies. With appropriate expertise and resources, adjuncts to standard cardiac arrest resuscitation provide additional data to support and enhance care delivery. Adjuncts—such as POCUS, $ETCO_2$ monitoring, blood gas analysis, or arterial lines—may enable the incorporation of precise physiologic parameters to optimize individual resuscitation.

Head-up CPR seeks to augment conventional supine CPR to increase cerebral perfusion pressure with the goal of improving neurologically favorable outcome. Head-up CPR has been studied as a bundle of care combining mechanical chest compressions, an impedance threshold device, and application of an automated device to control sequential elevation of the head and thorax during compressions.

While emerging but limited data exist for many of these CPR adjuncts, more research is needed to inform future guidelines.

Recommendation-Specific Supportive Text

1. $ETCO_2$ values during CPR serve as a surrogate for cardiac output.[1,2] A secondary analysis of the Pragmatic Airway Resuscitation Trial found that temporal increases in $ETCO_2$ were associated with ROSC.[3] A systematic review of 8 observational studies found that an abrupt increase in $ETCO_2$ was a predictor of ROSC; however, no absolute cutoff value was identified.[4] Data suggests that a sudden increase greater than 10 mm Hg may indicate ROSC,[5,6] although ROSC can still occur with $ETCO_2$ increases of less than 10 mm Hg.[7] These findings may be influenced by other factors known to impact $ETCO_2$, including minute ventilation, CPR quality, the administration of epinephrine or sodium bicarbonate, airway management strategies, and the etiology of cardiac arrest.[8,9]
2. Multiple observational studies report the use of POCUS during cardiac arrest to aid in the identification of potentially reversible causes of cardiac arrest, such as pulmonary embolism, cardiac tamponade, effusion, myocardial infarction, aortic dissection, and hypovolemia. However, evidence for diagnosing these target conditions is limited by inconsistent clinical protocols, sonographic measures, and operator experience, resulting in a high degree of heterogeneity among the studies with a high concern for bias.[10] Furthermore, the use of POCUS has been associated with longer interruptions in chest compressions, longer duration of resuscitation, and higher rates of interventions.[11,12] Therefore, even when a user with adequate skill and expertise uses POCUS during cardiac arrest, attention to minimizing interruptions in CPR is a priority.[10,13–16]
3. POCUS has been used to assess cardiac activity and, in the absence of cardiac motion in conjunction with other modalities, to terminate resuscitative efforts.[14,17–20] However, only a small number of observational studies, with significant limitations, including variability in the definitions of sonographic findings, describe its use in this setting.[21–23] A single small RCT, multiple systematic reviews, and a meta-analysis of observational studies have consistently found no improvement in outcomes with the use of POCUS during cardiac arrest.[23–25] Future research that standardizes image acquisition and other study methodology to examine the utility of POCUS for this indication are required. An alternative modality, transesophageal echocardiography, has the potential to provide high-quality imaging of cardiac structure and function without interrupting CPR. However, the utility of transesophageal echocardiography during CPR remains a knowledge gap.
4. No adult human trials directly compare levels of inspired oxygen concentration during CPR. Retrospective studies have found that higher intra-arrest partial pressure of oxygen in the alveoli is associated with survival to hospital admission,[26] survival to hospital discharge,[27] and survival with favorable neurological outcome.[28] However, these findings may be influenced by patient selection, airway management strategies, and the quality of resuscitation.
5. Small prospective studies with significant limitations have found arterial blood gas parameters, such as partial pressure of oxygen and partial pressure of carbon dioxide, to be predictive of ROSC.[29,30] However, both partial pressure of oxygen and partial pressure of carbon dioxide are dependent on cardiac output and can be influenced by patient factors and the quality of CPR. Additionally, numerous retrospective studies have assessed intra-arrest blood gas analysis as a predictive tool for outcomes but suffer from similar limitations, compounded by their retrospective design.[26–28,31–38]
6. A retrospective study from the AHA's Get With the Guidelines-Resuscitation found the use of $ETCO_2$ or diastolic blood pressure monitoring during CPR was associated with increased rate of ROSC.[39] $ETCO_2$ values reflect pulmonary circulation and cardiac output[1,2] and are positively correlated with increased compression depth[40–42] and release velocity.[40,41] Multiple systematic reviews have found numeric $ETCO_2$ measures to be a predictor of ROSC.[4,43] An $ETCO_2$ less than 10 mm Hg is generally associated with poor outcomes, whereas values above 10 mm Hg, and

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ideally above 20 mm Hg, are associated with increased rates of ROSC.[43] The combination of the association of higher $ETCO_2$ with ROSC and the findings that CPR quality can increase $ETCO_2$ suggests that targeting compressions to a value of at least 10 mm Hg, and ideally 20 mm Hg or greater, may indicate mechanically adequate technique. Other factors known to impact $ETCO_2$ values need to be considered, including minute ventilation, drug administration, airway management strategies, and cardiac arrest etiology. $ETCO_2$ monitoring is most reliable when measured through an endotracheal tube, but it can also be used with a supraglottic airway or bag-mask ventilation with unclear utility. When an invasive arterial line is in place, arterial diastolic pressure can approximate coronary perfusion pressure and myocardial perfusion during CPR.[44] The use of diastolic blood pressure monitoring during cardiac arrest is associated with higher ROSC, but there are inadequate adult data to suggest any specific pressure in adults.

7. If an arterial line is in place, the development of an arterial waveform or a sudden increase in diastolic pressure during a rhythm check showing an organized rhythm may indicate ROSC.[45] When a waveform is present, it is important to ensure it correlates with a palpable pulse to verify ROSC. The placement of an arterial line requires appropriate expertise and resources; however, placement during cardiac arrest may detract from the provision of high-quality CPR.
8. Original work evaluating head-up CPR was done in porcine models, which demonstrated conflicting evidence of efficacy.[46,47] A recent ILCOR systematic review identified no randomized controlled trials and only 3 observational studies, each with significant methodological limitations.[48–50] With these and other challenges the systematic review identified, for the outcome of survival to discharge and survival to discharge with favorable neurological outcome, evidence on Head up CPR was considered very low–certainty of evidence downgraded for serious risk of bias. Taken together, current evidence regarding head-up CPR is limited in the absence of RCTs or appropriate comparisons. Furthermore, implementation of this approach requires specialized equipment (automated positioning device, mechanical CPR device, an impedance threshold device) and significant training. Based on this, there is currently insufficient evidence for its use outside of well-designed clinical trials, although future work is needed to evaluate this adjunct.

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TERMINATION OF RESUSCITATIVE MEASURES

Recommendations for Termination of Resuscitation		
COR	**LOE**	**Recommendations**
1	B-NR	1. When TOR is being considered, BLS prehospital professionals should use the BLS TOR rule for adult patients in OHCA, where ALS is not available or may be significantly delayed.
2a	B-NR	2. It is reasonable for ALS prehospital professionals to use the ALS TOR rule to terminate resuscitation efforts in the field for adult patients with OHCA.
2a	B-NR	3. In a tiered EMS system with both ALS and BLS professionals, it is reasonable to use the Universal TOR rule for adult patients with OHCA.
2b	C-LD	4. In intubated adult patients, failure to achieve an end-tidal CO_2 of greater than 10 mm Hg by waveform capnography after 20 minutes of ALS resuscitation may be considered as a component of a multimodal approach to decide when to end resuscitative efforts.
3: Harm	C-EO	5. In nonintubated adult patients, a specific end-tidal CO_2 cutoff value at any time during CPR should not be used as an indication to end resuscitative efforts.

Synopsis

OHCA is a resource-intensive condition associated with low rates of survival. It is important for EMS professionals to differentiate patients in whom continued resuscitation is futile from patients with a chance of survival who should receive continued resuscitation and transportation to hospital. This will aid in both resource use and optimizing a patient's chance for survival. Using a validated TOR rule will help ensure accuracy in determining futility in cardiac arrest patients. Though many TOR rules have been proposed,[3] TOR rules that have been highly studied in North America include the BLS, ALS, and UTOR rules (Figures 3 and 4).

TOR rules are applicable for the specific scope of practice of the EMS agency upon which they were validated. For example, an EMS agency with only BLS-trained professionals (first responders or emergency medical technicians [EMTs]) the BLS TOR rule is appropriate; for an EMS agency with only ALS-trained professionals, the ALS TOR rule is appropriate; and for an agency or system with both BLS- and ALS-trained professionals (commonly referred to as a tiered-response system) the UTOR rule is appropriate.

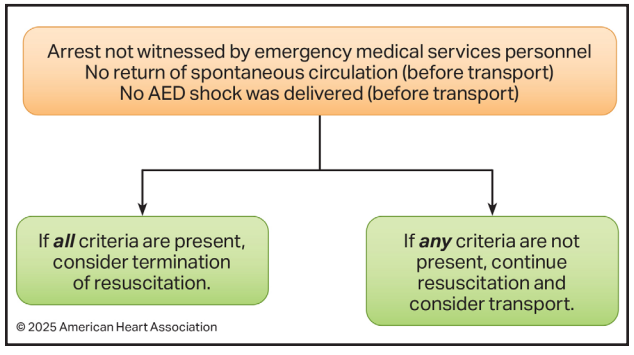

Figure 3. BLS/Universal Termination of Resuscitation Rules.
AED indicates automated external defibrillator; and BLS, basic life support.

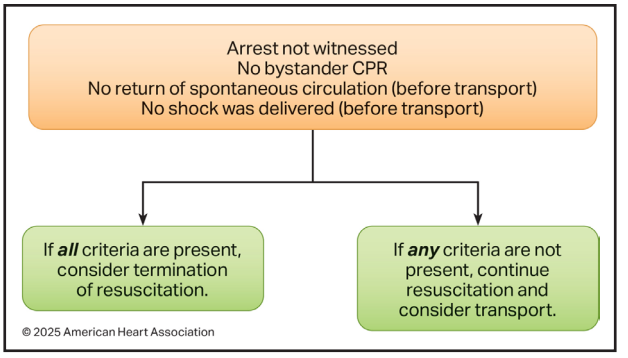

Figure 4. ALS Termination of Resuscitation Rule.
ALS indicates advanced life support; and CPR, cardiopulmonary resuscitation.

These TOR rules are inappropriate for populations in which they have not been validated, such as for patients with overdose, trauma, or IHCA. Further research is needed to evaluate the appropriate application of existing TOR rules to gain a clearer understanding of the risks and benefits associated with their use.

Recommendation-Specific Supportive Text

1. In a meta-analysis of 7 published BLS TOR studies primarily in North America (33 795 patients pooled from retrospective and prospective observational studies), only 0.13% (95% CI, 0.03%–0.58%) of patients who fulfilled the BLS termination criteria survived to hospital discharge.[1] A 2024 international meta-analysis[2] of 6 reclassified retrospective validation studies from EMS systems primarily in Asia suggests that the specificity of the BLS rule, when generalized outside of North America may be lower than previously reported. The analysis reclassified EMS agencies, included heterogeneous methodologies and response characteristics, and relied heavily on retrospective data. These limitations highlight the importance of further rigorous, prospective research to validate the specificity and applicability of BLS TOR rules by diverse EMS agencies.
2. In a meta-analysis of 2 published retrospective observational studies (10 178 patients) of the ALS TOR rule, only 0.01% (95% CI, 0.00%–0.07%) of patients who fulfilled the ALS termination criteria survived to hospital discharge.[1] The same 2024 international meta- analysis described above[2] analyzed 17 published studies on ALS TOR patients, finding a pooled specificity of 96% (95% CI, 0.93–0.99).

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3. The UTOR rule, which uses the same criteria as the BLS rule (ie, arrest not witnessed by EMS professionals; no shock delivered; no ROSC), has been prospectively validated in combined BLS/ALS, or tiered response, EMS agencies.[3] Although the rule did not have adequate specificity after 6 minutes of resuscitation (false-positive rate: 2.1%) it did achieve better than 99% specificity after approximately 15 minutes of attempted resuscitation while still reducing transportation by half. A retrospective analysis found that the application of the UTOR rule at 20 minutes of resuscitation was able to predict futility, identifying over 99% of survivors and patients with good neurological outcome.[4] Another meta-analysis[2] also examined the UTOR rule in 19 studies, many of which had initially been classified as employing the BLS TOR rule in tiered BLS + ALS EMS systems. After reclassification, the pooled specificity of the UTOR rule was reported to be 88% (95% CI, 0.88–0.94). Notably, 10 of the 11 reclassified studies were conducted outside of North America.
4. In intubated patients, an $ETCO_2$ measurement of less than 10 mm Hg indicates little to no cardiac output. Several small retrospective studies provide evidence showing that an $ETCO_2$ less than 10 mm Hg after 20 minutes of ALS resuscitation is strongly but not perfectly predictive of futility.[5–8] These small observational studies suffer from a high risk of bias. Alternative $ETCO_2$ thresholds, time points, and changes in $ETCO_2$ over time have been proposed.[9–12] The use of $ETCO_2$ alone to predict patient outcome needs to be validated in a large prospective study.[2] No data is available that addresses $ETCO_2$ measurement with supraglottic airways and predicts poor outcomes. Additionally, isolated $ETCO_2$ values greater than 20 mm Hg, at later stages of resuscitation, should not be used in isolation as a potential indicator for continued resuscitation, particularly when other prognostic indicators are not favorable. High-quality studies assessing the role of $ETCO_2$ for termination of resuscitation in patients on mechanical CPR have not been conducted and are an active area of research.
5. No studies were found that specifically examined the use of $ETCO_2$ in cardiac arrest patients without an advanced airway. It is not known whether $ETCO_2$ values during bag-mask ventilation are as reliable as those with an advanced airway in place. There is insufficient evidence to support a universal "cutoff value" of $ETCO_2$ for decisions about TOR in a nonintubated patient.

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ADVANCED AIRWAY PLACEMENT DURING RESUSCITATION

Recommendations for Advanced Airway Placement During Resuscitation

COR	LOE	Recommendations
1	B-NR	1. Frequent experience or frequent retraining is recommended for health care professionals who perform endotracheal intubation in adults with cardiac arrest.
1	C-LD	2. If advanced airway placement will interrupt chest compressions, health care professionals should defer insertion of the airway until the adult in cardiac arrest fails to respond to initial CPR and defibrillation attempts or obtains ROSC.
1	C-LD	3. Continuous waveform capnography is recommended in addition to clinical assessment as the most reliable method of confirming and monitoring correct placement of an endotracheal tube in adults with cardiac arrest.

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Recommendations for Advanced Airway Placement During Resuscitation (Continued)		
COR	LOE	Recommendations
1	C-EO	4. Emergency medical services systems that perform prehospital intubation in adults with cardiac arrest should provide a program of ongoing quality improvement to minimize complications and track overall supraglottic airway and endotracheal tube placement success rates.
2a	B-R	5. If an advanced airway is used for adults with OHCA, a supraglottic airway can be acceptable in settings with low endotracheal intubation success rate or minimal training opportunities.
2a	B-R	6. If an advanced airway is used, either a supraglottic airway or endotracheal tube can be used for adults with OHCA in settings with high endotracheal intubation success rates or optimal training opportunities for endotracheal tube placement.
2a	B-NR	7. If an advanced airway is used for adults in cardiac arrest in the in-hospital setting by expert health care professionals trained in these procedures, either a supraglottic airway or endotracheal tube can be used.
2b	B-R	8. Either bag-mask ventilation or an advanced airway strategy may be considered during CPR for adult cardiac arrest in any setting depending on the situation and skill set of the professional.
2b	C-LD	9. If an advanced airway is in place, it may be reasonable for the clinician to deliver 1 breath every 6 s (10 breaths/min) while continuous chest compressions are being performed.

Synopsis

Airway management during cardiac arrest usually commences with a basic strategy such as BMV. In addition, it may be helpful for professionals to become proficient in one advanced airway strategy—endotracheal intubation (ETI) or supraglottic airway (SGA) insertion—as well as a second (backup) strategy for use if they are unable to establish the first-choice airway adjunct. Because placement of an advanced airway may result in interruption of chest compressions, a malpositioned device, or hyperventilation, professionals need weigh these risks against potential benefits. The 2019 focused update on use of advanced airways and Part 3: Adult Basic and Advanced Life Support from the 2020 Guidelines addressed the use of advanced airways in cardiac arrest. The 2020 Guidelines state that BMV or an advanced airway strategy may be considered during CPR for adult cardiac arrest in any setting.[1,2] A key aspect of airway management decision-making is the health care professional's airway management skill and experience, frequent retraining and ongoing quality improvement to minimize airway management complications. Thus, the ultimate decision of the use, type, and timing of an advanced airway will require consideration of a host of patient and professional characteristics that are not easily defined in a global recommendation (Figure 5).

Recommendation-Specific Supportive Text

1. Frequent retraining is important to maintain a health care professional's psychomotor airway management skills.[3,4] The manner in which this training is best accomplished is unclear. Research is necessary to address the specific type, amount, and frequency of training experiences that optimize airway management performance during cardiac arrest.
2. Although an advanced airway can be placed without interrupting chest compressions,[5] interruptions frequently occur. Therefore, health care professionals should weigh the potential benefits of an advanced airway with the benefits of maintaining a high chest compression fraction.[6–8] This is particularly true in cardiac arrest patients with shockable rhythms where CPR and defibrillation must take priority due to the strong association of early CPR and defibrillation with enhanced survival with favorable neurological outcome. In contrast, in arrests with non-shockable rhythms, early airway management is possible in resuscitations where CPR performance and epinephrine administration have already been optimized.
3. In a small clinical trial and several observational studies, waveform capnography was 100% specific for confirming endotracheal tube position during cardiac arrest.[9–11] The sensitivity of waveform capnography decreases after a prolonged cardiac arrest.[9–11] The use of waveform capnography to assess the placement of other advanced airways (eg, Combitube, laryngeal mask airway) has not been studied.
4. The writing group acknowledges the critical roles of tracking the overall success rate for systems performing ETI. This data will allow systems to make informed decisions as to whether practice should allow for ETI, move toward SGA, or simply use BMV for patients in cardiac arrest; recommendations will vary depending on the overall success rate in a given system. There is a clear need for further research with both patient- and professional- centered outcomes to assess the impact of prehospital quality improvement on selecting and maintaining the most appropriate airway management approach for EMS professionals within an agency.

5 and 6. One RCT of OHCA comparing SGA (iGel) to ETI in a non–physician-based EMS system (ETI success, 69%) found no difference in survival or survival with favorable neurologic outcome at hospital discharge.[12] A second RCT of OHCA comparing SGA (laryngeal tube) to ETI in a non–physician-based EMS system (ETI success,

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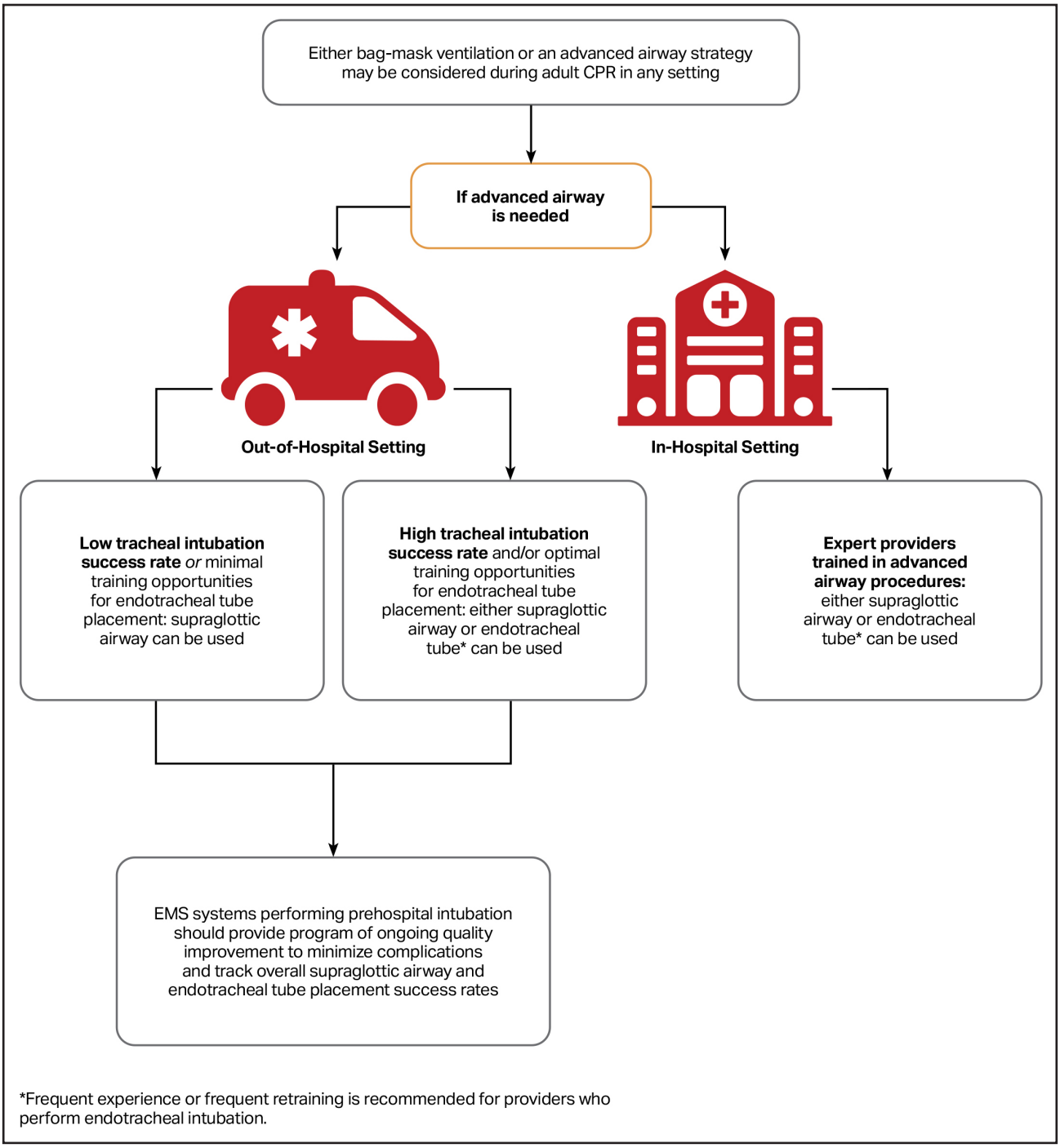

Figure 5. Schematic representation of ALS recommendations for use of advanced airways during CPR.
*Frequent experience or frequent retraining is recommended for health care professionals who perform endotracheal intubation. ALS indicates advanced life support; CPR, cardiopulmonary resuscitation; and EMS, emergency medical services.

52%) found both higher survival to hospital discharge and higher survival to hospital discharge with good neurologic outcome in the patients managed with SGA.[13] A recent systematic review noted that while SGAs may be associated with faster placement and increased rate of ROSC, there is no clear survival benefit to SGA or ETI, and the effect of SGA versus ETI on neurological survival remains uncertain.[14] Outcomes likely depend on patient and professional characteristics, especially EMS professional exposure to initial and ongoing advanced airway training and experience. Precise thresholds for high or low ETI success rates have not been identified. The decision to place an advanced airway requires an understanding of patient and professional

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characteristics that are not easily defined in a global recommendation. There is a need for further research, specifically on the interface between patient factors and the experience, training, tools and skills of the professional.

7. IHCA recommendations on advanced airway management have been extrapolated from OHCA. There is currently no high-certainty evidence that suggests benefit for any specific airway management strategy for IHCA. There is a need for further research to identify the IHCA patient and professional characteristics in airway management that impact clinical outcomes.
8. A 2024 ILCOR CoSTR summary[15] demonstrated no new data to change the recommendation regarding the use of BMV or advanced airway strategies. One large RCT of OHCA comparing BMV to ETI in a physician-based EMS system showed no significant benefit for either technique for 28-day survival or survival with favorable neurological outcome.[16] The success rate of ETI in this study was 98%, suggesting a relatively optimal setting for the potential success of ETI as an intervention. Further research is required to determine equivalence or superiority between the two approaches for acute airway management, as well as any potential benefit of a stepwise approach (eg, BVM followed by advanced airway placement).
9. A 2017 systematic review identified 1 observational human study and 10 animal studies comparing different ventilation rates after advanced airway placement.[17] While no clear benefit from a rate of 10 breaths per minute was identified, no other rate was found to be superior. A 2017 ILCOR systematic review did not identify any new evidence to alter this recommendation, which was reiterated in the "2017 AHA Focused Update on Adult BLS and CPR Quality: An Update to the AHA Guidelines for CPR and Emergency Cardiovascular Care."[18,19]

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WIDE-COMPLEX TACHYCARDIA

Recommendations for the Management of Adult Patients With Wide-Complex Tachycardia		
COR	LOE	Recommendations
1	B-NR	1. Synchronized cardioversion is recommended for acute treatment of adult patients with hemodynamically unstable wide-complex tachycardia.
1	B-NR	2. Synchronized cardioversion is recommended for acute treatment of adult patients with hemodynamically stable wide-complex tachycardia when vagal maneuvers and pharmacological therapy is ineffective or contraindicated.
2b	B-R	3. Administration of IV amiodarone, procainamide, or sotalol may be considered for the treatment of adults with wide-complex tachycardia.
2b	B-NR	4. In hemodynamically stable adult patients with regular monomorphic wide-complex tachycardia, IV adenosine may be considered for treatment or aiding rhythm diagnosis when the cause of the rhythm cannot be determined.
3: Harm	B-NR	5. Verapamil and diltiazem should not be administered for adult patients with wide-complex tachycardia.
3: Harm	C-LD	6. Adenosine should not be administered for adult patients with hemodynamically unstable, irregularly irregular, or polymorphic wide-complex tachycardia.

Synopsis

Wide-complex tachycardia (WCT) is generally defined as a rhythm greater than 150/min with a QRS duration of 0.12 second or more.[1,2] There are 4 means of achieving a wide QRS complex: (1) conduction of ventricular origin, (2) left or right bundle branch block, (3) conduction through a bypass tract, and (4) ventricular pacing. Rarely, hyperkalemia or sodium channel blockade can present with a WCT. Thus, WCTs can be ventricular (VT or VF), or supraventricular tachycardias resulting from mechanisms 2, 3, or 4. WCT can have a monomorphic or nonmonomorphic (ie, polymorphic) QRS. Polymorphic QRS complexes are typical of torsades de pointes, VF, or AF with a bypass tract. Most other rhythms are monomorphic. Patients with WCT can be hemodynamically stable or unstable. Hemodynamically stable patients with WCT allow the professional time to obtain a 12-lead electrocardiogram, place an IV, and administer IV drugs, while patients who are unstable require prompt cardioversion (Figure 6).

Recommendation-Specific Supportive Text

1. In hemodynamically unstable patients with WCT it is critical to promptly restore sinus rhythm. If the patient is unstable as a result of the WCT (eg, systolic blood pressure <80 mm Hg or altered mentation) immediate synchronized cardioversion is warranted.[3]
2. In stable patients with WCT, vagal maneuvers or adenosine may be attempted; however, if the patient remains in WCT following these therapies, synchronized cardioversion is recommended. If time and clinical stability permits, administration of procedural sedation may be appropriate.[3]
3. Amiodarone has a relatively slow onset of action, and some solutes may cause hypotension. IV procainamide can also cause hypotension and must be infused no faster than 50 mg/min. IV sotalol is a newer agent without these concerns for hypotension. Direct comparisons of efficacy are generally between lidocaine and these three antiarrhythmic medications. Lidocaine's kinetic properties are less effective for VT at hemodynamically tolerated rates than amiodarone, procainamide, or sotalol,[4] and it is unclear if lidocaine is more efficacious than placebo. Conclusions based on limited available evidence from small heterogeneous human studies for the treatment of stable, monomorphic VT, procainamide and sotalol each appear to have similar efficacy; amiodarone was not more effective than procainamide.[5–9] Avoiding coadministration of these drugs is important because their combined effects may be arrhythmogenic. When any of these drugs are administered, the immediate availability of a defibrillator is encouraged because each drug may convert a WCT to a more rapid, malignant (ie, hemodynamically unstable) form, depending upon its underlying cause.
4. Adenosine blocks the atrioventricular (AV) node and decreases automaticity. Thus, WCTs in which the AV node is part of the circuit will be terminated by an effective dose of adenosine as described in therapies for narrow-complex tachycardia (NCT). Adequate adenosine administration may momentarily block the AV node, allowing the underlying rhythm to be correctly assessed. Therefore, adenosine can be diagnostic and therapeutic in a stable, regular, monomorphic WCT.[10,11]
5. Verapamil is a calcium channel blocker that slows AV node conduction, shortens the refractory period of accessory pathways, and acts both as a negative inotrope and vasodilator. The vasodilatory effects are relatively profound, and thus, hypotension is common with administration. Verapamil will not terminate a WCT of ventricular origin and may cause profound hypotension leading to shock and cardiac arrest.[12,13]
6. Adenosine will not terminate a WCT of ventricular origin, may cause profound hypotension leading to shock, or precipitate VF and cardiac arrest.[14,15]

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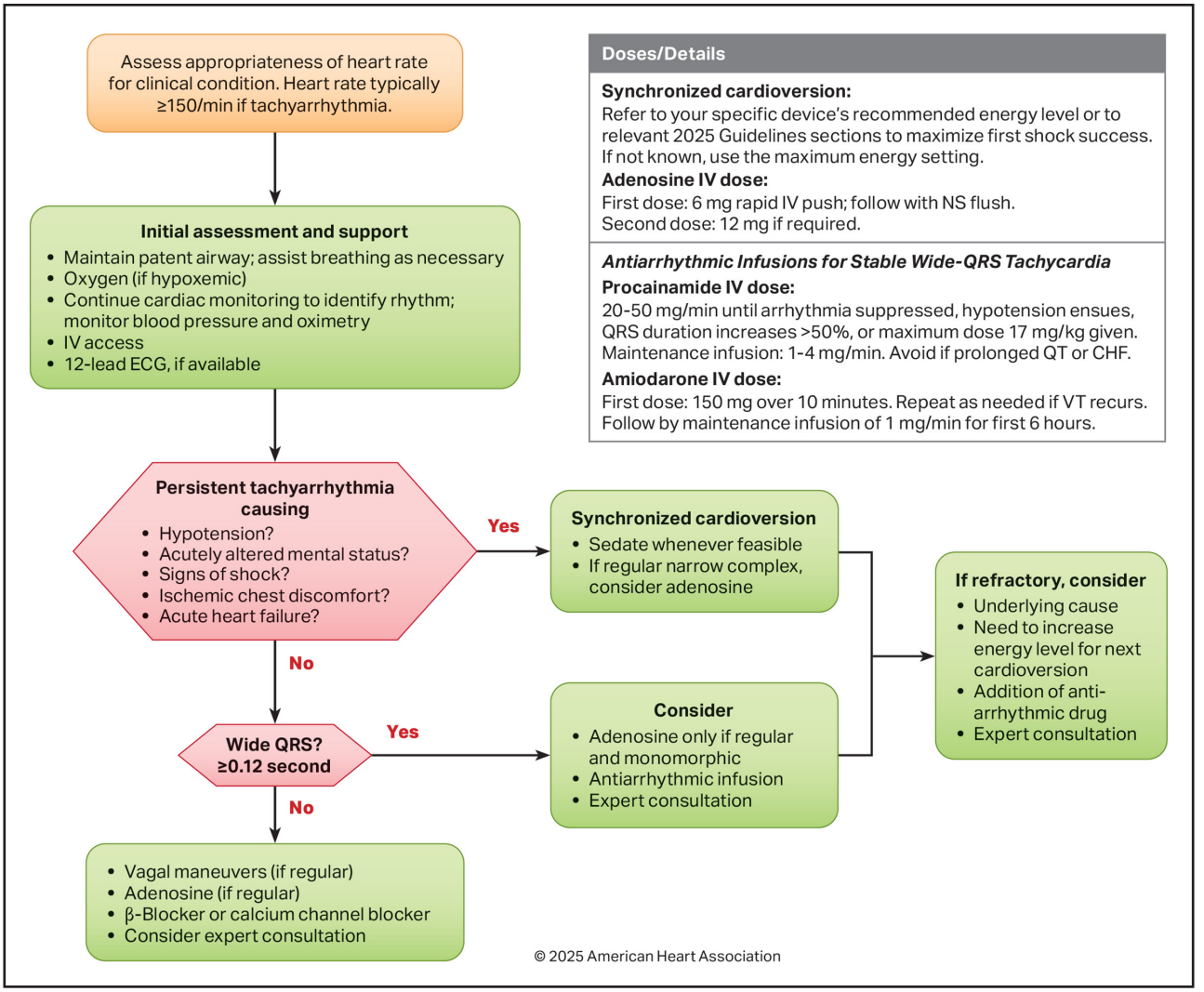

Figure 6. Adult Tachyarrhythmia With a Pulse Algorithm.
CHF indicates congestive heart failure; ECG, electrocardiogram; IV, intravenous; NS, normal saline; and VT, ventricular tachycardia.

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POLYMORPHIC VENTRICULAR TACHYCARDIA

Recommendations for Treatment of Adults With Polymorphic Ventricular Tachycardia		
COR	**LOE**	**Recommendations**
1	B-NR	1. Immediate unsynchronized shock is recommended for adults with sustained polymorphic ventricular tachycardia.
2b	C-LD	2. Magnesium may be considered for treatment of adults with recurrences of polymorphic ventricular tachycardia associated with a long QT interval (torsades de pointes).
2b	C-LD	3. IV lidocaine, amiodarone, and measures to treat myocardial ischemia may be considered to treat recurrences of polymorphic VT in adults in the absence of a prolonged QT interval.
3: No Benefit	C-LD	4. Routine use of magnesium is not recommended for the treatment of polymorphic VT in adults with a normal QT interval.

Synopsis

Polymorphic VT refers to a wide-complex tachycardia of ventricular origin with differing configurations of the QRS complex from beat to beat. However, the most critical feature in the diagnosis and treatment of polymorphic VT is not the morphology of the rhythm but rather what is known (or suspected) about the patient's underlying QT interval. It is often difficult to know whether the tachycardia is pVT or ventricular fibrillation (VF). Most VF begins with pVT and if pVT is prolonged it will usually degenerate into VF (Figure 6).

Torsades de pointes is a form of polymorphic VT that is associated with a prolonged heart rate–corrected QT interval when the rhythm is normal and VT is not present. The risk for developing torsades increases when the corrected QT interval is greater than 500 milliseconds and accompanied by bradycardia.[1] Torsades can be due to an inherited genetic abnormality[2] or can be caused by drugs and electrolyte imbalances that lengthen the QT interval.[3]

Conversely, polymorphic VT not associated with a long QT is most often due to acute myocardial ischemia.[4,5] Other potential causes include catecholaminergic polymorphic VT, a genetic abnormality in which polymorphic VT is provoked by exercise or emotion[6]; "short QT" syndrome, a form of polymorphic VT associated with an unusually short QT interval (corrected QT interval less than 330–370 milliseconds)[7,8]; idiopathic right ventricular outflow tract polymorphic VT; and bidirectional VT seen in digitalis toxicity in which the axis of alternate QRS complexes shifts by 180°.[9] There are no RCTs examining the acute pharmacological treatment of polymorphic VT. Supportive data, with and without long corrected QT interval, are largely based on case reports and case series.

Recommendation-Specific Supportive Text

1. Regardless of the underlying QT interval, all forms of polymorphic VT are considered hemodynamically and electrically unstable. Episodes of polymorphic VT may repeatedly recur and remit spontaneously, become sustained, or degenerate to VF. When the QRS complex of a VT is of uniform morphology, electric cardioversion synchronized to the QRS complex minimizes the risk of provoking VF during the vulnerable period of the cardiac cycle (T wave). In contrast, polymorphic VT cannot be synchronized reliably because of the differing characteristics of each QRS complex and requires high-energy (maximum manufacturer's setting) unsynchronized shock. Assessment of a patient's mental status is important when the appropriateness of sedation is considered before defibrillation. While effective in terminating polymorphic VT, defibrillation may not prevent its recurrence, for which pharmacological therapies are often required and the primary focus of subsequent recommendations.
2. Torsades de pointes typically presents in a recurring pattern of self-terminating, hemodynamically unstable polymorphic VT in context of a known or suspected long QT abnormality, often with an associated bradycardia. Termination of torsades by defibrillation may not prevent its recurrence, which requires additional pharmacological interventions. In small case series, IV magnesium has been effective in suppressing and preventing recurrences.[10–13] Magnesium is believed to suppress fluctuations in the myocardial action potential that can trigger torsades.[14] Correcting electrolyte abnormalities, particularly hypokalemia, is also advisable.

   Treatment of torsades with antiarrhythmic medications may prolong the QT interval and promote the arrhythmia. When given acutely, β-adrenergic blockers can also precipitate torsades by causing or worsening bradycardia. In patients with bradycardia or pause-precipitated torsades, expert consultation is best sought for additional measures such as overdrive pacing or isoproterenol.[15] There is literature to support instances of medication induced torsades, so prevention of drug induced prolonged QT is an important priority for professionals.
3. Polymorphic VT that is clearly not associated with QT prolongation, is most often triggered by acute myocardial ischemia or infarction and often rapidly degenerates into VF.[3,5] Polymorphic VT may be difficult to differentiate from VF initially, but, as with other ventricular arrhythmias (VT and VF), is terminated with immediate defibrillation. However, termination of polymorphic VT with defibrillation may not prevent its recurrence, requiring additional pharmacological measures. No RCTs have been performed to determine the optimal pharmacological management of

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polymorphic VT. Treatment of causative myocardial ischemia (eg, β-adrenergic blockers or emergent coronary intervention) as well as lidocaine and amiodarone,[16–22] in concert with defibrillation, may be synergetic when the arrhythmia is sustained. β-Adrenergic blockers have also been shown to reduce the incidence of ventricular arrhythmias in acute coronary syndromes.[23,24]

Expert consultation is advisable when alternative causes of polymorphic VT are suspected, for which β-adrenergic blockers and antiarrhythmics may also have efficacy.[6,25] Since the 2018 AHA Focused Update on Advanced Cardiovascular Life Support Use of Antiarrhythmic Drugs During and Immediately After Cardiac Arrest,[26] no new evidence has been identified.

4. In the absence of long QT, magnesium has not been shown to be effective in the treatment of polymorphic VT[10] or other ventricular tachyarrhythmias.[12] A single case series with 5 patients showed no benefit of magnesium administration for polymorphic VT with normal QT. Since the 2018 AHA focused update on antiarrhythmic drugs during and immediately after cardiac arrest no new evidence has been identified.

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REGULAR NARROW-COMPLEX TACHYCARDIA

Recommendations for the Treatment of Regular Narrow-Complex Tachycardia in Adults		
COR	**LOE**	**Recommendations**
1	B-R	1. Vagal maneuvers are recommended for acute treatment of adult patients with regular narrow-complex tachycardias.

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Recommendations for the Treatment of Regular Narrow-Complex Tachycardia in Adults (Continued)		
COR	LOE	Recommendations
1	B-R	2. Adenosine is recommended for acute treatment of adult patients with regular narrow-complex tachycardias.
1	B-NR	3. Synchronized cardioversion is recommended for acute treatment of adult patients with hemodynamically unstable narrow-complex tachycardias.
1	B-NR	4. Synchronized cardioversion is recommended for acute treatment of adult patients with hemodynamically stable narrow-complex tachycardias when vagal maneuvers and pharmacological therapy is ineffective or contraindicated.
2a	B-R	5. Intravenous diltiazem or verapamil can be effective for acute treatment of adult patients with hemodynamically stable narrow-complex tachycardias that are regular.
2a	C-LD	6. Intravenous β-adrenergic blockers are reasonable for acute treatment of adult patients with hemodynamically stable narrow-complex tachycardias that are regular.

Synopsis

In most patients narrow-complex tachycardias (NCTs), which include sinus tachycardia, atrial flutter, AV nodal reentrant tachycardia, AV reentrant tachycardia, and other atrial tachycardia, and previously referred to imprecisely as supraventricular tachycardia, generally are not hemodynamically unstable, and health care professionals have an opportunity to attempt vagal maneuvers. Adenosine may also be effective in terminating arrhythmias in these patients.

For hemodynamically unstable patients with NCTs, electrical therapies are warranted (Figure 6). However, there must be a reasonable expectation that the NCT is causing instability rather than being a manifestation of instability caused by another clinical diagnosis (eg, sepsis). Hemodynamically unstable patients with NCT may have hypotension, acutely altered mental status, signs of shock, chest pain, or acute heart failure. Most patients with NCTs have conversion success rates of up to 98% with vagal maneuvers, pharmacological management, or both, described below (eg, adenosine, diltiazem, verapamil).

If nasally administered calcium channel blockers become available in the future, they will be evaluated for their efficacy and safety and considered for inclusion in these guidelines and the corresponding treatment algorithm.[1–3]

These recommendations are supported by the 2015 American College of Cardiology, AHA, and Heart Rhythm Society Guidelines for the Management of Adult Patients With Supraventricular Tachycardia and a 2025 evidence update.

Recommendation-Specific Supportive Text

1. The Valsalva maneuver is effective in terminating 20 to 30% of NCTs.[4,5] With modified techniques, termination improves to up to 50%.[6–9] Vagal maneuvers include having the patient blow into a 10 cc syringe, bearing down, and carotid massage. However, more effective approaches have been described, such as passive leg raise, supine repositioning, and passive leg elevation immediately after Valsalva, blowing into a syringe attached to a sphygmomanometer, and pressing the epigastric region 10 seconds after Valsalva. When performing carotid massage, caution is advised because the technique can precipitate a stroke in patients with carotid atherosclerosis.
2. Adenosine has demonstrated very high rates of conversion of AV nodal reentrant tachycardia, AV reentrant tachycardia, and many atrial tachycardias.[10] It also blocks the AV node, confirming a diagnosis of atrial flutter or fibrillation. Adenosine has a very short half-life and may be less effective if infused in a peripheral vein. Adequate dosing is assured by alteration of the NCT, including termination or the patient's symptoms of flushing and a feeling of dread. Adenosine may have profound effects in patients with central lines or post–heart transplant patients; 1 mg IV may be adequate to terminate the NCT. Adenosine can cause severe bronchospasm in patients with asthma, and thus, is contraindicated.
3. In hemodynamically unstable patients with NCT, it is critical to promptly restore sinus rhythm. If unstable, immediate cardioversion is warranted.[11]
4. Cardioversion can be used to treat stable patients with NCT not responsive to vagal maneuvers and pharmacological therapy.[11] Assessment of a patient's mental status and clinical stability is important when the appropriateness of sedation is considered before cardioversion.
5. IV diltiazem and verapamil convert NCT to normal sinus rhythm in 64% to 98% of patients. The efficacy of verapamil is similar to adenosine but with significant concerns for inducing hypotension.[12–18] Diltiazem and verapamil are particularly useful in patients with recurrent supraventricular tachycardia after treatment with adenosine because they are longer acting. Hypotension is a common side effect, and these medications must be infused slowly.[19] For patients with NCT and suspicion of systolic heart failure, diltiazem and verapamil are best avoided.
6. Intravenous β-adrenergic blockers are generally safe and have been shown to terminate NCT in adult patients with hemodynamically stable narrow-complex tachycardias that are regular.

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ATRIAL FIBRILLATION OR FLUTTER WITH RAPID VENTRICULAR RESPONSE: PART 1

ELECTRICAL THERAPIES

Recommendations for Electrical Therapies for Atrial Fibrillation/Flutter

COR	LOE	Recommendations
1	C-LD	1. In adult patients with hemodynamic instability attributable to atrial fibrillation or atrial flutter with rapid ventricular rates, immediate electrical cardioversion should be performed to restore sinus rhythm.
1	C-LD	2. Urgent direct-current cardioversion of new onset atrial fibrillation or atrial flutter with rapid ventricular rates in the setting of acute coronary syndrome is recommended for adult patients with hemodynamic compromise, ongoing ischemia, or inadequate rate control.
2a	B-R	3. For synchronized cardioversion of atrial fibrillation in adults using any currently US-approved biphasic waveform defibrillator, an initial energy setting of at least 200 J is reasonable and incremented in the event of shock failure, depending on the biphasic defibrillator used.
2b	B-R	4. The usefulness of double synchronized cardioversion of atrial fibrillation in adults as an initial treatment strategy is uncertain.
2b	C-LD	5. For synchronized cardioversion of atrial flutter in adults, an initial energy setting of 200 J may be reasonable and incremented in the event of shock failure, depending on the biphasic defibrillator used.
2b	C-LD	6. The usefulness of double synchronized cardioversion as a rescue treatment for shock-refractory atrial fibrillation in adults is uncertain.

Synopsis

Atrial fibrillation (AF) is a disorganized atrial rhythm due to multiple reentry (self-circulating) circuits throughout atrial myocardium. Atrial flutter is a more organized tachyarrhythmia caused by a single macroreentrant atrial circuit. The two arrhythmias are common, often co-exist, and are treated similarly. Treating AF/flutter with rapid ventricular rates depends on hemodynamic stability. Unstable patients and those with rate-related ischemia often need urgent electrical cardioversion (Figure 7). Stable patients can be treated pharmacologically to achieve rate or rhythm control. Conversion of AF/flutter greater than 48 hours in nonanticoagulated patients risks thromboembolic events. For acute AF/flutter assessed as less than 48 hours, decision-making is more nuanced, requiring expert consultation unless emergent cardioversion is needed. Pre-excited AF/flutter (Wolff-Parkinson-White) is covered under Wide-Complex Tachycardias.[1]

Electrical cardioversion is influenced by many factors. Technical features (beyond energy setting) affecting shock success include pad dimensions, pad location, minimizing impedance barriers, shock waveform, and timing (proper electrocardiogram

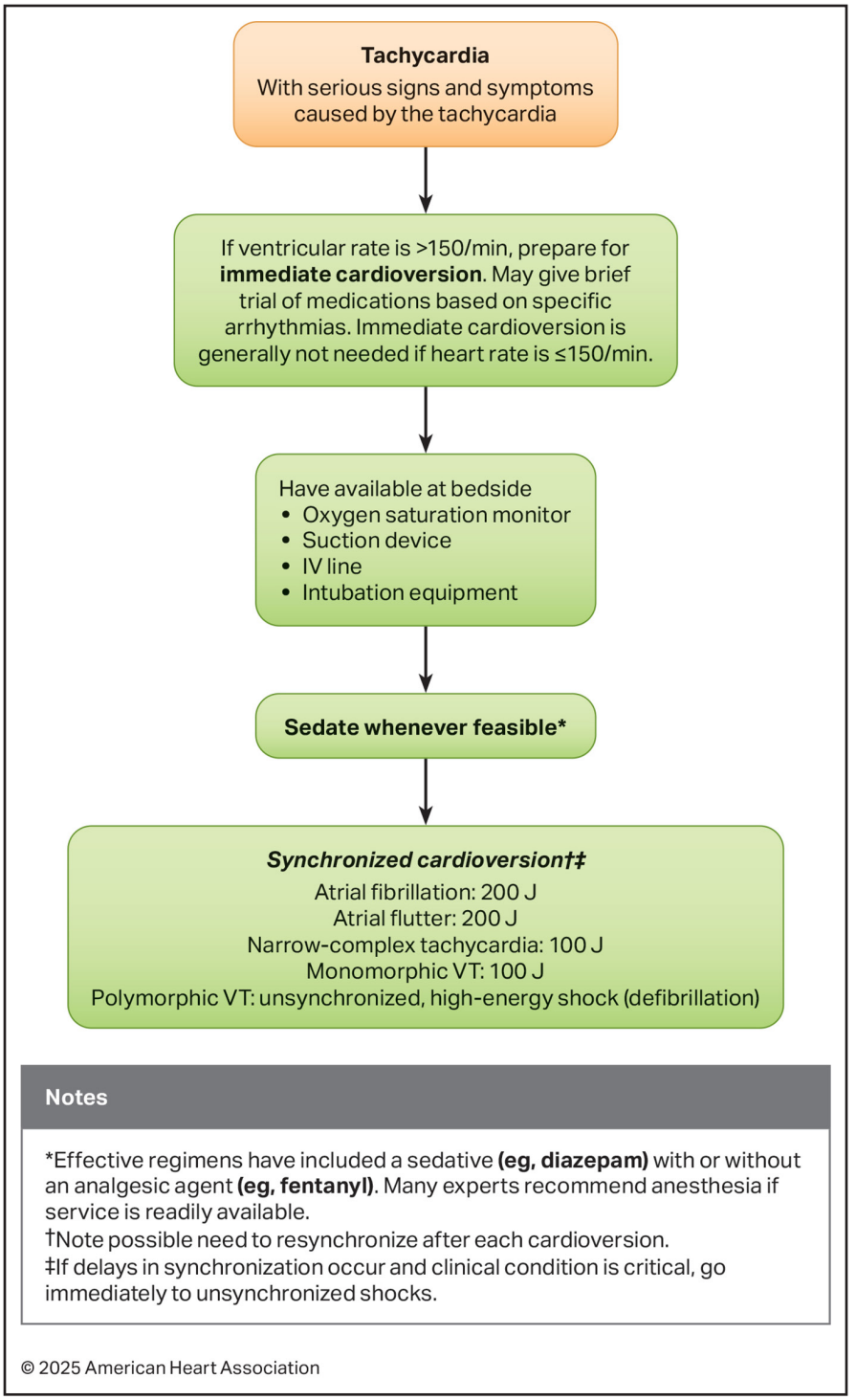

Figure 7. Electrical Cardioversion Algorithm.
IV indicates intravenous; and VT, ventricular tachycardia.

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synchronization).[2,3] Clinical factors influencing cardioversion outcome include body habitus, cardiac status (ventricular function, atrial size), rhythm duration, and concomitant medication use. Any of these, alone or together, can affect outcome as much or more than the energy setting itself.[4,5] Apart from energy, electrical cardioversion requires regard for the details of how the procedure itself is conducted and the characteristics of the patient in whom it is performed.[6]

These recommendations are supported by the "2023 ACC/AHA/ACCP/HRS Guideline for the Management of Atrial Fibrillation" and a 2025 evidence update.

Recommendation-Specific Supportive Text

1 and 2. Uncontrolled tachycardia may impair ventricular filling, cardiac output, and coronary perfusion while increasing myocardial oxygen demand.

While an expeditious trial of medications, intravenous fluids, or both may be appropriate in some cases, unstable patients or patients with ongoing cardiac ischemia caused or exacerbated by atrial fibrillation/flutter require prompt cardioversion.[7–9] One should also consider whether the arrhythmia is causative or secondary to a rapid ventricular response driven by underlying factors (eg, sepsis), as this may guide initial pharmacologic strategies for hemodynamic stabilization. Limited data exist on these strategies in hemodynamically unstable patients; however, the hemodynamic benefits of successful cardioversion have been documented.[10,11] In addition, risk of hypotension and hypoperfusion with negative inotropes has been demonstrated even in normotensive patients.[12–14]

Hemodynamically unstable patients and those with ongoing cardiac ischemia are likely to benefit from improved hemodynamic status from immediate restoration of sinus rhythm and avoidance of hypotension caused by pharmacological therapies. Depending on the clinical scenario, patients cardioverted from atrial fibrillation/flutter of greater than 48 hours' duration are candidates for anticoagulation. Appropriate selection of patients and medications for anticoagulation are addressed elsewhere and beyond the scope of these guidelines.[1]

3. Guidance for monophasic waveform cardioversion of AF/flutter is found in previous guidelines,[15] displaced by biphasic waveforms due to their greater efficacy. Given proprietary differences in electrical characteristics, guidelines previously deferred biphasic cardioversion energy settings to manufacturer specifications.[16] However, interim randomized head-to-head trials together with a network meta-analysis involving >3000 AF patients found that 200-J shocks achieved greater than 90% cumulative cardioversion success across all 3 biphasic platforms currently available in the United States.[6,17–21]

   Previous guidelines advocated lower energy settings over concerns that higher energies posed greater risk for cardiac injury and complications.[18,22–25] Subsequent clinical studies observed no association between starting biphasic shock energies of up to 360 J with energy-associated elevations in cardiac-specific enzymes, postcardioversion arrhythmias, cardiac dysfunction, or other sequelae.[26–28] Notably, low-energy monophasic shocks were significantly more likely to provoke VF when cardioverting AF, and AF when cardioverting atrial flutter than a 200-J or greater setting.[29] This observation is consistent with the upper limit of vulnerability principle: that an energy threshold exists above which a shock will not induce fibrillation.[30,31] A higher starting energy was also found to be more efficient than "starting low, titrating higher" approaches, achieved greater first-shock cardioversion success, required fewer overall shocks, and could shorten the period of anesthesia needed for serial shock attempts.[18,22]

   Considering efficacy, safety, efficiency, simplicity, and consistency with other professional guidelines, evidence supports a starting energy of 200 J.[16–21] Regardless of energy setting, appropriate sedation for cardioversion is advisable in awake patients, given shock is a painful procedure.

4. One approach to synchronized cardioversion is double synchronized cardioversion. Administering 2 simultaneously-synchronized high-energy shocks from separate defibrillators and pads has been described anecdotally, in small case series, and a single randomized trial. As an "initial" cardioversion strategy, a modestly-sized randomized trial comprised of class II obesity patients (39% had prior cardioversion attempts) found first shock efficacy improved with 400 J double synchronized cardioversion versus 200 J synchronized cardioversion (98% versus 87%, p=0.002).[32] Although not consistently reported, double synchronized cardioversion has not been associated with proarrhythmia, hemodynamic complications, cardiac-specific enzyme elevation,[28] or postprocedure discomfort but has caused defibrillator damage.[33]

   A concern in all studies has been the vagueness of procedural specifications, particularly how 2 independently-initiated shocks from separate defibrillators being reliably simultaneously-synchronized was assured.[34] Given the high success of optimal synchronized cardioversion using biphasic waveforms, the incremental benefit from double synchronized cardioversion is modest.

5. Organized rhythms like atrial flutter, caused by a discrete reentry circuit, require less energy for termination than AF, whose multiple reentry circuits broadly engulf the atrial myocardium.[35] However, periodic transitions between the two arrhythmias are common. Distinguishing AF from flutter in an emergent setting with only single-lead monitoring can be challenging. Studies evaluating rectilinear and truncated exponential biphasic waveforms available in the United States, while indirect and fewer in number than for AF, have shown comparable cumulative

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cardioversion success for atrial flutter between these waveforms at the same energy settings, ranging from 50% to 75% at 50 J, improving to 85% to 90% at 100 J, and approaching 100% at 200 J.[23,28,36–38] Using a higher (200 J) initial energy setting for flutter cardioversion also affords shorter procedural times without causing cardiac injury or compromising safety,[23,26,36–38] accompanied by a lower risk of provoking AF or undertreating AF if mistaken as flutter.[27,36] The likelihood of greater efficacy, efficiency, and simplicity, without safety concerns, supports a starting energy of 200 J for flutter cardioversion using any currently US-marketed biphasic defibrillator; incremented in the event of shock failure, depending on the defibrillator's features.[23,28,36,37]

6. *Shock-refractory AF,* defined as AF that remains incessant after maximum-energy shocks, is relatively uncommon with biphasic shock waveforms and distinguished from recurrent AF, which returns after an initially successful shock. As in many situations, shock success can be optimized by minimizing transthoracic impedance[3] by improving pad-skin contact and applying pad pressure; relocating pads to redirect the shock vector; or adding antiarrhythmic drugs to alter the defibrillation threshold.[2,5,6,39,40]

   Another possibility is the use of double synchronized cardioversion.[41] Data on this approach are limited, including procedural uncertainties described above (item 4). Observational studies found double-synchronized cardioversion to be successful in 75% to 100% of patients who had previously failed standard cardioversion.[41–43] Alternatively, a large prospective observational study evaluated a systematic approach to shock-refractory AF. It found applied pad pressure improved synchronized cardioversion success from 87% to 93% and with pad repositioning to 96%, after which the added increment from double-synchronized cardioversion only modestly improved to 98%.[2]

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ATRIAL FIBRILLATION AND FLUTTER WITH RAPID VENTRICULAR RESPONSE: PART 2

MEDICAL THERAPIES

Recommendations for Medical Therapies for Atrial Fibrillation/Flutter

COR	LOE	Recommendations
1	B-NR	1. IV administration of a β-adrenergic blocker or nondihydropyridine calcium channel antagonist is recommended to slow the ventricular heart rate in the acute setting in adult patients with atrial fibrillation or atrial flutter with rapid ventricular response without preexcitation.
2a	B-NR	2. IV amiodarone can be useful for rate control in critically ill adult patients with atrial fibrillation with rapid ventricular response without preexcitation.
3: Harm	C-LD	3. In adult patients with preexcitation atrial fibrillation or atrial flutter, digoxin, nondihydropyridine calcium channel antagonists, β-adrenergic blockers, and IV amiodarone should not be administered because they may increase the ventricular response and result in VF.
3: Harm	C-EO	4. Nondihydropyridine calcium channel antagonists and IV β-adrenergic blockers should not be used in adult patients with left ventricular systolic dysfunction and decompensated heart failure because these may lead to further hemodynamic compromise.

Synopsis

Control of rapid heart rates in the emergency setting are achievable using an intravenous nondihydropyridine calcium channel antagonist (eg, diltiazem, verapamil) or β-adrenergic blocker (eg, metoprolol, esmolol). Pharmacologic rhythm control (chemical cardioversion) employs intravenous drugs such as amiodarone, procainamide, or sotalol to convert AF/flutter to sinus rhythm and prevent its recurrence. Amiodarone is unique in that it can also be used for rate control in patients with heart failure in

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whom calcium channel or β-adrenergic blockers may not be tolerated.

These recommendations are supported by the "2023 ACC/AHA/ACCP/HRS Guideline for the Diagnosis and Management of Atrial Fibrillation" and a 2025 evidence update.[1]

Recommendation-Specific Supportive Text

1. Clinical trial evidence shows that nondihydropyridine calcium channel antagonists (eg, diltiazem, verapamil) and β-adrenergic blockers (eg, metoprolol, esmolol, propranolol), are effective for rate control in patients with atrial fibrillation/flutter.[2–9] Systematic reviews show that IV diltiazem improves heart rate control in atrial fibrillation/flutter without preexcitation with rapid ventricular response when compared to IV metoprolol.[10–18] However, most of the included studies were limited by small sample size, retrospective data, and many did not report relevant clinical outcomes and comorbidities. Randomized clinical trials examining verapamil are lacking, thus, diltiazem is generally preferred.
2. Amiodarone is effective for rate control in patients with atrial fibrillation/flutter without preexcitation in patients with contraindications for nondihydropyridine calcium channel antagonists or β-adrenergic blockers.[2–9] Digoxin is less commonly used in the acute setting because of the slow onset of effect.[19–21] In an observational study, the optimal amiodarone dosing for heart rate control (<115–80/min) was examined in 80 critically ill patients, most with cardiogenic shock or sepsis.[22] The dose needed to achieve heart rate control was nearly twice as high in patients with persistent versus paroxysmal atrial arrhythmias, but patients who were taking amiodarone prior to intensive care unit admission required lower doses.
3. Based on limited case reports and small case series, there is concern that patients with concomitant preexcitation and atrial fibrillation or atrial flutter may develop VF in response to accelerated ventricular response after the administration of AV nodal blocking agents such as digoxin, nondihydropyridine calcium channel antagonists, β-adrenergic blockers, or IV amiodarone.[23–26] In this setting, cardioversion is recommended as the most appropriate management.
4. Because of their negative inotropic effect, nondihydropyridine calcium channel antagonists (eg, diltiazem, verapamil) may further decompensate patients with left ventricular systolic dysfunction and symptomatic heart failure.[7] Patients with heart failure with preserved ejection fraction may tolerate better nondihydropyridine calcium channel antagonists. While β-blockers can be safe in patients with cardiomyopathy, they can be harmful in patients who are decompensated.[20,21,27] Limited evidence suggests that intravenous diltiazem may cause increased risk of decompensation compared to intravenous β-adrenergic blockers, but more data are needed to support preferential use.[28] Multiple studies have demonstrated β-adrenergic blockers are safe for use in patients with chronic obstructive pulmonary disease.[29] Refer to Table 2.

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Table 2. IV Medications Commonly Used for Acute Rate Control in Atrial Fibrillation and Atrial Flutter

Medication	Bolus dose	Infusion rate	Notes
Nondihydropyridine calcium channel blockers			
Diltiazem	0.25 mg/kg IV bolus over 2 min	5–10 mg/h	Avoid in hypotension, heart failure, cardiomyopathy, and acute coronary syndromes
Verapamil	0.075–0.15 mg/kg IV bolus over 2 min; may give an additional dose after 30 min if no response	0.005 mg/kg per min	Avoid in hypotension, heart failure, cardiomyopathy, and acute coronary syndromes
β-Adrenergic blockers			
Metoprolol	2.5–5 mg over 2 min, up to 3 doses		Avoid in decompensated heart failure
Esmolol	500 mcg/kg IV over 1 min	50–300 mcg/kg per min	Short duration of action; avoid in decompensated heart failure
Propranolol	1 mg IV over 1 min, up to 3 doses		Avoid in decompensated heart failure
Other medications			
Amiodarone	300 mg IV over 1 h	10–50 mg/h over 24 h	Multiple dosing schemes exist for amiodarone
Digoxin	0.25 mg IV, repeated to maximum dose 1.5 mg over 24 h		Typically used as adjunctive therapy with another option from above; caution in patients with renal impairment

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INITIAL MANAGEMENT OF BRADYCARDIA

Recommendations for Initial Management of Bradycardia		
COR	**LOE**	**Recommendations**
1	C-EO	1. In adult patients presenting with acute symptomatic bradycardia, evaluation and treatment of reversible causes are recommended.
2a	B-NR	2. In adult patients with acute bradycardia associated with hemodynamic compromise, administration of atropine is reasonable to increase heart rate.
2a	C-LD	3. In adult patients with persistent hemodynamically unstable bradycardia refractory to medical therapy, temporary transvenous pacing is reasonable to increase heart rate and improve symptoms.
2b	C-LD	4. If bradycardia is unresponsive to atropine, IV adrenergic agonists with rate-accelerating effects (eg, epinephrine, dopamine) or transcutaneous pacing may be effective while the adult patient is prepared for emergent transvenous temporary pacing if required.
2b	C-EO	5. Immediate pacing might be considered in unstable adult patients with high-degree AV block when IV/IO access is not available.

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Synopsis

Bradycardia has historically been defined as a ventricular heart rate of less than 60/min. However, the "2018 ACC/AHA/HRS Guideline on the Evaluation and Management of Patients With Bradycardia and Cardiac Conduction Delay" adopted a lower threshold of less than 50/min, reflecting population studies that commonly use this lower cutoff.[1] Bradycardia can be a normal finding in healthy adults, athletes, or during sleep.[1] The clinical manifestation of bradycardia ranges from stable (asymptomatic) through symptomatic to unstable (symptomatic and associated with signs of poor perfusion). Patients with symptomatic bradycardia can present with dizziness or light-headedness, acute altered mental status, ischemic chest discomfort, acute heart failure, hypotension, or syncope due to decreased cardiac output and tissue hypoperfusion. Clinicians must evaluate bradycardia within the clinical context to determine whether it is a manifestation of another underlying disease process (eg, myocardial ischemia, hypoxia, electrolyte disturbance, acidosis, hypothermia) or the primary driver of the clinical presentation. Immediate treatment of symptomatic bradycardia as described in Figure 8 is focused on both supporting perfusion and identifying and reversing the underlying cause(s). The 2018 ACC/AHA/HRS Guideline provides comprehensive recommendations on the evaluation and management of chronic stable and unstable bradycardia.

These recommendations remain supported by the 2018 ACC/AHA/HRS Guideline and a 2025 evidence update.

Recommendation-Specific Supportive Text

1. Symptomatic bradycardia may be caused by a number of potentially reversible or treatable causes, including myocardial ischemia, hypoxemia, hypothyroidism, infections, structural heart disease, increased vagal tone, metabolic derangement, electrolyte abnormalities, or medications/toxins.[1] Bradycardia may be difficult to resolve without addressing the underlying cause(s), underscoring the importance of evaluating potential etiologies while simultaneously initiating emergent stabilization measures. A large retrospective review of prehospital patients undergoing transcutaneous pacing identified hypoxia and initial nonbradycardic rhythms as factors associated with pacing failure and increased mortality, emphasizing the critical need to address underlying causes alongside stabilization efforts.[2]
2. Atropine has been shown to be effective for the treatment of symptomatic bradycardia in observational studies.[3–7] In a study in patients with OHCA and a nonshockable heart rhythm (asystole or pulseless electrical activity), the addition of atropine following epinephrine was a predictor of survival to hospital admission.[8] In a study among patients with IHCA, the administration of atropine for nonshockable heart rhythms did not improve survival.[9]
3. When symptomatic bradycardia is refractory to medical management, cardiac pacing is a reasonable alternative. Transcutaneous pacing is noninvasive, can be performed quickly at bedside, and is typically used as a bridge to placement of a temporary transvenous pacing catheter. Transcutaneous pacing is often painful in the conscious patient and procedural tolerance may necessitate sedation. Evidence for transvenous pacing consists of limited observational studies, many of which have focused on indications and the relatively high complication rate (including bloodstream infections and pneumothorax, among others).[10–13] When the heart rate does not improve with medications and shock persists, transvenous pacing can improve the heart rate and symptoms until more definitive treatment (correction of underlying cause or permanent pacemaker placement) can be implemented.
4. If atropine is ineffective, alternative agents to increase heart rate and blood pressure or transcutaneous pacing are reasonable alternatives. For medical management of a periarrest patient, epinephrine has gained popularity, including IV infusion and use of "push-dose" administration for acute bradycardia and hypotension. Studies on push-dose epinephrine for bradycardia specifically are lacking, although limited data support its use for hypotension.[14,15] Use of push-dose vasopressors require careful attention to correct dosing. Medication errors and adverse hemodynamic effects have been reported.[16] Dopamine infusion can also increase heart rate.[17] There are limited studies comparing medications to transcutaneous pacing for the treatment of bradycardia. A randomized feasibility study in patients failing atropine compared dopamine to transcutaneous pacing and found no difference in survival to discharge.[17] Whether to trial transcutaneous pacing, epinephrine, dopamine, or other vasoactive agent will likely, therefore, depend on clinician experience and resources available.
5. For severe symptomatic bradycardia causing shock, if no IV or IO access is available, immediate transcutaneous pacing while access is being pursued may be undertaken. A 2006 systematic review involving seven studies of transcutaneous pacing for symptomatic bradycardia and bradyasystolic cardiac arrest in the prehospital setting did not find a benefit from pacing compared with standard ALS, although a subgroup analysis from a single trial suggested a possible benefit in patients with symptomatic bradycardia.[18] More recent studies have underscored persistent challenges for

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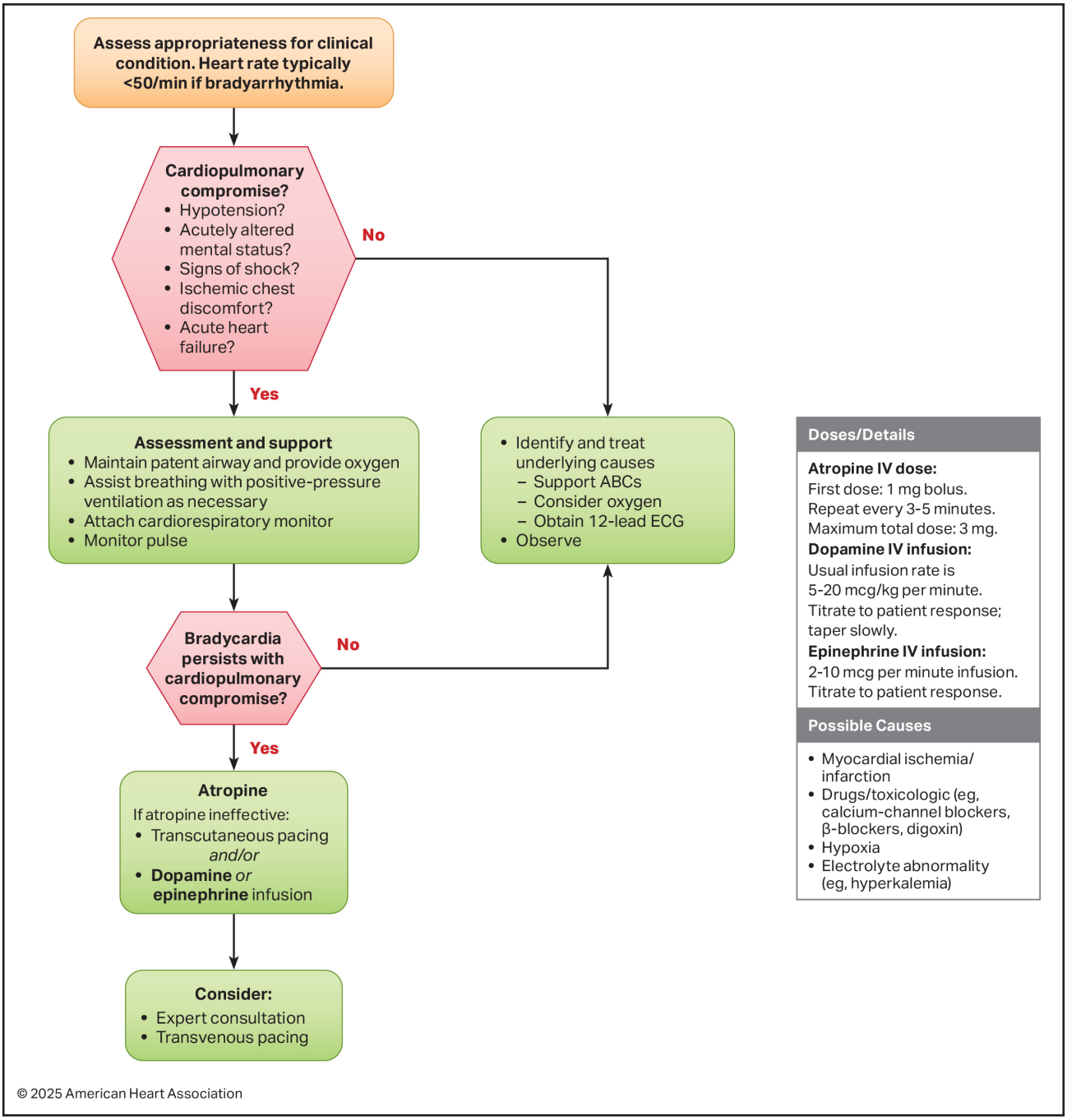

Figure 8. Adult Bradycardia With a Pulse Algorithm.

clinicians in achieving and maintaining both electrical and mechanical capture during pacing.[19,20] These difficulties may limit patient benefit in certain scenarios, emphasizing the need for improved methods to distinguish true electrical capture from false capture. Future research is needed to determine optimal pad placement and develop reliable methods for confirming initial and sustained capture, such as the practicality and preferred location of pulse palpation, hemodynamic findings, pulse oximetry characteristics, continuous $ETCO_2$ monitoring, and ultrasound.

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Disclosures

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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix 2. Reviewer Disclosures

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Bryan McNally	Emory University School of Medicine	CDC CARES Expansion and Modernization Grant (Funding for the Cardiac Arrest Registry to Enhance Survival (CARES))†	None	None	None	None	Qilu Hospital†; St Lukes Hospital*; Duke University*; Cedars Sinai Hospital*	None
Robert W. Neumar	University of Michigan	NIH (Research Grants)†; AHA (Research Grant)†; Laerdal Foundation (Research Grant)*	None	None	None	None	None	None
Robert A. Swor	William Beaumont Hospital	None	None	None	None	None	None	None

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Circulation

Part 10: Adult and Pediatric Special Circumstances of Resuscitation: 2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Dazhe Cao, MD, Chair; Ann M. Arens, MD; Sheryl L. Chow, PharmD; Sarah Rae Easter, MD; Robert S. Hoffman, MD; Anthony T. Lagina III, MD; Eric J. Lavonas, MD, MS; Kaustubha D. Patil, MD; Lauren D. Sutherland, MD; Janice A. Tijssen, MD, MSc; George Sam Wang, MD; Carolyn M. Zelop, MD; Amber J. Rodriguez, PhD; Ian R. Drennan, ACP, PhD; Mary E. McBride, MD, MEd, Vice Chair

ABSTRACT: In these guidelines, the American Heart Association provides updated guidance for resuscitation of adults and children in cardiac arrest or with a life-threatening condition due to special circumstances, including anaphylaxis, asthma, cardiac arrest in the cardiac intervention suite, cardiac arrest following cardiac surgery, drowning, electrocution, gas embolism, high-consequence respiratory pathogens, hyperkalemia, hyperthermia, hypothermia, left ventricular assist device failure, pregnancy, pulmonary embolism, and poisoning due to benzodiazepines, β-blockers, calcium channel blockers, cocaine, cyanide, digoxin and related cardiac glycosides, local anesthetic systemic toxicity, methemoglobinemia, opioids, organophosphates and carbamates, sodium channel blockers, sympathomimetics, and volatile hydrocarbons. Recommendations are also provided for alternatives to cardiopulmonary resuscitation and the use of extracorporeal membrane oxygenation for poisoned patients. Adults and children with these conditions require modification of basic life support and advanced life support. These guidelines are based on systematic evidence reviews and provide separate graded recommendations for adults and children.

Key Words: AHA Scientific Statements ■ communicable diseases, emerging ■ drowning ■ heart arrest ■ poisoning ■ pregnancy complications ■ resuscitation

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TOP 10 TAKE-HOME MESSAGES FOR SPECIAL CIRCUMSTANCES OF RESUSCITATION

1. Anaphylaxis: Isotonic intravenous (IV) fluids may be used for fluid resuscitation in cardiac arrest from anaphylaxis, whereas standard anaphylaxis dose of epinephrine administered via autoinjector or intramuscularly may not offer benefit. Glucagon may be reasonable to administer in cases refractory to standard treatment when β-blocker exposure is suspected. Extracorporeal membrane oxygenation (ECMO) is reasonable in refractory cases.
2. Cardiac interventional laboratory: Some adults in cardiac arrest in the cardiac interventional laboratory may require specialized interventions, including performing a corrective procedure to treat the etiology of the arrest, mechanical cardiopulmonary resuscitation (CPR), extracorporeal life support (ECLS), or intracoronary epinephrine.
3. ECLS: While ECLS is not available in every setting, adults and children in cardiac arrest or a peri-arrest state with a potentially reversible etiology may be supported with ECLS devices, such as venoarterial ECMO (VA-ECMO), in disease processes such as anaphylaxis, asthma, cardiac surgery, cardiac interventional laboratory, hypothermia, and pulmonary embolism (PE) and in poisonings like β-blockers, calcium channel blockers (CCBs), cocaine, local anesthetics, sodium channel blockers, and sympathomimetics.

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4. High-consequence respiratory pathogen: Chest compressions, bag-mask ventilation, defibrillation, suctioning, and endotracheal intubation should be considered aerosol-generating procedures, which pose a risk of infection to resuscitation team members. However, a real-world study found that rates of severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2) transmission to resuscitation team members using personal protective equipment (PPE) were low.
5. Hyperkalemia: Clinical evidence supporting IV calcium or IV sodium bicarbonate administration is limited in humans and uncertain to improve survival or favorable neurological outcomes. The utility of other therapies intended to lower potassium concentrations in the setting of cardiac arrest is unclear when weighing their possible benefits against the risk of harm if well-established interventions, such as CPR, are interrupted.
6. Hyperthermia: Adults and children with life-threatening hyperthermia from environmental causes, cocaine poisoning, or sympathomimetic poisoning should be rapidly cooled, ideally at a rate of at least 0.15 °C/min (0.27 °F/min). This is best achieved with immersion in ice water.
7. Hypothermia: Adults and children with life-threatening environmental hypothermia may survive with good neurological outcomes even after prolonged cardiac arrest. Patients should be rewarmed concurrently with resuscitation efforts. ECLS can be used where available.
8. Left ventricular assist device (LVAD): The absence of a palpable pulse can make confirming cardiac arrest in adults and children with an LVAD difficult; thus perfusion is assessed using skin color, skin temperature, capillary refill, mean arterial pressure, and partial pressure of end-tidal carbon dioxide. Treatment includes prioritization of CPR while simultaneously assessing and attempting to restart LVAD function if a second rescuer is available.
9. Pregnancy: Management of cardiac arrest during pregnancy is a complex clinical scenario that requires resuscitation strategies that accommodate for the physiological changes of pregnancy. Resuscitation priorities include early airway management and left lateral uterine displacement.
10. Opioids: An opioid antagonist (eg, naloxone) should be given to people with respiratory arrest from suspected opioid overdose. Trained rescuers, lay rescuers, and members of the general public can all administer naloxone. During resuscitation of cardiac arrest due to presumed opioid overdose, an opioid antagonist may be reasonable to administer if high-quality CPR is not interrupted.

PREAMBLE

The chain of survival is a series of steps in the process of cardiac arrest management that begins with prevention and concludes with survivorship. Throughout, coordinated efforts are required of laypeople and health care professionals in a variety of disciplines across the health care system. These guidelines contain recommendations for basic life support (BLS) and advanced life support (ALS) for adults and children in special circumstances resulting in cardiac arrest and are based on the best available resuscitation science. For these recommendations, children are defined as those without signs of puberty in the BLS setting and those who are <18 years of age in the ALS setting. Depending on the clinical data immediately available, there are numerous special circumstances in which additional interventions or modifications to BLS and ALS in adults and children may be required, spanning each link in the chain of survival. Management of patients in cardiac arrest from these special circumstances often differs from standard resuscitation. For example, patients may develop hypotension from β-adrenergic receptor antagonist (eg, β-blocker) or calcium channel antagonist (eg, CCB) poisoning that does not respond to atropine, standard vasopressors, or cardiac pacing but is amenable to targeted therapies, such as high-dose insulin. In addition, specific recommendations about the training of resuscitation professionals are provided in "Part 12: Resuscitation Education Science" and recommendations about systems of care are provided in "Part 4: Systems of Care."

INTRODUCTION

Scope of the Guidelines

These guidelines are designed primarily for North American health care professionals treating adults and children in cardiac arrest or a life-threatening state from a special circumstance requiring modification of BLS and ALS. Life-threatening conditions include a range of medical emergencies that pose an immediate risk to survival (eg, respiratory arrest, refractory hypotension, critical metabolic acidosis), while a cardiac arrest refers to the cessation of cardiac output and, with that, cessation of oxygen delivery throughout the body. Depending on the data available, recommendations are made for the management of patients in cardiac arrest or for patients with life-threatening conditions inclusive of cardiac arrest. Additionally, for certain topics, the relevant literature regarding the management of cardiac arrest in these settings may be limited to patients in a life-threatening condition. The same therapies are recommended for life-threatening conditions and cardiac arrest unless otherwise stated.

These guidelines contain recommendations for BLS and ALS for both adults and children. Unless otherwise

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specified, the interventions recommended here are intended for use in addition to standard BLS, pediatric BLS, ALS, and pediatric ALS (PALS) resuscitation. Although many of these treatments are impractical outside of the hospital setting, several can be initiated by emergency medical services and some (eg, giving breaths to drowning victims) may be relevant to lay rescuers. These guidelines are intended to be used in conjunction with topic-specific references and advice from local and regional experts.

The special circumstances guidelines have historically been developed from predominantly adult data. As is common in pediatric medicine, these recommendations were often applied to the resuscitation of children in similar contexts. For the 2025 recommendations, the literature searches performed included all age groups, and for which pediatric data are available, recommendations were made in line with those data. For those where there are sparse to no pediatric data, the recommendations will be absent or extrapolated from adult data.

Throughout these guidelines, recommendations may include therapies including procedures that all centers are not sufficiently resourced to offer, such as ECLS, hyperbaric oxygen therapy, and mechanical thrombectomy. These therapies may, however, be available for select centers and in those settings should be implemented or considered depending on the strength of the evidence and the clinical context. It is important for health care professionals to follow their institutional guidelines as well as the available literature.

Organization of the Writing Group

The writing group included a diverse group of experts with backgrounds in emergency medicine, pediatric emergency medicine, adult and pediatric critical care, anesthesiology, adult and pediatric cardiology, electrophysiology, obstetrics and gynecology, maternal fetal medicine, hyperbaric medicine, medical toxicology, pharmacy, trauma care, education, and research. Group members were appointed by the American Heart Association (AHA) Emergency Cardiovascular Care Science Subcommittee. Each recommendation was developed and formally approved by the writing group and subsequently reviewed and approved by the AHA Emergency Cardiovascular Care Science Subcommittee.

The AHA has rigorous conflict-of-interest policies and procedures to minimize the risk of bias or improper influence during the development of guidelines. Before appointment, writing group members disclosed all relevant commercial relationships and other potential (including intellectual) conflicts. These procedures are described more fully in "Part 2: Evidence Evaluation and Guidelines Development" in the *2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care*. The Writing Group Disclosures table at the end of this document lists the writing group members' relevant relationships with industry (Appendix 1).

METHODOLOGY AND EVIDENCE REVIEW

The writing group members first created and approved a list of special circumstances topics, drawing on the scope of prior guidelines and new topics that have gained prominence since the 2020 publication. A population, intervention, comparison, outcome, study design, and time frame (PICOST) question was created for each topic. Guided by the writing group chairs and with assistance from a professional medical librarian as needed, the writing group performed a structured evidence evaluation for each topic, which was internally peer reviewed. These searches were executed in Medline and the Excerpta Medica Database (Embase) using the Ovid search interface, and the Cochrane Central Register of Controlled Trials. International Liaison Committee on Resuscitation (ILCOR) evidence reviews published since 2020 were reviewed, and the dates of updated searches were harmonized with these reviews to avoid search overlap. Final complete searches were executed in July 2024 with single database searches in November through December 2024. Structured searches were supplemented by bibliography review and ad hoc searches when needed. Search results were imported into Covidence (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia). At least 2 writing group members performed dual screening of the titles and abstracts of all articles identified from each search and identified articles for full-text review. Screening conflicts were resolved between the 2 writing group members and writing group leadership before full-text review. Two writing group members reviewed the full text of all selected articles and applied the information contained to develop treatment recommendations appropriate for each clinical question. Each draft recommendation was created by a group of 2 writing group members and then reviewed and refined by all writing group members during regular virtual meetings and 2 in-person meetings. Completed draft recommendations were reviewed by organizational leaders in the AHA with recommendations incorporated as draft revisions. Final draft recommendations were then externally peer reviewed. A more comprehensive description of these methods is provided in "Part 2: Evidence Evaluation and Guidelines Development."

Class of Recommendation and Level of Evidence

Each recommendation was assigned a Class of Recommendation (COR) based on the strength and consistency of the evidence, alternative treatment options, and impact

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on patients and society (Table 1). Recommendation wording flows in a structured manner based on the COR determination. The Level of Evidence (LOE) is based on the quality, quantity, relevance, and consistency of the available evidence. For each recommendation, the writing group discussed and approved specific recommendation

Table 1. Applying Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care (updated December 2024)*

CLASS (STRENGTH) OF RECOMMENDATION

Class 1 (STRONG) — Benefit >>> Risk

Suggested phrases for writing recommendations:
- Is recommended
- Is indicated/useful/effective/beneficial
- Should be performed/administered/other
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is recommended/indicated in preference to treatment B
  - Treatment A should be chosen over treatment B

Class 2a (MODERATE) — Benefit >> Risk

Suggested phrases for writing recommendations:
- Is reasonable
- Can be useful/effective/beneficial
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is probably recommended/indicated in preference to treatment B
  - It is reasonable to choose treatment A over treatment B

Class 2b (WEAK) — Benefit ≥ Risk

Suggested phrases for writing recommendations:
- May/might be reasonable
- May/might be considered
- Usefulness/effectiveness is unknown/unclear/uncertain or not well-established

Class 3: No Benefit (MODERATE) — Benefit = Risk (Generally, LOE A or B use only)

Suggested phrases for writing recommendations:
- Is not recommended
- Is not indicated/useful/effective/beneficial
- Should not be performed/administered/other

Class 3: HARM (STRONG) — Risk > Benefit

Suggested phrases for writing recommendations:
- Potentially harmful
- Causes harm
- Associated with excess morbidity/mortality
- Should not be performed/administered/other

LEVEL (QUALITY) OF EVIDENCE‡

Level A
- High-quality evidence‡ from more than 1 RCT
- Meta-analyses of high-quality RCTs
- One or more RCTs corroborated by high-quality registry studies

Level B-R (Randomized)
- Moderate-quality evidence‡ from 1 or more RCTs
- Meta-analyses of moderate-quality RCTs

Level B-NR (Nonrandomized)
- Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies
- Meta-analyses of such studies

Level C-LD (Limited Data)
- Randomized or nonrandomized observational or registry studies with limitations of design or execution
- Meta-analyses of such studies
- Physiological or mechanistic studies in human subjects

Level C-EO (Expert Opinion)
- Consensus of expert opinion based on clinical experience

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR 1 and 2a; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely-used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

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wording and the COR and LOE assignments. In determining the COR, the writing group considered the LOE and other factors, including systems issues, economic factors, and ethical factors, such as equity, acceptability, feasibility, and risk of harm. These evidence review methods, including specific criteria used to determine COR and LOE, are described more fully in "Part 2: Evidence Evaluation and Guidelines Development" of the 2025 Guidelines.

Despite improvements in the design and funding support for emergency care research, the overall quality of the evidence for special circumstances science is very low. Only 2 of the 235 recommendations in these guidelines are supported by Level A evidence (high-quality evidence from more than 1 randomized controlled trial [RCT] or 1 or more RCTs corroborated by high-quality registry studies). Nine recommendations are supported by Level B randomized evidence (moderate evidence from 1 or more RCTs) and 32 by Level B nonrandomized evidence. The majority of recommendations are based on Level C evidence, including those based on limited data (67 recommendations) and expert opinion (125 recommendations). Accordingly, the strength of recommendations is weaker than optimal; 66 Class 1 (strong) recommendations, 84 Class 2a (moderate) recommendations, and 58 Class 2b (weak) recommendations are included in these guidelines. In addition, 21 recommendations are designated Class 3: No Benefit and 6 recommendations are Class 3: Harm. Clinical trials, thoughtfully designed intervention studies with real-world applicability, and well-controlled observational studies in special circumstances science are needed.

Guideline Structure

These guidelines are organized into modular knowledge chunks grouped into discrete modules of information on specific topics or management issues. Each modular knowledge chunk includes a table of recommendations that uses standard AHA nomenclature of COR and LOE. A brief introduction is provided for topics with multiple sets of recommendations, and a synopsis may also be written to put the recommendations into context with important background information and overarching management or treatment concepts. Recommendation-specific supportive text clarifies the rationale and key study data supporting the recommendations. When appropriate, figures, flow diagrams, and additional tables are included.

Document Review and Approval

All guidelines were reviewed and approved for publication by the AHA Emergency Cardiovascular Care Science Advisory Committee, the AHA Scientific Advisory and Coordinating Committee, and the AHA Executive Committee. These guidelines were also submitted for blinded peer review to subject matter experts nominated by the AHA. Before appointment, all peer reviewers were required to disclose relationships with industry and any other conflicts of interest, and all disclosures were reviewed by AHA journal staff. Comprehensive disclosure information for peer reviewers is listed in the Reviewer Disclosure Table (Appendix 2).

These recommendations supersede the last full set of AHA special circumstances guidelines, published in 2020, and recommendations from the focused updates on toxicology and drowning.[1–3]

To maintain consistency across the different chapters of the guidelines, the LOE for some recommendations that were previously assigned LOE B-NR (nonrandomized) or C-LD (limited data) based on uncontrolled observational studies, case reports, and nonhuman studies were modified to C-EO (expert opinion). Supporting data are provided in the recommendation-specific supportive text.

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MAJOR CONCEPTS

Overview

Survival and recovery from cardiac arrest depend on a complex system working together to achieve the best outcomes. The main focus of treatment of adults and children in cardiac arrest includes rapid recognition, prompt provision of CPR, defibrillation of malignant shockable rhythms, adequate ventilation, post–return of spontaneous circulation (ROSC) supportive care, and treatment of underlying causes. This approach recognizes that cardiac arrest is due to either primary cardiac causes, such as myocardial infarction and electric disturbances, or without a primary cardiac origin, such as respiratory failure or toxic ingestion. In such cases, treatment for reversible underlying causes is important for the rescuer to consider. For any cardiac arrest, rescuers are instructed

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to call for help, perform CPR with breaths, and apply an automated external defibrillator (AED) to directly treat ventricular fibrillation (VF) or ventricular tachycardia (VT), if present. Although the majority of resuscitation success is achieved by the provision of high-quality CPR and defibrillation, other specific treatments for likely underlying causes may be helpful in some cases.

These guidelines, focusing on the special circumstances as etiologies of cardiac arrest, provide and evaluate specific treatment options meant to be administered in addition to, and alongside, traditional resuscitation care. Unless otherwise specified, all patients should receive standard airway management, support of breathing, and treatment of hypotension, arrhythmias, and cardiac arrest consistent with local protocols and the resources available at the site of treatment.

ALTERNATIVE CPR TECHNIQUES

Introduction

In addition to defibrillation, several alternative and pseudoelectrical therapies have been explored as possible treatment options during cardiac arrest. Precordial thump is a single, sharp, high-velocity impact (or "punch") to the middle of the sternum delivered by the ulnar aspect of a tightly clenched fist. A precordial thump can generate an electric impulse, theoretically interrupting a life-threatening tachyarrhythmia or "kick-starting" the heart in asystole.[1] However, if a precordial thump is administered during the electrically vulnerable portion of an organized rhythm (T wave), like an unsynchronized shock or commotio cordis, there is a risk of deterioration of cardiac rhythm. Percussion (fist) pacing is the delivery of serial, rhythmic, relatively low-velocity impacts to the sternum by the ulnar aspect of a closed fist. This is administered to stimulate an electric impulse sufficient to cause myocardial depolarization and electrically pace the heart in cases of asystole or a life-threatening bradyarrhythmia.[1] Cough CPR involves a deep breath followed immediately by a cough, repeated every few seconds, to provide transient hemodynamic support at the onset of a hemodynamically significant arrhythmia in a patient who is both conscious and cooperative. Interposed abdominal compression CPR is a 3-rescuer technique that involves conventional chest compressions combined with alternating abdominal compressions. The dedicated rescuer who provides manual abdominal compressions will compress the abdomen midway between the xiphoid and the umbilicus during the relaxation phase of chest compression. Alternative techniques for performing interposed abdominal compression involve use of compression devices. One such device consists of pressure application handles, a compression plate, and a display panel showing compression force, and a second device uses a seesaw-like function, causing abdominal decompression during sternal compression and vice versa.[2,3] These devices are not currently available in North America and are therefore outside the scope of these recommendations.

Recommendations for precordial thump, precordial pacing, and interposed abdominal compression in adults and children inform the management of adults and children in cardiac arrest. Recommendations for cough CPR inform the management of adults and children who have life-threatening arrhythmias but are conscious and able to follow commands.

Precordial Thump

Recommendations for Precordial Thump in Adults and Children in Cardiac Arrest

COR	LOE	Recommendations
3: No Benefit	B-NR	1. A precordial thump should not be performed on adults in cardiac arrest.
3: No Benefit	C-EO	2. A precordial thump should not be performed on children in cardiac arrest.

Recommendation-Specific Supportive Text

1. The use of a precordial thump during routine cardiac arrest care in the out-of-hospital setting did not improve survival to hospital discharge compared with standard CPR in adults in 2 nonrandomized studies.[4,5] Defibrillation, as a first-line intervention, is significantly more likely to result in ROSC.[4] In adults, precordial thump resulted in immediate ROSC in some cases of in-hospital cardiac arrest (IHCA) and out-of-hospital cardiac arrest (OHCA) but also led to rhythm degeneration, such as from VT to VF or asystole.[4,6–9] The majority of reports of successful use of precordial thump are for ventricular arrhythmias in adults with IHCA with success more likely in cases with VT than VF.[7,9–15] There are also cases of a precordial thump successfully causing ROSC in adults with asystole.[5,6] There are reports of successful use of a precordial thump for restoration of cardiac output in adult cases of induced ventricular tachyarrhythmias in the inpatient cardiology setting, but the majority of cases failed to respond.[16–19] Across studies, there is a lack of standardization in the technique of precordial thump, the number of times it was used, pharmacological therapy administered before or after its delivery, and—in some cases—its timing related to the onset of the arrhythmia.
2. There are no studies on the use of precordial thump during cardiac arrest in children. Extrapolating from data for adults, it can be stated that precordial thump does not improve outcomes compared with standard ALS in OHCA, and there are no comparative studies for IHCA. There are case reports of

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serious complications due to the use of precordial thump in children.[4,5,20]

Percussion Pacing

Recommendations for Percussion Pacing in Adults and Children in Cardiac Arrest		
COR	**LOE**	**Recommendations**
2b	**C-EO**	1. Percussion (fist) pacing may be considered in adults as a temporizing measure in the witnessed, monitored, in-hospital (eg, cardiac intervention laboratory or intensive care unit [ICU]), onset of asystole or a nonperfusing bradyarrhythmia before loss of consciousness and if performed without delaying definitive therapy.
3: No Benefit	**C-EO**	2. Percussion pacing should not be performed routinely in adults in cardiac arrest.
3: No Benefit	**C-EO**	3. Percussion pacing should not be performed in children in cardiac arrest.

Recommendation-Specific Supportive Text

1. Limited evidence from adult descriptive studies demonstrates effective use of percussion pacing during witnessed inpatient asystolic or life-threatening bradycardic events with favorable outcomes of survival to hospital discharge, ROSC, or restoration of cardiac output.[21–25]
2. No controlled or comparative studies show that the use of percussion pacing improves outcomes compared with standard therapy in adults. It would not be appropriate to prioritize percussion pacing over other measures with proven efficacy.[25]
3. No controlled or comparative studies show that the use of percussion pacing improves outcomes compared with standard therapy in children. Two pediatric cases show successful generation of a QRS complex and pulse with percussion pacing.[25,26] It would not be appropriate to prioritize percussion pacing over other measures with proven efficacy.

Cough CPR

Recommendations for Cough CPR in Adults and Children With Life-Threatening Arrhythmias		
COR	**LOE**	**Recommendations**
2b	**C-LD**	1. Cough CPR may be reasonable as a temporizing measure in the witnessed, monitored, in-hospital (eg, cardiac intervention laboratory or ICU), onset of a hemodynamically significant tachyarrhythmia or bradyarrhythmia before loss of consciousness and if performed without delaying definitive therapy in adults.
3: No Benefit	**C-EO**	2. Cough CPR should not be performed routinely by adults with life-threatening arrhythmias.
3: No Benefit	**C-EO**	3. Cough CPR should not be performed by children with life-threatening arrhythmias.

Recommendation-Specific Supportive Text

1. Some evidence suggests that cough CPR increases aortic and left ventricular pressures.[27,28] Observational studies describe the use of cough CPR in conscious adults at the witnessed onset of several arrhythmias (VT, VF, high-degree atrioventricular [AV] blocks, severe bradycardia, and asystole) with successful termination and prevention of loss of consciousness.[6,27–29] In 1 study of 115 adults with Morgagni-Adams-Stokes syndrome and frequent fainting episodes during arrhythmias, patients were trained in cough CPR. On follow-up, 66 patients applied cough CPR in a total of 365 events, 80% of which were reported as effective, but these occurred in an unmonitored setting so the cardiac rhythm at the time of symptoms is unknown.[28] Importantly, while cough CPR may be reasonable in specific circumstances, it may divert time, effort, and attention from clinicians performing high-quality CPR or patients seeking medical attention.
2. No controlled or comparative studies show that use of cough CPR improves outcomes compared with standard therapy in adult patients. The risks are (1) that it delays effective treatment (early call for help, early CPR and defibrillation if the patient loses consciousness and stops breathing normally) and (2) that members of the public who confuse *cardiac arrest* with *heart attack* delay seeking help when suffering chest pain or other symptoms indicating a possible ischemic cardiac event. An untrained adult is unlikely to be able to reliably identify a cardiac arrest rhythm in time to initiate coughing to maintain a cardiac output. It would not be appropriate to prioritize cough CPR over other measures with proven efficacy.
3. There are no studies of cough CPR in children. There is risk of delaying effective treatment, and younger children are unlikely to understand or correctly perform the technique. It would not be appropriate to prioritize cough CPR over other measures with proven efficacy.

Interposed Abdominal Compression

Recommendations for Interposed Abdominal Compression in Adults and Children in Cardiac Arrest		
COR	**LOE**	**Recommendations**
2b	**B-R**	1. The effectiveness of interposed abdominal compression CPR is uncertain in adults.
2b	**C-EO**	2. The effectiveness of interposed abdominal compression CPR is uncertain in children.

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Recommendation-Specific Supportive Text

1. Two early, relatively small, unblinded adult RCTs of interposed abdominal compression CPR compared with standard CPR for IHCA done at a single institution during different time periods showed improved ROSC, short-term survival, and survival to hospital discharge.[30,31] Two recent, relatively small, unblinded adult RCTs of interposed abdominal compression CPR in IHCA showed no difference in ROSC.[32,33] Two RCTs of adult OHCA did not show any increase in ROSC.[34,35] More evaluation is needed to define the optimal clinical scenario for this technique.
2. There are no studies on the use of interposed abdominal compression CPR in children. More evaluation is needed to define the optimal clinical scenario for this technique.

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ANAPHYLAXIS

Recommendations for Adults and Children in Cardiac Arrest From Anaphylaxis		
COR	LOE	Recommendations
2a	C-EO	1. It is reasonable to fluid resuscitate adults and children in cardiac arrest from anaphylaxis with isotonic IV fluids.
2a	C-EO	2. It is reasonable to use extracorporeal CPR (ECPR) for adults and children in cardiac arrest from anaphylaxis refractory to pharmacological interventions.
2b	C-EO	3. It may be reasonable to administer glucagon to adults and children who are in cardiac arrest from anaphylaxis with suspected or confirmed concurrent β-blocker use and who are refractory to standard ALS or PALS medications.
2b	C-EO	4. For adults and children in cardiac arrest from rocuronium-induced anaphylaxis, the effectiveness of sugammadex is uncertain.
2b	C-EO	5. For adults and children in cardiac arrest from anaphylaxis, the effectiveness of standard anaphylaxis intramuscular (IM) epinephrine dose is uncertain.

Synopsis

Anaphylaxis represents a severe multisystem immune modulated reaction to a substance that can occur across all age groups. Common triggers include insects, foods, and medications, such as anesthetics, antibiotics, blood products, and chemotherapeutics. Perioperative anaphylaxis can be challenging to diagnose and has resulted in delayed treatment.[1] Anaphylaxis after neuromuscular blockade resulting in cardiac arrest has been associated with high mortality (34.7%) even when ALS guidelines are followed.[2] Acute coronary syndrome resulting from a rare allergic reaction, also known as Kounis syndrome, with patient-specific complexities is beyond the scope of this review.[3]

Immune activation can manifest systemically, most commonly affecting the skin, gastrointestinal, pulmonary, and cardiovascular systems. The rapidity of onset and progression to airway occlusion with potential cardiovascular collapse make timely diagnosis and treatment essential for positive outcomes.

Options for treatment of anaphylaxis in the peri-arrest setting include epinephrine (IM or IV), antihistamines, bronchodilators, corticosteroids, glucagon, and discontinuation or removal of the trigger.

Our review did not identify any interventional studies for cardiac arrest from anaphylaxis. All reviewed studies were observational studies of anaphylaxis, which included subgroups with cardiac arrest. These recommendations inform the management of adults and children in cardiac arrest from anaphylaxis.

Recommendation-Specific Supportive Text

1. Intravascular volume depletion secondary to fluid extravasation is a reversible cause of cardiac arrest. The use of isotonic fluid resuscitation for cardiac arrest from anaphylaxis is supported only by case studies. In 1 adult case report, 73% of administered fluid had been reported to extravasate to the extravascular space via third spacing and increased vascular permeability during anaphylaxis.[4] In a non–cardiac arrest clinical trial of adult patients with anaphylaxis, patients had more rapid improvement in symptoms with IV fluids.[5] There is no data specific to children.
2. Evidence for ECPR in the setting of anaphylaxis is limited to case reports. In 1 case series of 6 patients (5 adults and 1 adolescent), only 1 of the 4 adults in cardiac arrest received ECPR.[6] The patient survived and had a favorable neurological outcome. In a case series of 6 adults with cardiac arrest from anaphylaxis following succinylcholine exposure, only 1 received ECPR but died after 12 days.[7]
3. Indirect evidence from anaphylaxis-induced hypotension in adult case reports supports the administration of glucagon (1–5 mg IV in adults, 20–30 mcg/kg IV push up to 1 mg in children) in the treatment of refractory anaphylaxis in patients with concurrent β-blocker use or suspected exposure.[8–10] Administration should not preclude standard ALS or PALS protocols. There is no data specific to children.
4. In an adult observational study of severe anaphylaxis after exposure to neuromuscular blocking agents, a history of cardiovascular disease other than hypertension was identified as a risk factor for death from cardiac arrest.[2] The survival from cardiac arrest in this study was 156/199 (78%). Case reports exist suggesting sugammadex as a potential treatment for anaphylaxis associated with rocuronium. However, a case series in adults did not show improvement in outcomes of anaphylaxis without cardiac arrest.[11] A second study in adults found decreased vasopressor requirements in 4 of 7 patients who received sugammadex.[1] There are no data specific to children.
5. Extrapolation of findings from studies in adults and children indicates that the bioavailability and time to peak blood concentration for equal-dose (eg, mg/kg) IM epinephrine is inferior to IV and intraosseous (IO) routes of administration. When comparing pharmacokinetics across different studies, anaphylaxis dose IM epinephrine had lower and delayed peak epinephrine concentrations as compared to IV epinephrine in cardiac arrest.[12–16] There is limited high-quality data directly comparing IV or IO epinephrine with IM epinephrine, including no data for cardiac arrest secondary to anaphylaxis. In a before-and-after implementation study of an early, first-dose IM epinephrine (5 mg) for 1405 adults with OHCA compared with usual care, IM

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epinephrine was associated with improved survival to hospital admission (adjusted odds ratio [aOR], 1.37; 95% CI, 1.06–1.77), hospital survival (aOR, 1.73; 95% CI, 1.10–2.71), and favorable neurologic status at hospital discharge (aOR, 1.72; 95% CI, 1.07–2.76).[17] Notably, the dose of epinephrine administered by the IM route was much higher than standard ALS or PALS IV or IO dosing and standard dosing for anaphylaxis management.[18] In cardiac arrest from anaphylaxis, standard anaphylaxis IM epinephrine dose may be insufficient.

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ASTHMA

Recommendations for Adults and Children With Life-Threatening Asthma		
COR	**LOE**	**Recommendations**
1	C-LD	1. In adults and children with life-threatening asthma, sudden elevation in peak inspiratory pressures or difficulty ventilating should prompt evaluation for tension pneumothorax.
2a	C-LD	2. It may be reasonable to use ECLS for adults and children with life-threatening asthma refractory to standard therapies.
2a	C-LD	3. A ventilation strategy of low respiratory rate and tidal volume is reasonable in adults with life-threatening asthma.
2a	C-EO	4. A ventilation strategy of low respiratory rate and tidal volume is reasonable in children with life-threatening asthma.
2b	C-LD	5. Treatment with volatile anesthetics for adults and children with life-threatening asthma refractory to standard therapies may be considered.
2b	C-EO	6. Active exhalation maneuvers in adults and children with life-threatening asthma refractory to standard therapies may be considered.

Synopsis

Asthma can lead to cardiac arrest primarily from increased lower airway obstruction leading to hypoxemia, hypercarbia, respiratory acidosis, and increased intrathoracic pressure leading to decreased cardiac output.[1] Care of the patient in the setting of an acute asthma exacerbation includes bronchodilators, steroids, and noninvasive ventilation and in cardiac arrest standard resuscitation.[2] There are insufficient data to comment on the use of magnesium or ketamine in patients with life-threatening asthma.

These recommendations inform the management of adults and children with life-threatening asthma exacerbation, including cardiac arrest.

Recommendation-Specific Supportive Text

1. Tension pneumothorax is a rare life-threatening complication of asthma and a potentially reversible cause of cardiac arrest. Although tension pneumothorax usually occurs in mechanically ventilated patients, cases are also reported in spontaneously breathing adults and children.[3–5]

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High peak airway pressures resulting from positive-pressure ventilation can lead to pneumothorax. While difficulty ventilating an adult or child with asthma in extremis is more likely due to hyperinflation and high intrathoracic pressure, evaluation for tension pneumothorax remains important.[3–5]

2. Multiple observational studies in adults and children have demonstrated the use of ECLS in the context of respiratory failure from asthma refractory to standard care.[6–13] Survival rates in these studies are 83.5% to 100%. Most patients in these studies were supported with venovenous ECMO; however, patients with hemodynamic instability in addition to persistent hypoxia, hypercarbia, or barotrauma may require VA-ECMO support.

3 and 4. Acute respiratory failure can precipitate cardiac arrest in adults and children with asthma, which is characterized by severe obstruction leading to air trapping. Because of the limitation in exhalation air flow, delivery of large tidal volumes at a higher respiratory rate can lead to progressive worsening of air trapping and a decrease in effective ventilation. An approach described in adult asthma patients using lower tidal volumes, lower respiratory rate, and increased expiratory time may minimize the risk of intrinsic positive end-expiratory pressure and barotrauma.[14,15] This approach may be extrapolated to children with life-threatening asthma.

5. Several observational studies in adults and children have demonstrated the use of volatile anesthetics in the context of respiratory failure from asthma refractory to bronchodilators, steroids, intubation, mechanical ventilation, sedation, and neuromuscular blockade.[7,10,16–20] Survival ranged from 87% to 100% in these studies. Two of these studies compared ECLS versus volatile anesthetics.[7,10] These studies did not show a significant difference in mortality but had mixed results in other clinical endpoints, such as length of stay, complication rate, and occurrence of patient procedures.

6. Adults and children with severe asthma have limited ability to exhale and have a phenomenon known as *breath stacking*. This, in turn, can lead to an increase in intrathoracic pressure, decrease in venous return, decrease in blood pressure, decrease in coronary perfusion pressure, and, ultimately, cardiac arrest. Adults and children manifest with difficulty ventilating, high airway pressure during ventilation, or a sudden decrease in blood pressure. Brief disconnection from the ventilator or a pause in bag-mask ventilation and compression of the thorax to aid exhalation may relieve hyperinflation. This practice is informed by several case series with mixed conclusions. In 3 case series, adults and children received active exhalation maneuvers via external compression to relieve air trapping with improvement in clinical status.[21–23] However, 1 case series of 4 adults showed no improvement with external compression during exhalation.[24]

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CARDIAC INTERVENTION LABORATORY

Recommendations for Adults in Cardiac Arrest in the Cardiac Intervention Laboratory		
COR	**LOE**	**Recommendations**
2a	**C-LD**	1. It is reasonable to use mechanical CPR devices to provide chest compressions to adults in cardiac arrest in the cardiac intervention laboratory.
2a	**C-LD**	2. It is reasonable to use ECLS in adults in cardiac arrest in the cardiac intervention laboratory when initial therapy is failing.
2b	**C-LD**	3. It may be reasonable to use intracoronary epinephrine for adults in cardiac arrest in the cardiac intervention laboratory during percutaneous coronary intervention (PCI).

Synopsis

Diagnostic and therapeutic cardiovascular procedures—such as coronary angiography, PCI, transcatheter valvular intervention, and catheter ablation—are performed in the cardiac intervention laboratory. Potential procedural risks include coronary or myocardial injury associated with coronary ischemia, pericardial effusion or cardiac tamponade, severe valvular dysfunction, or malignant arrhythmia, all of which can lead to cardiac arrest. Severe cardiovascular comorbidities are common in these patients, increasing the risk of cardiovascular complications.

Cardiac arrest during PCI has better survival than in other settings, including in-hospital units, likely because of vigilant monitoring, immediate defibrillator availability, established intravascular access, and rapid intervention to treat the cause of cardiac arrest.[1–10]

Many patients with cardiac arrest in the cardiac intervention laboratory will respond to standard advanced cardiovascular life support (ACLS). In some cases, high-quality CPR may interfere with corrective interventions (eg, pericardiocentesis) or vice versa.

These recommendations inform the management of adults in cardiac arrest and do not pertain to adults who are in cardiogenic shock without cardiac arrest or those who are in cardiac arrest prior to arrival in the cardiac interventional laboratory.

These recommendations are specific to adults because studies specific to children were not included in the literature review.

Recommendation-Specific Supportive Text

1. Observational studies in adults have demonstrated the feasibility of using mechanical CPR devices for administering chest compressions to adults in cardiac arrest in the cardiac intervention laboratory.[11–17] This allows performance of potentially lifesaving interventions, such as PCI or placement of mechanical circulatory support, while avoiding gaps in the performance of CPR. Most studies utilized a mechanical piston device, and 1 used a load-distributing band.[11,13–17] Two studies on mechanical CPR in adults in cardiac arrest that specifically occurred in the cardiac intervention laboratory showed 25% survival with good neurological outcome, and 1 showed improved outcomes compared with manual CPR.[16,17] In another comparative study including adults in cardiac arrest prior to arrival in the cardiac intervention laboratory, patients receiving mechanical chest compressions were more likely to achieve ROSC than those receiving manual chest compressions.[15] However, both comparative studies were nonrandomized, had small sample sizes, and compared against a historical cohort, which coincided with major changes in resuscitation guidelines.[15,16]
2. There are no comparative studies on the use of ECLS versus standard therapy for adults in cardiac arrest in the cardiac intervention laboratory. The recommendation for ECLS is informed by prospective observational studies.[18–24] However, many studies include adults receiving ECLS for cardiac arrest that occurred prior to the cardiac intervention laboratory or ECLS use for cardiogenic shock without cardiac arrest. The Extracorporeal Life Support Organization (ELSO) Registry found survival to hospital discharge was 39% in patients receiving ECLS for cardiac arrest in the cardiac intervention laboratory, with a lower risk-adjusted odds of mortality in this population than in those with cardiac arrest receiving ECLS in an ICU or in a hospital bed.[21] Notably, some patients in this study received mechanical circulatory support prior to cardiac arrest, which may confound outcome data. The largest study of adults who specifically had initial cardiac arrest in the cardiac

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intervention laboratory showed a 30-day survival of 44%.[23] There are reports of successful use of standby ECMO in adults undergoing high-risk PCIs and transcatheter aortic valve replacements in the cardiac intervention laboratory.[25,26] Standby ECMO (placement of small-bore vascular sheaths and preprimed ECMO circuits with appropriately sized cannulas ready prior to cannulation) was associated with lower low-flow time, lower rate of acute kidney injury, and improved 30-day survival compared with extemporaneous ECMO (no cannulation or preparation of an ECMO circuit prior to cardiac arrest) in high-risk PCI.[25]

3. Two prospective cohort studies compared epinephrine (1 mg every 3–5 minutes) via intracoronary versus IV (peripheral or central) administration in 320 adults who developed cardiac arrest in the cardiac intervention laboratory.[27,28] Both showed improved outcomes, such as ROSC and survival with favorable neurological outcome, with intracoronary epinephrine. However, both studies were limited by potential confounding because the route of epinephrine administration was at the physician's discretion and due to some inherent differences between groups.

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CARDIAC SURGERY

Introduction

Cardiac arrest after cardiac surgery occurs in patients relatively infrequently, although these patients typically have better outcomes than those with other etiologies of cardiac arrest in different settings.[1] Common causes of cardiac arrest in this setting include VF (typically secondary to ischemia or pacemaker malfunction), cardiac tamponade, and severe hypovolemia from bleeding. Unique to this setting is the highly monitored nature of the postoperative ICU as well as the potential for cardiac trauma with chest compressions given the recent surgical suture lines. This population also often has the potential for temporary pacing through epicardial wires attached at the time of the operation as well as the relative ease of performing emergent resternotomy and internal cardiac massage, which provides improved output compared with external chest compressions.[2] The 2017 Society of Thoracic Surgeons (STS) consensus statement on this topic, including recommendations for children, minimally invasive heart surgeries, LVADs, transplant patients, and sternotomy and nonsternotomy operations, in addition to evidence review from the writing group informs these guidelines. Further, these societal guidelines are focused on the initial hospitalization from the operation itself, particularly during the ICU course.[1] Refer to other relevant sections of the 2025 AHA guidelines for recommendations related to cardiac arrest during or immediately after cardiac catheterization (refer to Cardiac Intervention Laboratory) or cardiac arrest in patients with LVADs who are remote from the immediate postoperative period (refer to Left Ventricular Assist Devices).

These recommendations inform the management of adults and children in cardiac arrest after cardiac surgery.

Recommendations for Adults in Cardiac Arrest After Cardiac Surgery

COR	LOE	Recommendations
1	B-NR	1. For adults in cardiac arrest after cardiac surgery, external chest compressions should be performed if emergency resternotomy is not immediately available.

Recommendations for Adults in Cardiac Arrest After Cardiac Surgery (Continued)

COR	LOE	Recommendations
1	C-EO	2. For adults in VF cardiac arrest after cardiac surgery, if a trained professional witnesses the cardiac arrest, immediate 3-stacked defibrillation should be performed, and CPR should be initiated if defibrillation is not successful within 1 minute.
1	C-EO	3. For adults in asystole or a bradycardic arrest after cardiac surgery, if a trained professional witnesses the arrest and temporary pacing wires are already in place, immediate pacing is recommended and CPR should be initiated within 1 minute if pacing is unsuccessful.
2a	B-NR	4. For adults in cardiac arrest early after cardiac surgery, it is reasonable to perform rapid resternotomy in an appropriately staffed and equipped ICU.
2a	B-NR	5. Internal cardiac massage can be useful in adults after cardiac surgery if cardiac arrest develops when the chest or abdomen is open or in the early postoperative period after cardiothoracic surgery when the chest can be reopened rapidly.
2a	C-EO	6. For adults in cardiac arrest after cardiac surgery who are refractory to standard resuscitation, ECLS can be effective.

Recommendation-Specific Supportive Text

1. Chest compressions following cardiac surgery have the potential for cardiac trauma as demonstrated in adult case reports as well as cardiac trauma in others who have not had cardiac surgery.[3,4] However, adult observational studies have not reported such trauma.[5,6] External chest compressions remain the primary means of providing perfusion while the chest is closed. In these cases, the benefit of perfusion using external chest compressions outweighs the risk of potential cardiac trauma.
2. VF is a common presenting rhythm in cases of cardiac arrest after cardiac surgery often secondary to ischemia or pacemaker malfunction. Immediate defibrillation presents distinct advantages in these adult patients, whereas the potential morbidity associated with external chest compressions or resternotomy may impact recovery.[7] Limited adult data are available from defibrillator threshold testing with backup transthoracic defibrillation using variable waveforms and energy doses.[8–10] First-shock success over 90% was observed in most of these studies, though pooled results from 15 studies found a defibrillation success rate of 78% for the first shock, 35% for the second, and 14% for the third.[11] The STS Task Force on Resuscitation After Cardiac Surgery and the European Association for Cardio-thoracic Surgery recommend 3-stacked defibrillations within 1 minute, before initiation of CPR or resternotomy.[1,7] This departure from standard ACLS is likely warranted in the post–cardiac surgery setting because

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of the highly monitored setting and unique risks of compressions and resternotomy.

3. Immediate pacing of adults in asystole or a bradycardic arrest after cardiac surgery is supported by surgical societies.[1,7] Available hemodynamic monitoring modalities in conjunction with manual pulse detection provide an opportunity to confirm myocardial capture and adequate cardiac function. When pacing attempts are not successful within 1 minute, standard ACLS including CPR is indicated.
4. No RCTs of resternotomy have been published. Improved outcomes have been observed with rapid resternotomy protocols when performed by experienced health care professionals in an appropriately equipped ICU.[5,6,12–18] Other observational studies show no benefit of resternotomy compared with standard ACLS therapy.[19–23] The STS recommends that resternotomy be a standard part of the resuscitation protocols for at least 10 days after surgery.[1] Resternotomy performed outside of the ICU results in poor outcomes.[16,21]
5. A systematic review of external cardiac compressions compared with internal cardiac massage that included animal studies as well as 9 human studies consistently demonstrated improved cardiac index and coronary perfusion pressure with internal massage.[1,2,12,21,24–29] The authors of the systematic review concluded that prompt conversion from external chest compressions to internal cardiac massage improves opportunities for ROSC.[2] The STS expert consensus statement and the European Resuscitation Council (ERC) guidelines recommend converting to internal cardiac massage unless brief resuscitation with defibrillation, pacing, or medication is successful.[2,7]
6. Many case series in adults, collectively inclusive of over 4000 patients, have reported rescue with ECLS (eg, ECMO, ventricular assist device, cardiopulmonary bypass [CPB]) in the setting of refractory cardiac arrest or persistent cardiogenic shock after cardiac surgery with a survival range of 36% to 78%.[30–34] Cannulation for cardiogenic shock and cardiac arrest postcardiotomy has been demonstrated to be feasible, although with a low survival rate (11%) in adults.[35]

Recommendations for Children in Cardiac Arrest After Cardiac Surgery

COR	LOE	Recommendations
1	C-EO	1. For children in cardiac arrest after cardiac surgery, external chest compressions should be performed if emergency resternotomy is not immediately available.
2a	C-LD	2. For children in cardiac arrest early after cardiac surgery, it is reasonable to perform resternotomy early in an appropriately staffed and equipped ICU.

Recommendations for Children in Cardiac Arrest After Cardiac Surgery (Continued)

COR	LOE	Recommendations
2a	C-LD	3. For children in cardiac arrest after cardiac surgery who are refractory to standard resuscitation procedures, ECLS can be effective.
2a	C-EO	4. Internal cardiac massage can be useful in children after cardiac surgery if cardiac arrest develops when the chest or abdomen is open or in the early postoperative period after cardiothoracic surgery when the chest can be reopened rapidly.

Recommendation-Specific Supportive Text

1. Chest compressions following cardiac surgery have the potential for cardiac trauma as demonstrated in adult case reports as well as cardiac trauma in others who have not had cardiac surgery.[3,4,36] However, adult observational studies have not reported such trauma and external chest compressions remain the primary means of providing perfusion while the chest is closed.[5,6] No evidence was identified specific to the pediatric population. While there is no specific pediatric data, extrapolating from adult literature to children in cardiac arrest following cardiac surgery, the benefit of perfusion using external chest compressions outweighs the risk of potential cardiac trauma.
2. No RCTs of resternotomy have been published. Outcomes for resternotomy in the pediatric population are extrapolated from mixed positive and neutral studies in adults with rapid resternotomy protocols in an appropriately equipped ICU.[5,6,12–20,22,23,37] One observational study including adults and children showed proportionally greater survival in children with resternotomy and open chest cardiac compression.[21] The STS recommends that resternotomy be a standard part of the resuscitation protocols for at least 10 days after surgery.[1] Resternotomy performed outside of the ICU results in poor outcomes.[16,21]
3. One study compared children receiving external chest compressions and those receiving ECPR for cardiac arrest post–cardiac surgery.[38] Those who received ECPR had an odds ratio for survival of 2.2. Additionally, many case series in children have reported rescue with ECLS (eg, ECMO, ventricular assist device, CPB) in the setting of refractory cardiac arrest or persistent cardiogenic shock after cardiac surgery with a survival range of 36% to 78%.[38–46]
4. A systematic review of external cardiac compressions compared with internal cardiac massage that included animal studies as well as 9 human studies consistently demonstrated improved cardiac index and coronary perfusion pressure with internal

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massage.[1,2,12,21,25,27,28] One of the 9 human studies included 34 children in the analysis.[21] The authors of the systematic review concluded that prompt conversion from external chest compressions to internal cardiac massage improves opportunities for ROSC.[2] The STS expert consensus statement and the ERC guidelines recommend converting to internal cardiac massage unless brief resuscitation with defibrillation, pacing, or medication is successful.[2]

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DROWNING

Introduction

Drowning is the third leading cause of death from unintentional injury worldwide, accounting for 7% of all injury-related deaths.[1] Physical trauma, such as head injuries, spinal injuries, or fractures from accidents (eg, diving and boating accidents), can impair a person's ability to remain conscious, swim, or stay afloat, increasing the risk of drowning. Drowning generally progresses from initial respiratory arrest due to submersion-related hypoxia to cardiac arrest; thus, it can be challenging to distinguish respiratory arrest from cardiac arrest because pulses are difficult to accurately palpate within the recommended 10-second window. Therefore, resuscitation from cardiac arrest attributable to this specific circumstance must focus on restoring breathing as much as it does circulation.[2]

These guidelines are designed for health care professionals, trained rescuers, and untrained lay rescuers resuscitating adults and children who have drowned. We have defined *trained rescuer* as an individual with appropriate training to perform the task discussed in a given recommendation. This is independent of the individual's occupation or ethical duty to respond. Lifeguards, swimming instructors, emergency medical technicians, paramedics, police, firefighters, other volunteers, and off-duty health care professionals, if appropriately trained for the task mentioned in the recommendation, would be considered trained rescuers and would be expected to respond in the recommended manner.[3] The Drowning Chain of Survival (Figure 1) highlights a series of interventions that reduce drowning-associated mortality when put into action by trained rescuers or untrained lay rescuers.[2,4]

We acknowledge the contributions of the authors of "2024 American Heart Association and American Academy of Pediatrics Focused Update on Special Circumstances: Resuscitation Following Drowning: An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care."[2,3]

In-Water Breaths

Recommendation for In-Water Breaths for Adults and Children		
COR	**LOE**	**Recommendation**
2b	C-LD	1. It may be reasonable for appropriately trained rescuers to provide in-water breaths to an unresponsive adult or child who has drowned if it does not compromise their own safety.

Figure 1. Drowning Chain of Survival. Reproduced from Szpilman D, Webber J, Quan L, et al. 2014;85:1149–1152. doi: 10.1016/j.resuscitation.2014.05.034.[4]

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Synopsis

Whenever an unresponsive person is found in the water, the rescuer is confronted with a difficult choice of whether to initiate breaths immediately or once the drowned person has been removed from the water. The drowning process involves initial hypoxia that may progress to respiratory arrest followed by cardiac arrest if not promptly addressed.[5–12]

This recommendation informs the management of adults and children who are unresponsive after drowning and not necessarily confirmed in cardiac arrest.

Recommendation-Specific Supportive Text

1. One retrospective observational study of in-water resuscitation of nonbreathing drowned adults and children rescued by lifeguards found higher odds of survival to hospital discharge and hospital survival with favorable neurological outcome compared with similar individuals who did not receive in-water resuscitation.[12] Rescuers must consider personal safety, availability of equipment, and distance to shore when determining the appropriateness of performing in-water breaths. When respiratory arrest is addressed by breaths that interrupt the drowning process, the death rate is lower (44%) than in those cases that progress to cardiac arrest and receive CPR (93%).[6,7,9–12]

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Oxygen Administration Following Drowning

Recommendation for Oxygen Administration in Adults and Children in Cardiac Arrest Following Drowning		
COR	**LOE**	**Recommendation**
1	**C-EO**	1. Trained rescuers should provide supplemental oxygen if available to adults and children with cardiac arrest following drowning.

Synopsis

Hypoxia is the major sequela of drowning and when severe and prolonged can lead to cardiac arrest. Even with effective CPR, cardiac output, cerebral oxygenation, and blood flow range from 12% to 42% of prearrest values.[1–3] Additionally, there is decreased diffusion capacity of the lungs from aspiration. A full discussion of the pathophysiology of drowning is beyond the scope of this guideline.[4] Adult BLS and pediatric BLS guidelines support the use of maximal available oxygen concentration during CPR (refer to "Part 6: Pediatric BLS" guidelines and "Part 7: Adult BLS" guidelines). Oxygen administration has regulatory and legal restrictions in several countries and requires the provision, use, and maintenance of equipment as well as an understanding of the mechanisms and risks of oxygen administration and storage. Use of oxygen may be limited in low- and middle-income countries. These recommendations inform the management of adults and children in cardiac arrest following drowning.

Recommendation-Specific Supportive Text

1. No study directly addresses the use, timing, or concentration of oxygen delivery to drowned adults and children. The use of supplementary oxygen during and after CPR is accepted practice for trained rescuers providing resuscitation from drowning due to the hypoxic nature of the arrest.[5,6] Hypoxemia is associated with decreased survival to hospital admission, and rapid reversal of hypoxemia through prompt bystander CPR is associated with improved survival to hospital admission and neurologically favorable survival from drowning.[7–15] We do not make a recommendation about the use of pulse oximetry monitoring during drowning because of uncertainty regarding the effectiveness

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or the accuracy of pulse oximetry in the setting of CPR.[16–19]

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Prehospital Ventilation With or Without Equipment for Adults and Children in Cardiac or Respiratory Arrest Following Drowning

Recommendations for Prehospital Ventilation With or Without Equipment for Adults and Children in Cardiac or Respiratory Arrest Following Drowning

COR	LOE	Recommendations
2a	C-EO	1. It is reasonable for trained rescuers to provide breaths or ventilations by the first means available (eg, mouth-to-mouth, pocket mask, or bag-mask ventilation) for adults and children in cardiac or respiratory arrest following drowning to avoid any delay in ventilation.
2a	C-EO	2. It is reasonable to provide ventilations using equipment (bag-mask device or advanced airways) for adults in cardiac arrest following drowning.
2a	C-EO	3. It is reasonable to provide ventilations using equipment (bag-mask device or supraglottic airway) for children in cardiac arrest following drowning.
2a	C-EO	4. It is reasonable to provide rescuers with a competency-based training program with regular retraining and maintenance of equipment.

Synopsis

Adequate ventilation is a priority during resuscitation in cardiac arrest following drowning.[1,2] This can be achieved with the use of mouth-to-mouth breathing, pocket masks, or other equipment (bag-mask device, supraglottic airway, or endotracheal intubation) according to the rescuer's training and availability of ventilatory equipment. In 30:2 CPR following OHCA, lung inflation with bag-mask ventilation is infrequent but is associated with improved ROSC, survival to discharge, and survival with favorable neurological outcomes.[3] In OHCA in general, current guidelines support the use of bag-mask ventilation or an advanced airway (supraglottic airway or endotracheal tube), depending on the situation and the skill set of the rescuer (refer to "Part 8: PALS" and "Part 9: ALS" in these guidelines).[3] Three RCTs comparing different airway strategies in adult OHCA yielded similar results when the rescuers were adept at advanced airway techniques (eg, endotracheal intubation, supraglottic airway) but inferior outcomes when they were not.[4–6] These studies highlight the critical importance of effective ventilation by ensuring secondary measures, such as monitoring chest rise and fall.

These recommendations inform the management of adults and children who are either in respiratory arrest without cardiac arrest or who are in cardiac arrest following drowning.

Recommendation-Specific Supportive Text

1. Providing breaths by the first means available is associated with improved survival to hospital discharge or 30 days for adults and children in cardiac arrest following drowning.[7–10]

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No human drowning studies have directly compared the different methods of delivering breaths.[1,2] Manikin studies enrolling lifeguards showed that mouth-to-mouth ventilation resulted in fewer chest compression interruptions and more effective ventilation and tidal volume delivery than the use of a pocket mask, bag-mask device, or face shield.[11,12]

2 and 3. Providing ventilations with equipment has not been compared with no equipment during resuscitation following drowning.[1,2] In 2 large observational studies of adults with cardiac arrest from drowning, there was no difference in survival with good neurological outcome between adults who had endotracheal intubation and those with supraglottic airway or bag-mask ventilation.[13,14] In children with cardiac arrest from drowning, endotracheal intubation was associated with worse neurologic outcomes.[15,16]

4. CPR education research demonstrates that providing effective breaths is a difficult skill to master. Training is most effective when it incorporates a hands-on aspect and is repeated to build retention.[17–19]

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CPR for Adults and Children in Cardiac Arrest Following Drowning

Recommendations for CPR for Adults and Children in Cardiac Arrest Following Drowning

COR	LOE	Recommendations
1	B-NR	1. For adults and children in cardiac arrest following drowning and after removal from the water, CPR with breaths and chest compressions should be provided.
2a	B-NR	2. For adults in cardiac arrest following drowning, if the rescuer is unwilling, untrained, or unable to provide breaths, it is reasonable to provide chest compressions only, until help arrives.
2b	C-EO	3. For children in cardiac arrest following drowning, if the rescuer is unwilling, untrained, or unable to provide breaths, it may be reasonable to provide chest compressions only, until help arrives.
2b	C-EO	4. For adults and children in cardiac arrest following drowning, it may be reasonable for trained rescuers to initiate CPR with breaths first followed by chest compressions.

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Synopsis

While these recommendations adhere to standard BLS principles, adults and children removed from the water without normal breathing or consciousness have important physiologic considerations that may modify standard algorithms. Cardiac arrest following drowning is most often due to a hypoxic mechanism, whereas sudden cardiac arrest, particularly in adults, is more likely to occur with fully oxygenated blood. An emphasis on breaths is highlighted in these recommendations.

These recommendations inform the management of adults and children in cardiac arrest following drowning.

Recommendation-Specific Supportive Text

1. Multiple large observational studies of adults and children in cardiac arrest following drowning show improved outcomes when CPR included breaths.[1–4]

2 and 3. One study including primarily elderly patients in hot tubs found no difference in outcomes between conventional (eg, CPR with breaths) and compression-only CPR. However, the demographics of the individuals who drowned in this study differed from those in most other drowning studies.[5,6] Most cardiac arrests from drowning are hypoxic in nature, and breaths are important. However, the etiology of the arrest may be unknown and some individuals in cardiac arrest from drowning will have a primary cardiac etiology where compression-only CPR is reasonable. No pediatric data on compression-only CPR following drowning were identified, thus, the pediatric recommendation is extrapolated from the adult data.

4. There is no direct evidence evaluating the sequence of resuscitation in cardiac arrest following drowning in adults or children (eg, airway-breathing-circulation versus circulation-airway-breathing). One small observational study found improved survival and neurological outcome among nonbreathing adults and children who may have had cardiac arrest following drowning and received immediate in-water breaths compared with delayed on-land resuscitation.[7] A manikin study that was not specific to drowning found that the time to completion of first CPR cycle (30 compressions and 2 breaths) was 15 seconds shorter in a compression-first strategy compared with an airway and breathing–first strategy.[8] Initiating CPR with airway, breathing, and chest compressions by trained rescuers may be appropriate as long as the initiation of breaths does not delay compressions (eg, waiting for ventilation equipment).

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AED First Versus CPR First in Cardiac Arrest Following Drowning

Recommendations for the Use of AED in Adults and Children in Cardiac Arrest Following Drowning		
COR	**LOE**	**Recommendations**
1	B-NR	1. For adults and children in cardiac arrest following drowning, CPR with breaths should be started before AED or defibrillator application.
2a	B-NR	2. AED use is reasonable for adults and children in cardiac arrest following drowning.

Synopsis

Cardiac arrest following drowning is most commonly from a hypoxic drowning process; however, it less commonly may be from a primary cardiac event.[1] Initial shockable rhythms constitute a minority (2%–12%) of cardiac arrests following drowning but are associated with higher odds of survival.[2–8] Shockable rhythms following drowning may be less common because of longer durations of submersion or longer response times. The low incidence of shockable rhythm supports the emphasis placed on high-quality CPR with breaths elsewhere in this document.[2,4,6] Individuals may also present with shockable cardiac arrest due to nondrowning causes in an aquatic setting. AEDs are feasible and safe to use in cardiac arrest following drowning.[9,10] A trend toward more frequent application of AEDs in cardiac arrest following drowning has been demonstrated.[11]

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These recommendations inform the management of adults and children in cardiac arrest following drowning.

Recommendation-Specific Supportive Text

1. Observational studies in adults and children of OHCA, and specifically cardiac arrest following drowning, show improved survival to hospital discharge or 30 days when CPR including breaths were initiated promptly.[8,12–14] AED application may present delays to CPR. In a study of 919 adult and children with cardiac arrest from drowning, where only 7.4% had an initial shockable rhythm, an AED was applied before emergency medical services arrival in 32.4% and was associated with a decreased likelihood of favorable neurological outcome in the adjusted analyses (aOR, 0.42; 95% CI, 0.23–0.77; $P<0.005$), which may have been due to a delay in the initiation of high-quality CPR with breaths and compressions.[8]
2. It is difficult to quantify the benefit of AED use in cardiac arrest following drowning given that shockable rhythms occur less commonly in the drowning process. When shockable rhythms are present, AED application is practical and a shockable rhythm confers a survival benefit in studies of adults and children with cardiac arrest after drowning.[4,6,8–11,15]

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Public Access Defibrillation Programs for Drowning

Recommendation for Public Access Defibrillation Programs for Drowning		
COR	**LOE**	**Recommendation**
2a	**C-EO**	1. Implementation of public access defibrillation programs is reasonable in areas where there is a high risk of cardiac arrest, including aquatic environments.

Synopsis

Cardiac arrest can occur in high-use public areas, such as airports, parks, beaches, pools, and other areas with high population density, with frequent utilization, where other forms of exercise are performed, or with long distances or response time to the nearest AED. Early defibrillation is associated with increased odds of survival; therefore, ensuring public access to defibrillators is important. Public access defibrillation (PAD) programs have been associated with improved outcomes for OHCA.[1,2] Although initial shockable rhythms from drowning are uncommon (occurring in 2%–12% of cases of cardiac arrest following drowning), for those who do have an initial shockable rhythm, early defibrillation can be lifesaving.[3–6] PAD programs have been demonstrated to be cost-effective.[7] Targeted AED placement compared with nationwide deployment has been demonstrated to have incremental cost-effectiveness; however, cost-effectiveness data for AED placement in aquatic environments are lacking. This recommendation applies only to the programmatic placement of AEDs in aquatic environments (eg, through public policies), not to their specific use in resuscitation following drowning.[8]

Recommendation-Specific Supportive Text

1. There is no direct evidence evaluating PAD programs for cardiac arrest following drowning. Twenty-six observational studies and 1 RCT evaluating PAD programs in adult OHCA and 2 observational studies evaluating PAD programs in pediatric OHCA demonstrated improved outcomes.[1,2,9,10] Two

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studies of PAD programs for cardiac arrest following drowning demonstrated feasibility in lifeboat and water park environments.[5,11]

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ELECTROCUTION

Recommendation for Adults and Children in Cardiac Arrest From Electrocution		
COR	**LOE**	**Recommendation**
1	**C-EO**	1. Adults and children in cardiac arrest due to electrical injury should receive standard resuscitation.

Synopsis

Electricity causes various injuries depending on the voltage, duration of contact, type of current (alternating or direct), and pathway of current traveling through the body.[1] Depending on the type of exposure, patients may experience significant burns, traumatic injuries, arrhythmias, cardiac injury, or cardiac arrest. Multiple arrhythmias are described following electrical injuries, including atrial fibrillation, VF, VT, and pulseless electrical activity (PEA).[1,2] The care of patients with burns, cardiac dysfunction, myocardial infarction, and traumatic injuries from electricity is beyond the scope of this recommendation.

These recommendations inform the management of adults and children in cardiac arrest from electrocution.

Recommendation-Specific Supportive Text

1. The mainstay of care of adults and children in cardiac arrest following electrical injury includes adherence to standard BLS and pediatric BLS as well as ALS and PALS guidelines, including rapid defibrillation and high-quality CPR as well as scene safety for responders. No clinical trials or controlled observational studies are available to inform the care of adults and children in cardiac arrest or peri-arrest following electrical injury. Numerous adult and pediatric case reports and case series describe patients with cardiac arrest, including with VF, VT, and PEA, who responded to standard resuscitation.[2,3] There are adult and pediatric case reports of patients surviving with good neurologic outcome following prolonged CPR (up to 70 minutes) for cardiac arrest following electrical injury.[4–6]

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GAS EMBOLISM

Recommendations for Adults and Children With Life-Threatening Gas Embolism		
COR	LOE	Recommendations
1	C-EO	1. Adults and children with life-threatening gas embolism should receive 100% oxygen.
2a	B-NR	2. It is reasonable to use hyperbaric oxygen for adults with life-threatening gas embolism.
2a	C-EO	3. It is reasonable to use hyperbaric oxygen for children with life-threatening gas embolism.
2a	C-EO	4. It is reasonable to position adults and children with life-threatening gas embolism supine or in the recovery position, on a level surface.
2b	C-EO	5. For adults, it may be reasonable to attempt aspiration of life-threatening right ventricular gas embolism, using a needle or a catheter, when the location of gas is known and accessible.

Synopsis

Arterial or venous gas embolism can occur due to medical intervention, trauma, barotrauma, decompression sickness, and other causes. Bubble composition may comprise air, nitrogen, and carbon dioxide.[1]

Gas in the arterial system rises to the least dependent vascular bed. Cerebral arterial gas embolism can occlude arteries, causing ischemic stroke. Coronary artery gas embolism can cause myocardial infarction, cardiogenic shock, or cardiac arrest. Venous gas can occlude right ventricular or pulmonary arterial blood flow, causing shock and cardiac arrest. Venous gas can reach the arterial system ("paradoxical gas embolism") through a patent foramen ovale or transpulmonary passage. In addition to obstructing blood vessels, gas embolism causes vascular injury, vasospasm, and thromboinflammation.[2]

Whether the same treatment is ideal for arterial and venous gas embolism, for all types of gas, or for all mechanisms of embolism production is unclear. No clinical trials have been conducted, and animal studies may not fully translate to humans. Treatment is informed by many case reports, case series, and observational comparison studies, almost all involving adults.

Nothing about the presence of gas embolism provides a contraindication to standard resuscitation, and some patients recover with standard resuscitation alone.[3]

The use of lidocaine or other medications for neuroprotection in patients with stroke due to cerebral arterial gas embolism is outside the scope of these guidelines.

These recommendations inform the management of adults and children with life-threatening gas embolism, including cardiac arrest.

Recommendation-Specific Supportive Text

1. In addition to treating tissue hypoxia, supplemental oxygen increases the diffusion of nitrogen out of gas bubbles while also improving oxygenation of adjacent ischemic tissues.[4] This recommendation is supported by adult and pediatric case reports.[5]

2 and 3. Hyperbaric oxygen therapy for gas embolism is supported by 2 adult nonrandomized observational studies, adult case series, limited pediatric case series, and animal studies.[3,6–10] Hyperbaric oxygen therapy compresses gas bubbles, increases diffusion of nitrogen and other gases from the bubble, oxygenates adjacent tissue, and reduces inflammatory cascades.[11] It is not feasible to provide hyperbaric oxygen therapy for patients in cardiac arrest in most settings.

4. The Undersea and Hyperbaric Medical Society recommends that people with gas embolism who have normal mental status be positioned supine and that those with altered mental status be positioned in the recovery position, which is consistent with standard first aid principles.[12–14] The US Navy Diving Manual also recommends level positioning during transport to definitive therapy.[15] Neither organization currently recommends head-down (Trendelenburg) positioning. These recommendations are not universally accepted, with some experts recommending the Durant position (left lateral decubitus, head down), at least for venous gas embolism.[16,17] Studies of whether head-down positioning results in redistribution of intravascular bubbles are contradictory, and limited animal data suggest that head-down positioning may worsen cerebral edema.[18–21] Effective CPR cannot be performed in the recovery (lateral decubitus) position, and standard resuscitation practice calls for compressions to be administered with the patient positioned supine (refer to "Part 7: Adult BLS" guidelines). Treatment recommendations from the Undersea and Hyperbaric Medical Society do not comment on age; supporting data are largely based on animal studies and adult case reports, and, thus, recommendations for children are extrapolated.

5. Aspiration of gas from the right ventricle using either a needle or catheter is described in adult case reports and animal studies.[22–24] The success rate of this procedure and whether it can safely be performed without ultrasound or fluoroscopic guidance is unknown.[25] No data were identified for gas aspiration in children.

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HIGH-CONSEQUENCE RESPIRATORY PATHOGENS

Recommendations to Reduce the Risk of Transmission of High-Consequence Respiratory Pathogens During Treatment of Cardiac Arrest in Adults and Children

COR	LOE	Recommendation
1	C-LD	1. Chest compressions, bag-mask ventilation, defibrillation, suctioning, and endotracheal intubation should be considered aerosol-generating procedures (AGPs) for adults and children with confirmed or suspected high-consequence respiratory pathogens.
1	C-LD	2. Resuscitation team members should wear PPE when in the resuscitation environment, including respiratory protection (N-95 respirator or purifying air-powered respirator), eye protection, gloves, and protection against contamination of clothing.
1	C-LD	3. When performing endotracheal intubation of adults with confirmed or suspected high-consequence respiratory pathogens, video laryngoscopy is preferred compared with direct laryngoscopy.
1	C-EO	4. When performing endotracheal intubation of children with confirmed or suspected high-consequence respiratory pathogens, video laryngoscopy is preferred compared with direct laryngoscopy.
1	C-EO	5. Whenever possible, all ventilation devices applied to adults and children with confirmed or suspected high-consequence respiratory pathogens should include a high-efficiency particle air filter to remove fugitive aerosols from ventilation device outflow.
1	C-EO	6. Resuscitation team leaders should minimize the number of people present in the room during resuscitation, consistent with effective resuscitation.
2a	C-LD	7. It is reasonable to dedicate a resuscitation team member to monitor and coach team members to adhere to PPE procedures.
2a	C-LD	8. It is reasonable to use mechanical CPR devices to provide compressions in adults with confirmed or suspected high-consequence respiratory pathogens, with the goal of maintaining consistent CPR quality while reducing the number of at-risk resuscitation team members.
2a	C-EO	9. It is reasonable to perform endotracheal intubation, rather than bag-mask ventilation, for adults with confirmed or suspected high-consequence respiratory pathogen to reduce the number of respirable particles generated during resuscitation.
2b	C-EO	10. It may be reasonable to perform endotracheal intubation, rather than bag-mask ventilation, for children with confirmed or suspected high-consequence respiratory pathogens to reduce the number of respirable particles generated during resuscitation.

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Recommendations to Reduce the Risk of Transmission of High-Consequence Respiratory Pathogens During Treatment of Cardiac Arrest in Adults and Children (Continued)		
COR	**LOE**	**Recommendations**
3: No Benefit	**C-LD**	11. The use of intubating boxes and other improvised barrier devices during intubation of adults and children with confirmed or suspected high-consequence respiratory pathogens is not recommended.

Synopsis

Worldwide pandemics caused by *high-consequence pathogens*, as termed by the Centers for Disease Control, are common. Recent examples include SARS (2002–2003), influenza H1N1 (2009–2010), Middle East respiratory syndrome coronavirus (MERS-CoV, approximately 2012–2015), and SARS-CoV-2 (or COVID-19, approximately 2019–2022). These infections are spread by direct contact with a combination of respiratory secretions, droplets, and aerosols.[1] Effective vaccines and treatment may not be available during the early stages of a pandemic, putting resuscitation team members at risk. The AHA released interim guidance for BLS and ALS modifications for patients with suspected or confirmed SARS-CoV-2 in 2020 and 2022 to provide effective resuscitation while minimizing risk.[2,3] The recommendations in this section supersede that guidance, broaden the recommendations to encompass all high-consequence pathogens, and acknowledge the limitations of not knowing the transmissibility of future pathogens.

Most studies in this area relate to IHCA, with less literature related to emergency medical services personnel and almost no studies related to lay rescuers. Lay rescuer CPR rates decreased in some regions during the early stages of the SARS-CoV-2 pandemic, and resuscitation outcomes from OHCA were worse compared with before the pandemic.[4–8] Availability of PPE may improve laypeople's willingness to perform CPR.[9] The most effective strategy to protect members of the general public providing CPR during a disease outbreak represents a major knowledge gap.

Ethical considerations of performing resuscitation in the setting of personal risk are discussed in "Part 3: Ethics."

Recommendation-Specific Supportive Text

1. Systematic reviews identified CPR, bag-mask ventilation, intubation, and suctioning as AGPs.[10–16] Other studies were less conclusive about CPR, intubation, and suctioning as AGPs.[10,17–20] A human and animal study that evaluated aerosol particle concentration during cardiac arrest found that compressions, bag-mask ventilation, and defibrillation all generate aerosols.[21]
2. The use of PPE, including respiratory protection, eye protection, gloves, and barrier gowns reduces the risk of infection to health care personnel.[10,13–15,17] In an observational study of over 1500 health care professionals wearing PPE for approximately 180 SARS-CoV-2–positive patients requiring AGPs, only 1 health care professional became positive in the 2 weeks after the encounter.[22,23] For prehospital professionals wearing PPE, only 1% became SARS-CoV-2 positive following care for approximately 190 patients with SARS-CoV-2 receiving AGP.[24]
   Simulation studies show a delay in CPR initiation of 30 to 60 seconds to don PPE.[11,25–27] Simulation studies about the effect of PPE on CPR quality are mixed.[15,28–45] An IHCA study of 800 adult resuscitations before and after implementation of a resuscitation PPE policy showed a delay to initiation of compressions by 20 seconds, 2 minutes for rhythm analysis, no difference to first shock, 1 minute for epinephrine, and 1 minute 40 seconds for intubation.[46] A prospective observational study found similar first-pass intubation success when intubation (98% adults) was performed by a health care professional wearing full PPE.[47] No difference in survival was found in this study or in 2 other studies of adult OHCA and emergency department resuscitation.[48,49] In a prospective observational study of 3435 adult emergency department intubations, rates of peri-intubation adverse events were not increased when full barrier PPE was used.[22]

3 and 4. Simulation studies and adult observational studies of intubations with PPE use suggest that operators wearing PPE could perform video laryngoscopy faster than direct laryngoscopy with similar intubation success rates and that video laryngoscopy could be performed with the intubator's face farther from the source of aerosols.[50–53] One adult observational study showed increased time to intubation with video laryngoscopy compared with direct laryngoscopy.[50] A large RCT of adult intubation conducted near the end of the SARS-CoV-2 pandemic (March to November 2022) found better first-attempt intubation success with video laryngoscopy than direct laryngoscopy.[54] The type of PPE used was not reported in this study. No pediatric data on the use of video versus direct laryngoscopy with PPE were identified, thus, the recommendation for children is extrapolated from the adult data.

5. High-efficiency particle air and high-efficiency bacterial-viral filters remove more than 99.9% of transmissible viruses and other infectious aerosols from prefiltered air. Placing a filter

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with high viral filtration efficacy on the exhaust limb of ventilation devices, such as bag-mask ventilation devices or bag devices attached to a tracheal tube or supraglottic airway, reduces fugitive aerosol emissions in the treatment environment and is, therefore, recommended by anesthesiology safety groups and other organizations.[55–62]

6. Decreasing the number of people in the room during resuscitation reduces the number of people at risk of disease transmission. A simulated study showed that although quality of CPR metrics did not change with less personnel in the room, there was a delay in resuscitation task completion with less personnel in the room.[25] An audio link to team members outside the room enables tasks, such as contemporaneous clinical documentation and drug preparation, to be performed by personnel outside the high-risk environment.
7. Resuscitation team adherence to proper PPE procedures is often incomplete, and proper mask fit during compressions can be compromised.[11,22,26,63,64] Just as assigning a team member to monitor and provide real-time feedback about CPR improves CPR quality, dedicating a team member to supervise PPE use may improve PPE adherence and, therefore, team member safety. Ideally, this would be done without exposing an additional person to the infectious resuscitation environment. It is standard in cases of suspected viral hemorrhagic fever to have a "trained observer" who is dedicated to providing real-time feedback to team members about their PPE use.[65,66] This concept has been tested in simulated SARS-CoV-2 resuscitation and using remote video monitoring.[26,67–69]
8. Performing chest compressions while wearing PPE increases rescuer fatigue, and several simulation studies showed that wearing PPE also negatively impacts compression depth and resuscitation timing.[15,29,30,36,41–45,70–73] Mechanical CPR devices can maintain high-quality chest compressions while reducing the number of people required to perform resuscitation. Although a simulation study found that mechanical CPR devices are associated with better compression quality than human compressors wearing PPE, an observational study of adults with OHCA (421 propensity-matched pairs) did not find a difference in survival or neurologic outcomes when a mechanical CPR device was used compared with manual CPR with PPE.[74,75] No data were identified on mechanical CPR devices compared with manual CPR with PPE in children.
9 and 10. A case report of a healthy adult volunteer who had an awake intubation showed that the risk of exposure to aerosol particles is increased for personnel within 3 meters of the patient.[76] However, a study of 3 adults undergoing intubation showed that the mean particle concentrations were 200 to 300 times baseline during bag-mask ventilation, compared with 30 to 50 times baseline during endotracheal tube insertion.[77] While no longer emphasized in standard resuscitation, endotracheal intubation redirects a patient's exhaled gas, respiratory droplets, and respiratory aerosols away from personnel in the room and contains them.[76,77] No pediatric data on endotracheal intubation to contain respiratory droplets and aerosol particles were identified, thus, the recommendation for children is extrapolated from the adult data. No studies were identified on the use of supraglottic airways to contain respiratory droplets and aerosol particles.
11. Intubation boxes, also known as aerosol boxes, were evaluated in a systematic review that included 20 simulation studies and showed a reduction in droplets but not aerosols and an increased time to endotracheal tube placement.[78] This was further supported by more recent simulation studies with the same conclusions, although interpretation of the data could be limited by box design heterogeneity between studies.[79–83] Minimizing gaps and using negative pressure devices may improve the box's performance. Patient draping has also been investigated with similar issues.[28,40,79,83,84]

Table 2 summarizes the key steps to reduce transmission of these pathogens.

Table 2. Transmission Reduction in High-Consequence Respiratory Pathogens in Cardiac Arrest

Key steps to take to reduce the risk of transmission of high-consequence respiratory pathogens during treatment of cardiac arrest in adults and children
Resuscitation team members should wear PPE
N95 respirator or PAPR, eye protection, gloves, gown
Consider designating a PPE monitor or coach
Minimize the number of people in the room
It is reasonable to use a mechanical CPR device
Monitor for team member fatigue
Consider intubating early in resuscitation
Video laryngoscopy is preferred
Use a HEPA filter to reduce fugitive aerosols from bag-mask ventilation device or ventilator
Intubating boxes and other improvised barrier devices are not recommended

CPR indicates cardiopulmonary resuscitation; HEPA, high-efficiency particle air; PAPR, powered air-purifying respirator; and PPE, personal protective equipment.

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HYPERKALEMIA

Recommendations for Adults and Children in Cardiac Arrest From Suspected Hyperkalemia

COR	LOE	Recommendations
2b	C-LD	1. The effectiveness of IV calcium administration for adults and children in cardiac arrest from suspected hyperkalemia is not well established.
2b	C-EO	2. The effectiveness of IV sodium bicarbonate administration for adults and children in cardiac arrest from suspected hyperkalemia is not well established.
2b	C-EO	3. The effectiveness of IV insulin and glucose for adults and children in cardiac arrest from suspected hyperkalemia is not well established.
3: No Benefit	C-EO	4. Inhaled β_2-agonists for adults and children in cardiac arrest from suspected hyperkalemia is not recommended.

Synopsis

Hyperkalemia, defined as serum potassium concentration greater than 5.0 mEq/L in adults and greater than 5.5 mEq/L in children, can lead to life-threatening cardiac arrhythmias and cardiac arrest.[1,2] While the prevalence of hyperkalemia in the adult population is estimated at 2% to 3%, hospitalized adults face a greater incidence of severe hyperkalemia (>6.5 mEq/L), ranging from 1% to 10%.[3–6] Risk factors contributing to the development of hyperkalemia in both adults and children include impaired kidney function, potassium supplements, potassium-sparing diuretics, angiotensin-converting enzyme inhibitors or angiotensin receptor blockers (ARBs), brisk hemolysis, and crush injuries. Acidemia during cardiac arrest can also temporarily cause potassium to shift extracellularly, resulting in elevated serum potassium concentrations, which may conflate the etiology of cardiac arrest.[7] Laboratory confirmation is not required for initial treatment, although patient history and electrocardiogram changes can support suspicion of hyperkalemia as an underlying etiology. Characteristic electrocardiogram abnormalities of

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hyperkalemia may include peaked T waves, flattened P wave, PR interval lengthening, QRS complex prolongation, and ST segment depression followed by merging of S and T waves (sine wave), though the sensitivity and specificity of these findings are low.[8]

These recommendations are only applicable to the management of adults and children in cardiac arrest from hyperkalemia and do not discuss the treatment of life-threatening hyperkalemia with therapies such as loop diuretics and potassium binders.

Recommendation-Specific Supportive Text

1. The benefits of IV calcium administration for myocardial protection during hyperkalemia in the setting of cardiac arrest are based on an 1883 in vitro study, a 1939 dog study, and a series of 5 adult cases in 1964.[9–11] Calcium administration alone in a randomized controlled porcine model of hyperkalemic cardiac arrest did not increase ROSC (OR, 1.2; 95% CI, 0.4–4.0; *P*=0.76) or time to ROSC (HR, 1.5; 95% CI, 0.8–2.9; *P*=0.23) when compared with placebo.[12] There are no high-quality human observational studies or clinical trials evaluating IV calcium to treat patients with hyperkalemic cardiac arrest. One human adult retrospective observational study on the effectiveness of calcium and sodium bicarbonate is limited by small sample size, retrospective design, and multiple conflicting regression analyses, leading to low certainty of results.[13] The study did not inform this recommendation. Furthermore, no significant benefit of IV calcium was observed in a subanalysis of adult out-of-hospital PEA arrests in which hyperkalemia was suspected as defined by electrocardiogram abnormalities rather than prearrest potassium concentrations.[14] Limited data in children seem to demonstrate findings consistent with adults. In a separate subgroup analysis of observational data in pediatric hospitals, 8 children receiving calcium during in-hospital hyperkalemia-induced cardiac arrest showed no significant differences or trends in survival to hospital discharge or favorable neurological outcome.[15]
2. Sodium bicarbonate shifts potassium intracellularly and is theoretically beneficial when severe hyperkalemia exists with cardiac arrest. In a randomized controlled pig model of hyperkalemic cardiac arrest, sodium bicarbonate significantly increased ROSC (24/26 [92%] versus 13/26 [50%]; OR, 12.0; 95% CI, 2.3–61.5; *P*=0.003) and reduced time to ROSC (HR, 3.6; 95% CI, 1.8–7.5; *P*<0.001).[12] One human adult retrospective observational study on the effectiveness of calcium and sodium bicarbonate is limited by small sample size, retrospective design, and multiple conflicting regression analyses, leading to low certainty of results.[13] The study did not inform this recommendation. There is a paucity of published literature of sodium bicarbonate in children, and, thus, recommendations are extrapolated from available adult data.
3. Insulin and glucose shift potassium intracellularly. Treatment with IV insulin in the setting of hyperkalemic cardiac arrest has produced variable results and is limited to case reports and case series. Notably, standard IV insulin therapy was ineffective in a reported case series of 11 adults and 5 children.[16] However, a recent case report of 2 adults indicated a potential benefit of high-dose insulin (1 U/kg IV) on ROSC in the presence of hyperkalemia.[17] The ILCOR *2024 International Consensus on CPR and Emergency Cardiovascular Care Science With Treatment Recommendations* recommends the combination of insulin and glucose for adults and children with cardiac arrest from suspected hyperkalemia based on indirect non–cardiac arrest evidence demonstrating the lowering of serum potassium concentrations.[18,19] The use of insulin and glucose risks hypoglycemia and has the opportunity cost of forgoing other potentially efficacious interventions. Doses for insulin and glucose for cardiac arrest from suspected hyperkalemia are listed in Table 3.
4. Stimulation of the β_2-adrenergic receptors promotes intracellular movement of potassium by activation of the Na-K ATPase pump. There are no data demonstrating additional benefit using additional β_2-adrenergic agonists over basic resuscitation in either adults or children with cardiac arrest from suspected hyperkalemia. Epinephrine is far

Table 3. Insulin-Glucose Dosing for Cardiac Arrest From Suspected Hyperkalemia

Population	Glucose	Insulin	Administration notes
Adults			
Standard dose	$D_{50}W$ or glucose 50%: 50 g IV bolus	10 Units regular insulin	Administer insulin IV over 15–30 min
Children			
Standard dose	$D_{10}W$ or Glucose 10%: 5 mL/kg IV bolus	0.1 Units/kg regular insulin	Administer insulin IV over 15–30 minutes max 10 U for severe hyperkalemia

$D_{50}W$ indicates 50% dextrose in water; $D_{10}W$, 10% dextrose in water; and IV, intravenous.

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more effective at β-adrenergic activation than β_2-specific agonists (eg, albuterol or salbutamol).[20] Furthermore, differential effects on serum potassium concentrations may occur over the course of therapy.[21] Excessive β_2-agonist–induced peripheral vasodilation and the potential for interruptions or ineffective CPR to deliver inhaled therapy could negatively impact patient outcomes.

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HYPERTHERMIA

Introduction

Life-threatening hyperthermia (defined as a core temperature ≥40 °C [104 °F]) is a preventable cause of cardiac arrest that has multiple etiologies, including exertional heatstroke, environmental exposure, and medication or drug overdose. Animal data suggests that temperature and duration are critical determinants of survival.[1–3] Prolonged temperature elevation leads to multiorgan failure that resembles septic shock.[1]

Children are at higher risk of hyperthermia compared to adults for several reasons. Children are at higher risk for heat gain because they have larger ratios of body surface area to body mass, increased metabolic heat production, and ineffective sweat glands to dissipate heat. Young children also are unable to recognize or self-extricate from hyperthermic environments.[4,5]

No RCT on cooling patients with hyperthermic cardiac arrest has been performed. As a result, recommendations are made from data derived from adults with life-threatening hyperthermia and experimental models of hyperthermia in human volunteers. The following recommendations only apply to adults and children with exertional heatstroke, environmental exposure, and medication or drug overdose. The treatment of patients with malignant hyperthermia and sepsis is outside the scope of these recommendations.

Specific discussion of the management of adults and children with life-threatening cocaine and sympathomimetics poisoning can be found elsewhere (refer to the Toxicology: Cocaine and Toxicology: Sympathomimetics sections). These recommendations inform the management of adults and children with life-threatening hyperthermia, including cardiac arrest.

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Recommendations for Adults With Life-Threatening Hyperthermia (Core Temperature >40 °C [104 °F])		
COR	LOE	Recommendations
1	C-EO	1. Active cooling is recommended to be initiated concurrently with standard resuscitation for adults with life-threatening hyperthermia.
2a	B-R	2. It is reasonable to choose immersion in ice water (1–5 °C [33.8–41 °F]) over other cooling methods in adults with life-threatening hyperthermia.
2a	B-R	3. If ice water immersion is not available, it is reasonable to choose immersion in tepid water (8–17 °C [46.4–62.6 °F]) or tarp-assisted ice water cooling over other cooling methods in adults with life-threatening hyperthermia.
2a	C-LD	4. It is reasonable to cool adults with life-threatening hyperthermia as rapidly as possible with a decrease of at least 0.15 °C/min (0.27 °F/min).
2a	C-LD	5. It is reasonable to stop active cooling for life-threatening hyperthermia when the core temperature of the adult patient reaches 38.6 °C (101.5 °F).
3: No Benefit	B-R	6. Dantrolene is not useful to treat adults with life-threatening hyperthermia from causes other than malignant hyperthermia.

Recommendation-Specific Supportive Text

1. Standard resuscitation enhances circulation, which helps dissipate excess heat through vascular distribution of blood from the core to the extremities.[6] Rapid body cooling addresses hyperthermia while preventing further rises in temperature.[6]
2. A systematic review of cooling rates that included 63 studies of primarily adults (25 randomized clinical trials, 12 nonrandomized clinical trials, 2 cohort studies, and 24 case series) concluded that ice water immersion provided faster cooling rates than numerous other techniques (Figure 2).[7] The superiority of ice water (1–5 °C [33.8–41 °F]) immersion is supported by 1 adult volunteer RCT.[8] This recommendation is consistent with the 2025 Society of Critical Care Medicine Guidelines for the Treatment of Heat Stroke.[9]
3. When ice water immersion is not available, full body immersion in tepid water (8–17 °C [46.4–62.6 °F]) still often achieves adequate cooling rates in multiple systematic reviews of primarily adult populations.[7,10] When immersion is not feasible, tarp-assisted ice water cooling produces adequate cooling rates in adults (Figure 2).[10,11] This recommendation is consistent with the 2025 Society of Critical Care Medicine Guidelines for the Treatment of Heat Stroke.[9]
4. A systematic review of case reports and case series identified an increase in mortality in adults cooled slower than 0.15 °C/min (0.27 °F/min).[12] This recommendation is consistent with the 2025 Society of Critical Care Medicine Guidelines for the Treatment of Heat Stroke.[9]
5. A controlled trial of 10 healthy adult volunteers with non–life-threatening hyperthermia (core temperature, 39.5 °C [103.1 °F]) demonstrated that those who were removed from ice water immersion at a core temperature of 38.6 °C (101.5 °F) had lower risk of overcooling compared with those removed at 37.5 °C (99.5 °F).[13] Overcooling to below normothermia could cause complications, such as coagulopathy and adverse hemodynamic effects.[14]
6. Four studies that investigated the effects of dantrolene in life-threatening hyperthermia (from causes other than malignant hyperthermia) were included in the data review and demonstrated mixed results. An adult case series (n=20) of dantrolene use in hyperthermia for exposure-related heat stroke was associated with more rapid cooling but no difference in neurologic outcomes.[15] An RCT (n=52 adults) of dantrolene (2 mg/kg IV) for environmental hyperthermia (>40.1 °C [104.2 °F]) did not find a reduction in cooling time.[16] Data on dantrolene for 3,4-methylenedioxymethamphetamine (MDMA)–induced hyperthermia is also conflicting. A meta-analysis of patients aged ≥15 years identified case reports and case series totaling 71 cases and found that dantrolene use was associated with improved survival.[17] However, a case series of 9 adults did not find clinical differences between patients who received dantrolene versus those who did not.[18] This recommendation is consistent with the 2025 Society of Critical Care Medicine Guidelines for the Treatment of Heat Stroke.[9]

Recommendations for Children With Life-Threatening Hyperthermia (core temperature, >40 °C [104 °F])		
COR	LOE	Recommendations
1	C-EO	1. Active cooling is recommended to be initiated concurrently with standard resuscitation for children with life-threatening hyperthermia.
2a	C-EO	2. It is reasonable to choose immersion in ice water (1–5 °C; 33.8–41 °F) over other cooling methods in children with life-threatening hyperthermia.
2a	C-EO	3. If ice water immersion is not available, it is reasonable to choose immersion in tepid water (8–17 °C; 46.4–62.6 °F) or tarp-assisted ice water cooling over other cooling methods in children with life-threatening hyperthermia.
2a	C-EO	4. It is reasonable to cool children with life-threatening hyperthermia as rapidly as possible with a decrease of at least 0.15 °C/min (0.27 °F/min).
2a	C-EO	5. It is reasonable to stop active cooling for life-threatening hyperthermia when the core temperature of a child reaches 38.6 °C (101.5 °F).
3: No Benefit	C-EO	6. Dantrolene is not useful to treat children with life-threatening hyperthermia from causes other than malignant hyperthermia.

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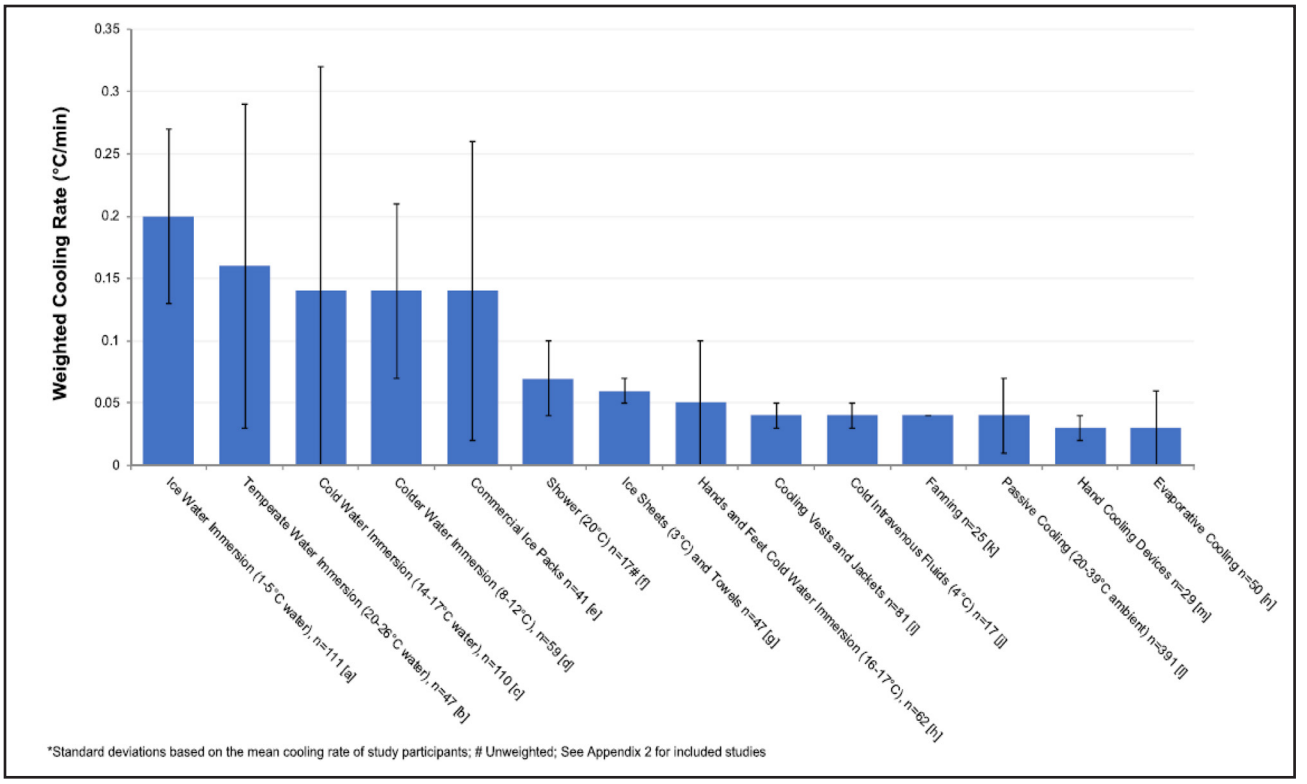

Figure 2. Weighted mean cooling rates by cooling method.[7]
Reproduced from Douma MJ, Aves T, Allan KS, et al. First aid cooling techniques for heat stroke and exertional hyperthermia: A systematic review and meta-analysis. *Resuscitation*. 2020;148:173-190. doi: 10.1016/j.resuscitation.2020.01.007

Recommendation-Specific Supportive Text

1. Standard resuscitation enhances circulation, which helps dissipate excess heat through vascular distribution of blood from the core to the extremities.[6] Rapid body cooling addresses hyperthermia while preventing further rises in temperature.[6]
2. A systematic review of cooling rates that included 63 studies of primarily adults (25 randomized clinical trials, 12 nonrandomized clinical trials, 2 cohort studies, and 24 cases series) concluded that ice water immersion provided faster cooling rates than numerous other techniques (Figure 2).[7] The superiority of ice water (1–5 °C [33.8–41 °F]) immersion is supported by 1 adult volunteer RCT.[8] No pediatric data for cooling rates with ice water immersion were identified, and, thus, the recommendation for children is extrapolated from this adult data. This recommendation is consistent with the 2025 Society of Critical Care Medicine Guidelines for the Treatment of Heat Stroke.[9]
3. When ice water immersion is not available, full body immersion in tepid water (8–17 °C [46.4–62.6 °F]) still often achieves adequate cooling rates, as shown in multiple systematic reviews of primarily adult populations.[7,10] When immersion is not feasible, tarp-assisted ice water cooling produces adequate cooling rates in adults (Figure 2).[10,11] No pediatric data for cooling rates with tepid water immersion or tarp-assisted ice water cooling procedures were identified, and, thus, the recommendation for children is extrapolated from this adult data. This recommendation is consistent with the 2025 Society of Critical Care Medicine Guidelines for the Treatment of Heat Stroke.[9]
4. A systematic review of case reports and case series identified an increase in mortality in adults cooled slower than 0.15 °C/min (0.27 °F/min).[12] No pediatric data for cooling rates were identified, and, thus, the recommendation for children is extrapolated from this adult data. This recommendation is consistent with the 2025 Society of Critical Care Medicine Guidelines for the Treatment of Heat Stroke.[9]
5. A controlled trial of 10 healthy adult volunteers with non–life-threatening hyperthermia (core temperature, 39.5 °C [103.1 °F]) demonstrated that those who were removed from ice water immersion at a core temperature of 38.6 °C (101.5 °F) had lower risk of overcooling compared with those removed at 37.5 °C (99.5 °F).[13] Overcooling to below normothermia could cause complications, such as coagulopathy and adverse hemodynamic effects.[14] No pediatric data for the optimal temperature at which

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to terminate cooling were identified, and, thus, the recommendation for children is extrapolated from this adult data.

6. Four studies that investigated the effects of dantrolene in life-threatening hyperthermia (from causes other than malignant hyperthermia) were included in the data review and demonstrated mixed results. An adult case series (n=20) of dantrolene use in hyperthermia for exposure-related heat stroke was associated with more rapid cooling but no difference in neurologic outcomes.[15] An RCT (n=52 adults) of dantrolene (2 mg/kg IV) for environmental hyperthermia (>40.1 °C [104.2 °F]) did not find a reduction in cooling time.[16] Data on dantrolene for MDMA-induced hyperthermia are also conflicting. A meta-analysis of patients aged ≥15 years identified case reports and case series totaling 71 cases and found that dantrolene use was associated with improved survival.[17] Both pediatric patients (a 16- and a 17-year-old patient) included in the study died.[17] Furthermore, a case series in adults did not find clinical differences between patients who received dantrolene versus those who did not.[18] Limited pediatric data on the use of dantrolene to treat life-threatening hyperthermia were identified; thus, the recommendation for children is extrapolated primarily from the adult data. This recommendation is consistent with the 2025 Society of Critical Care Medicine Guidelines for the Treatment of Heat Stroke.[9]

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HYPOTHERMIA

Introduction

Severe environmental hypothermia (core body temperature, <30 °C [86 °F]) can cause cardiac arrest as well as findings that mimic death.[1] Pulse and respiratory rates may be slow or difficult to detect, and the electrocardiogram may show asystole. Apparent rigor mortis or fixed dilated pupils may not be reliable signs of death in this setting.[2–4] Hypothermia decreases the body's metabolic rate and oxygen consumption, improving the chance of survival and neurological recovery even after prolonged cardiac arrest.[5–7]

Hypothermic cardiac arrest often occurs in dangerous environmental conditions, and verification of scene safety prior to implementing resuscitative measures is important. Following removal from environmental exposure and removal of wet clothing, passive rewarming may include techniques such as providing a blanket, and active rewarming may include providing a warm forced-air blanket, administration of warmed IV or IO fluids, warm humidified oxygen, warm water lavage of the thoracic and peritoneal cavities, blood rewarming using a kidney replacement therapy circuit, or use of endovascular temperature control catheters.[8–13] Warming through ECLS is possible at some centers and also provides circulatory support.

Children are at higher risk of hypothermia compared with adults due to a larger ratio of body surface area to body mass and decreased insulation by fat. Infants cannot produce heat through shivering, and both infants and children have limited glycogen stores required to produce heat and are unable to self-extricate from hypothermic environments.[14]

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In the absence of human evidence, these guidelines do not make a recommendation about the use of antiarrhythmic medications for patients in cardiac arrest from environmental hypothermia. These recommendations are specific to hypothermia management. Other specific treatment recommendations related to the setting of drowning can be found elsewhere (refer to Drowning).[15] Treatment recommendations related to avalanche are outside of the scope of these guidelines.

These recommendations inform the management of adults and children with life-threatening environmental hypothermia, including cardiac arrest. Other specific treatment recommendations related to adults and children with hypothermia that is not immediately life-threatening can be found in the AHA and American Red Cross 2024 Guidelines for First Aid.[16]

Recommendations for Adults With Life-Threatening Environmental Hypothermia (Core Temperature <30 °C [86 °F])		
COR	LOE	Recommendations
1	C-LD	1. For adults with life-threatening environmental hypothermia with no obvious lethal injury, full resuscitative measures should be performed immediately and continued concurrently with rewarming.
2a	B-NR	2. It is reasonable to rewarm adults in hypothermic cardiac arrest using ECLS.
2a	B-NR	3. It is reasonable to use prognostication scores to guide the decision for initiating ECLS rewarming for adults in hypothermic cardiac arrest.
2b	C-LD	4. It may be reasonable to rewarm adults with environmental hypothermia (core temperature <28 °C [82.4 °F]) and not in cardiac arrest using ECLS.
2b	C-LD	5. For adults in hypothermic cardiac arrest, it may be reasonable to defibrillate once and if unsuccessful, defer further defibrillation until the core temperature is ≥30 °C (86 °F).
2b	C-LD	6. It may be reasonable to rewarm adults with life-threatening environmental hypothermia with ECLS at a rate of 1.5–5 °C/hour (2.7–9 °F/hour).
2b	C-EO	7. It may be reasonable to defer administration of epinephrine until the core temperature is ≥30 °C (86 °F) for adults in hypothermic cardiac arrest.
2b	C-EO	8. If standard CPR is not possible due to environmental conditions, it may be reasonable to perform delayed or intermittent CPR during the resuscitation of adults in hypothermic cardiac arrest to facilitate rapid extraction.
2b	C-EO	9. It may be reasonable to transport adults in hypothermic cardiac arrest to a center with ECLS capability if it can be reached within 6 hours.
3: No Benefit	B-NR	10. It is not recommended to use end-tidal carbon dioxide ($ETCO_2$) to predict outcomes for adults in hypothermic cardiac arrest.

Recommendation-Specific Supportive Text

1. Obvious lethal injury (eg, decapitation, truncal transection, whole body incineration, or frozen solid) are suggested conditions to withhold or terminate CPR.[17] Absent these signs, numerous case reports and the International Hypothermia Registry describe ROSC prior to or concurrently with rewarming in adults.[18–20]
2. A multicenter prospective observational study of 242 adults with severe environmental hypothermia showed improved survival and favorable neurologic outcome for adults in cardiac arrest treated with ECMO compared with conventional rewarming.[21] Multiple retrospective observational studies of adults in hypothermic cardiac arrest rewarmed with ECLS have demonstrated a survival benefit and improved neurological outcome over conventional CPR.[22–24] The use of ECMO is preferable over CPB; a meta-analysis including 464 adults and children in cardiac arrest due to hypothermia showed a 41% greater probability of survival with ECMO.[25]
3. The Hypothermia Outcome Prediction After ECLS (HOPE) probability score includes age, sex, asphyxia, CPR duration, serum potassium concentration, and temperature.[26] A HOPE score <0.1 has been validated for predicting mortality of adults in hypothermic cardiac arrest placed on ECLS for rewarming.[27,28] The HOPE score is superior to serum potassium threshold of ≥12 mmol/L alone in adults and children.[26] The International Accidental Hypothermia ECLS (ICE) survival score includes sex, asphyxia, and serum potassium concentration, and a score >12 has also been validated in predicting survival after hypothermic cardiac arrest in adults and children.[29] Other prognostic factors in isolation have been associated with higher mortality in adults and children with hypothermic cardiac arrest, including high serum potassium concentration, high serum lactate, low pH, asphyxia, unwitnessed cardiac arrest, male sex, older age, higher or lower initial body temperature, and longer resuscitation duration.[19,20,25,27,30–33] These prognostic factors are less well-validated than the HOPE or ICE scores. The ELSO eligibility criteria for ECLS in normothermic OHCA may miss adults in hypothermic cardiac arrest who would benefit from ECLS.[11]
4. Retrospective observational studies in adults with core temperature <28 °C (82.4 °F) who are not in cardiac arrest have shown successful and even faster rewarming with ECLS compared with conventional methods.[22,24,34,35] A multicenter prospective observational study showed improved survival and neurological outcomes with the use of ECMO for adults in hypothermic cardiac arrest. However, adults with hemodynamic instability (eg, not in cardiac arrest) from hypothermia who were placed on ECMO had decreased event-free days (ICU, ventilator, and catecholamine administration)

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and increased hemorrhagic complications without the benefit of improved survival or neurological outcome.[21]

5. Defibrillation before rewarming can be successful in adults, but the hypothermic heart may be less responsive to defibrillation.[18,20,32,36,37] The temperature at which defibrillation should first be tried and the number of defibrillation attempts that should be made are not well-studied in humans. If VT or VF persists, excessive defibrillation attempts may lead to myocardial injury. In a large retrospective observational study, while a shockable initial rhythm in adults in hypothermic OHCA was associated with better survival and neurologically favorable survival, prehospital defibrillation and increasing the number of defibrillation attempts were not.[38] However, only a small number of adults with shockable rhythms were not defibrillated, so the study may have been underpowered to detect a difference in outcomes in this population. The Wilderness Medical Society guideline recommends defibrillating once initially and deferring additional defibrillation attempts until core temperature reaches 30 °C (86 °F) when defibrillations are more likely to be successful.[39,40] ERC guidelines allow up to 3 defibrillation attempts before rewarming to 30 °C (86 °F).[41]
6. The optimal rate for rewarming hypothermic adults with ECLS is unknown. Slow rewarming may delay the return of organ perfusion, and rapid rewarming may cause relative cerebral hyperthermia, potentially worsening neurological outcomes. A secondary review of a meta-analysis of observational studies and case reports of 658 adults and children rewarmed with ECLS evaluated the optimal threshold rewarming rate. Rewarming rates less than 5 °C/hour (9 °F/hour) had a 2.41 greater odds (95% CI, 1.75–3.31) of neurologically intact survival over rewarming rates greater than 5 °C/hour (9 °F/hour).[42] Neurologically intact survival decreased by 1.9% for each 1 °C/hour (1.8 °F/hour) increase in rewarming rate.[42] Another meta-analysis of case reports and case series showed a lower relative hazard of death in adults who were rewarmed at rates between 1.5 °C (2.7 °F) and 4 °C/hour (7.2 °F), though the former study had a substantially higher mean rewarming rate than the latter.[30]
7. The temperature at which epinephrine should first be administered and the optimal dosing interval in the severely hypothermic adult has not been well-studied. Some adult and adolescent cases of hypothermic cardiac arrest have normal responses to epinephrine before rewarming.[18] However, hypothermic hearts may be less responsive to cardiovascular drugs, and slowed metabolism due to hypothermia raises concerns for epinephrine accumulation and toxicity.[41,43,44]
8. In cases of prolonged CPR or dangerous environmental conditions, it may be suboptimal or impossible to perform continuous high-quality CPR. Delayed or interrupted CPR may facilitate rapid extraction or transportation and allow for optimal CPR as soon as feasible or safe. Successful resuscitation has been documented in adult cases with delayed or intermittent CPR.[45] The acceptable frequency and duration of CPR interruptions and which adults can best tolerate this are unknown.
9. Rapid hospital transport is important to allow for aggressive rewarming with both noninvasive and invasive techniques. Two studies utilizing the same database conflicted on the association of low-flow time (time from cardiac arrest to the establishment of ECMO) with outcomes for adults in cardiac arrest due to hypothermia.[46,47] An observational study showed that transportation to centers with ECLS capability improved neurologically favorable outcomes and 1-month survival in adults.[38] Adults have been resuscitated using ECLS after hypothermic cardiac arrest lasting over 6 hours, so the ERC supports transporting to an ECLS-capable center if within 6 hours.[41,48,49]
10. $ETCO_2$ measurement by waveform capnography is utilized for confirmation of correct endotracheal tube placement and monitoring ventilation during endotracheal intubation. For adults in nonhypothermic cardiac arrest, $ETCO_2$ is often used to monitor and optimize CPR quality, and an abrupt increase in $ETCO_2$ can indicate ROSC. In an observational study comparing adults with and without hypothermic cardiac arrest assessed for ECLS, those in hypothermic cardiac arrest had significantly lower $ETCO_2$ and temperature was positively correlated with $ETCO_2$.[27] Also, 45% of adult survivors had $ETCO_2$ ≤10 mm Hg at hospital admission and $ETCO_2$ value did not predict survival.[27]

Recommendations for Children With Life-Threatening Environmental Hypothermia (Core Temperature <30 °C [86 °F])

COR	LOE	Recommendations
1	C-EO	1. For children with life-threatening environmental hypothermia with no obvious lethal injury, full resuscitative measures should be performed immediately and continued concurrently with rewarming.
2a	C-LD	2. It is reasonable to rewarm children in hypothermic cardiac arrest using ECLS.
2a	C-LD	3. It is reasonable to use prognostication scores to guide the decision for initiating ECLS rewarming for children in hypothermic cardiac arrest.
2b	C-LD	4. It may be reasonable to rewarm children with life-threatening environmental hypothermia with ECLS at a rate <5 °C/hour (9 °F/hour).

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Recommendations for Children With Life-Threatening Environmental Hypothermia (Core Temperature <30 °C [86 °F]) (Continued)		
COR	LOE	Recommendations
2b	C-EO	5. It may be reasonable to rewarm children with environmental hypothermia (core temperature <28 °C [82.4 °F]) and not in cardiac arrest using ECLS.
2b	C-EO	6. For children with hypothermic cardiac arrest, it may be reasonable to defibrillate once and if unsuccessful, defer further defibrillation until the core temperature is ≥30 °C (86 °F).
2b	C-EO	7. It may be reasonable to defer administration of epinephrine until core temperature is ≥30 °C (86 °F) for children in hypothermic cardiac arrest.
2b	C-EO	8. If standard CPR is not possible due to environmental conditions, it may be reasonable to perform delayed or intermittent CPR during the resuscitation of children in hypothermic cardiac arrest to facilitate rapid extraction.
2b	C-EO	9. It may be reasonable to transport children in hypothermic cardiac arrest to a center with ECLS capability if it can be reached within 6 hours.
3: No Benefit	B-NR	10. It is not recommended to use $ETCO_2$ to predict outcomes for children in hypothermic cardiac arrest.

Recommendation-Specific Supportive Text

1. Obvious lethal injury (eg, decapitation, truncal transection, whole body incineration, or frozen solid) are suggested conditions to withhold or terminate CPR.[17] Absent these signs, numerous case reports and the International Hypothermia Registry describe ROSC prior to or concurrently with rewarming in adults.[18–20] Data for chest compressions for children in cardiac arrest from environmental hypothermia is lacking, and the recommendation is extrapolated from adult data.
2. A multicenter prospective observational study and multiple retrospective observational studies in adults have shown a survival benefit and favorable neurological outcomes with ECLS over conventional CPR for adults in cardiac arrest due to severe environmental hypothermia over conventional CPR.[21–24] In a case series of children with hypothermic drowning, survival was better with conventional rewarming compared with ECMO.[50] However, due to clear clinical differences in illness severity with the ECMO group having lower pH, higher serum potassium, and longer submersion time, this case series does not change the recommendation for use of ECLS in children. ECMO is preferable over CPB; a meta-analysis including 464 adults and children in cardiac arrest due to hypothermia showed a 41% greater probability of survival with ECMO.[25]
3. The HOPE probability score includes age, sex, asphyxia, CPR duration, serum potassium concentration, and temperature and has been validated in a cohort of adults and children for predicting mortality and ineffective use of extracorporeal rewarming.[27,28] In adults, a threshold HOPE score of <0.1 has been validated, but there are cases of children surviving with lower HOPE scores.[28,51] The HOPE score may be useful in prognostication for children with a more conservative lower cutoff of 0.05.[51] The ICE survival score includes sex, asphyxia, and serum potassium concentration, and a score >12 has also been validated in predicting survival after hypothermic cardiac arrest in a mixed cohort of adults and children.[29] Other prognostic factors in isolation have been associated with higher mortality in combined cohorts of adults and children in hypothermic cardiac arrest, including high serum potassium concentration, high serum lactate, low pH, asphyxia, unwitnessed cardiac arrest, male sex, older age, greater initial body temperature, and longer resuscitation duration.[19,25,27,33] These prognostic factors are less well-validated than the HOPE or ICE scores. The HOPE score is superior to serum potassium threshold of ≥12 mmol/L alone in predicting survival in a cohort of adults and children.[26]
4. The optimal rate for rewarming hypothermic children with ECLS is unknown. Slow rewarming may delay the return of organ perfusion, and rapid rewarming may cause relative cerebral hyperthermia, potentially worsening neurological outcomes. An analysis of case report data from 658 adults and children aggregated in the International Accidental Hypothermia Extracorporeal Life Support dataset evaluated the optimal threshold rewarming rate. Rewarming rates less than 5 °C/hour (9 °F/hour) had a 2.41 greater odds (95% CI, 1.75–3.31) of neurologically intact survival over rewarming rates greater than 5 °C/hour (9 °F/hour).[42] Neurologically intact survival decreased by 1.9% for each 1 °C/hour (1.8 °F/hour) increase in rewarming rate.[42]
5. There are no studies on rewarming with ECLS in children with severe environmental hypothermia and not in cardiac arrest, so this recommendation is extrapolated from studies in adults. Retrospective observational studies have shown successful rewarming as well as faster rewarming for adults who are not in cardiac arrest with core temperature <28 °C (82.4 °F) with ECLS compared with conventional methods.[22,24,35] A multicenter prospective observational study showed improved outcomes with use of ECMO for adults in hypothermic cardiac arrest; however, patients with hemodynamic instability without cardiac arrest who received ECMO had decreased event-free days (ICU, ventilator, and catecholamine administration)

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and increased hemorrhagic complications without improving survival or neurological outcomes.[21]

6. Defibrillation before rewarming can be successful in adults and adolescents.[18,20,36,37] The hypothermic heart may be less responsive to defibrillation, and the temperature at which defibrillation should first be tried in the severely hypothermic child and the number of defibrillation attempts that should be made are not well studied. If VT or VF persists, excessive defibrillation attempts may lead to myocardial injury. In a large retrospective observational study, while a shockable initial rhythm in adult patients with hypothermic OHCA was associated with better survival and neurologically favorable survival, prehospital defibrillation and increasing the number of defibrillation attempts were not.[38] However, only a small number of adults with shockable rhythms were not defibrillated, so the study may have been underpowered to detect a difference in outcomes in this population. The Wilderness Medical Society guideline recommends defibrillating once initially and deferring additional defibrillation attempts until core temperature reaches 30 °C (86 °F) because these are more likely to be successful.[39,40] ERC guidelines allow up to 3 defibrillation attempts before rewarming to 30 °C (86 °F).[41] There are no relevant societal guidelines specific to children, and, thus, recommendations are extrapolated from adult data.
7. The temperature at which epinephrine should first be administered and the optimal dosing interval in the severely hypothermic child has not been well-studied. Some adult and adolescent cases of hypothermic cardiac arrest have normal responses to epinephrine before rewarming.[18] However, hypothermic hearts may be less responsive to cardiovascular drugs and slowed metabolism due to hypothermia raises concerns for epinephrine accumulation and toxicity.[41,43,44] There are no relevant societal guidelines specific to children, and, thus, recommendations are extrapolated from adult data.
8. In cases of prolonged CPR or dangerous environmental conditions, it may be suboptimal or impossible to perform continuous high-quality CPR. Delayed or interrupted CPR may facilitate rapid extraction or transportation and allow for optimal CPR as soon as feasible or safe. Adult cases with delayed or intermittent CPR have led to successful resuscitations, but there are no reported cases in children.[45] The acceptable frequency and duration of CPR interruptions and which children can best tolerate this are unknown.
9. Rapid hospital transport is important to allow for aggressive rewarming with both noninvasive and invasive techniques. Two studies utilizing the same database conflicted on the association of low-flow time (time from cardiac arrest to the establishment of ECMO) with outcomes for adults in cardiac arrest due to hypothermia, but there are no such studies in children.[46,47] Adults have been resuscitated using ECLS after hypothermic cardiac arrest lasting over 6 hours, so the ERC supports transporting to an ECLS-capable center if within 6 hours.[41,48,49] An observational study showed that transportation to centers with ECLS capability improved neurologically favorable outcomes and 1-month survival in adults.[38] There is no data in children, and, thus, the recommendation is extrapolated from adult data.
10. $ETCO_2$ measurement by waveform capnography is utilized for confirmation of correct endotracheal tube placement and monitoring ventilation during endotracheal intubation. For children in nonhypothermic cardiac arrest, $ETCO_2$ is often used to monitor and optimize CPR quality and an abrupt increase in CO_2 can indicate ROSC. In an observational study comparing adults with hypothermic with nonhypothermic cardiac arrest assessed for ECLS, those in hypothermic cardiac arrest had significantly lower $ETCO_2$ and temperature was positively correlated with $ETCO_2$.[27] Also, 45% of adult survivors had $ETCO_2$ ≤10 mm Hg at hospital admission, and the value of $ETCO_2$ did not predict survival.[27] There are no studies available in children, and, thus, recommendations are extrapolated from adult data.

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LEFT VENTRICULAR ASSIST DEVICES

Recommendations for Unresponsive Adults and Children With Durable LVADs and Impaired Perfusion

COR	LOE	Recommendations
1	C-EO	1. In unresponsive adults and children with durable LVADs and impaired perfusion, chest compressions should be performed.
2b	C-EO	2. In unresponsive adults and children with durable LVADs and impaired perfusion, it may be reasonable to start chest compressions immediately while simultaneously assessing for device-related reversible causes.
2b	C-EO	3. In unresponsive adults and children with durable LVADs and impaired perfusion, it may be reasonable to utilize an algorithmic approach to concurrently assess and respond to impaired perfusion.

Synopsis

LVADs deliver blood from the weakened left ventricle to the systemic circulation.[1] A durable LVAD comprises an inflow from the apex of the left ventricle, an implanted electrical pump, an outflow to the ascending aorta, a percutaneous driveline connection, and an external controller powered by batteries (Figure 3). The only currently implanted durable LVAD in adults and children in the United States has a centrifugal pump (eg, HeartMate 3 LVAD [Abbott]) and is fully magnetically levitated to prevent mechanical wear and decrease the risk of thrombosis. There are patients living with older durable LVADs, such as HeartMate II (Abbott) and HeartWare Ventricular Assist Device (Medtronic).

Cardiac arrest can occur in people with durable LVADs in cases of device malfunction, inadequate device flow, or low cardiac output of the unsupported right ventricle, whereas some typical causes of cardiac arrest, such as ventricular arrhythmias, may be better tolerated.[2,3] Current durable LVADs have continuous rather than pulsatile flow, so most patients do not have a palpable pulse, making detection of cardiac arrest difficult. Additionally, automated noninvasive blood pressure and pulse oximetry can be unreliable. Perfusion is considered adequate if any of the following is present: (1) normal skin color and temperature; (2) normal capillary refill; (3) mean arterial pressure greater than 50 mm Hg; (4) partial pressure of end-tidal carbon dioxide greater than 20 mm Hg. (Figure 4). An unresponsive patient with an LVAD without adequate perfusion is likely in cardiac arrest.

Potential concerns related to performing chest compressions in adults and children with LVADs are device

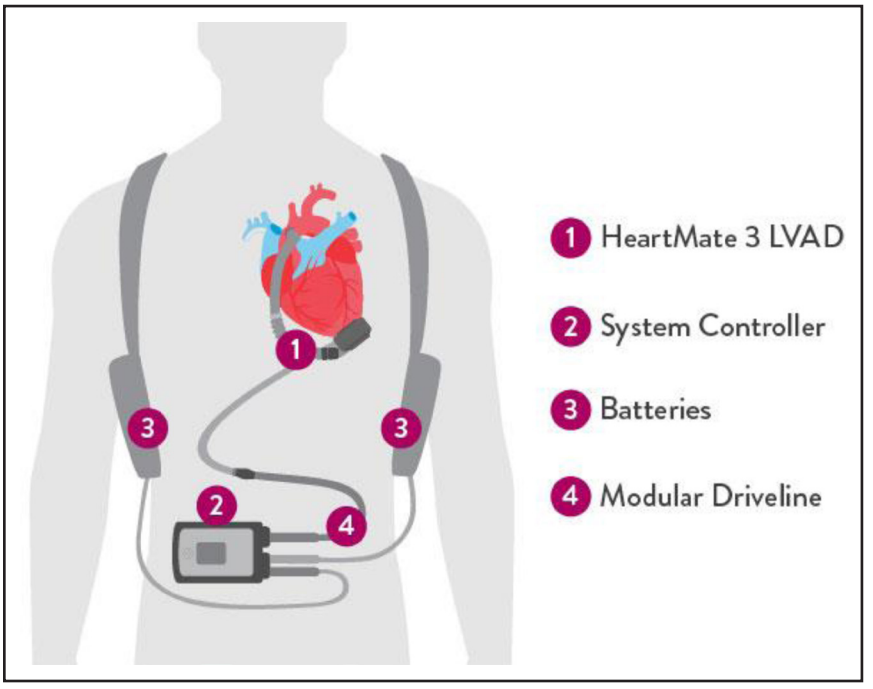

Figure 3. Components of the Abbott HeartMate 3 LVAD.
LVAD indicates left ventricular assist device. HeartMate, HeartMate II, and HeartMate 3 are trademarks of Abbott or its related companies. Reproduced with permission of Abbott. ©2025 Abbott. All rights reserved.

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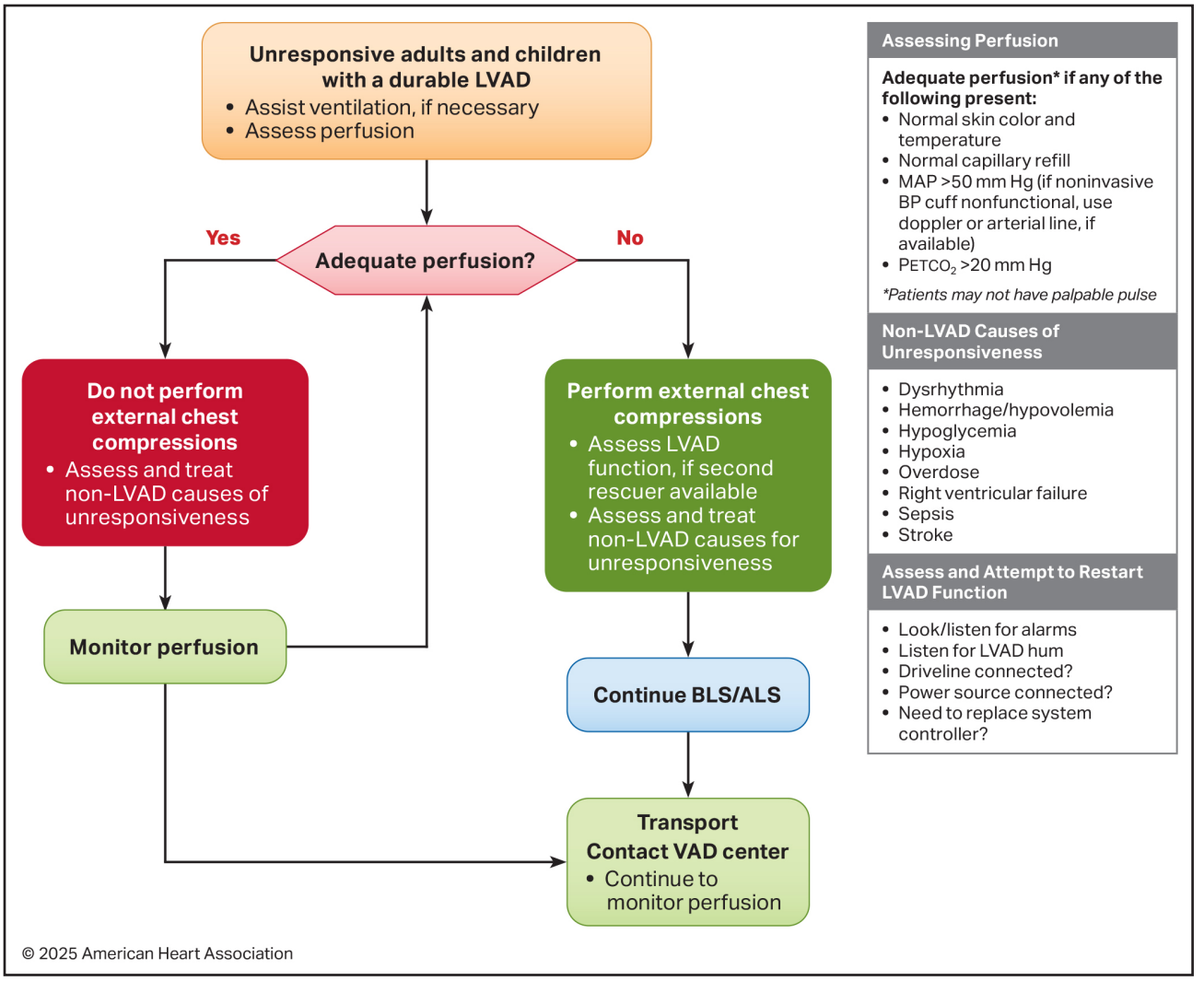

Figure 4. Adult and Pediatric Durable LVAD Algorithm.
ALS indicates advanced life support; BLS, basic life support; BP, blood pressure; ET, endotracheal; LVAD, left ventricular assist device; MAP, mean arterial pressure; $PETCO_2$, partial pressure of end-tidal carbon dioxide; and VAD, ventricular assist device.

dislodgement and ineffective or retrograde blood flow through a valveless LVAD during chest compressions.

These recommendations inform the management of adults and children with durable LVADs in cardiac arrest beyond the index placement hospitalization. Management of cardiac arrest in the peri-implantation period is discussed in the recommendations detailed in the Cardiac Surgery section.

Recommendation-Specific Supportive Text

1. There are no RCTs or high-quality observational studies comparing chest compressions versus not performing chest compressions in adults or children with an LVAD. The largest study, a retrospective cohort of 578 adults with LVADs with cardiac arrest, showed patients who received chest compressions had higher in-hospital mortality than those who did not, and CPR was an independent predictor of mortality.[4] In another retrospective cohort study including 58 adults with LVADs who had cardiac arrest, there was no difference in survival in those receiving chest compressions versus those not receiving compressions.[5] In a case series of 16 adults, 2 of 9 (22.2%) patients who received chest compressions survived to discharge compared with 3 of 7 (42.9%) who did not receive chest compressions.[6] There is high risk of bias in these retrospective studies, with potentially poorer outcomes occurring in patients receiving chest compressions due to a delay in initiation in this patient population and failure of this subset of patients to respond to other ALS interventions, such as defibrillation or epinephrine. There is also high risk of misclassification of patients as having a cardiac arrest when not truly in cardiac arrest. There are many case reports of successful use of chest compressions in adults

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and children with an LVAD.[7–14] No study reported dislodgement or other LVAD device dysfunction after chest compressions. In 1 study, 3 adults underwent autopsy to confirm the LVAD was in appropriate position, including 1 patient who underwent 2.5 hours of chest compressions.[15] Despite the mechanical left ventricular support provided by an LVAD, CPR can provide temporary circulatory support in cardiac arrest resulting from device malfunction or right ventricular failure. CPR in the absence of LVAD saves lives, and poor outcomes may have resulted from hesitancy to start CPR in this patient population. The benefit of immediate initiation of CPR in unresponsive adults and children with LVADs and impaired perfusion outweighs the risk.

2. Multiple case series and case reports have reported delays in initiation of chest compressions in adults with an LVAD, and delays were longer for patients with an LVAD compared with controls without an LVAD.[6,9,10,12] The most common reason for clinicians not performing chest compressions in patients with an LVAD with acutely impaired perfusion was a belief that chest compressions were contraindicated in this population.[5] Delays in chest compressions have been highlighted as a potential contributor to poor outcomes.[5,9] While the British Societies recommend delaying chest compressions in patients with an LVAD for up to 2 minutes while attempting to restart the device, these efforts could occur in parallel to prevent delays in chest compressions per the 2024 ILCOR scoping review (Figure 4).[16]
3. Because of the difficulty assessing perfusion and uncertainty regarding the safety of chest compressions in adults and children with an LVAD, several studies and reviews have proposed algorithms for the resuscitation of this population (Figure 4).[1,6,9,14,17,18] Signs and symptoms related to poor tissue perfusion, such as altered mentation or unresponsiveness, agonal breathing or apnea, cool temperature, and delayed capillary refill, are important for initial patient evaluation. The primary consideration for a patient with an LVAD with acutely altered perfusion is whether the device is functioning, and this can be assessed by auscultating for a mechanical ventricular assist device hum over the left chest and left upper abdomen.[1] Troubleshooting an LVAD includes assessment of the controller for alarms, assessment of the driveline for disconnection or fracture and reconnecting if possible, and ensuring an adequate power source connection.[17] Doppler with a manual cuff or an arterial line can more reliably measure blood pressure in a patient with an LVAD, and waveform capnography can aid in assessment of perfusion.

There are no studies demonstrating improved outcomes with utilization of an algorithm for managing adults or children with a durable LVAD in cardiac arrest.

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PREGNANCY

Introduction

Cardiac arrest in pregnancy is infrequent, but the rate appears to be increasing.[1,2] Because of the relative rarity of the event, the exclusion of pregnant people from clinical trials, and ethical considerations, most studies addressing cardiac arrest in pregnancy are observational. Variability in the populations included in these studies further challenges the interpretation of literature. The term *obstetrics* encompasses pregnancy, childbirth, and postpartum states, whereas the term *peripartum* includes late pregnancy, intrapartum, and immediate postpartum periods. Existing recommendations center on maintaining best resuscitation practices with modifications to account for the physiologic changes of pregnancy and address underlying etiologies specific to obstetric patients.[1,3,4] Reversible causes of cardiac arrest in pregnancy parallel those in the nonobstetric population in terms of the underlying pathophysiology (eg, hypovolemia, hypoxemia, thrombosis). A pregnancy-specific mnemonic (Figure 5) emphasizes the leading causes of death in obstetric patients (eg, hemorrhage, sepsis, and hypertension) while highlighting diagnoses unique to, or commonly encountered in, the peripartum period (eg, amniotic fluid embolism, anesthetic complications, cardiomyopathy, and medications such as magnesium infusions).

Reported rates of survival for the pregnant patient and newborn infant vary widely, reflecting differences in the causes of cardiac arrest, readiness of the clinical team, resources available, location, and gestational age at the time of the event.[1,4,5] Optimizing outcomes for both the pregnant patient and newborn infant requires advanced planning to ensure the clinical team can provide timely and effective resuscitation.[6]

Guidelines for the resuscitation of newborn infants are provided in "Part 5: Neonatal Life Support." Ethical considerations of performing resuscitation on pregnant patients are discussed in "Part 3: Ethics."

Recommendations for Team Preparation for Cardiac Arrest in Pregnancy

COR	LOE	Recommendations
1	C-LD	1. Establishing a team prepared to manage cardiac arrest in a pregnant person is recommended.
1	C-LD	2. The resuscitation team should access resources, including health care professionals, their expertise, and the necessary equipment, to perform a resuscitative delivery at the diagnosis of cardiac arrest in a pregnant patient.
1	C-LD	3. Role-specific training should be provided for health care professionals with the potential to respond to cardiac arrest in a pregnant patient.

Synopsis

The management of cardiac arrest in a pregnant patient requires modifications to account for the physiology of pregnancy, unique causes of cardiac arrest, and the potential need for a resuscitative delivery if ROSC cannot be achieved. Essential roles of a resuscitation team include performing left lateral uterine displacement; providing high-quality, minimally interrupted CPR; managing the difficult airway; and performing a resuscitative delivery.[3] If resuscitative delivery is effective in achieving ROSC, teams may be tasked with the medical and surgical management of life-threatening postpartum hemorrhage. Resuscitative delivery may lead to the birth of a viable newborn infant in need of resuscitation, which will ideally be provided by a dedicated team experienced with the resuscitation of term and preterm infants. Timely access to the resources and personnel capable of coordinating this multidisciplinary endeavor will vary based on the local environment. The complexity of this clinical scenario underscores the need for teams to prepare and train for this situation.

These recommendations inform team preparation by facilities capable of responding to and treating pregnant patients in cardiac arrest.

Recommendation-Specific Supportive Text

1. Team composition will vary according to local resources but may include (1) a team leader skilled in the management of cardiac arrest and aware of pregnancy-specific modifications; (2) an anesthesiologist or other operator familiar with intubating pregnant patients and supporting massive transfusion; (3) an obstetrician or surgeon with experience performing cesarean deliveries and surgically managing hemorrhage; (4) a designated neonatal resuscitation team; and (5) nurses, pharmacists, and other professionals skilled at IV access, medication selection, medication administration, and other key resuscitation tasks.[3] Health care professionals capable of performing cannulation for VA-ECMO

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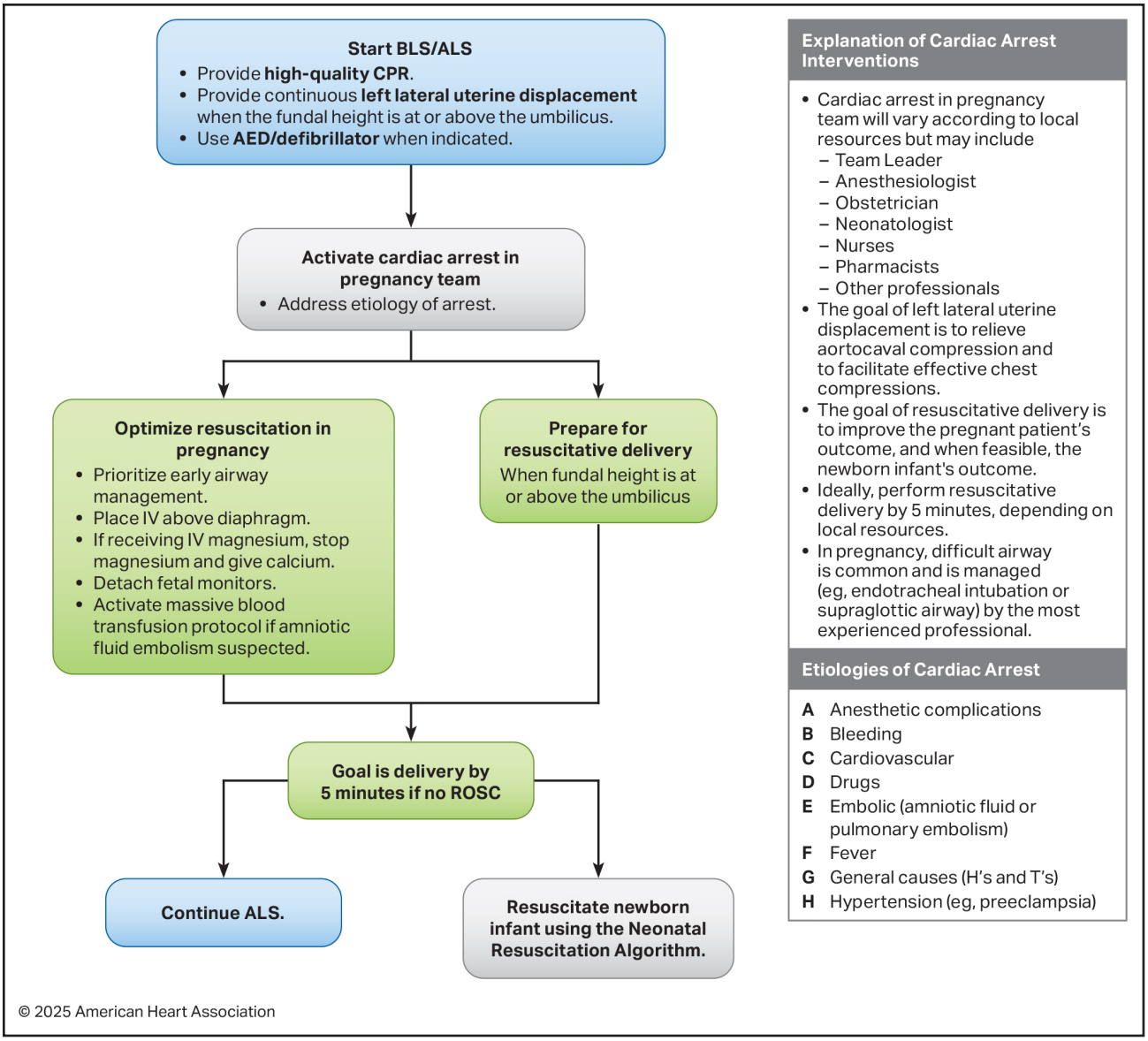

Figure 5. Cardiac Arrest in Pregnancy Algorithm.
AED indicates automated external defibrillator; ALS, advanced life support; BLS, basic life support; CPR, cardiopulmonary resuscitation; IV, intravenous; and ROSC, return of spontaneous circulation.

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may play a role in settings where this resource is available. An analysis of 561 cases of IHCA using the Get With The Guidelines-Resuscitation registry demonstrated an association between the location of cardiac arrest within the hospital and survival.[5] A cardiac arrest occurring in the ICU or postanesthesia care unit conferred a 3 times increased adjusted odds of mortality (aOR, 3.32; 95% CI, 2.00–5.52) compared with those with a cardiac arrest occurring in the labor and delivery unit. This association could reflect residual confounding based on morbidity burden, but it may also reflect lack of readiness of the team for cardiac arrest in pregnancy.

2. Despite longstanding guidelines recommending that a resuscitative delivery (historically referred to as a *perimortem cesarean delivery*) be initiated if ROSC is not achieved within 4 minutes of cardiac arrest, in most cases this intervention is not performed in the recommended timeframe.[3,7–11] Institutions and organizations that may be required to manage cardiac arrest in a pregnant patient can prioritize developing, training, and implementing processes to perform a resuscitative delivery rapidly and safely.[6] In cases of IHCA, this will include summoning an obstetrician or surgeon, if available, prepared to perform a resuscitative delivery along with requisite tools for this procedure

as well as the necessary equipment for neonatal resuscitation. Optimal management of OHCA during pregnancy poses significant clinical challenges and requires performing high-quality resuscitation while rapidly transporting the pregnant patient to a center capable of safely performing the procedure. A population-based study from France evaluated 55 pregnant patients with OHCA and reported that 30-day survival was 14.5% with neonatal survival rates of 10.0% when cardiac arrest occurred in the second trimester and 23.5% in the third trimester.[12] This underscores the potential for a good outcome for the patient and newborn infant when effective resuscitation is provided.

3. Population-based reviews of resuscitation in pregnant patients highlight opportunities for improvement. A population-based surveillance study of cardiac arrest in pregnancy from the Netherlands demonstrated that less than a third of pregnant patients (4/14 [29%]) received maneuvers to alleviate aortocaval compression.[13] A study from the United Kingdom found similar results with only 44% (n=29/66) receiving maneuvers to relieve aortocaval compression.[14] Data from the Netherlands demonstrated improved rates of appropriate resuscitative delivery before and after implementation of the Managing Obstetric Emergencies and Trauma course for health care professionals in the country (0.36/year versus 1.6/year; *P*=0.01), but the 15-year time period of the study limits causal inference.[15] Simulation-based studies demonstrate improved knowledge of cardiac arrest in pregnancy, underscoring a need for training as a key step to improve readiness.[6,16,17]

Recommendations for Pregnant Patients in Cardiac Arrest

COR	LOE	Recommendations
1	B-NR	1. Resuscitative delivery is indicated for a pregnant patient in cardiac arrest when fundal height is at or above the umbilicus and ROSC is not achieved with standard resuscitation.
1	B-NR	2. Preparation for resuscitative delivery for a pregnant patient in cardiac arrest should begin at the recognition of cardiac arrest, with the goal to complete delivery by 5 minutes.
1	C-LD	3. Resuscitative delivery for a pregnant patient with IHCA should be performed at the location of the arrest, without attempts to move the pregnant patient to the operating room.
1	C-LD	4. Manual left lateral uterine displacement should be provided in conjunction with chest compressions for a pregnant patient in cardiac arrest when the fundal height is at or above the umbilicus.
1	C-LD	5. Airway management should be prioritized during the resuscitation of a pregnant patient in cardiac arrest.
2a	B-NR	6. It is reasonable to use extracorporeal cardiopulmonary resuscitation in pregnant or peripartum patients in cardiac arrest not responsive to standard resuscitation.
2a	C-EO	7. Placing IV or IO access in the upper extremities as opposed to the lower extremities is reasonable for a pregnant patient in cardiac arrest.
2a	C-EO	8. Administration of calcium to a pregnant patient who develops cardiac arrest while receiving IV magnesium sulfate is reasonable.
3: No Benefit	C-EO	9. Fetal monitors should be removed, and fetal monitoring should not be performed for a pregnant patient in cardiac arrest.

Synopsis

Modifications to resuscitation in the pregnant patient with cardiac arrest are based on the anatomic and physiologic changes of pregnancy.[3] The growing uterus can cause position-dependent aortocaval compression when the pregnant person is supine. Compression of the inferior vena cava leads to a decrease in preload, stroke volume, and cardiac output, which must be overcome to enable adequate blood flow.[18]

The increased oxygen consumption in the pregnant person underscores the importance of ensuring adequate oxygenation and ventilation as a part of resuscitation. Pregnancy is characterized as a compensated respiratory alkalosis driven by an increased tidal volume with metabolic compensation. The increased tidal volume with the enlarging uterus results in a lower functional residual capacity. The decrease in functional residual capacity along with increased oxygen demand leads to a greater risk of hypoxemia during advanced airway placement.[3]

If interventions to enhance oxygen delivery and reverse underlying causes do not achieve ROSC, attention is then focused on increasing forward blood flow and decreasing oxygen demand by delivering the fetus. The primary purpose of delivery is for resuscitation of the pregnant patient by relieving aortocaval compression and by returning blood sequestered in the uterus to the systemic circulation.[19] Improving neonatal prognosis by limiting intrauterine hypoxemia and its consequences is the secondary benefit of this intervention, noting that fetal survival is dependent on either maternal survival or resuscitative delivery.[8]

These recommendations inform the management of pregnant patients in cardiac arrest.

Recommendation-Specific Supportive Text

1. The term *resuscitative delivery* has replaced the historical term *perimortem cesarean delivery* to reflect its central role in the resuscitation of the pregnant patient and to support attempts to avoid

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unnecessary surgery when feasible.[10] Resuscitative delivery most commonly occurs via laparotomy and hysterotomy (eg, cesarean delivery), but delivery can be achieved via assisted vaginal delivery if the cervix is fully dilated at the time of cardiac arrest. Associating the performance of resuscitative delivery and improved outcomes is challenging because selection bias favors better outcomes for those who achieve ROSC early enough in resuscitation that the procedure is no longer needed. Case series, a meta-analysis of case reports, and a prospective observational study all demonstrate an increased likelihood of survival of the pregnant patient and the newborn infant with shorter time intervals between cardiac arrest and resuscitative delivery.[8,14,20]

2. Resuscitative delivery initiated at 4 minutes and completed by 5 minutes from the onset of cardiac arrest was first proposed in 1986 and has remained the recommended time interval for this procedure based on practicality and available evidence.[21] From a pragmatic standpoint, a time interval of 4 minutes allows for 2 rounds of CPR including administration of epinephrine, defibrillation in the setting of a shockable rhythm, and attempts to address reversible causes. A population-based study evaluating cardiac arrest in obstetric hospitals in the United Kingdom demonstrated a shorter time interval between cardiac arrest and resuscitative delivery in surviving pregnant patients compared with nonsurvivors (3 versus 12 minutes; P=0.001).[14] In a systematic review of 94 cases of cardiac arrest, resuscitative delivery within 10 minutes of cardiac arrest was associated with 5 times increased odds of survival of the pregnant patient.[8] In the subgroup analysis of 57 people undergoing resuscitative delivery, time from arrest to delivery was shorter in neonatal survivors compared with nonsurvivors (14 versus 22 minutes; P=0.02).[8] This was supported by a review of published cases, which found a consistent association between injury-free survival for the pregnant patient and newborn infant and early resuscitative delivery. No delivery time inflection point or cut-off time was found.[7]
3. Moving the pregnant patient from the site of cardiac arrest for resuscitative delivery was associated with lower rates of ROSC in a small observational study, though results were potentially confounded by the inclusion of OHCA cases, which have overall poorer prognosis.[20] A simulation-based study randomized multidisciplinary teams to perform resuscitative delivery at the location of the arrest or movement to the operating room for resuscitative delivery. The teams performing the delivery at the location of the arrest achieved delivery 3.5 minutes faster with fewer disruptions in chest compressions compared with those moving to the operating room for delivery.[22] In a simulation study evaluating the impact of transport on the quality of cardiopulmonary resuscitation, teams randomized to transporting the manikin to the operating room showed lower rates of correct chest compressions with higher rates of interruption compared with the group randomized to stay in the location of simulated cardiac arrest.[23]
4. Manual left lateral uterine displacement (Figure 6) alleviates aortocaval compression while allowing the patient to remain in a supine position during the resuscitation. A prospective cohort study used quantitative cardiac magnetic resonance imaging to demonstrate that pregnant people have decreased cardiac output in the supine position compared with the left lateral position at 20 weeks and 32 weeks of pregnancy.[18] Left ventricular end diastolic volume, left atrial volume, and stroke volume were higher in the left lateral compared with supine position, supporting the ability of position to increase preload and cardiac output. A meta-analysis including 8 simulation-based crossover trials demonstrated superior chest compression technique when the manikin was placed in a supine as opposed to a left lateral tilt position.[24] One of the included studies used a porcine model to demonstrate improved coronary perfusion pressure when chest compressions were performed when supine

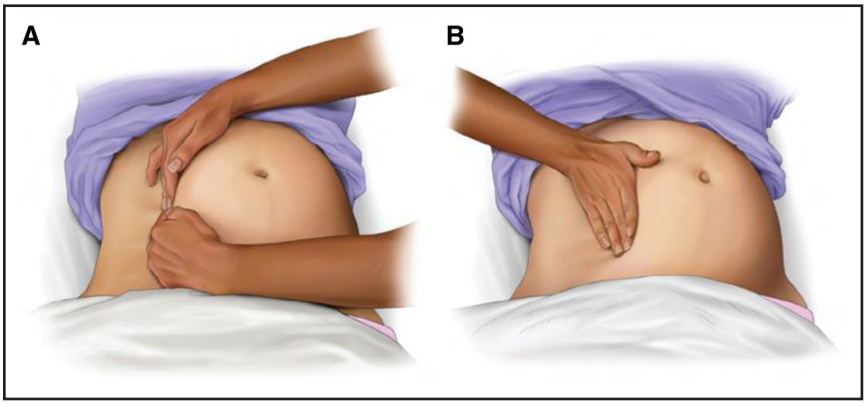

Figure 6. Manual left lateral uterine displacement performed with 2-handed technique (A) and 1-handed technique (B) during resuscitation.

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with left lateral uterine displacement versus supine positioning alone.[25]

5. The physiologic changes of pregnancy render pregnant people less tolerant of apneic oxygenation and more vulnerable to hypoxemia, hypercarbia, and subsequent acidosis than other people in cardiac arrest. Providing adequate oxygenation and ventilation optimizes the resuscitation of the pregnant patient while maintaining favorable gradients of oxygen and carbon dioxide across the uteroplacental interface, which is critical to neonatal outcomes.[3] Anatomic and hormonal changes increase the risk of aspiration in pregnancy, making endotracheal intubation ideal for airway management, but the likelihood of airway edema contributes to higher rates of difficult or failed intubation in pregnant patients.[26,27] The "difficult" airway is navigated with a smaller endotracheal tube by a team member with expertise in laryngoscopy and consideration of a supraglottic airway after 2 failed intubation attempts.[3,28]
6. Theoretical concerns about bleeding and thrombosis in obstetric patients have delayed the use of ECLS in peripartum patients, but emerging data support its use. A systematic review of 358 obstetric patients managed with ECLS reported a 30-day survival rate of 75%.[29] Fifty-seven of these patients were cannulated for the indication of cardiac arrest during pregnancy or in the first 24 hours after delivery with an 87% 30-day survival rate.[29] Only 13% of patients in this study experienced severe bleeding necessitating laparotomy or hysterectomy, with a 3% rate of venous thromboembolism. A 2020 analysis of 277 obstetric patients in the ELSO Registry found a 55% rate of survival among the 42 patients receiving ECLS for the indication of cardiac arrest.[30] This 55% survival rate among obstetric patients cannulated for an indication of cardiac arrest compares favorably with the 29% rate of survival for patients receiving ECPR in the ELSO Registry over a similar time period.[31] ELSO guidelines suggest summoning available resources, including health care professionals, their expertise, and the necessary equipment, for evaluation for possible ECPR after 10 to 15 minutes of standard resuscitation without ROSC.[32]
7. Although not directly studied, aortocaval compression likely impedes delivery of resuscitation drugs administered in the lower extremities to the central circulation. A radionucleotide study in nonpregnant canines found that drugs instilled into the superior vena cava reached the heart faster than drugs instilled into the inferior vena cava.[32] However, studies from OHCA (excluding pregnant people) have not consistently demonstrated favorable neurologic outcomes when IO devices were placed in the upper extremity compared to the lower extremity.[33–35]
8. Magnesium sulfate is a commonly utilized medication in obstetrics, administered as a bolus dose followed by a continuous infusion for management of preeclampsia and for other specific patients at risk of preterm delivery. Life-threatening and fatal hypermagnesemia due to medication error has been reported in obstetric and nonobstetric patients.[36–38] A meta-analysis examining adverse effects from magnesium sulfate administration stratified by indication and regimen found an increased risk of respiratory depression in patients with preeclampsia receiving magnesium.[36] A study of patients on magnesium infusions for obstetric indications demonstrated that increasing concentrations of serum magnesium were associated with lower ionized calcium concentration and increased urinary calcium excretion.[39] Calcium administration may improve hemodynamics in the setting of magnesium toxicity, informing its use in cardiac arrest.[40] Most patients in case reports received calcium along with multiple concurrent interventions, limiting the usefulness of these reports.
9. The physiologic dependence of the fetus on the circulation of the pregnant patient coupled with the high survival rate of newborn infants in the setting of ROSC prior to resuscitative delivery underscores the importance of prioritizing resuscitation of the pregnant patient.[8] Fetal monitoring will not change management and may worsen outcomes by distracting the team and limiting timely defibrillation and resuscitative delivery when indicated.[3] Removal of external and internal fetal monitors at the diagnosis of cardiac arrest avoids these distractions and minimizes risk of rescuer injury in the setting of defibrillation.

The 2025 treatment algorithm for the management of cardiac arrest in pregnancy is shown in Figure 5.

Recommendations for Peripartum Patients With Life-Threatening Suspected Amniotic Fluid Embolism		
COR	**LOE**	**Recommendations**
1	**C-LD**	1. A massive transfusion protocol with a balanced transfusion strategy should be used for peripartum patients with life-threatening suspected amniotic fluid embolism.
1	**C-LD**	2. Tranexamic acid should be administered to peripartum patients with life-threatening suspected amniotic fluid embolism.
2a	**C-LD**	3. It is reasonable to use VA-ECMO for peripartum patients with life-threatening suspected amniotic fluid embolism.
2a	**C-EO**	4. Use of inhaled pulmonary vasodilators is reasonable for peripartum patients with life-threatening suspected amniotic fluid embolism.
3: No Benefit	**C-EO**	5. Use of atropine in the absence of bradycardia is not recommended for peripartum patients with life-threatening suspected amniotic fluid embolism.

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Synopsis

Amniotic fluid embolism (AFE) is a clinical diagnosis characterized by sudden hemodynamic and respiratory compromise during labor or shortly after delivery that can lead to cardiac arrest.[41] The presence of disseminated intravascular coagulation and resultant hemorrhage is a hallmark feature of the disease.[42,43] A key feature in the pathophysiology of AFE involves exposure to fetal antigens with proteins, such as tissue factor and endothelin.[41] A complete understanding of the molecular mechanism triggering this hyperimmune response is still a topic of investigation, but the historic perspective of the pathophysiology of AFE characterized by fetal cells obstructing the pulmonary vasculature is incorrect.[44,45]

Tremendous overlap in the clinical features of AFE and other common causes of cardiac arrest make a high index of suspicion, timely diagnosis, and interventions addressing the underlying pathophysiology of critical importance.[46] Echocardiography evaluating for increased pulmonary vascular resistance and right ventricular failure along with viscoelastic testing assessing for hyperfibrinolysis have been proposed to aid in timely diagnosis.[47–50] National guidelines for the diagnosis vary without a reference standard clinical or pathologic diagnosis.[51]

These recommendations inform the management of pregnant patients with life-threatening AFE, including cardiac arrest.

Refer to Figure 5 for pregnancy modifications to standard ALS.

Recommendation-Specific Supportive Text

1. Balanced transfusion characterized by the transfusion of red blood cells, fresh frozen plasma, and platelets equivalent to the constitution of whole blood is a cornerstone in the management of active bleeding and hemorrhagic shock in obstetric and nonobstetric patients.[52,53] A massive transfusion protocol is an institution-specific response to expedite access to support a large-volume transfusion of whole blood components in the setting of life-threatening hemorrhage.[53] The pathophysiology of hyperfibrinolysis alongside population-level data from multiple countries support the potential need for this intervention in the setting of suspected AFE.[53,54] A population-based study evaluating cases of suspected AFE in France reported 10 units of red blood cells as the median transfusion volume (range, 0–22 units) while also noting 16 of 36 people received suboptimal hemorrhage management.[55] The importance of a balanced transfusion strategy that replaces coagulation factors along with red blood cells is underscored in a multinational nested case-control study evaluating the association between hemorrhage management and death in the setting of suspected AFE.[51] An analysis of 216 subjects identified by the United Kingdom Obstetric Surveillance System demonstrated a reduced risk of death in the setting of transfusion of concentrated fibrinogen (aOR, 0.44; 95% CI, 0.21–0.92) and platelets (aOR, 0.23; 95% CI, 0.10–0.52), noting the importance of coagulation factors in addition to red blood cells.
2. Tranexamic acid (TXA) works through competitive binding to limit the activation of plasmin—the enzyme that prevents excess clot formation in physiologic states by cleaving fibrinogen to fibrin and its split products. The hyperfibrinolysis of disseminated intravascular coagulation destabilizes existing blood clots while generating fibrin split products that cause microvascular injury. Therefore, the mechanism of action of TXA is to prevent clot degradation and downstream microangiopathy—not to promote clot formation. Two RCTs of more than 20 000 adult patients each demonstrated a mortality benefit with TXA administration in the setting of hemorrhage. In the CRASH-2 trial, receipt of TXA reduced the risk of death in the setting of trauma without an increase in venous thromboembolism.[56] The WOMAN trial showed a mortality benefit in obstetric patients with postpartum hemorrhage, but not specifically AFE, randomized to receive TXA.[57] International guidelines from the World Health Organization support the use of TXA in the setting of postpartum hemorrhage, with recommendations from the Society for Maternal-Fetal Medicine underscoring its unique role in the management of suspected AFE.[58,59]
3. ECLS with VA-ECMO has been used as a bridge to recovery in case reports and case series of peripartum women with suspected AFE refractory to medical management.[60,61] A retrospective case series from 2 high-volume ECMO centers in France evaluated outcomes for the 10 peripartum patients with suspected AFE placed on VA-ECMO over a 13-year period.[60] Seven of the 10 patients suffered from cardiac arrest, 2 of whom were cannulated during ECPR. Seven of the patients were alive at hospital discharge, representing 70% survival in this case series. An ELSO Registry study reported a 62% rate of survival among the 34 patients placed on VA-ECMO in the setting of AFE over a 5-year period.[62] Reported outcomes vary in the setting of AFE, with estimated survival rates predating more widespread use of ECMO ranging between 11% and 44%.[63] The comparatively high rate of survival in patients with suspected AFE receiving ECLS suggests a role for this therapy as a bridge to recovery in this rare disease.
4. Inhaled pulmonary vasodilators selectively dilate pulmonary capillaries receiving alveolar gas

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exchange without causing systemic vasodilation, and case reports have described their use for the management of pulmonary hypertension during labor and delivery.[64–66] A case report of the use of inhaled nitric oxide demonstrated rapid reversal of hemodynamic compromise in the setting of AFE.[67] These limited data alongside biologic plausibility supporting the use of inhaled nitric oxide in the unique pathophysiology of AFE suggests a potential role for this therapy in this life-threatening disease.[53]

5. Case reports have highlighted the use of atropine in conjunction with ondansetron and ketorolac for targeted therapy for peripartum patients with AFE.[68,69] These case reports include patients receiving other interventions and hemodynamic support making the contribution of this novel regimen to the reported outcome uncertain. Serotonin and thromboxane antagonism with ondansetron and ketorolac, respectively, manifest limited hemodynamic consequence.[68] Atropine has been included in this pathway regardless of the presenting rhythm, presumably because of its role as a pulmonary vasodilator or its chronotropic effect.[70] Atropine may cause nonselective pulmonary vasodilation, potentially worsening ventilation and perfusion mismatch. The increased heart rate limits diastolic filling time, which can impact the coronary and systemic circulations, particularly in settings of right ventricular pressure overload. The lack of benefit alongside the availability of other vasoactive agents capable of providing chronotropic and inotropic support inform this recommendation.

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PULMONARY EMBOLISM

Introduction

PE is the occlusion of 1 or more pulmonary arteries and is a potentially reversible cause of hemodynamic instability or cardiac arrest. Partial or complete occlusion of pulmonary arteries results in ventilation and perfusion mismatch and increases in pulmonary artery pressures, causing impaired right ventricular function and, ultimately, cardiovascular collapse.[1,2] In 1 large review of hospitalized patients diagnosed with PE, mortality of hemodynamically unstable patients was 76.6% and of hemodynamically stable patients was 10.8%, highlighting the severity of this disease process.[3] Mortality in OHCA secondary to PE is reported as high as 91%.[4] Most patients in cardiac arrest secondary to PE exhibit PEA (26%–75%) or asystole (19%–73%).[4–6] Treatment of patients in cardiac arrest from PE include systemic and catheter-guided fibrinolysis, surgical and mechanical embolectomy, and ECMO. Each augments resuscitation by restoring pulmonary and systemic circulation.

The diagnosis of PE in children is often delayed because of diagnostic challenges and differences in symptomatology compared with adults.[7] Considering children are able to compensate for shock states with increased systemic vascular resistance, hypotension is a late sign of shock in children.[7] There are limited data available and no RCTs to inform the care of children.

These recommendations are modifications to standard ACLS for adults and children in cardiac arrest from confirmed or suspected PE. The treatment of patients with life-threatening PE not in cardiac arrest are outside of the scope of these recommendations, although several studies cited in the recommendations contain overlapping populations of hemodynamically unstable patients with PE and patients with PE in cardiac arrest.

Recommendations for Adults in Cardiac Arrest From PE

COR	LOE	Recommendations
2a	B-NR	1. For adults with confirmed PE as the precipitant of cardiac arrest, systemic fibrinolysis, surgical embolectomy, and percutaneous mechanical embolectomy are reasonable treatment options.
2a	B-NR	2. It is reasonable to use ECLS in adults with cardiac arrest from confirmed or suspected PE.
2b	B-NR	3. For adults in cardiac arrest from suspected PE, systemic fibrinolysis may be considered.
2b	C-EO	4. The optimal duration of CPR after administration of systemic fibrinolytic to adults in cardiac arrest from confirmed or suspected PE is unclear.

Recommendation-Specific Supportive Text

1. The treatment of adults in cardiac arrest from a confirmed PE may differ between institutions depending upon the available resources. In 1 retrospective multicenter study of 104 adult patients, including 70 patients in cardiac arrest who received systemic fibrinolytics, patients with confirmed PE had significantly greater survival to hospital discharge compared with those with a presumed PE (26% versus 4%; $P=0.01$).[8] A review of 153 adults who experienced cardiac arrest from PE who underwent surgical embolectomy showed 56% survival.[9] One retrospective case series of hemodynamically unstable adults with confirmed PE, including patients who required CPR, showed lower in-hospital mortality for those who underwent percutaneous mechanical pulmonary embolectomy compared with no embolectomy (64.4% versus 76.8%; $P<0.001$).[3] The benefit of systemic fibrinolysis is weighed against the risk of bleeding complications. One study of adults with OHCA from PE observed the same risk of death from hemorrhage in patients who were treated with systemic fibrinolytics compared with those who were not (6% versus 5%; $P=0.73$).[4] Another study observed 37.9% of adults developed bleeding complications, including intracranial hemorrhage in 9.1% of adults.[10]
2. ECLS, including VA-ECMO, for adults in cardiac arrest has become increasingly available.[11] In 1 retrospective before-and-after implementation study of ECPR in 39 adults who suffered cardiac arrest

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due to suspected or confirmed PE, 19 underwent VA-ECMO cannulation during CPR.[12] Adults who received VA-ECMO during CPR had higher ICU survival (26% versus 5%; $P<0.01$) and higher survival with favorable neurologic outcomes (21% versus 0%; $P<0.05$) than those patients receiving conventional CPR.[12] In a systematic review and meta-analysis of 77 studies including 301 adults who suffered cardiac arrest from PE, 65% of patients placed on VA-ECMO during CPR survived to hospital discharge.[13] Two separate retrospective reviews of adults treated with venovenous ECMO or VA-ECMO for hemodynamic instability or cardiac arrest from confirmed PE showed no difference in survival rate in adults who received unfractionated heparin alone compared with those who received systemic fibrinolytics or surgical or interventional thrombectomy.[14,15] One meta-analysis showed no increased risk of mortality for adults who received systemic fibrinolysis prior to VA-ECMO or venovenous ECMO cannulation.[13]

3. Investigating the efficacy of systemic fibrinolytics to treat suspected PE is challenging due to variations in patient enrollment, which often lead to the inclusion of many patients with cardiac arrest from causes unrelated to PE. The definition of suspected PE in reviewed studies is not well-defined, and research is conflicting. Two RCTs found that administration of systemic fibrinolytics did not improve survival in adults and children (>16 years of age) with undifferentiated cardiac arrest.[16,17] In 1 retrospective registry study of 58 adult OHCA patients treated with systemic fibrinolysis for suspected PE, systemic fibrinolytics provided no survival benefit at 24 hours versus control (66% versus 63%; $P=0.76$); however, a 30-day mortality benefit was identified after the population was appropriately weighted ($P=0.005$; adjusted log-rank test).[4] Two additional retrospective investigations of adults with confirmed or suspected PE as a cause of cardiac arrest showed no increased rates of ROSC or 30-day survival with systemic fibrinolytics.[10,18]
4. There are no trials comparing different durations of continued resuscitation following systemic fibrinolysis administration to adults in cardiac arrest from any cause, including confirmed or suspected PE. The 2019 European Society of Cardiology guidelines for the diagnosis and management of acute PE recommend continuing CPR for at least 60 to 90 minutes after administration of a systemic fibrinolytic based upon case reports and case series of adults who survived after 90 to 100 minutes of CPR.[2,19,20] There is significant variation in the duration of CPR after fibrinolysis between studies. One randomized trial investigating the use of systemic fibrinolysis to treat adults in PEA arrest continued CPR for at least 15 minutes after systemic fibrinolytic administration.[16] A second randomized trial continued CPR for at least 30 minutes after systemic fibrinolytic administration to adults in cardiac arrest.[17]

Recommendations for Children in Cardiac Arrest From PE

COR	LOE	Recommendations
2a	C-LD	1. For children with confirmed PE as the precipitant of cardiac arrest, systemic fibrinolysis, surgical embolectomy, and percutaneous mechanical embolectomy are reasonable treatment options.
2a	C-LD	2. It is reasonable to use ECLS in children with cardiac arrest from confirmed or suspected PE.
2b	C-EO	3. For children in cardiac arrest from suspected PE, systemic fibrinolysis may be considered.
2b	C-EO	4. The optimal duration of CPR after administration of systemic fibrinolytic to children in cardiac arrest from confirmed or suspected PE is unclear.

Recommendation-Specific Supportive Text

1. The recommendation for the treatment of children in cardiac arrest from confirmed PE is based on pediatric case series and data extrapolated from adults. One retrospective review of 33 children (<19 years of age) with confirmed PE included 3 children who underwent surgical embolectomy, 3 who received catheter-based therapies, and 1 who received systemic thrombolysis.[7] Of these children, 4 experienced cardiac arrest, 2 survived but the specific therapies they received were not described.[7] Overall, 3 of the children died of PE-related causes.[7] Another retrospective review of 170 children (≤18 years of age) with confirmed PE included 25 (15%) patients with shock or cardiac arrest.[21] Twenty-two of these children received systemic fibrinolysis, catheter-directed therapies, or surgical thrombectomy.[21] Eleven (6%) children in this case series died of PE-related causes.[21] In 1 retrospective multicenter study of 104 adults, including 70 patients in cardiac arrest who received systemic fibrinolytics, patients with confirmed PE had significantly greater survival to hospital discharge compared with those with a presumed PE (26% versus 4%; $P=0.01$).[8] The benefit of systemic fibrinolysis is weighed against the risk of bleeding complications, which is conflicting in adult studies, ranging from 6% to 37.9% of cardiac arrest patients with suspected PE.[4]
2. The treatment of children who experience cardiac arrest from PE with ECLS, including VA-ECMO, is limited by resources available to individual institutions and individual patient factors. The recommendation for the treatment of children in cardiac arrest with ECLS is based on a pediatric

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registry study and data extrapolated from adults. One review of the ELSO Registry included 54 children ≤18 years of age treated with ECMO who received a primary diagnosis code of PE.[22] The number of children who experienced cardiac arrest prior to treatment with ECMO was not described, however, 13 of the included children were treated with ECPR.[22] Thirty-three (61%) children in this cohort survived to hospital discharge.[22] In 1 retrospective before- and after-ECPR implementation study of 39 adults who suffered cardiac arrest due to suspected or confirmed PE, 19 underwent VA-ECMO cannulation during CPR.[12] Adults who received VA-ECMO during CPR had higher ICU survival (26% versus 5%; $P<0.001$) and higher survival with favorable neurologic outcomes (21% versus 0%; $P<0.05$) than those patients receiving conventional CPR.[12] In a systematic review and meta-analysis of 77 studies including 301 adults who suffered cardiac arrest from PE 65% of patients placed on VA-ECMO during CPR survived to hospital discharge.[13]

3. Investigating the efficacy of systemic fibrinolytics to treat suspected PE is challenging due to variations in patient enrollment, which often lead to the inclusion of many patients with cardiac arrest from causes unrelated to PE. The definition of suspected PE in reviewed studies is not well-defined, and research is conflicting. Two RCTs found that administration of systemic fibrinolytics did not improve survival in adults and children (>16 years of age) with undifferentiated cardiac arrest.[16,17] One retrospective registry study of 58 adult OHCA patients treated with systemic fibrinolysis for suspected PE found that systemic fibrinolytics provided no survival benefit at 24 hours versus control (66% versus 63%; $P=0.76$); a 30-day mortality benefit was identified after the population was appropriately weighted ($P=0.005$; adjusted log-rank test).[4] Two additional retrospective investigations of adults with confirmed or suspected PE as a cause of cardiac arrest showed no increased rates of ROSC or 30-day survival with systemic fibrinolytics.[10,18] Data for systemic fibrinolytics in children with cardiac arrest from suspected PE is lacking, and the recommendation is extrapolated from adult data.
4. There are no trials available to inform the optimal duration of continued resuscitation following systemic fibrinolysis administration to adults or children in cardiac arrest from any cause, including PE. The 2019 European Society of Cardiology guidelines for the diagnosis and management of acute PE recommends continuing CPR for at least 60 to 90 minutes after administration of a systemic fibrinolytic based on case reports and case series of adults who survived after 90 to 100 minutes of CPR.[2,19,20] There is significant variation in time to continued CPR after fibrinolysis between studies. One randomized trial investigating the use of systemic fibrinolysis to treat adults in PEA arrest continued CPR for at least 15 minutes after systemic fibrinolytic administration.[16] A second randomized trial continued CPR for at least 30 minutes after systemic fibrinolytic administration to adults in cardiac arrest.[17]

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TOXICOLOGY

Introduction

Over 105 000 people in the United States died from drug overdose in 2023.[1] More than 92% of these deaths were unintentional. Over time, the population of people with fatal drug overdose is aging; overdose death rates are increasing in people aged ≥35 years and decreasing in younger people. Although most deaths are due to synthetic and semisynthetic opioids, such as fentanyl, many different poisons are responsible for these deaths.

Poisoning in this guideline refers to the cellular injury or death that results from the exposure to an exogenous substance.[2,3] Management of patients with critical poisoning, defined as those in cardiac arrest, refractory shock, or other conditions posing an imminent threat of cardiac arrest, may require special techniques and antidotes in addition to standard resuscitation care to achieve survival and recovery. For example, patients may develop hypotension from β-adrenergic receptor antagonist (β-blocker) or calcium channel antagonist (CCB) poisoning that does not respond to atropine, standard vasopressors, or cardiac pacing but is amenable to targeted therapies, such as high-dose insulin. Specific antidotes are available for many life-threatening poisonings but are only safe and effective if given in the proper dose and with careful patient selection (Table 4). The ideal dose is rarely known, and in many cases, equally well-supported alternative dosing strategies exist. Many poisoned patients are often ideal candidates for ECLS techniques, such as VA-ECMO, because temporary circulatory support is a bridge to survival until the poison can be eliminated, either by natural or artificial means.

Research involving poisoned patients is ethically and logistically challenging. As a result, much data about human poisoning are descriptive and observational. Variations and uncertainty in exposure, history, co-ingestions, and comorbidities make comparisons based on clinical observations challenging. High-quality animal studies broaden understanding. Applying clinical research across species is challenging, and current evidence-based medicine structures discount the contribution of animal studies to the level or certainty of evidence about an intervention.

This section of the guidelines is designed primarily for health care professionals, but opioid overdose—by far the most common cause of poisoning death—can be treated by adults and adolescents in the community with brief training.

In the United States, Canada, and much of the rest of the world, regional poison centers can provide expert treatment guidance for the management of specific poisoning cases. Each of the 55 poison centers operating in the United States and 5 in Canada is supported by board-certified medical and clinical toxicologists with specialized training in poisoning resuscitation. Poison centers provide clinical advice to clinicians and the general public about how to manage poison emergencies. A single number is used to reach the regional poison center in the United States (1-800-222-1222) and in Canada (1-844-764-7669 [1-844-POISON-X]).

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Table 4. Commonly Used Doses of Antidotes for Resuscitation in Critical Poisoning

Antidote	Indication	Initial dose (adult)*	Initial dose (pediatric)*	Maintenance infusion	Notes
Atropine	Organophosphates Carbamates	1–2 mg, doubled every 5 min	0.02 mg/kg, doubled every 5 min	10%–20% of the total loading dose per hour up to 2 $mg \cdot h^{-1}$ (adults)	Titrate to reversal of bronchorrhea, bronchospasm, and bradycardia.
Calcium chloride	β-blockers CCBs	2000 mg 28 mEq Ca^{2+} 20 mL 100 mg/mL solution	20 mg/kg 0.28 mEq Ca^{2+}/kg 0.2 mL/kg 100 mg/mL solution	20–40 $mg \cdot kg^{-1} \cdot h^{-1}$ 0.28–0.56 mEq $Ca^{2+} \cdot kg^{-1} \cdot h^{-1}$ 0.2–0.4 $mL \cdot kg^{-1} \cdot h^{-1}$ 100 mg/mL solution	Titrate to blood pressure. Do not exceed serum ionized calcium concentration 1.5–2 times the upper limits of normal. Administer through central line, especially in children.
Calcium gluconate	β-blockers CCBs	6000 mg 28 mEq Ca^{2+} 60 mL 100 mg/mL solution	60 mg/kg 0.28 mEq/kg Ca^{2+} 0.6 mL/kg 100 mg/mL solution	60–120 $mg \cdot kg^{-1} \cdot h^{-1}$ 0.28–0.56 mEq $Ca^{2+} \cdot kg^{-1} \cdot h^{-1}$ 0.6–1.2 $mL \cdot kg^{-1} \cdot h^{-1}$ 100 mg/mL solution	Titrate to blood pressure. Do not exceed serum ionized calcium concentration 1.5–2 times the upper limits of normal.
Digoxin immune Fab	Digoxin	Acute overdose: 1 vial for every 0.5 mg digoxin ingested Chronic poisoning: Use formula: dose in vials=serum digoxin concentration (ng/mL)×weight (kg)/100 Acute overdose, critically ill, ingested dose unknown: 10–20 vials	Same as adult	None	1 vial contains 40 mg Fab. Lower doses may be equally effective.[4]
Digoxin immune Fab	Yellow oleander Bufo toad venom and other cardioactive steroids	1200 mg (30 vials)	Unknown	None	
Glucagon	β-blockers CCBs	2–10 mg	0.05–0.15 mg/kg	1–15 $mg \cdot h^{-1}$ (adult)	Anticipate vomiting.
Flumazenil	Benzodiazepines	0.2 mg, titrated up to 1 mg	0.01 mg/kg	None	Many contraindications
Hydroxocobalamin	Cyanide	5 g	70 mg/kg	Repeat doses may be necessary.	Transient hypertension
Insulin	β-blockers CCBs	1 U/kg	Same as adult	1–10 $U \cdot kg^{-1} \cdot h^{-1}$	Regular human insulin. Monitor for hypoglycemia, hypokalemia, volume overload.
Intravenous lipid emulsion	Local anesthetics	<70 kg: 1.5 mL/kg >70 kg: bolus 100 mL over 2–3 min	Same as adult	<70 kg: 0.25 $mL \cdot kg^{-1} \cdot min^{-1}$ for up to 30 min >70 kg: 200–250 mL over 15–20 min	All studies use 20% lipid emulsion.
Methylene blue	CCBs Methemoglobinemia	1–2 mg/kg, repeated every hour if needed	Same as adult	1 $mg \cdot kg^{-1} \cdot h^{-1}$ (for vasodilatory shock)	Maximum 7 mg/kg
Naloxone	Opioids	0.2–2 mg IV/IO/IM 2–4 mg intranasal Repeat every 2–3 min as needed	0.1 mg/kg	Two thirds of the waking dose per hour	Titrate to reversal of respiratory depression and restoration of protective airway reflexes.
Pralidoxime	Organophosphates	2 g IV infusion over 15–30 min (do not bolus) or 0.6 g IM up to 3 doses	20–50 mg/kg	1 $g \cdot h^{-1}$ (adult) 10–20 $mg \cdot kg^{-1} \cdot h^{-1}$ (pediatric)	
Sodium bicarbonate†	Sodium channel blockers Cocaine Local anesthetics	50–150 mEq	1–3 mEq/kg	Prepare 150 mEq/L solution, infuse at 1–3 $mL \cdot kg^{-1} \cdot h^{-1}$	Watch for hypernatremia, alkalemia, hypokalemia, hypochloremia.

(*Continued*)

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Table 4. Continued

Antidote	Indication	Initial dose (adult)*	Initial dose (pediatric)*	Maintenance infusion	Notes
Sodium nitrite	Cyanide	300 mg	6 mg/kg	None	Watch for hypotension.
Sodium thiosulfate	Cyanide	12.5 g	250 mg/kg	None	

β-blockers indicates β-adrenergic receptor antagonists; CCBs, calcium channel blockers; Fab, fragment antigen binding; IM, intramuscular; IO, intraosseous; IV, intravenous; and U, units.

*Unless otherwise stated, the route of administration should be intravenous or intraosseous. Maximum pediatric dose should not exceed adult dose. Most antidotes should be repeated frequently and titrated to achieve control of critical signs and symptoms. The ideal dose of most antidotes is not known and is often controversial. Large doses are sometimes required to overcome competitive inhibition of molecular targets such as adrenergic receptors and ion channels. Consult a medical or clinical toxicologist, regional poison center, or topic-specific reference for detailed dosing and administration instructions.

†Different sodium bicarbonate solutions are typically used for adults (1 mEq/mL) and children (0.5 mEq/mL). Both formulations are hypertonic.

TOXICOLOGY: BENZODIAZEPINES

Introduction

Benzodiazepines are commonly used sedative-hypnotics for treatment of anxiety, insomnia, seizures, and withdrawal syndromes and as a component of general anesthesia and procedural sedation. Benzodiazepines are implicated in a large number of poisoning-related deaths, usually in combination with other central nervous system (CNS) depressants, such as opioids and alcohol.[1,2] Benzodiazepine overdose causes CNS depression through agonist effects at the gamma-aminobutyric acid-A receptor with resultant respiratory compromise through loss of protective airway reflexes. The subsequent hypoxemia and hypercarbia cause tissue cellular injury or death.

Flumazenil, a competitive antagonist at the benzodiazepine binding site on the gamma-aminobutyric acid-A receptor, reverses CNS and respiratory depression, potentially preventing the need for intubation and mechanical ventilation.[3,4] However, flumazenil administration may precipitate refractory benzodiazepine withdrawal in patients with benzodiazepine tolerance, including seizures and arrhythmias, likely by removing benzodiazepine-mediated suppression of sympathetic tone.[5]

Overdose with multiple drugs is common. Flumazenil may not fully reverse respiratory depression, particularly in mixed overdoses, and it may increase the risk of seizures and arrhythmias in these situations.

These recommendations inform the management of adults and children with life-threatening benzodiazepine poisoning, including cardiac arrest.

Recommendations for Adults With Life-Threatening Benzodiazepine Poisoning

COR	LOE	Recommendations
2a	B-NR	1. If combined opioid and benzodiazepine poisoning is suspected, it is reasonable to administer naloxone first (before other antidotes) in adults with respiratory depression or respiratory arrest.
2a	C-LD	2. Flumazenil can be effective in select adults with respiratory depression or respiratory arrest caused by pure benzodiazepine poisoning who do not have contraindications to flumazenil.

Recommendations for Adults With Life-Threatening Benzodiazepine Poisoning (Continued)

COR	LOE	Recommendations
3: No Benefit	C-EO	3. Flumazenil has no role in cardiac arrest related to benzodiazepine poisoning in adults.
3: Harm	B-R	4. Flumazenil administration is associated with harm in adults who are at increased risk for seizures or arrhythmias.

Recommendation-Specific Supportive Text

1. While isolated benzodiazepine poisoning rarely causes life-threatening hypoventilation or hemodynamic instability in adults, overdoses usually occur with concomitant opioid, ethanol, or other CNS depressant poisoning.[1,2] Flumazenil (Table 4) attenuates benzodiazepine-associated respiratory depression in healthy patients receiving a combination of benzodiazepines and opioids, but this only produces a partial restoration of respiratory function. Naloxone reverses opioid poisoning, which is more common and causes more significant respiratory depression than benzodiazepine poisoning.[4] This is particularly important given the presence of opioid-adulterated illicit drugs[2,6] (refer to the Toxicology: Opioid Overdose section).
2. Flumazenil (Table 4) is safe in some low-risk presentations in adults (eg, iatrogenic overdoses during procedural sedation) and when high-risk conditions (eg, chronic benzodiazepine dependence and coingestion of other dangerous substances) can be reliably excluded. One healthy adult volunteer randomized crossover study of alfentanil plus midazolam-induced respiratory depression showed that 1 mg of flumazenil significantly improved consciousness and respiratory depression over placebo.[4]
3. Flumazenil does not directly affect cardiac rhythm or restore spontaneous circulation in adults.[7]
4. In a meta-analysis of randomized clinical trials of adults with confirmed or suspected benzodiazepine overdose, higher rates of serious adverse effects, including seizures and arrhythmias, were observed in patients treated with flumazenil compared

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with standard care.[5] There are few reports of flumazenil-provoked seizures in adults with preexisting seizure disorder in the absence of other risk factors.[8] While the most common cardiac adverse event associated with flumazenil was supraventricular tachycardia, ventricular arrhythmias and asystole have also been reported in adults.[5,9–13] The risks of flumazenil likely exceed the benefit in patients with undifferentiated coma for whom medical history and co-intoxications are unknown.

Recommendations for Children With Life-Threatening Benzodiazepine Poisoning		
COR	**LOE**	**Recommendations**
2a	**B-R**	1. Administration of flumazenil can be effective in select children with respiratory depression or respiratory arrest caused by pure benzodiazepine poisoning who do not have contraindications to flumazenil.
2a	**C-EO**	2. If combined opioid and benzodiazepine poisoning is suspected, it is reasonable to administer naloxone first (before other antidotes) in children with respiratory depression or respiratory arrest.
3: No Benefit	**C-EO**	3. Flumazenil has no role in cardiac arrest related to benzodiazepine poisoning in children.
3: Harm	**C-LD**	4. Flumazenil administration is associated with harm in children who are at increased risk for seizures or arrhythmias.

Recommendation-Specific Supportive Text

1. Flumazenil (Table 4) has been used safely in children when there is low risk of precipitating seizures or arrhythmias. Two RCTs of healthy children who received benzodiazepines as part of a procedural anesthetic demonstrated safety with no differences in cardiorespiratory status and no seizures reported in those who received flumazenil compared with those who did not.[14,15] Awakening was faster in children who received flumazenil after general anesthesia, but there was no difference with flumazenil use after conscious sedation.[14,15] A prospective nonrandomized study of children receiving midazolam for conscious sedation showed 96% had a complete or partial response to flumazenil with no significant adverse events, but children with risk factors for seizures were excluded.[16] In a retrospective study of 83 children with clinical poisoning who received flumazenil after alleged benzodiazepine and nonbenzodiazepine poisoning, no flumazenil-related seizures occurred, and effectiveness was not reported.[17]
2. There are no specific studies investigating the effects of flumazenil on respiratory depression for combination benzodiazepine and opioid overdose in children, thus, the pediatric recommendation is extrapolated from the adult data.
3. Flumazenil does not directly affect cardiac rhythm or restore spontaneous circulation in children.[7]
4. There are reports of seizure recurrence after flumazenil use to reverse benzodiazepine-induced respiratory depression after prolonged seizures in children.[18,19] In a meta-analysis of randomized clinical trials in mostly adults with presumed benzodiazepine overdose, higher rates of serious adverse effects, including seizures and arrhythmias, occurred with flumazenil compared with standard care alone.[5] Harms were uncommon, and in most cases, readily managed. The risks of flumazenil likely exceed the benefit in children with undifferentiated coma for whom past medical history, substance use history, and the potential poison(s) involved are unknown.

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TOXICOLOGY: β-BLOCKERS

Recommendations for Adults and Children With Life-Threatening β-Blocker Poisoning		
COR	**LOE**	**Recommendations**
1	C-LD	1. High-dose insulin or euglycemia therapy should be administered for hypotension refractory to vasopressor therapy in adults and children with life-threatening β-blocker poisoning.
1	C-EO	2. Vasopressors should be administered for the treatment of hypotension in adults and children with life-threatening β-blocker poisoning.
2a	C-LD	3. It is reasonable to administer a bolus of glucagon followed by continuous infusion for treatment of symptomatic bradycardia or hypotension in adults and children with life-threatening β-blocker poisoning.
2a	C-LD	4. It is reasonable to use ECLS in adults with β-blocker poisoning in cardiogenic shock refractory to pharmacological interventions.
2a	C-EO	5. It is reasonable to use ECLS in children with β-blocker poisoning in cardiogenic shock refractory to pharmacological interventions.
2b	C-LD	6. It may be reasonable to use hemodialysis for life-threatening poisoning from atenolol, nadolol, or sotalol in adults with life-threatening β-blocker poisoning.
2b	C-EO	7. It may be reasonable to use hemodialysis for life-threatening poisoning from atenolol, nadolol, or sotalol in children with life-threatening β-blocker poisoning.
2b	C-EO	8. The usefulness of IV lipid emulsion (ILE) for adults and children with refractory shock due to β-blocker poisoning is uncertain.
2b	C-EO	9. It may be reasonable to administer calcium in adults and children with life-threatening β-blocker poisoning.

Synopsis

Direct antagonism of the β-adrenergic receptors in patients with β-blocker poisoning results in hypotension from decreased cardiac contractility, bradycardia, and AV nodal blockade.[1] β-blocker poisoning has also been associated with hypoglycemia.[2–6] A limited number of β-blockers cause arrhythmias from blockade of cardiac sodium (eg, propranolol) or potassium (eg, sotalol) channels and vasodilation from alpha-1 adrenergic antagonism (eg, labetalol, carvedilol).[7,8] Fortunately, while unintentional exposure to β-blockers in children is common, severe toxicity including bronchospasm, cardiogenic shock, hypoglycemia, seizure, and symptomatic bradycardia were not reported in 1 review of 208 children <6 years of age.[5] No studies have evaluated the use of therapies specific to cardiac arrest due to β-blocker poisoning. Therefore, recommendations are derived from studies in poisoned patients with severe β-blocker–induced shock.

These recommendations inform the management of adults and children with life-threatening β-blocker poisoning, including cardiac arrest.

Recommendation-Specific Supportive Text

1. High-dose insulin (Table 4) improves inotropy in case series of adults and children in cardiogenic shock from β-blocker poisoning.[9,10] In some case reports of adults and children, high-dose insulin therapy appears to be vasopressor sparing. Recurrence of vasopressor-resistant hypotension after insulin therapy was also reduced or stopped, although this is not reported consistently.[8,9,11,12] Protocolized care reduces the risk of hypoglycemia.[13,14] Hypokalemia and volume overload are additional concerns.[10,13]
2. Successful use of inotropes and vasopressors is described in a systematic review of descriptive studies including adults and children as well as animal studies.[8] Because they are readily available and act quickly, vasopressors, such as norepinephrine and epinephrine, are almost always the initial therapy for β-blocker–induced hypotension. Other nonadrenergic vasopressors, such as vasopressin, angiotensin II, amrinone, milrinone, methylene blue, and hydroxocobalamin, are not supported by sufficient evidence to support a recommendation.
3. Intravenous glucagon (Table 4) increased contractility and improved hemodynamics in case reports and case series of adults and children with β-blocker poisoning and in 1 adult trial involving a nontoxic dose of esmolol.[8,11,15–17] However, 1 retrospective observational study of adults and children did not support these effects.[18] The doses used to treat hemodynamic instability from β-blocker poisoning are larger than those used to treat hypoglycemia. Nausea and vomiting are common, and in 1 animal model, rapid tachyphylaxis occurred with continuous infusion.[8,19]

4 and 5. Adult and pediatric case reports, adult case series, and adult observational studies demonstrated VA-ECMO may be lifesaving for adults

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and children with persistent cardiogenic shock refractory to maximal supportive care.[20–23] Limited pediatric data on the use of VA-ECMO for the treatment of children with β-blocker poisoning were identified; thus, the pediatric recommendation for children is extrapolated from the adult data.

6 and 7. The Extracorporeal Treatments in Poisoning workgroup based on case reports and mechanistic studies of adults with impaired kidney function provides weak recommendations for hemodialysis to manage critical poisoning due to atenolol or sotalol.[24] Nadolol is also considered dialysable, but clinical data are lacking.[24] No pediatric data on the use of hemodialysis for the treatment of children with β-blocker poisoning were identified; thus, the recommendation for children is extrapolated from the adult data.

8. Survival after ILE therapy (Table 4) has been described in adult case reports and case series with patients with β-blocker poisoning.[25–27] One case of a 7-month-old female did not have improved hemodynamics after ILE administration.[28] Two adult cases of severe β-blocker poisoning, combined with bupropion in 1 case and diltiazem in another, reported abrupt cardiac arrest immediately after ILE administration.[29] An expert consensus recommendation by international medical toxicology collaborators advises against the routine use of ILE for β-blocker poisoning.[25] Given pediatric data on the use of ILE therapy are limited, the recommendation for children is extrapolated from the adult data.

9. Survival after IV calcium administration (Table 4) has been described in adult case reports of cardiac arrest after β-blocker overdose.[30,31] These cases are confounded by the concurrent administration of other vasoactive medications, and data for isolated calcium administration is lacking.[30,31] No pediatric data on the use of calcium for β-blocker poisoning were identified, thus, recommendations for children are extrapolated from the adult case reports.

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TOXICOLOGY: CALCIUM CHANNEL BLOCKERS

Recommendations for Adults and Children With Life-Threatening CCB Poisoning		
COR	**LOE**	**Recommendations**
1	B-NR	1. High-dose insulin should be administered for hypotension in adults and children with life-threatening CCB poisoning.
1	C-LD	2. Vasopressors should be administered for hypotension in adults and children with life-threatening CCB poisoning.
2a	B-NR	3. It is reasonable to use ECLS in adults with CCB poisoning that is refractory to pharmacological interventions.
2a	C-LD	4. It is reasonable to use ECLS in children with CCB poisoning that is refractory to pharmacological interventions.
2a	C-EO	5. It is reasonable to administer calcium in adults and children with life-threatening CCB poisoning.
2b	C-EO	6. The usefulness of a glucagon bolus followed by continuous infusion for adults and children with life-threatening CCB poisoning is uncertain.
2b	C-EO	7. The usefulness of methylene blue for adults and children with refractory vasodilatory shock due to CCB poisoning is uncertain.
2b	C-EO	8. The usefulness of ILE for adults and children with refractory shock due to CCB poisoning is uncertain.

Synopsis

Antagonists of the L-type calcium channel (commonly called CCBs) are divided into 2 pharmacological classes: dihydropyridines (eg, nifedipine, amlodipine) and nondihydropyridines (eg, diltiazem, verapamil). At therapeutic doses, nondihydropyridines have more pronounced effects on cardiac tissue, including the atrioventricular node, resulting in negative chronotropy. In contrast, dihydropyridines primarily cause peripheral vasodilation. Amlodipine can cause profound vasodilation mediated by nitric oxide release.[1] These distinctions are often lost when therapeutic doses are exceeded, and patients present with severe shock from bradycardia, vasodilation, or loss of inotropy. Prolonged effects are common given that CCBs are frequently prescribed in sustained-release forms (eg, diltiazem, verapamil, nifedipine) or have long half-lives (eg, amlodipine). As a result, CCBs are a leading cause of poisoning mortality reported to poison centers.[2] Commonly used treatment modalities include atropine, calcium, vasopressors, high-dose insulin therapy, methylene blue (a nitric oxide synthase inhibitor), and ILE therapy. ECLS, such as VA-ECMO, has been used in refractory cases.

These recommendations inform the management of adults and children with life-threatening CCB poisoning, including cardiac arrest.

Recommendation-Specific Supportive Text

1. High-dose insulin (Table 4) improves inotropy in adults and children with severe cardiogenic shock from CCB poisoning.[3–6] One large observational study including adults and children reported favorable outcomes with lower rates of vasoconstrictive complications than vasopressor-only therapy.[3] One retrospective cohort study of adults and children suggested that patients with dihydropyridine toxicity may require more vasopressor support along with high-dose insulin because of additive vasodilation.[7] Protocolized care reduces the risk of hypoglycemia.[3,5] Hypokalemia and volume overload are additional concerns.[3,8]
2. Many adults and children with CCB-induced shock reported to a poison center registry and in 1 case series received vasopressor therapy.[2,9,10] One retrospective case series of 48 adults and children demonstrated excellent survival rates with the primary use of vasopressors (most commonly norepinephrine at doses up to 100 mcg/min in adults), with low rates of ischemic complications.[9] Three patients in this series had cardiac arrest before vasopressor therapy. There is no evidence to guide the choice of vasopressors. Other nonadrenergic vasopressors, such as vasopressin, angiotensin II, amrinone, milrinone, and hydroxocobalamin, are not supported by sufficient evidence for a recommendation.

3 and 4. The use of VA-ECMO for adults and children with refractory cardiogenic shock or cardiac arrest after CCB overdose is described in a

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case series with reported survival rates as high as 77%.[11–16] A study using data from the ELSO Registry of adults with CCB poisoning found a mortality rate of 40.6%, which is lower than the general mortality rate of 50% for all adults on ECMO.[17] The study also found that a pH <7.1 and the use of kidney replacement therapy prior to initiation of ECLS were associated with increased odds of mortality.[17]

5. The available literature on calcium monotherapy for severe CCB toxicity is limited (Table 4). Improvements in heart rate, blood pressure, and conduction abnormalities are reported in adults and children.[18,19] However, most patients require additional treatments.[3,15,18,20] In 1 case series of adults, high doses of calcium gluconate (targeting ionized calcium concentrations up to twice normal) appeared to be more effective than lower doses.[18]
6. Glucagon is an adjunctive therapy for severe CCB poisoning in adults and children.[3,9,20] Reported response rates are variable, vomiting is common, and tachyphylaxis may occur.[19,21,22]
7. Methylene blue (Table 4), a nitric oxide synthase inhibitor, is described in adult case series and case reports as an effective adjunct to treat refractory vasodilatory shock after CCB overdose (involving primarily amlodipine).[23] However, responses are mixed, and the effects may be transient. Data for the treatment of children with methylene blue for CCB poisoning is lacking, and recommendations are extrapolated from adult data.
8. An adult case series and a systematic review of adult and pediatric case reports with CCB poisoning identified cases where ILE appeared beneficial.[24–26] In 1 report of 2 adults, the use of ILE was associated with abrupt cardiac arrest.[8] An expert consensus recommendation by international medical toxicology collaborators advises against the routine use of ILE for CCB poisoning.[24] The role of ILE in patients who have failed other modalities and are in cardiac arrest or peri-arrest is unclear.[21,24] Data for the treatment of children with ILE for CCB poisoning is limited, and recommendations are extrapolated primarily from adult data.

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TOXICOLOGY: COCAINE

Introduction

The clinical manifestations of cocaine poisoning are mainly caused by sympathetic nervous system effects. Cocaine produces a sympathomimetic toxidrome marked by tachycardia, hypertension, hyperthermia, diaphoresis, increased psychomotor activity, and seizures.[1] Cocaine induces tachycardia (postsynaptic β-adrenergic receptor agonism) and hypertension (peripheral postsynaptic alpha-adrenergic receptor agonism) by enhanced catecholamine release and catecholamine reuptake inhibition. The release and reuptake blockade of norepinephrine, epinephrine, dopamine, and serotonin also causes the CNS and neuropsychiatric symptoms of cocaine poisoning.[1,2] Cocaine-induced coronary atherosclerosis and vasospasm predisposes individuals to acute coronary syndromes.[3]

The electrocardiographic changes and dysrhythmogenic properties of cocaine are a result of the effect of cocaine on cardiac sodium and potassium channels.[4] Sodium channel blockade leads to slowed conductance during phase 0 of the cardiac action potential. As a result, patients may develop QRS complex prolongation and wide-complex tachycardia similar to what occurs with Vaughan-Williams Ia and Ic medications.[5,6] Cocaine also causes QT interval prolongation and torsade de pointes through potassium channel blockade.[1,7] Cocaine-induced arrhythmias include asystolic cardiac arrest and pulseless VT. Like other local anesthetics, cocaine blocks neuronal sodium channels.

These recommendations inform the management of adults and children with life-threatening cocaine poisoning, including cardiac arrest.

Recommendations for Adults With Life-Threatening Cocaine Poisoning

COR	LOE	Recommendations
1	B-R	1. Sedation is recommended for adults with severe agitation from cocaine poisoning.
1	C-LD	2. Rapid external cooling with ice water immersion is recommended for adults with life-threatening hyperthermia (Core Temperature >40 °C [104 °F]) from cocaine poisoning.

Recommendations for Adults With Life-Threatening Cocaine Poisoning (Continued)

COR	LOE	Recommendations
2a	C-LD	3. In adults with wide-complex tachycardia or cardiac arrest from cocaine poisoning, it is reasonable to administer sodium bicarbonate.
2a	C-LD	4. In adults with wide-complex tachycardia or cardiac arrest from cocaine poisoning, it is reasonable to administer lidocaine.
2a	C-LD	5. In adults with cocaine-induced coronary vasospasm or hypertensive emergencies, it is reasonable to administer vasodilators (eg, nitrates, phentolamine, CCBs).
2a	C-EO	6. It is reasonable to use ECLS in adults with cardiogenic shock from cocaine poisoning refractory to other treatment measures.
3: No Benefit	C-LD	7. In adults with cocaine-induced coronary vasospasm or hypertensive emergencies, administration of β-adrenergic antagonists is not recommended.
3: Harm	C-LD	8. Prolonged use of physical restraint in adults with life-threatening cocaine poisoning without sedation is potentially harmful.

Recommendation-Specific Supportive Text

1. Sedatives (eg, benzodiazepines and antipsychotics) have been successful in treating adults with cocaine-induced agitation.[8] Small animal pretreatment and rescue studies comparing chlorpromazine to diazepam demonstrated improved survival with both compared with controls.[9,10] One adult randomized clinical trial comparing droperidol versus lorazepam for acutely agitated patients from cocaine or methamphetamine intoxication found adequate sedation with both medications, but droperidol had faster onset of sedation and required fewer repeat doses.[11]
2. Hyperthermia (Core temperature >40 °C [104 °F]) can be rapidly life-threatening in cocaine poisoning.[12,13] High-quality data on cooling measures for hyperthermic cocaine-intoxicated adults are lacking, but immersion seems effective.[14] Evaporative or immersive cooling modalities reduce temperature more rapidly in adults than cooling blankets, the application of cold packs, or endovascular cooling devices.[12,15–21] Ice water immersion resulted in the fastest cooling rates in adults and may cool faster than 0.15 °C/min (0.27 °F/min), which has been associated with increased survival (refer to the Hyperthermia section).[16,22]
3. Canine studies demonstrate the ability of sodium bicarbonate (Table 4) to reverse cocaine-induced QRS prolongation through competitive binding between sodium bicarbonate and cocaine at the sodium channel.[23–25] Adult case reports and case series describe the successful use of hypertonic sodium bicarbonate to treat wide-complex

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tachycardia from severe cocaine poisoning.[26–30] The successful use of hypertonic sodium bicarbonate in the resuscitation has also been reported in an adult case report with asystolic cardiac arrest and subsequent wide-complex Brugada pattern.[28]

4. Lidocaine administration has demonstrated safety in a multicenter retrospective observation study of 27 adults with cocaine-induced myocardial infarction.[31] The use of lidocaine for cocaine-associated cardiac arrest with ventricular arrhythmias is supported by 1 adult and a pediatric case report in a 17-year-old female patient.[32,33]
5. Adult clinical trials demonstrate improvements in coronary blood flow and myocardial oxygen delivery in patients with cocaine-induced coronary vasospasm after treatment with vasodilators (eg, phentolamine, nitrates, verapamil).[34–38] These studies did not include patients with cardiac arrest or in peri-arrest. Adults with refractory ischemia from cocaine were successfully treated with phentolamine.[35,39]
6. ECLS, including VA-ECMO and intra-aortic balloon pump, has been used successfully to support cardiac output in adults in cardiogenic shock after myocardial infarction.[40,41] Evidence in patients with cocaine-associated circulatory failure is lacking.
7. While a 2008 AHA scientific statement suggests potential benefits of β-adrenergic blockade after acute management of cocaine-related myocardial infarction, evidence to support the use of β-adrenergic blockade in adults with acute life-threatening cocaine toxicity is lacking.[42] In controlled animal trials, propranolol failed to prevent cocaine lethality.[9,10,43] In adults who received cocaine while undergoing cardiac catheterization, propranolol exacerbated coronary vasoconstriction.[44] In the same human model, labetalol was no better than saline at reversing coronary vasoconstriction.[45] In at least 1 case report, the administration of metoprolol to an adult with persistent cocaine-induced hypertension and tachycardia resulted in crushing substernal chest pain, which was followed by PEA and death.[46] In a case series of adults with acute cocaine toxicity, the effect of esmolol was inconsistent, failing to treat tachycardia in 1 patient and raising diastolic blood pressure (possibly an unopposed alpha-adrenergic effect) in others, 1 of which was severe.[47]
8. Although physical restraints may be necessary temporarily, their sustained use without effective sedation is associated with death in adults with severe agitation from exposure to cocaine and other sympathomimetics.[48,49]

Recommendations for Children With Life-Threatening Cocaine Poisoning

COR	LOE	Recommendations
1	C-EO	1. Sedation is recommended for children with severe agitation from cocaine poisoning.
1	C-EO	2. Rapid external cooling with ice water immersion is recommended for children with life-threatening hyperthermia (Core Temperature >40 °C [104 °F]) from cocaine poisoning.
2a	C-EO	3. In children with wide-complex tachycardia or cardiac arrest from cocaine poisoning, it is reasonable to administer sodium bicarbonate.
2a	C-EO	4. In children with wide-complex tachycardia or cardiac arrest from cocaine poisoning, it is reasonable to administer lidocaine.
2a	C-EO	5. In children with cocaine-induced coronary vasospasm or hypertensive emergencies, it is reasonable to administer vasodilators (eg, nitrates, phentolamine, CCBs).
2a	C-EO	6. It is reasonable to use ECLS in children with cardiogenic shock from cocaine poisoning refractory to other treatment measures.
3: No Benefit	C-EO	7. In children with cocaine-induced coronary vasospasm or hypertensive emergencies, administration of β-adrenergic antagonists should not be performed.
3: Harm	C-EO	8. Prolonged use of physical restraint in children with life-threatening cocaine poisoning without sedation is potentially harmful.

Recommendation-Specific Supportive Text

1. Sedatives (eg, benzodiazepines and antipsychotics) have been successful in treating adults with cocaine-induced agitation.[8] Small animal pretreatment and rescue studies comparing chlorpromazine, an antipsychotic, to diazepam, a benzodiazepine, demonstrated improved survival with both compared with controls.[9,10] One adult randomized clinical trial comparing droperidol versus lorazepam for acutely agitated patients with cocaine or methamphetamine intoxication found adequate sedation with both medications, but droperidol had faster onset of sedation and required fewer repeat doses.[11] No pediatric data on the use of sedatives for life-threatening cocaine poisoning were identified, thus, the recommendation for children is extrapolated from the adult data.
2. Hyperthermia (Core Temperature >40 °C [104 °F]) can be rapidly life-threatening in cocaine poisoning.[12,13] Evaporative or immersive cooling modalities reduce temperature more rapidly in adults than cooling blankets, the application of cold packs, or endovascular cooling devices.[12,15–21] Ice water immersion resulted in the fastest cooling rates in adults and critically may cool faster than 0.15 °C/min (0.27 °F/min), which has been associated with increased survival.[16] High-quality data on cooling measures for hyperthermic cocaine-intoxicated adults are lacking, but immersion seems effective.[14] No pediatric data on the use of rapid external

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cooling for life-threatening cocaine poisoning were identified, thus, the recommendation for children is extrapolated from the adult data (refer to the Hyperthermia section).

3. Canine studies demonstrate the ability of sodium bicarbonate (Table 4) to reverse cocaine-induced QRS prolongation through competitive binding between sodium bicarbonate and cocaine at the sodium channel.[23–25] Adult case reports and case series describe the successful use of hypertonic sodium bicarbonate to treat wide-complex tachycardia from severe cocaine poisoning.[26–30] The successful use of hypertonic sodium bicarbonate in resuscitation has also been reported in an adult with asystolic cardiac arrest and subsequent wide-complex Brugada pattern.[28] No pediatric data on the use of hypertonic sodium bicarbonate for wide-complex tachycardia or cardiac arrest from cocaine poisoning were identified, thus, the recommendation for children is extrapolated from the adult data.
4. Lidocaine administration has demonstrated safety in a multicenter retrospective observation study of 27 adults with cocaine-induced myocardial infarction.[31] The use of lidocaine for cocaine-associated cardiac arrest with ventricular arrhythmias is supported by 1 adult and a pediatric case report in a 17-year-old female patient.[32,33] No other pediatric data on the use of lidocaine for wide-complex tachycardia or cardiac arrest from cocaine poisoning were identified, thus, the recommendation for children is extrapolated from the adult data.
5. Adult clinical trials demonstrate improvements in coronary blood flow and myocardial oxygen delivery in patients with cocaine-induced coronary vasospasm after treatment with vasodilators (eg, phentolamine, nitrates, verapamil).[34,37,38] These studies did not include patients with cardiac arrest or peri-arrest states. Adults with refractory ischemia from cocaine were successfully treated with phentolamine.[35,39] No pediatric data on the use of vasodilators for cocaine-induced coronary vasospasm or hypertensive emergencies were identified, thus, the recommendation for children is extrapolated from the adult data.
6. ECLS, including VA-ECMO and intra-aortic balloon pump, has been used successfully to support cardiac output in adults in cardiogenic shock after myocardial infarction.[40,41] Evidence in patients with cocaine-associated circulatory failure is lacking. No pediatric data on the use of ECLS for cardiogenic shock from cocaine poisoning were identified, thus, the recommendation for children is extrapolated from the adult data.
7. While a 2008 AHA scientific statement suggests potential benefits of β-adrenergic blockade after acute management of cocaine-related myocardial infarction, evidence to support the use of β-adrenergic blockade in adults with acute life-threatening cocaine toxicity is lacking.[42] In controlled animal trials, propranolol and labetalol failed to prevent cocaine lethality. In adults who receive cocaine while undergoing cardiac catheterization, propranolol exacerbates coronary vasoconstriction.[9,10,43,44] In the same human model, labetalol was no better than saline at reversing coronary vasoconstriction.[45] In at least 1 case report, the administration of metoprolol to an adult with persistent cocaine-induced hypertension and tachycardia resulted in crushing substernal chest pain, which was followed by PEA and death. In a case series of adults with acute cocaine toxicity, the effect of esmolol was inconsistent, failing to treat tachycardia in 1 patient and raising diastolic blood pressure (possibly an unopposed alpha-adrenergic effect) in others, 1 of which was severe.[47] No pediatric data on the use of β-adrenergic blockade for cocaine-induced coronary vasospasm or hypertensive emergencies were identified, thus, the recommendation for children is extrapolated from the adult data.
8. Although physical restraints may be necessary temporarily, their sustained use without effective sedation is associated with death in adults with severe agitation from exposure to cocaine and other sympathomimetics.[48,49] No pediatric data on the use of restraints for life-threatening cocaine poisoning were identified, thus, the recommendation for children is extrapolated from the adult data.

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TOXICOLOGY: CYANIDE

Introduction

Cyanide may be encountered through multiple industrial sources, including jewelry cleaning and electroplating or by the metabolism of naturally occurring cyanogens found in the pits of stone fruits, such as apricots. Cyanide gas is liberated by the incomplete combustion of nitrogen-containing products, such as plastics and vinyl, during house fires. It may also be ingested as cyanide salts in poisonings.

Cyanide inhibits cellular respiration in the mitochondria, causing cardiovascular collapse, metabolic acidosis with elevated plasma lactate concentrations, depressed mental status, seizures, and death.[1] Confirmatory testing is not rapidly available, and thus, diagnosis and management are dictated by clinical presentation.

Hydroxocobalamin (vitamin B_{12a}) scavenges cyanide on an equimolar basis to form nontoxic cyanocobalamin. Hydroxocobalamin has a rapid onset of action, is simple to use, and is adequate when given alone for cyanide poisoning.[2] Administration of hydroxocobalamin leads to deep red coloration of plasma and urine, which may interfere with laboratory analyses and erroneously trigger hemodialysis "blood leak" detectors.[2]

Alternatively, sodium nitrite and sodium thiosulfate have also been used to treat cyanide poisoning. Sodium nitrite oxidizes hemoglobin to methemoglobin, which then binds cyanide to form cyanmethemoglobin.[3,4] Sodium thiosulfate acts as a substrate for cyanide metabolism, slowly forming minimally toxic thiocyanate.[3]

These recommendations inform the management of adults and children with life-threatening cyanide poisoning, including cardiac arrest.

Recommendations for Adults With Life-Threatening Cyanide Poisoning

COR	LOE	Recommendations
1	C-LD	1. Hydroxocobalamin should be administered to adults with life-threatening cyanide poisoning.
1	C-LD	2. The combination of sodium nitrite and sodium thiosulfate should be administered to adults with life-threatening cyanide poisoning when hydroxocobalamin is unavailable.
2a	C-EO	3. In adults with concurrent carbon monoxide and cyanide poisoning (eg, from a house fire), administration of sodium thiosulfate alone is reasonable when hydroxocobalamin is unavailable.
2b	C-EO	4. In addition to administering hydroxocobalamin, it may be reasonable to administer sodium thiosulfate to adults with cyanide poisoning.

Recommendation-Specific Supportive Text

1. Hydroxocobalamin (Table 4) has been demonstrated to improve the survival of patients with cyanide poisoning. One prospective observational case series included 69 adults with suspected cyanide poisoning from house fires who were treated with hydroxocobalamin.[5] Fifty (72%) of the patients survived. Fifteen patients received hydroxocobalamin while in cardiac arrest, and only 2 (13%) survived.[5] In a case series of 13 adults and a 14-year-old patient with cyanide poisoning not associated with house fires, 10 (71%) patients survived, including 7 (78%) patients who were treated with hydroxocobalamin alone.[6] The 4 fatalities in this study were all patients who were in cardiac arrest when they received hydroxocobalamin.[6] Overall, mortality of adults in cardiac arrest from cyanide poisoning is high despite hydroxocobalamin administration, highlighting the severity of disease. Adverse effects of hydroxocobalamin include transient hypertension, skin discoloration, rash, acute kidney injury, interference with colorimetric laboratory assays, and erroneously triggering of hemodialysis "blood leak" detectors.[5–9]
2. The combination of sodium nitrite and sodium thiosulfate was more protective against lethality in a canine model than either sodium nitrite or sodium thiosulfate alone.[10] Adult cases of life-threatening cyanide poisoning have demonstrated survival using the sodium nitrite and sodium thiosulfate combination (Table 4).[11] To avoid excessive methemoglobin formation, the dosing of sodium nitrite in patients with anemia must be precise; the prescribing information lists specifications.[12]
3. Sodium nitrite can produce methemoglobinemia, reduces oxygen-carrying capacity, and may worsen cellular hypoxia in adults with concomitant carbon monoxide poisoning.[10] The sodium thiosulfate alone was protective against lethality in a canine model compared with controls.[10] A conflicting porcine model found sodium thiosulfate alone did not reverse shock in pigs with cyanide poisoning.[13] No human clinical trial exists to inform the use of sodium thiosulfate alone to treat cyanide poisoning. Adults with life-threatening cyanide poisoning have survived after treatment with sodium thiosulfate alone (Table 4).[14,15]
4. Survival after hydroxocobalamin with sodium thiosulfate to treat cyanide poisoning has been reported in adult cases (Table 4).[16,17] There are no human trials comparing the use of hydroxocobalamin alone versus in combination with sodium thiosulfate. One porcine study showed no difference in mean arterial pressures or survival when sodium thiosulfate was administered in combination with hydroxocobalamin versus hydroxocobalamin alone.[13]

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Recommendations for Children With Life-Threatening Cyanide Poisoning		
COR	LOE	Recommendations
1	C-EO	1. Hydroxocobalamin should be administered to children with life-threatening cyanide poisoning.
1	C-EO	2. The combination of sodium nitrite and sodium thiosulfate should be administered to children with life-threatening cyanide poisoning when hydroxocobalamin is unavailable.
2a	C-EO	3. In children with concurrent carbon monoxide and cyanide toxicity (eg, from a house fire), administration of sodium thiosulfate alone is reasonable when hydroxocobalamin is unavailable.
2b	C-EO	4. In addition to administering hydroxocobalamin, it may be reasonable to administer sodium thiosulfate to children with cyanide poisoning.

Recommendation-Specific Supportive Text

1. Hydroxocobalamin (Table 4) has been demonstrated to improve the survival of patients with cyanide poisoning. One prospective observational case series included 69 adults with suspected cyanide poisoning from house fires who were treated with hydroxocobalamin.[5] Fifty (72%) of the patients survived. Fifteen patients received hydroxocobalamin while in cardiac arrest, and only 2 (13%) survived.[5] In a case series of 13 adults and a 14-year-old patient with cyanide poisoning not associated with house fires, 10 (10/14; 71%) patients survived, including 7 (7/9; 78%) patients who were treated with hydroxocobalamin alone.[6] The 4 fatalities in this review were all patients who were in cardiac arrest when they received hydroxocobalamin.[6] Overall, mortality of patients in cardiac arrest from cyanide poisoning is high despite hydroxocobalamin administration, highlighting the severity of disease. Adverse effects of hydroxocobalamin include transient hypertension, skin discoloration, rash, acute kidney injury, interference with colorimetric laboratory assays, and erroneously triggering of hemodialysis "blood leak" detectors.[5–9,18] Limited pediatric data on the treatment of life-threatening cyanide poisoning with hydroxocobalamin were identified, thus, the recommendation for children is extrapolated primarily from the adult data.
2. The combination of sodium nitrite and sodium thiosulfate was more protective against lethality in a canine model than either sodium nitrite or sodium thiosulfate alone.[10] Adult cases of life-threatening cyanide poisoning have demonstrated survival using the sodium nitrite and sodium thiosulfate combination.[11] To avoid excessive methemoglobin formation, the dosing of sodium nitrite in children or in patients with anemia must be precise; the prescribing information lists specifications.[12] No pediatric data on the treatment of life-threatening cyanide poisoning with the combination sodium nitrite and sodium thiosulfate were identified, thus, the recommendation for children is extrapolated from the adult data (Table 4).
3. Sodium nitrite can produce methemoglobinemia, reduces oxygen-carrying capacity, and may worsen cellular hypoxia in adults with concomitant carbon monoxide poisoning.[10] The sodium thiosulfate alone was protective against lethality in a canine model compared with controls.[10] A conflicting porcine model found sodium thiosulfate alone did not reverse shock in pigs with cyanide poisoning.[13] No human clinical trial exists to inform the use of sodium thiosulfate alone to treat cyanide poisoning. Adults and children in cases of life-threatening cyanide poisoning have survived after treatment with sodium thiosulfate alone (Table 4).[14,15]
4. Survival after hydroxocobalamin with sodium thiosulfate to treat cyanide poisoning has been reported in adult cases.[16,17] There are no human trials comparing the use of hydroxocobalamin alone versus in combination with sodium thiosulfate. One porcine study showed no difference in mean arterial pressures or survival when sodium thiosulfate was administered in combination with hydroxocobalamin versus hydroxocobalamin alone.[13] No pediatric data on the treatment of life-threatening cyanide poisoning with the combination of hydroxocobalamin with sodium thiosulfate were identified, thus, the recommendation for children is extrapolated from the adult data (Table 4).

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TOXICOLOGY: DIGOXIN AND RELATED CARDIAC GLYCOSIDES

Recommendations for Adults and Children With Life-Threatening Poisoning From Digoxin and Related Cardiac Glycosides

COR	LOE	Recommendations
1	B-NR	1. Digoxin-specific antibody fragments (digoxin-Fab) should be administered for adults and children with life-threatening digoxin or digitoxin poisoning.
2a	C-LD	2. It is reasonable to administer digoxin-Fab for adults and children with life-threatening poisoning due to Bufo toad and yellow oleander toxins.
2b	C-EO	3. It may be reasonable to administer digoxin-Fab to treat adults and children with life-threatening poisoning from cardiac glycosides other than digoxin, digitoxin, Bufo toad toxins, and yellow oleander toxins.
2b	C-EO	4. It may be reasonable to administer lidocaine or phenytoin to treat adults and children with ventricular arrhythmias caused by digoxin and related cardiac glycoside poisoning until digoxin-Fab can be administered.
3: No Benefit	B-NR	5. The use of hemodialysis, hemofiltration, hemoperfusion, or plasmapheresis to treat adults and children with life-threatening poisoning from digoxin and related cardiac glycosides is not recommended.

Synopsis

Cardiac glycoside poisoning can be caused by medications such as digoxin and digitoxin, plants such as foxglove and oleander, and certain toad venoms ingested as ethnopharmaceuticals or hallucinogens. Patients with cardiac glycoside poisoning may develop gastrointestinal symptoms, confusion, hyperkalemia, and cardiac conduction abnormalities, including atrioventricular nodal block, VT, VF, or asystole. Although cardiac glycosides include a range of structurally similar cardioactive steroids, most data involve digoxin poisoning.

Digoxin-specific immune antibody fragments (eg, digoxin-Fab) bind to and inactivate digoxin and structurally similar cardiac glycosides. Different dosing regimens are advocated worldwide.[1–3] The ideal empirical dose for cardiac arrest is unknown and likely differs for digoxin poisoning compared with other cardiac glycosides.

Standard ALS measures for bradycardia, such as atropine and electrical pacing, have variable effectiveness in cardiac glycoside poisoning. Prior recommendations addressing these interventions were removed since they are included as part of standard ALS measures.

These recommendations inform the management of adults and children with life-threatening poisoning from digoxin and related cardiac glycosides, including cardiac arrest.

Recommendation-Specific Supportive Text

1. A systematic review of digoxin poisoning in adults and children found observational studies showing resolution of life-threatening arrhythmias after digoxin-Fab administration (Table 4).[2] Most studies report response rates of 50% to 90%, with arrhythmia resolution in 30 to 45 minutes in most cases.[2] Although there are no RCTs studying cardiac arrest from digoxin or digitoxin poisoning, excellent survival (30/56 [54%] patients) was reported in an observational study of adults and children in cardiac arrest treated with digoxin-Fab.[4]
2. An RCT among hemodynamically stable adults and children with yellow oleander (*Thevetia peruviana*, also known as *Cascabela thevetia*) cardiotoxicity (bradycardia or atrial tachyarrhythmias) showed significant resolution of arrhythmia with digoxin-Fab, as do many case reports and case series including adults and children (Table 4).[5,6] A Cochrane review did not identify any trials in adults or children with severe yellow oleander toxicity.[7] In vitro studies showed affinity between cardiac glycosides found in Bufo toad toxin and digoxin-Fab, murine studies showed protection, and some published case reports of adults and children showed apparent response.[8–14]
3. Survival after the administration of digoxin-Fab for poisoning from cardiac glycosides other than digoxin, digitoxin, Bufo toad toxin, and yellow oleander are limited to case reports in adults only.[5,15–21] No pediatric data on the use of digoxin-Fab to treat poisoning from cardiac glycosides other than digoxin, digitoxin, Bufo toad toxin, and yellow

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oleander were identified, thus, the recommendation for children is extrapolated from the adult data (Table 4).

4. There are multiple case reports including adults and children describing the use of antidysrhythmic medications, including lidocaine and phenytoin, to treat ventricular arrhythmias caused by digoxin poisoning, with various responses.[22–24] No high-quality cohort studies or randomized trials have evaluated their effect.
5. A systematic review of adults and children receiving extracorporeal treatment for digoxin poisoning found that digoxin is not well removed because of its large volume of distribution.[25]

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TOXICOLOGY: LOCAL ANESTHETICS

Recommendations for Adults and Children With Life-Threatening Local Anesthetic Poisoning		
COR	**LOE**	**Recommendations**
1	C-LD	1. For adults and children with life-threatening local anesthetic poisoning, ILE should be administered.
1	C-LD	2. Benzodiazepines should be used to treat adults and children with seizures associated with local anesthetic systemic toxicity (LAST).
2a	C-EO	3. It is reasonable to administer sodium bicarbonate to adults and children for life-threatening wide complex tachycardia associated with local anesthetic toxicity.
2a	C-EO	4. It is reasonable to use ECLS in adults and children with local anesthetic toxicity with refractory cardiogenic shock.

Synopsis

Local anesthetics reversibly bind sodium channels to disrupt nerve transmission and block pain signals. Patients with local anesthetic poisoning present with a constellation of CNS and cardiovascular symptoms termed local anesthetic systemic toxicity (LAST). CNS toxicity includes agitation, confusion, obtundation, and seizures, whereas cardiovascular symptoms include asystole, bradycardia, cardiac

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collapse, conduction delays, hypertension, hypotension, and ventricular arrhythmias.[1–3] Cardiovascular and CNS toxicity can occur both in isolation and concomitantly.[3–5]

Local anesthetics vary in toxicity depending on the potency associated with their lipophilic side chains. At equal doses (eg, mg/kg), bupivacaine is a more potent cardiotoxin than lidocaine and ropivacaine through its greater affinity and binding durations to cardiac sodium channels.[6,7] However, at equipotent doses, all local anesthetics can precipitate toxicity.[2–4,8]

Both hypoxia and acidemia are associated with increased toxicity from bupivacaine in animal models.[9–11] As such, airway management and circulatory support are critical to resuscitation from LAST. Pharmacological interventions (eg, ILE, sodium bicarbonate) and mechanical support (eg, VA-ECMO) in addition to ACLS have been used for LAST.

Evidence-based dosing recommendations for ILE are lacking. The majority of animal studies and human experience for the treatment of LAST use 20% ILE.[9] Attempts to reproduce this dose using propofol (which contains 10 mg/mL propofol in 10% ILE) would be at 10 to 20 times the induction dose for general anesthesia and lead to serious CNS and cardiovascular adverse effects.

Local anesthetic poisoning can also produce methemoglobinemia; treatment recommendations are provided in the Toxicology: Methemoglobinemia section.

These recommendations inform the management of adults and children with life-threatening local anesthetic poisoning, including cardiac arrest.

Recommendation-Specific Supportive Text

1. Early administration of 20% ILE (Table 4) in patients with LAST is supported by animal studies, case reports (including in children and pregnant women), and registry studies.[1,4,9,12–19] In conjunction with prevention of hypoxia and acidemia through standard ALS measures, administration of ILE has been associated with successful resuscitation in these studies. The descriptive studies are subject to publication bias with only a few case reports where ILE failed to resuscitate patients with LAST associated with lidocaine, mepivacaine, and ropivacaine.[20–23] Three RCTs (n=40 volunteers) demonstrate a potential pharmacokinetic benefit of ILE for ropivacaine, levobupivacaine, bupivacaine, and lidocaine. These 3 studies found that coadministration of ILE decreased the maximum plasma concentration of ropivacaine, the concentration curve for lidocaine, and the context-sensitive half-life of bupivacaine.[12,24,25] This is consistent with animal models of the same phenomenon.[26,27]
2. In the case of isolated CNS toxicity, LAST may progress rapidly to cardiovascular toxicity. Seizures associated with LAST may worsen hypoxia and acidemia, increasing the risk of cardiotoxicity.[11] Administration of benzodiazepines can abort seizure-like activity and is commonly reported as part of a therapeutic regimen in adults and children.[2,15,28]
3. Sodium bicarbonate administration (Table 4) may overcome sodium channel blockade by local anesthetics and correct acidemia. Evidence to support the use of sodium bicarbonate is limited to case reports in adults and children as part of a therapeutic regimen.[15,28] However, some case reports showed limited efficacy in adults already in cardiac arrest.[29,30] There are multiple porcine RCTs demonstrating effective shortening of the QRS interval in bupivacaine and ropivacaine toxicity.[31,32]
4. Several case reports in adults and children describe successful use of mechanical circulatory support, such as CPB or VA-ECMO, for patients with LAST and refractory cardiogenic shock.[29,30,33–36] Unfortunately, lack of widespread availability of VA-ECMO limits use of these interventions.

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TOXICOLOGY: METHEMOGLOBINEMIA

Recommendations for Adults and Children With Life-Threatening Methemoglobinemia

COR	LOE	Recommendations
1	B-NR	1. For adults and children with life-threatening methemoglobinemia, methylene blue should be administered.
2b	C-EO	2. Exchange transfusion may be reasonable as a treatment for adults and children with life-threatening methemoglobinemia that is not responsive to methylene blue.
2b	C-EO	3. Hyperbaric oxygen therapy may be reasonable as a treatment for adults and children with life-threatening methemoglobinemia that is not responsive to methylene blue.
2b	C-EO	4. For adults and children with life-threatening methemoglobinemia, it may be reasonable to administer ascorbic acid only when methylene blue is contraindicated or not available.
3: No Benefit	B-R	5. N-acetylcysteine is not recommended as a treatment for adults with life-threatening methemoglobinemia.

Synopsis

Acquired methemoglobinemia occurs after exposure to an oxidant stressor that oxidizes iron in the hemoglobin molecule from the ferrous (Fe^{2+}) state to the ferric (Fe^{3+}) state. In the ferric state, hemoglobin no longer effectively binds and delivers oxygen to end organs. Common sources of oxidant stress that can cause methemoglobinemia include nitrates, nitrites, and many pharmaceuticals (eg, benzocaine, dapsone, phenazopyridine).[1–9] Patients with methemoglobinemia can appear cyanotic and dusky and complain of shortness of breath and fatigue. Frequently, a difference is observed between the oxygen saturation measured by pulse oximetry versus arterial blood gas. Although moderate methemoglobinemia is generally well-tolerated, severe methemoglobinemia can lead to cardiovascular collapse and death.[5,6,9]

The most widely accepted treatment for methemoglobinemia is methylene blue, which acts as a cofactor to reduce methemoglobin to hemoglobin.[10] Other treatment modalities that have been described include exchange transfusion, hyperbaric oxygen therapy, and ascorbic

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acid. No studies have examined the treatment of methemoglobinemia in the context of cardiac arrest.

These recommendations inform the management of adults and children with life-threatening methemoglobinemia, including cardiac arrest.

Recommendation-Specific Supportive Text

1. No randomized trial has evaluated methylene blue for the treatment for methemoglobinemia; however, observational studies and published case reports in adults and children consistently demonstrate that methylene blue effectively reverses methemoglobinemia (Table 4).[1–4,7,11–13] Methylene blue may not improve methemoglobinemia and may lead to hemolysis in patients who have glucose-6-phosphate dehydrogenase deficiency, which is present in about 2% of the US population.[13–17]
2. Exchange transfusion has been used successfully in case reports and case series in adults and children to treat methemoglobinemia and may be appropriate in patients for whom methylene blue is ineffective.[18–24]
3. Hyperbaric oxygen therapy has been used as monotherapy and in conjunction with other therapies in adults. Reduction of methemoglobinemia concentrations, however, can be delayed up to several hours.[25–27] Not all health care facilities will have hyperbaric oxygen therapy available, and its use may be impractical in the setting of cardiopulmonary collapse or cardiac arrest. There are no published pediatric cases of the use of hyperbaric oxygen therapy for methemoglobinemia. Recommendations for children are extrapolated from adult case reports.
4. Ascorbic acid, or vitamin C, has been used to treat methemoglobinemia.[23,28–32] Most published case reports in adults and children demonstrate its use in conjunction with other treatment modalities or as an alternative when methylene blue is contraindicated or unavailable. The clinical effect of ascorbic acid, however, is slow, often requires multiple doses over several hours, and might require higher doses to achieve similar reductions on methemoglobin.[5,28–30,32–34] It is, therefore, unlikely to have benefit when used alone in resuscitation situations.
5. N-acetylcysteine did not reduce sodium nitrite–induced methemoglobinemia in a double-blind crossover adult volunteer study.[35] No pediatric data on the use of N-acetylcysteine were identified.

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TOXICOLOGY: OPIOID OVERDOSE

Introduction

Opioid poisoning continues in the United States and other countries at epidemic levels.[1] Most opioid overdose deaths are unintentional, which underscores the need to develop and implement evidence-based interventions for primary prevention, emergency treatment, and recovery support for people with substance use disorder. Response to life-threatening opioid overdose is a critical resuscitation skill.

In formulating these recommendations, the writing group reviewed prior AHA publications about opioid overdose resuscitation and a 2024 ILCOR systematic review and performed a structured literature review through November 2024.[2–9] We acknowledge the contributions of the authors of prior AHA opioid overdose recommendations, members of the 2025 Adult Basic Life Support Writing Group, and Dr. Matthew Neth for their contributions to the Toxicology: Opioid Overdose section.[2–4,6–9]

Recommendations about training of the lay rescuers for opioid overdose recognition and response are provided in "Part 12: Resuscitation Education Science." The treatment of opioid-induced respiratory depression in newborn infants is outside the scope of these guidelines.

Recommendations for Adults and Children With Life-Threatening Opioid Overdose

COR	LOE	Recommendations
1	B-NR	1. For trained rescuers assisting an adult or child with suspected opioid overdose who has respiratory depression or respiratory arrest and has a definite pulse, breaths or bag-mask ventilation should be provided.
1	B-NR	2. For lay rescuers assisting an adult or child with suspected opioid overdose who is unresponsive and not breathing normally, CPR with breaths should be provided.
1	B-NR	3. For trained rescuers assisting an adult or child with suspected opioid overdose in respiratory arrest with a definite pulse, an opioid antagonist (eg, naloxone) should be administered.
1	C-EO	4. Lay and trained rescuers should not delay performing standard resuscitation or activating the emergency response system while administering an opioid antagonist (eg, naloxone) or awaiting the person's response to an opioid antagonist.
2b	B-NR	5. For lay and trained rescuers, opioid antagonist administration may be reasonable for adults in cardiac arrest with suspected opioid overdose, provided that opioid antagonist (eg, naloxone) administration does not interfere with the delivery of standard resuscitation including high-quality compression-ventilation CPR.
2b	C-EO	6. For lay and trained rescuers, opioid antagonist administration may be reasonable for children in cardiac arrest with suspected opioid overdose, provided that opioid antagonist (eg, naloxone) administration does not interfere with the delivery of standard resuscitation including high-quality compression-ventilation CPR.

Synopsis

Opioid overdose causes CNS and respiratory depression, progressing to respiratory arrest and ultimately cardiac arrest.[4] Most opioid deaths involve additional substances that contribute to respiratory depression.[10–15] Differentiating opioid overdose from other causes of cardiac and respiratory arrest can be difficult without an accurate history, which is often unavailable.[16] The mainstay of care remains early recognition, activation of the emergency response system, provision of breaths or ventilations, and the administration of opioid antagonists for adults and children in respiratory arrest (Figures 7 and 8).

Opioid antagonists can restore spontaneous respirations and protective airway reflexes in adults and children with respiratory depression or respiratory arrest from opioid overdose. For adults with cardiac arrest from opioid overdose, observational studies of naloxone administration have mixed results.[5]

Two opioid antagonists, naloxone and nalmefene, are currently available for reversal in the United States.[17] Both are high potency antagonists of the mu-opioid receptor. Naloxone is currently available for purchase with or without a prescription in the United States and Canada.[18,19]

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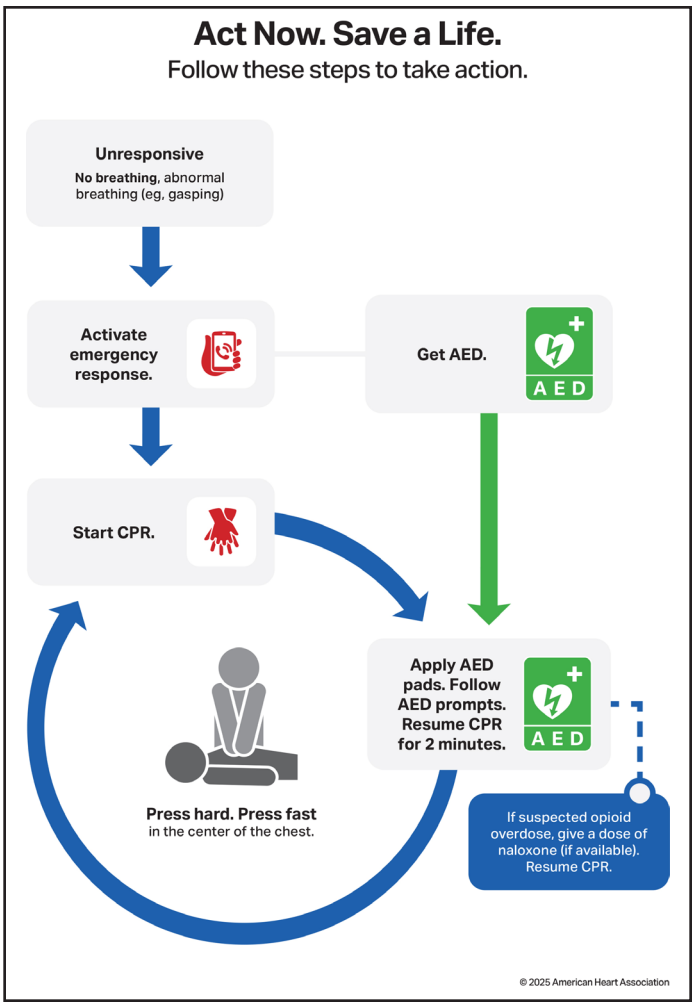

Figure 7. Adult Basic Life Support Lay Rescuer Infographic.

Intranasal nalmefene is available by prescription only.[20] To date, the published clinical data are more robust for naloxone than nalmefene.

These recommendations inform the management of adults and children with life-threatening opioid poisoning, including respiratory depression, respiratory arrest, and cardiac arrest.

Recommendation-Specific Supportive Text

1, 2, and 4. Initial management of opioid overdose should focus on support of the person's airway and breathing, as described in "Part 6: Pediatric BLS" and "Part 7: Adult BLS." Respiratory depression and respiratory arrest can be treated by opening the airway and providing breaths or ventilations, which may be all that is needed to prevent deterioration to cardiac arrest. CPR is indicated for any adult or child in known or suspected cardiac arrest, including in trained rescuer situations in which a definite pulse is not felt and in lay rescuer situations in which a pulse check is not performed. Opioid antagonists may require several minutes and repeated doses to reverse respiratory arrest, particularly when administered by the intranasal or IM route.[21–23] Nonopioid sedatives commonly contribute to respiratory depression and are typically not reversed by opioid antagonists. Opioid antagonists are extremely unlikely to benefit an adult or child in cardiac arrest who is not receiving CPR and do not reverse VF. For these reasons, standard BLS or ALS resuscitation should be provided immediately and continued until the adult or child is awake and breathing normally. Initiating compression-ventilation CPR before opioid antagonist administration differs from that of the prescribing information for naloxone or nalmefene.[19,20] The rationale to initiate standard resuscitation first and continue until the adult or child is breathing normally is articulated in this chapter and in prior AHA publications.[3]

3. Opioid antagonists restore protective airway reflexes and reverse respiratory arrest from opioid overdose in adults and children. More than 30 observational studies report return

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of alertness and resolution of respiratory depression in adults and children with opioid overdose when opioid antagonists are administered (for dosing, see Table 4).[22–56] No studies compared opioid antagonist administration to standard resuscitation or ventilatory support alone. Major complications are rare and dose related.

5 and 6. No clinical trials have evaluated the role of opioid antagonists in adults or children with cardiac arrest. The results of animal studies and adult observational studies of naloxone administration in undifferentiated cardiac arrest or cardiac arrest with suspected opioid overdose are conflicting and highly susceptible to confounding by indication.[57–64] As a result, the overall certainty of the evidence surrounding a potential role for opioid antagonist administration for adults in cardiac arrest is very low.[5] However, no human study has clearly demonstrated harm from naloxone administration in cardiac arrest. Pediatric data are sparse, and recommendations for children are extrapolated from adult studies. Identifying opioid overdose as the underlying cause of cardiac arrest may not always be obvious to the rescuer. Furthermore, resuscitation emergencies are task-saturated events. It is important that interventions with proven benefit, such as high-quality compression-ventilation CPR, be prioritized over interventions such as opioid antagonists, which do not have established benefit for adults and children in cardiac arrest and are unlikely to work in the absence of cardiac output.[5] For dosing information in adults and children, refer to Table 4.

Recommendations for Adults and Children With Opioid Overdose Following Successful Response to Opioid Antagonists

COR	LOE	Recommendations
1	C-LD	1. Adults with opioid overdose who respond to opioid antagonists (eg, naloxone) should be observed in a health care setting until a low risk of recurrent respiratory depression, normal level of consciousness, and normal vital signs are achieved.
1	C-EO	2. Children with opioid overdose who respond to opioid antagonists (eg, naloxone) should be observed in a health care setting until a low risk of recurrent respiratory depression, normal level of consciousness, and normal vital signs are achieved.
2a	C-LD	3. Repeated doses of opioid antagonists (eg, naloxone) can be beneficial in adults with opioid overdose who respond to opioid antagonists and develop recurrent respiratory depression.
2a	C-EO	4. Repeated doses of opioid antagonists (eg, naloxone) can be beneficial in children with opioid overdose who respond to opioid antagonists and develop recurrent respiratory depression.

Synopsis

People with opioid overdose who respond to opioid antagonist therapy may develop recurrent respiratory depression if the duration of action of the opioid exceeds the duration of the antagonist.

Recommendation-Specific Supportive Text

1–4. Adults and children with respiratory depression or respiratory arrest who respond to an opioid antagonist may develop recurrent CNS and respiratory depression. In 1 study, recurrent respiratory depression occurred in 72% of patients treated with titrated low doses of IV naloxone.[65] The ideal duration of observation is unknown and likely differs based on the substance involved, which may be unknown; the dose and route of opioid antagonist administration; and whether the patient received naloxone or nalmefene. Although abbreviated observation periods may be adequate for adults with fentanyl, morphine, or heroin overdose, a period of observation may be required to safely discharge an adult with a life-threatening overdose of a long-acting or sustained-release opioid.[26,49,53,66–74] Treatment options for recurrent respiratory depression include repeat doses of an opioid antagonist or an IV infusion of naloxone (Table 4).[49,67,69,74,75] No studies were identified to inform the minimum safe observation period for a child treated with opioid antagonists or the efficacy of opioid antagonists for recurrent respiratory depression in children, thus, recommendations are extrapolated from adult data.

Recommendations for Opioid Antagonist Education and Distribution Following Treatment for Opioid Overdose

COR	LOE	Recommendation
1	C-LD	1. Adults who are treated for opioid overdose should receive an opioid antagonist (eg, naloxone) and teaching at the time of discharge from a health care setting.
1	C-EO	2. Children who are treated for opioid overdose, or their caregivers as appropriate, should receive an opioid antagonist (eg, naloxone) and teaching at the time of discharge from a health care setting.

Synopsis

People who survive an opioid overdose are at increased risk of a subsequent overdose. Secondary and tertiary prevention strategies include screening, brief intervention, and referral to treatment (SBIRT); providing or prescribing opioid antagonists such as "take-home naloxone" programs; and prescribing medications for opioid use disorder.[76] These recommendations specifically relate to provision or prescribing of naloxone to opioid overdose survivors at the time of discharge from the emergency department

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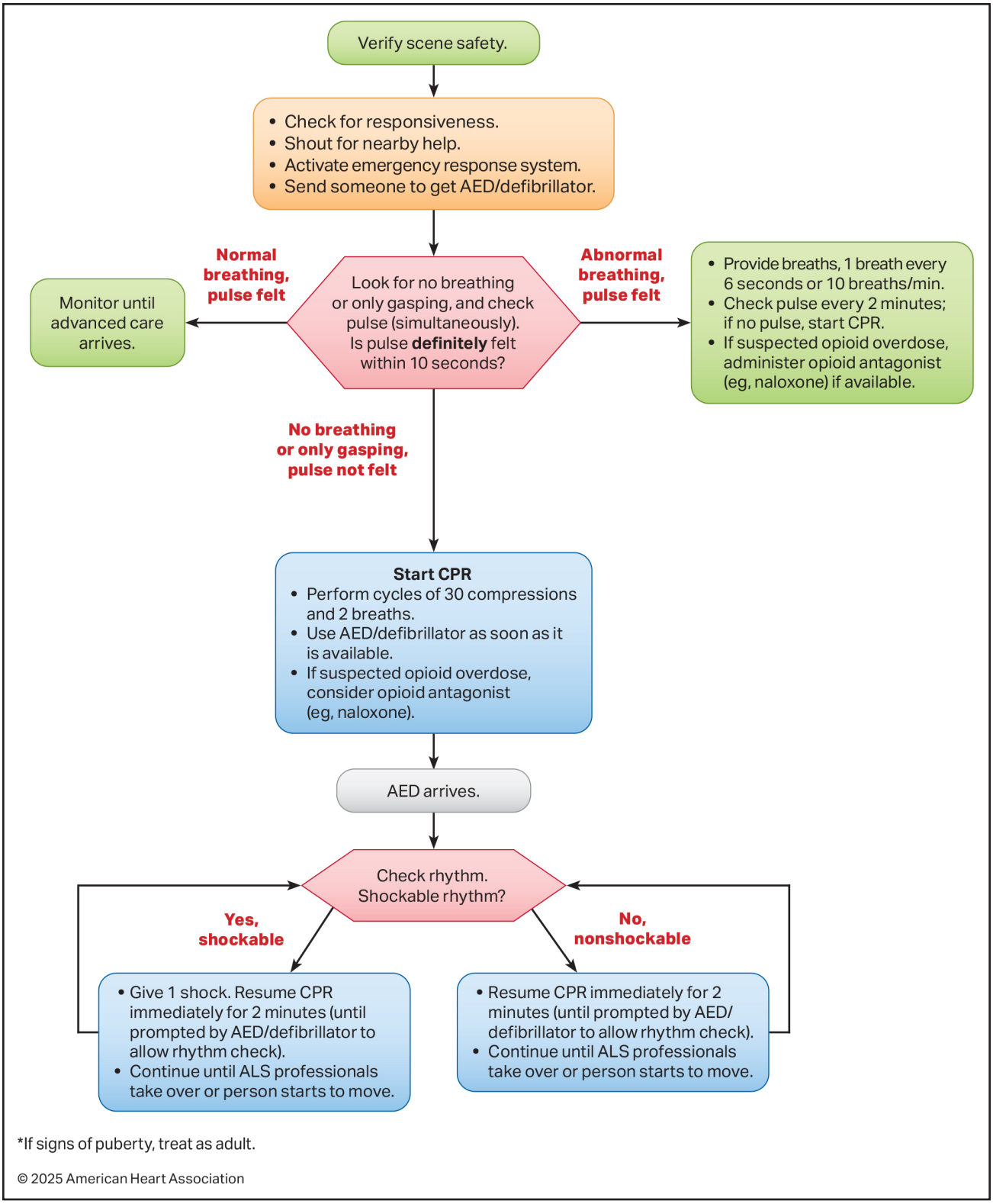

Figure 8. Adult* Basic Life Support for Health Care Professionals Algorithm.
*If signs of puberty, treat as adult. AED indicates automated external defibrillator; ALS, advanced life support; and CPR, cardiopulmonary resuscitation.

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or hospital. A 2024 scoping review summarizes 12 studies of programs that distribute ("take-home naloxone") or prescribe opioid antagonists to patients at the time of discharge from the emergency department or hospital following treatment for opioid overdose.[77] Although the programs contained many different components, naloxone distribution was widely accepted by adults and children in these studies. Naloxone kits were used more than 90 000 times over a 4-year period to reverse opioid overdoses in British Columbia.[78] In a US emergency medical services–based study, 24 000 adults and children received layperson-administered naloxone over a 2-year period.[79] Observational studies show that community-based naloxone distribution programs are associated with lower opioid overdose death rates and are cost-effective.[80,81]

Recommendation-Specific Supportive Text

1 and 2. Adults and children who survive opioid overdose are at high risk of subsequent fatal overdose.[82–85] The highest risk period is the first several days after the initial overdose, and the risk of overdose mortality remains high for at least a year. A 2016 systematic review found that take-home naloxone programs align with the Bradford Hill viewpoints for causality between exposure (opioid antagonist distribution) and outcome (reduced opioid overdose mortality).[86] In those studies that reported the age of participants, the majority of participants were adults. Pediatric recommendations are, therefore, extrapolated from adult data.

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TOXICOLOGY: ORGANOPHOSPHATES AND CARBAMATES

Recommendations for Adults and Children With Life-Threatening Organophosphate or Carbamate Poisoning

COR	LOE	Recommendations
1	A	1. Atropine should be administered immediately for adults and children with life-threatening organophosphate or carbamate poisoning.
1	C-LD	2. Early endotracheal intubation is recommended for adults with life-threatening organophosphate or carbamate poisoning.
1	C-EO	3. Early endotracheal intubation is recommended for children with life-threatening organophosphate or carbamate poisoning.
1	C-EO	4. Benzodiazepines should be administered to treat seizures and agitation for adults and children with life-threatening organophosphate or carbamate poisoning.
1	C-EO	5. Use of appropriate PPE is recommended when caring for adults and children with life-threatening organophosphate or carbamate exposure.
1	C-EO	6. Dermal decontamination for external organophosphate or carbamate exposure is recommended for adults and children with life-threatening organophosphate or carbamate exposure.
2a	A	7. For adults with life-threatening organophosphate poisoning, the use of pralidoxime is reasonable.
2a	B-R	8. For children with life-threatening organophosphate poisoning, the use of pralidoxime is reasonable.
3: No Benefit	C-EO	9. Use of neuromuscular blockers metabolized by cholinesterase (eg, succinylcholine and mivacurium) is not recommended for adults and children with life-threatening organophosphate or carbamate poisoning.

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Synopsis

Organophosphates and carbamates—found in pesticides, nerve agents, and some medications—inhibit acetylcholinesterase, resulting in muscarinic and nicotinic toxicity. They produce parasympathetic excess (bradycardia, bronchorrhea, bronchospasm, diaphoresis, diarrhea, hypersalivation, lacrimation, miosis, urination, vomiting), nicotinic excess (mydriasis, tachycardia, muscle fasciculations progressing to depolarizing neuromuscular blockade and paralysis), and CNS effects (altered mental status, central apnea, seizures).

Early and effective treatment may prevent deterioration to respiratory and cardiac arrest. Treatments include decontamination, atropine, benzodiazepines, and oximes.[1]

Atropine blocks parasympathetic overstimulation, mitigating bronchorrhea, bradycardia, bronchospasm, and CNS effects. Atropine does not block acetylcholine excess at the neuromuscular junction or nicotinic ganglia and, therefore, does not reverse paralysis. When administered early, oximes reactivate the acetylcholinesterase enzyme, reversing nicotinic effects to slowly improve respiratory and skeletal muscle strength, although this effect may be organophosphate specific.[2–5] Hemoperfusion or adsorption for organophosphate poisoning has been evaluated but is not available in North America.[6]

The evidence for the treatment of cholinesterase poisoning primarily involves adults and children with organophosphate poisoning. The basis for the treatment of patients with life-threatening carbamate poisoning is extrapolated from the limited evidence for carbamate poisoning and indirectly from evidence for organophosphate poisoning.

These recommendations inform the management of adults and children with life-threatening organophosphate or carbamate poisoning, including cardiac arrest.

Recommendation-Specific Supportive Text

1. For adults and children with life-threatening organophosphate or carbamate poisoning including cardiac arrest, bradycardia, hypotension, bronchorrhea, or bronchospasm, early atropine administration improved survival in 1 clinical trial.[7] Much larger doses of atropine are often required for this indication than for typical bradycardia (Table 4). The initial dose is doubled every 5 minutes until full atropinization is achieved (clear chest on auscultation; heart rate >80/min; systolic blood pressure >80 mm Hg). Maintenance of atropinization can be achieved by an atropine infusion (Table 4).[7]

2 and 3. Observational data, mostly in adults, show that patients who are intubated early in the course of organophosphate or carbamate poisoning have shorter durations of intubation than those who are intubated later in their course.[8,9] Whether this is due to prevention of aspiration pneumonia, differences in pathophysiology of respiratory failure, or some other cause is not known. Minimal pediatric data on airway management with organophosphate or carbamate poisoning were identified; thus, the recommendation for children is extrapolated from adult data.

4. Benzodiazepines, such as diazepam (first line) or midazolam, have demonstrated efficacy for treating organophosphate or carbamate-induced seizures and agitation in adults and children, and they effectively manage organophosphate-induced status epilepticus and mitigate neuronal injury in animal models.[10,11]
5. Health care professionals not wearing appropriate PPE have developed symptoms consistent with organophosphate exposure after being in close contact with adults and children poisoned by organophosphates, including patients with respiratory and dermal exposures only.[12–15] Appropriate health care professional PPE depends on the circumstances of the organophosphate exposure and potency of the involved organophosphate.
6. Dermal decontamination through removal of contaminated clothing and copious irrigation with soap and water performed by people wearing protective barriers is effective at preventing further absorption and prevents contamination of caregivers and the care environment.[1]

7 and 8. Metanalysis of 3 RCTs of primarily adults with organophosphate poisoning treated with oximes versus placebo did not find a mortality benefit. The 3 studies were heterogenous, used lower doses of pralidoxime, and all had risks of biases.[16] Two high-dose versus low-dose pralidoxime RCTs of primarily adults with moderate to severe organophosphate poisoning favored the high-dose groups with greater survival, lower rates of pneumonia, and lower mean atropine doses (see Table 4 for dosing information).[17] These findings are consistent with pralidoxime-induced protection with and without atropine against lethality in a rodent model of organophosphate poisoning.[18] Oximes are not universally effective; their effectiveness may be limited by rapid aging of some organophosphates (eg, tabun), their inability to cross the blood-brain barrier, structural differences among organophosphates, and rapid reinactivation of regenerated acetylcholinesterase in the presence of poison.[4,5] Although the available data are not sufficient to support

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a recommendation for or against oxime use in carbamate poisoning, oximes should not be withheld in cases of cholinesterase poisoning when the class of poison is unknown. A limited number of children were included in the RCTs of pralidoximes for organophosphate poisoning, thus, the recommendation for children is extrapolated from the adult data.

9. Neuromuscular blockade from medications metabolized by butyrylcholinesterase (pseudocholinesterase), such as succinylcholine and mivacurium, can be prolonged by several hours in the context of organophosphate or carbamate poisoning in adult and pediatric cases.[19–21] Other aminosteroid (eg, rocuronium, vecuronium) and benzylisoquinolinium (eg, atracurium, cisatracurium) neuromuscular blockers are not primarily metabolized by cholinesterases.

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TOXICOLOGY: SODIUM CHANNEL BLOCKERS

Recommendations for Adults and Children With Life-Threatening Sodium Channel Blocker Poisoning		
COR	**LOE**	**Recommendations**
1	B-NR	1. Sodium bicarbonate should be used to treat adults with life-threatening cardiotoxicity from tricyclic and tetracyclic antidepressant poisoning.
2a	C-LD	2. It is reasonable to use sodium bicarbonate to treat children with life-threatening cardiotoxicity from tricyclic and tetracyclic antidepressant poisoning.
2a	C-LD	3. It is reasonable to use hyperventilation in combination with sodium bicarbonate for mechanically ventilated adults and children with life-threatening sodium channel blocker poisoning.
2a	C-EO	4. It is reasonable to use ECLS in adults and children with refractory cardiogenic shock from life-threatening sodium channel blocker poisoning.
2a	C-EO	5. It is reasonable to use sodium bicarbonate to treat adults and children with life-threatening cardiotoxicity caused by poisoning from sodium channel blockers other than tricyclic and tetracyclic antidepressants.
2b	C-EO	6. It may be reasonable to use Vaughan-Williams class Ib antiarrhythmics (eg, lidocaine) to treat adults and children with life-threatening cardiotoxicity from class Ia or Ic sodium channel blockers.
2b	C-EO	7. It may be reasonable to use ILE to treat adults and children with life-threatening sodium channel blocker poisoning refractory to other treatment modalities.

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Synopsis

Many poisons block cardiac sodium channels with properties similar to Vaughan-Williams class Ia or Ic antiarrhythmics. Sodium channel blocker poisoning causes QRS prolongation, hypotension, seizures, ventricular arrhythmias, and cardiovascular collapse. Characteristic electrocardiogram changes usually precede ventricular arrhythmias in patients with sodium channel blocker poisoning. These include intraventricular conduction delay (QRS complex prolongation) and the development of a terminal rightward axis deviation, best appreciated in lead aVR (Figure 9). Many sodium channel blockers have additional effects on other cardiac receptors and ion channels.[1] Although poisoning from tricyclic antidepressants (TCAs) is best studied, many other poisons cause life-threatening sodium channel blockade.[2] Treatment recommendations for poisoning by other sodium channel blockers are often extrapolated from TCA studies. Management of life-threatening poisoning from local anesthetics, whose pharmacologic action is similar to class Ib antiarrhythmics, is discussed in the Toxicology: Local Anesthetics section. The treatment of cocaine poisoning, which has toxicity unique from other local anesthetics, is discussed in the Toxicology: Cocaine section. Management of chloroquine and hydroxychloroquine poisoning, which is unique, is outside the scope of these guidelines.

These recommendations inform the management of adults and children with life-threatening sodium channel blocker poisoning, including cardiac arrest.

Recommendation-Specific Supportive Text

1 and 2. Sodium loading and increasing the serum pH are each supported for the treatment of hypotension and arrhythmia from TCA poisoning by in vitro studies, animal studies, and case series and cohort studies of adults and children.[3–6] Administration of hypertonic sodium bicarbonate achieves both of these physiologic goals, though its mechanism is not fully elucidated. For dosing information, refer to Table 4. This practice is supported by case series in TCA poisoning, involving mostly adults.[4,5] Whether the target endpoints of initial hypertonic sodium bicarbonate bolus therapy should be biochemical (pH ≈7.50) or physiologic (resolution of hypotension and QRS prolongation) is debated.[3,7–9] After the goals of alkalinization are achieved, it is not known whether it is superior to monitor the patient and administer additional sodium bicarbonate boluses as needed or start a continuous infusion.[6] Experts recommend avoiding extremes of hypernatremia (serum sodium not to exceed 155 mEq/L) and alkalemia (serum pH not to exceed 7.55) to avoid iatrogenic harm.[3,6,10] If pH exceeds 7.55 and serum sodium is below 155 mEq/L, serum sodium can be increased by administration of hypertonic saline; if serum sodium exceeds 155 mEq/L and pH is below 7.55, pH can be

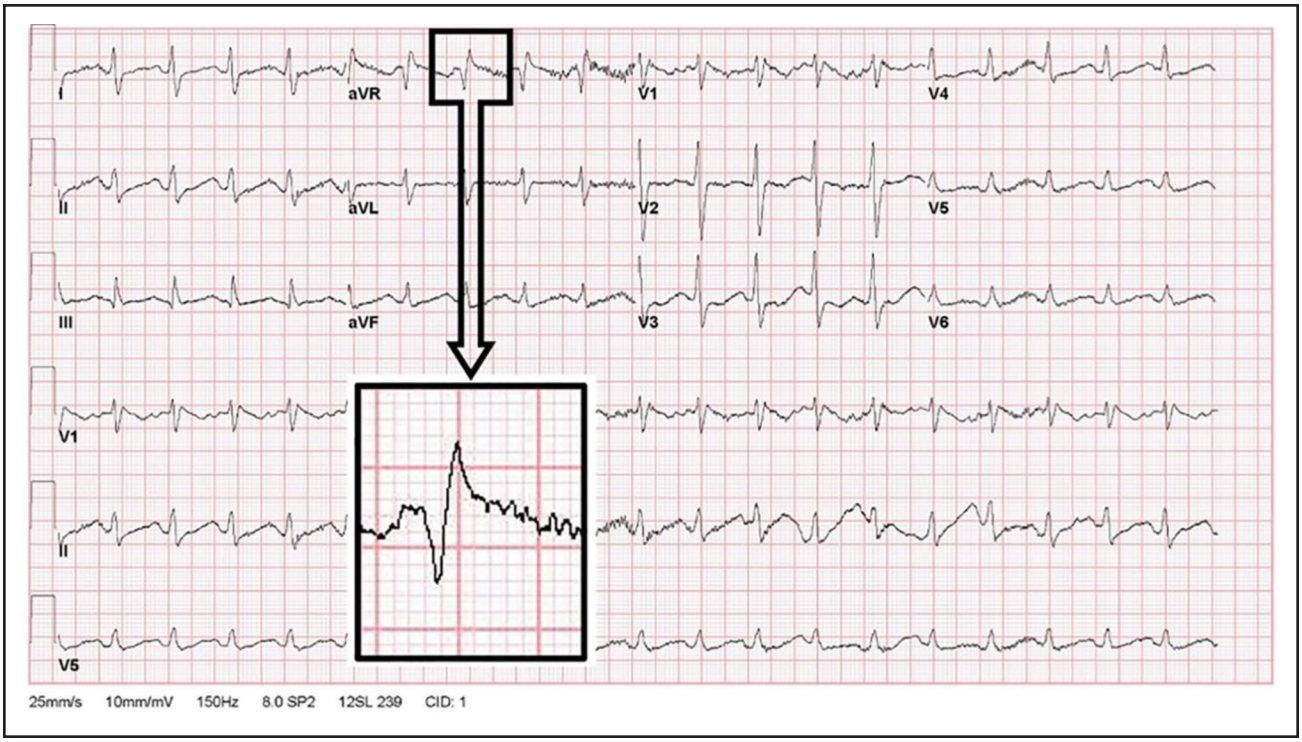

Figure 9. Sodium channel blocker electrocardiogram.
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controlled by adjusting minute ventilation in intubated adults and children.[5,11,12]

3. Observational data from adults and children (≥15 years of age) suggest that patients with tricyclic antidepressant poisoning who are treated with mechanical hyperventilation in addition to sodium bicarbonate may be more likely to achieve controlled alkalemia and correction of QRS prolongation compared with those receiving sodium bicarbonate alone.[5] The clinical threshold for intubation is unclear; in adults and children who are intubated, minute ventilation can be adjusted to achieve pH targets.[5,11]
4. ECLS, including VA-ECMO, has been used successfully in adult cases with refractory cardiogenic shock from sodium channel blocker poisoning.[13–17] One retrospective cohort study comparing 14 poisoned adults (7 poisoned by sodium channel blockers) treated with ECLS with 48 poisoned adults (14 poisoned by sodium channel blockers) with conventional therapies found that ECLS was associated with a lower mortality rate in the overall cohorts.[18] The study did not have a subgroup analysis of only sodium channel blocker poisoning. There is a single case report of a child with cardiac arrest secondary to TCA poisoning who was successfully treated with VA-ECMO.[19] No controlled observational studies or clinical trials were identified. Further discussion of the use of VA-ECMO in poisoning is provided in the Toxicology: ECMO section.
5. The use of sodium bicarbonate to treat sodium channel blocker poisoning other than from TCAs is based on case reports of adult poisoning by other sodium channel blockers.[3,20–23] No pediatric data were identified, thus, the recommendation for children is extrapolated from the adult data. For dosing information in adults and children, refer to Table 4.
6. Lidocaine, a class Ib antidysrhythmic, competes with Ia and Ic antiarrhythmics for binding at the sodium channel. Class Ib antiarrhythmics dissociate from the receptor more rapidly than Ia or Ic agents, such as TCAs, and, therefore, do not depress phase 0 depolarization.[24] The use of lidocaine to treat wide-complex tachycardia from TCA overdose is supported by animal studies and case reports of adults and children.[24] A similar role for phenytoin, another class Ib antiarrhythmic, is supported by adult case reports, though not consistently by animal studies.[24–27]
7. Most sodium channel blockers are highly lipophilic. Several case reports in adults and children describe temporal improvement following ILE administration, including successful treatment of TCA-induced cardiac arrest.[28–37] However, an RCT published in abstract form only found no benefit from ILE administration in treatment of hypotension or electrocardiogram abnormalities from TCA poisoning.[38] The administration of ILE may increase drug absorption in oral overdose in an animal model, and results of animal studies are inconsistent.[39–43] Nonetheless, existing evidence-based recommendations suggest ILE administration after failure of standard therapies for life-threatening amitriptyline poisoning, particularly if VA-ECMO or other forms of mechanical circulatory support are not readily available.[44]

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TOXICOLOGY: SYMPATHOMIMETICS

Introduction

The hallmark of sympathomimetic poisoning is increased activity of the adrenergic nervous system. Amphetamines, cathinones, and some synthetic cannabinoids produce sympathomimetic poisoning. Management of severe cocaine poisoning is discussed separately (refer to the Toxicology: Cocaine section). Complications of sympathomimetic poisoning result from excessive catecholamine release and an attendant increase in metabolic and psychomotor activity. Clinical manifestations include tachycardia, hypertension, agitation, seizures, hyperthermia, rhabdomyolysis, and acidosis.[1–4]

Sympathomimetic poisoning can cause sudden cardiac arrest, presenting as VF, VT, or PEA.[5–9] Vasospasm can cause myocardial infarction, even in patients with normal coronary arteries.[6,8,10,11] A stress (takotsubo) cardiomyopathy is also reported in sympathomimetic-poisoned patients; this condition can be fatal, but it resolves spontaneously in survivors.[10,12–15] Hyperthermia is a severe and rapidly life-threatening clinical manifestation.[3–5,16,17]

These recommendations inform the management of adults and children with life-threatening sympathomimetic poisoning, including cardiac arrest.

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Recommendations for Adults With Life-Threatening Sympathomimetic Poisoning		
COR	LOE	Recommendations
1	B-NR	1. Sedation is recommended for adults with severe agitation from sympathomimetic poisoning.
1	C-LD	2. Rapid external cooling with ice water immersion is recommended for adults with life-threatening hyperthermia (Core Temperature >40 °C [104 °F]) from sympathomimetic poisoning.
2a	C-EO	3. Vasodilators (eg, nitrates, phentolamine, CCBs) are reasonable for adults with coronary vasospasm from sympathomimetic poisoning.
2a	C-EO	4. It is reasonable to use ECLS in adults with cardiogenic shock from sympathomimetic poisoning refractory to other treatment measures.
2b	C-LD	5. The usefulness of dantrolene is uncertain for adults with life-threatening hyperthermia from MDMA toxicity.
3: Harm	C-LD	6. Prolonged use of physical restraint without sedation for adults is potentially harmful.

Recommendation-Specific Supportive Text

1. Sedatives (eg, benzodiazepines, antipsychotics) have been used in animal experiments to treat sympathomimetic poisoning.[18,19] Sedatives control psychomotor agitation that produces heat and rhabdomyolysis. Antipsychotics control agitation. Benzodiazepines mitigate agitation, relax muscles, and treat seizures. Although several adult clinical trials compare specific therapies for severe psychomotor agitation, it is difficult to separate patients with sympathomimetic poisoning from other patients in these studies, and cardiac arrest was rare.[20–24]
2. Hyperthermia (Core Temperature >40 °C [104 °F]) is rapidly life-threatening in sympathomimetic poisoning.[25] External and immersive cooling has been used to treat hyperthermia in adults and a 17-year-old patient with sympathomimetic poisoning.[5,26–28] Evaporative or immersive cooling modalities reduce temperature more rapidly in adults than cooling blankets, the application of cold packs, or endovascular cooling devices.[29–33] Ice water immersion resulted in the fastest cooling rates in adults and critically may cool faster than 0.15 °C/min (0.27 °F/min), which has been associated with increased survival.[34,35] High-quality data on cooling measures for hyperthermic sympathomimetic patients are lacking, but immersion seems effective (refer to the Hyperthermia section).[28]
3. Vasodilators, including alpha-adrenergic receptor antagonists, CCBs, and nitrates, have been used to treat coronary vasospasm, reversing electrocardiographic and biochemical markers of ischemia in sympathomimetic-poisoned adults.[36–38]
4. ECLS, including VA-ECMO and intra-aortic balloon pump, has been used successfully to support cardiac output in adults in cardiogenic shock while stress cardiomyopathy resolves.[10,13,39,40] Stress (takotsubo) cardiomyopathy can be fatal, but it often spontaneously resolves in days to weeks with circulatory support.
5. Data on dantrolene for MDMA-induced hyperthermia is conflicting. A meta-analysis of patients aged ≥15 years only identified case reports and series totaling 71 cases and found that dantrolene use was associated with improved survival, but a nonrandomized series of 9 adults with MDMA-induced hyperthermia did not find clinical differences between patients who received dantrolene and those who did not.[41,42]
6. Although physical restraints may be necessary temporarily, their sustained use without effective sedation is associated with death in adults with severe agitation from exposure to cocaine and other sympathomimetics.[37,43–45]

Recommendations for Children With Life-Threatening Sympathomimetic Poisoning		
COR	LOE	Recommendations
1	C-EO	1. Sedation is recommended for children with severe agitation from sympathomimetic poisoning.
1	C-EO	2. Rapid external cooling with ice water immersion is recommended for children with life-threatening hyperthermia (Core Temperature >40 °C [104 °F]) from sympathomimetic poisoning.
2a	C-EO	3. Vasodilators (eg, nitrates, phentolamine, CCBs) are reasonable for children with coronary vasospasm from sympathomimetic poisoning.
2a	C-EO	4. It is reasonable to use ECLS in children with cardiogenic shock from sympathomimetic poisoning refractory to other treatment measures.
2b	C-EO	5. The usefulness of dantrolene is uncertain for children with life-threatening hyperthermia from MDMA toxicity.
3: Harm	C-EO	6. Prolonged use of physical restraint without sedation for children is potentially harmful.

Recommendation-Specific Supportive Text

1. Sedatives (eg, benzodiazepines, antipsychotics) have been used in animal experiments to treat sympathomimetic poisoning.[18,19] Sedatives control psychomotor agitation that produces heat and rhabdomyolysis. Antipsychotics control agitation. Benzodiazepines mitigate agitation, relax muscles, and treat seizures. Although several adult clinical trials compare specific therapies for severe psychomotor agitation, it is difficult to separate patients with sympathomimetic poisoning from other patients in these studies, and cardiac arrest was rare.[20–24] No high-quality pediatric data on the sedatives for sympathomimetic were identified, thus, the recommendation for children is extrapolated from the adult data.
2. Hyperthermia (Core Temperature >40 °C [104 °F]) is rapidly life-threatening in sympathomimetic

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poisoning.[25] External and immersive cooling has been used to treat hyperthermia in adults and a 17-year-old patient with sympathomimetic poisoning.[5,27,28] Evaporative or immersive cooling modalities reduce temperature more rapidly in adults than cooling blankets, the application of cold packs, or endovascular cooling devices.[29–33] Ice water immersion resulted in the fastest cooling rates in adults and critically may cool faster than 0.15 °C/min (0.27 °F/min), which has been associated with increased survival.[34,35] High-quality data on cooling measures for hyperthermic sympathomimetic patients are lacking, but immersion seems effective.[28] Limited pediatric data on the rapid external cooling for life-threatening sympathomimetic poisoning were identified, thus, the recommendation for children is extrapolated primarily from the adult data (refer to the Hyperthermia section).

3. Vasodilators, including alpha-adrenergic receptor antagonists, CCBs, and nitrates, have been used to treat coronary vasospasm, reversing electrocardiographic and biochemical markers of ischemia in sympathomimetic-poisoned adults.[36–38] No pediatric data on the use of vasodilators for life-threatening sympathomimetic poisoning were identified, thus, the recommendation for children is extrapolated from the adult data.
4. ECLS, including VA-ECMO and intra-aortic balloon pump, has been used successfully to support cardiac output in adults in cardiogenic shock while stress cardiomyopathy resolves.[10,13,39,40] Stress (takotsubo) cardiomyopathy can be fatal, but it often spontaneously resolves in days to weeks with circulatory support. No pediatric data on the use of ECLS for life-threatening sympathomimetic poisoning were identified, thus, the recommendation for children is extrapolated from the adult data.
5. Data on dantrolene for MDMA-induced hyperthermia is conflicting. A meta-analysis of patients aged ≥15 years only identified case reports and series totaling 71 cases and found that dantrolene use was associated with improved survival, but a nonrandomized series of 9 adults with MDMA-induced hyperthermia did not find clinical differences between patients who received dantrolene and those who did not.[41,42] Limited pediatric data on the use of dantrolene to treat life-threatening sympathomimetic poisoning were identified, thus, the recommendation for children is extrapolated primarily from the adult data.
6. Although physical restraints may be necessary temporarily, their sustained use without effective sedation is associated with death in adults with severe agitation from exposure to cocaine and other sympathomimetics.[37,43–45] No pediatric data on the use of physical restraint for life-threatening sympathomimetic poisoning were identified, thus, the recommendation for children is extrapolated from the adult data.

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TOXICOLOGY: VOLATILES

Recommendation for Adults and Children With Life-Threatening Poisoning Following Volatile Hydrocarbon Exposure		
COR	**LOE**	**Recommendation**
2b	**C-EO**	1. It may be reasonable to use β-adrenergic antagonists for adults and children with ventricular arrhythmias refractory to standard therapy.

Synopsis

Cardiac arrest following volatile hydrocarbon use has been termed *sudden sniffing death*.[1] While the exact mechanism is unknown, in vitro and animal experiments suggest that hydrocarbons sensitize cardiac potassium, sodium, and calcium channels.[2–5] Hypoxia, catecholamine surge, or hypocalcemia (from fluorinated hydrocarbons) may also contribute to lethal arrhythmias. Animals treated with chloroform, a nonhydrocarbon volatile, have enhanced sensitivity to epinephrine, which led to death in some animals.[6,7] In a large case series, sudden death was frequently reported following exertion or a stressful situation.[1]

This recommendation informs the management of adults and children with life-threatening arrhythmias from volatile hydrocarbon exposure, including cardiac arrest.

Recommendation-Specific Supportive Text

1. β-adrenergic antagonists decrease myocardial sensitivity to epinephrine. Several case reports describe resuscitation with a β-adrenergic antagonist for cardiac arrest from volatile hydrocarbons. A 23-year-old patient suffered pulseless VT cardiac arrest following inhalation of 1,1-difluoroethane. In addition to amiodarone and defibrillation, recurrent VT was successfully treated with calcium, dexmedetomidine, esmolol, and cardiac bypass.[8] Another adult case report described myocardial

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infarction and VT after inhalation of a keyboard cleaner containing difluoroethane. Despite amiodarone, lidocaine, and metoprolol, the patient died of refractory cardiogenic shock.[9] The use of β-adrenergic antagonists is further supported by the extrapolation of data from withholding epinephrine. In a case series of 22 patients aged ≥13 years with cardiac arrest from volatile hydrocarbons, none of the 8 patients receiving epinephrine survived, while 5 of the 6 patients who did not receive epinephrine survived with good neurological outcome.[10]

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TOXICOLOGY: ECMO

Recommendations for the Use of VA-ECMO in Adults and Children With Life-Threatening Poisoning		
COR	**LOE**	**Recommendations**
2a	**B-NR**	1. It is reasonable to use VA-ECMO in adults and children with persistent cardiogenic shock or cardiac arrest due to poisoning that is refractory to pharmacological interventions.
2a	**C-EO**	2. It is reasonable to use VA-ECMO in adults and children with persistent arrhythmias due to poisoning when other treatments fail.
2b	**C-LD**	3. For adults and children with life-threatening poisoning, the effectiveness of VA-ECMO for poisoned patients with cardiovascular collapse from causes other than cardiogenic shock or arrhythmia has not been established.

Synopsis

VA-ECMO is a resuscitative measure providing both cardiac and pulmonary support.[1] In the setting of poisoning, VA-ECMO treats refractory cardiogenic shock by providing mechanical circulatory support while the offending poison is eliminated. The use of VA-ECMO in both poisoned adults and children is limited by availability, logistics of transport, patient comorbidities, and risks inherent to the procedure. Decisions to initiate VA-ECMO involve the understanding of both the pathophysiology of the specific poisoning and the clinical features of the patient and may include consultation from a poison center or medical toxicologist.

Other forms of mechanical circulatory support, such as implanted LVADs and percutaneous mechanical circulatory support devices (eg, intra-aortic balloon pump) are beyond the scope of this recommendation.

These recommendations inform the management of adults and children with life-threatening poisoning, including cardiac arrest.

Recommendation-Specific Supportive Text

1. In a retrospective cohort study of 64 adults treated with VA-ECMO for cardiac arrest or refractory shock regardless of cause, cardiotoxic poisoning was independently associated with survival.[2] A nonrandomized observational study of adults in cardiac arrest due to poisoning treated with VA-ECMO showed lower mortality than other patients treated with VA-ECMO and lower mortality compared with poisoned patients treated with standard critical care and antidotal therapy alone.[3] In a prospective observational study of 32 adults placed on VA-ECMO to treat cardiogenic shock or refractory cardiac arrest from poisoning, 78% of patients survived to hospital discharge.[4] A review of 407 patients with poisoning treated with either VA-ECMO or venovenous ECMO reported to the National Poison Data System included 75 patients <12 years of age and found similar mortality rates for adults and children (29.5% versus 32.0%, respectively).[5] Significant complications with VA-ECMO treatment include limb ischemia, bleeding, stroke, and infection.[1,4,6] Studies have reported complications of VA-ECMO following administration of lipid emulsion therapy, including cracking of stopcocks, clogging and malfunction of the membrane oxygenator, and increased blood clot and lipid aggregation in the circuits.[7,8] However, multiple case reports reported successful treatment with VA-ECMO concurrent with lipid emulsion therapy.[8,9]
2. For adults and children with persistent nonperfusing arrhythmias, VA-ECMO provides antegrade blood flow to allow poison elimination. Case reports

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describe neurologically intact survival with the use of VA-ECMO to support adult cases of poisoning with persistent arrhythmias.[10–13] One adult case resulted in return to normal sinus rhythm, but the patient subsequently suffered multisystem organ failure.[14] Similar to adults, there are case series and case reports of the use of VA-ECMO to treat children with persistent arrhythmias following poisoning.[15,16]

3. The mortality benefit of VA-ECMO is mixed in poisonings that cause refractory vasodilatory shock with preserved cardiac function, direct cellular toxicity, disruption of cellular oxygen use, or poisonings that are almost universally fatal despite temporary cardiac support. One retrospective registry study of patients reported to the National Poison Data System, including 75 children <12 years of age, showed that patients with hematological and metabolic poisons had higher mortality on ECMO compared with patients with other poisonings; however, this study was unable to determine the mode of ECMO utilized.[5] In contrast, in 1 retrospective case series, 80% of children <18 years of age who were treated with VA-ECMO (with or without continuous kidney replacement therapy) for vasodilatory shock from poisoning survived.[17] Similarly, multiple case reports have demonstrated mortality benefit of VA-ECMO for adults with cardiogenic shock, hypotension, and arrhythmias in the setting of aluminum phosphide poisoning, a pesticide and rodenticide that when exposed to water produces phosphine gas, a direct cellular toxin that causes depression of myocardial contractility and ventricular arrhythmias.[18] The pathophysiology of these poisons is not expected to differ significantly between adults and children, including aluminum phosphide.

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KNOWLEDGE GAPS AND PRIORITIES OF RESEARCH

Cardiac arrest and life-threatening states due to special circumstances are vastly under-researched. As part of the overall work for the development of these guidelines, the writing group reviewed a large amount of literature concerning the management of cardiac arrest and life-threatening states due to special circumstances. One expected challenge faced through this process was the lack of data in many areas. With some exceptions, cardiac arrests due to special circumstances are rare events and challenging to study. As a result, only the majority of guideline recommendations were based on low-grade evidence (LOE C).

Some critical knowledge gaps identified by the writing group are summarized in Table 5.

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Table 5. 2025 Adult and Pediatric Special Circumstances of Resuscitation Key Knowledge Gaps

Alternative CPR
Are there situations when a precordial thump can be used safely in adults and children in cardiac arrest in a well-monitored setting when a defibrillator is not immediately available?
Is percussion pacing more effective than transcutaneous pacing in adults and children with witnessed, monitored, in-hospital onset of asystole or a nonperfusing bradyarrhythmia before loss of consciousness?
Can cough CPR effectively prevent cardiac arrest after the onset of a hemodynamically significant arrhythmia before loss of consciousness in the out-of-hospital setting?
In which circumstances does interposed abdominal compression enhance the effectiveness of CPR in adults and children?
Anaphylaxis
Does early administration of epinephrine in adults and children offer benefit over standard ALS support protocols in shockable rhythms from anaphylaxis?
Does a higher dose of epinephrine, such as 5 mg administered intramuscularly in adults, confer benefit in cardiac arrest from anaphylaxis?
Do escalating doses of intravenous epinephrine in adults and children improve outcomes?
Asthma
What is the optimal timing of ECLS in adults and children with life-threatening asthma?
For adults and children in cardiac arrest, what is the benefit of active exhalation maneuvers?
What is the optimal timing of the addition of volatile anesthetics to the treatment of adults and children with life-threatening asthma?
Cardiac intervention laboratory
What interventions to treat adult cardiac arrest in the cardiac intervention laboratory are beneficial in RCTs?
Is there a survival benefit to immediate rapid defibrillation for shockable rhythms (prior to chest compressions) for adult cardiac arrest in the cardiac intervention laboratory?
Is there harm if chest compressions or CPR for adults in cardiac arrest in the cardiac intervention laboratory are paused during arrest to perform a corrective procedure (eg, pericardiocentesis)?
Which adults in cardiac arrest in the cardiac intervention laboratory are most likely to benefit from ECLS?
Is the use of intracoronary epinephrine to treat adult cardiac arrest in the cardiac intervention laboratory beneficial?
Cardiac surgery
What is the benefit to 3 stacked shocks in VF in adults after cardiac surgery compared with standard ALS?
What is the incidence of capture from pacing asystole or bradycardia with temporary wires in adults and children in the immediate postoperative period?
Drowning
Are untrained lay rescuers competent to distinguish respiratory arrest from cardiac arrest for adults and children following drowning?
Are lifeguards competent to use bag-mask or supraglottic ventilation for adults or children following drowning?
What is the competency level of different types of rescuers to perform in-water breathing following drowning?
What is the competency and associated training required of lifeguards to perform resuscitation in cardiac arrest following drowning on rescue crafts (eg, surfboards, stand-up paddleboards, personal watercrafts, boats)?
What is the outcome of resuscitation for adults and children in cardiac arrest following drowning in areas with and without trained lay rescuers (eg, lifeguards)?
How does resuscitation with and without oxygen affect the outcomes for adults and children in cardiac arrest following drowning?
How does resuscitation using airway-breathing-circulation versus circulation-airway-breathing affect outcomes for adults and children in cardiac arrest following drowning?
How does the use of an AED in the early stage versus in a later stage of the resuscitation affect outcomes for adults and children in cardiac arrest following drowning?
Does the use of oxygen during transport of a drowned adult or child to the hospital improve outcomes?
What is the outcome of different airway techniques (endotracheal intubation, supraglottic airway, bag-mask ventilation, noninvasive ventilation) during transport of a drowned adult or child to the hospital?
How does ECPR for adults and children in cardiac arrest following drowning affect outcomes?
Does targeted temperature management during or after resuscitation improve neurological outcomes for adults and children in cardiac arrest following drowning?
Does admission to a drowning center versus other health facilities (eg, regionalization of the treatment of drowned persons) affect outcomes in cardiac arrest following drowning?
Is drying the chest before using an AED on a drowned adult or child necessary for safe defibrillation? Does drying the chest affect defibrillation success?
Electrocution
What is the ideal resuscitation management for a given type of electrical injury in adults and children?
Is antiarrhythmic therapy earlier in the resuscitation of adults and children in cardiac arrest after electrocution beneficial?

(*Continued*)

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Table 5. Continued

Gas embolism
Does supplemental oxygen benefit adults and children after gas embolism?
High-consequence respiratory pathogens
How can teams mitigate the effects of PPE on resuscitation team performance and health care professional fatigue?
What factors contribute to PPE noncompliance, and how can these be addressed without compromising team performance?
How do we support lay rescuers in providing CPR and AED application in the safest way possible during a pandemic with a high-consequence respiratory pathogen?
Hyperkalemia
What is the benefit/harm of calcium in treatment of adults and children in cardiac arrest from hyperkalemia?
What is the benefit/harm of sodium bicarbonate in treatment of adults and children in cardiac arrest from hyperkalemia?
Hyperthermia
What is the survival benefit of cooling for adults and children in cardiac arrest from hyperthermia?
What is the survival benefit of the various types of cooling systems for adults and children in cardiac arrest from hyperthermia?
Hypothermia
In adults and children in cardiac arrest due to environmental hypothermia, what is the optimal temperature to rewarm to prior to defibrillation and administration of epinephrine?
Are there circumstances in which CPR can be safely delayed in adults and children in cardiac arrest due to environmental hypothermia until rewarming is initiated?
What is the best prognostication score or variable in children in cardiac arrest due to environmental hypothermia?
What is the farthest distance that an adult or child in cardiac arrest due to environmental hypothermia should be transported in order to utilize ECLS for rewarming?
Left ventricular assist device
What is the best method to confirm cardiac arrest in an adult or child with an LVAD?
What is the best sequence for resuscitation of an adult or child with an LVAD when a single rescuer is present (eg, prioritizing chest compressions versus assessing and restarting LVAD function)?
What is the role of ECLS in an adult or child with an LVAD with sustained cardiac arrest?
Is there a period of time from known LVAD stoppage after which it should not be restarted due to risk of thrombosis?
Pregnancy
What is the optimal management of cardiac arrest during pregnancy?
What are the survival benefits of airway management techniques in cardiac arrest in pregnancy, including placement of advanced airway, intubation, and use of video laryngoscopy?
What is the optimal management of out-of-hospital pregnancy cardiac arrest, especially when transport delays perimortem or resuscitative delivery?
For pregnant patients, who are the best candidates for ECLS to balance bleeding and clotting complications?
What is the optimal post–cardiac arrest care during pregnancy?
PE
What is the best diagnostic criteria for adults and children in cardiac arrest to suspect PE?
What is the optimal amount of time chest compressions should be continued after an adult or child receives systemic fibrinolytics?
Should there be monitoring of fibrin activity or other laboratory markers of fibrinolysis after receiving fibrinolytics to ensure the treatment has been effective?
Benzodiazepines
For which adults and children does the benefit of flumazenil exceed the risk of seizure?
β-Blockers and CCBs
Does high-dose insulin therapy, administered in addition to or instead of standard vasopressors, reduce mortality or ischemic complications of adults and children with life-threatening β-blocker or CCB poisoning?
What is the ideal vasopressor or inotropic strategy for adults and children in refractory shock from β-blocker or CCB overdose? Does tailoring therapy to cardiogenic versus vasoplegic shock improve outcomes? Are nonadrenergic vasopressors effective?
What are the benefits of glucagon for adults and children with life-threatening β-blocker or CCB poisoning?
What is the mortality benefit of hemodialysis for adults and children with life-threatening atenolol, sotalol, or nadolol poisoning?
What are the benefits of ILE for adults and children after oral overdose of lipophilic β-blockers or CCBs?
What are the benefits of gastrointestinal decontamination for adults and children with life-threatening β-blocker or CCB poisoning, particularly when extended-release formulations are involved?

(*Continued*)

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Table 5. Continued

Cocaine
What is the ideal management of cocaine-induced myocardial ischemia, hypertensive emergency, or arrhythmia?
Cyanide
Does the addition of sodium thiosulfate to either hydroxocobalamin or sodium nitrite therapy improve outcomes of adults and children with life-threatening cyanide poisoning?
Is there a carbon monoxide level for which sodium nitrite therapy is appropriate for adults and children with life-threatening cyanide poisoning?
Should adults and children with cyanide ingestion be treated differently than patients with hydrogen cyanide gas exposure?
Is there a role for VA-ECMO for adults and children with persistent shock from cyanide poisoning?
Digoxin
What is the best empirical dose of digoxin-Fab for adults and children in cardiac arrest from digoxin poisoning?
What is the appropriate dose of digoxin-Fab for adults and children in critical poisoning from cardiac glycosides other than digoxin?
Local anesthetics
What is the benefit of ILE when given in addition to standard resuscitation with vasopressors and sodium bicarbonate for adults and children with life-threatening local anesthetic cardiotoxicity?
What is the ideal dose of ILE for adults and children with life-threatening local anesthetic poisoning?
Is the optimal treatment for adults and children with life-threatening poisoning from other local anesthetics the same as for poisoning from bupivacaine?
Methemoglobinemia
What is the true risk of methylene blue therapy in adults and children with glucose-6-phosphate dehydrogenase deficiency?
How does methylene blue benefit adults and children in cardiac arrest from methemoglobinemia?
Opioids
What is the ideal initial dose of naloxone for adults and children with life-threatening opioid poisoning in settings of high fentanyl and fentanyl analog prevalence?
What is the benefit of naloxone when given to adults and children in cardiac arrest with suspected opioid overdose?
What is the minimum safe observation period for patients with opioid overdose treated with naloxone?
In addition to “take-home naloxone,” what are the other effective forms of secondary prevention for adults and children with opioid use disorder who survive overdose?
Organophosphates and carbamates
What PPE and decontamination protocols are necessary to protect health care professionals caring for adults and children with organophosphate and carbamate exposures?
Which adults and children with life-threatening organophosphate poisoning benefit from oxime therapy?
What is the most effective oxime for adults and children with life-threatening organophosphate poisoning? What is the most appropriate dose of oximes?
Do adults and children with life-threatening poisoning from highly toxic carbamates (eg, aldicarb) benefit from oxime therapy?
Sodium channel blockers
What is the ideal treatment for adults and children with life-threatening poisoning from sodium channel blockers other than TCAs?
What physiological or electrocardiographic targets are most appropriate for adults and children with sodium channel blocker poisoning to prevent deterioration to cardiac arrest?
Sympathomimetics
What factors predict which adults and children with sympathomimetic poisoning will suddenly decompensate to cardiac arrest?
What is the ideal medication or combination of medications for sedation of adults and children with severe psychomotor agitation?
Volatiles
Are there other heart rate control medications that would portend better outcomes for adults and children with life-threatening poisoning following volatile hydrocarbon exposure?
Role of VA-ECMO in poisoning
Which adults and children with poisoning have improved outcomes from VA-ECMO compared with standard critical care plus antidotal therapy?
In what situations can VA-ECMO benefit adults and children with distributive shock or cellular injury from poisoning?
What is the optimal timing of VA-ECMO initiation for adults and children following poisoning? Are outcomes better when VA-ECMO is initiated in the peri-arrest period or earlier in the course of illness?

AED indicates automated external defibrillator; ALS, advanced life support; β-blockers, β-adrenergic receptor antagonists; CCBs, calcium channel blockers; CPR, cardiopulmonary resuscitation; Fab, fragment antigen binding; ECLS, extracorporeal life support; ECPR, extracorporeal cardiopulmonary resuscitation; ILE, intravenous lipid emulsion; LVAD, left ventricular assist device; PE, pulmonary embolism; PPE, personal protective equipment; RCT, randomized controlled trial; TCA, tricyclic antidepressant; VA-ECMO, venoarterial extracorporeal membrane oxygenation; and VF, ventricular fibrillation.

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Disclosures

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Carolyn M. Zelop	The Valley Hospital and NYU	AHA/MERCK*	None	None	None	None	UpToDate*	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix 2. Reviewer Disclosures

Reviewer	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
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Carl H. Rose	Mayo Clinic	None	None	None	None	None	None	None
Kelly N. Sawyer	University of Pittsburgh	None	None	None	None	None	None	None

This table represents the relationships of reviewers that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all reviewers are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Significant.

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Circulation

Part 11: Post–Cardiac Arrest Care: 2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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ABSTRACT: Cardiac arrest is common and deadly, affecting up to 700 000 people in the United States annually. Advanced cardiac life support measures are commonly employed to improve outcomes. This 2025 guideline on adult post–cardiac arrest care from the American Heart Association summarizes the most recent published evidence for and recommendations on several important areas of post–cardiac arrest management. Based on structured evidence reviews, guidelines are provided for initial blood pressure, oxygen, ventilation, and glucose goals. Evidence evaluating the routine use of antibiotics after return of spontaneous circulation is reviewed. The update also reviews diagnostic testing modalities, temperature control goals and duration, and the use of percutaneous coronary intervention and mechanical circulatory support in the patient resuscitated from cardiac arrest. New data regarding the detection and management of seizures have been incorporated, along with updates regarding the timing and modalities used in neuroprognostication. These guidelines now differentiate prognostication for favorable versus unfavorable outcome. New sections on the utility of advanced neuromonitoring, along with definitions and treatment options for myoclonus, are included to guide the clinician. Expanded recommendations regarding how to optimize survivorship for patients, caregivers, and rescuers are reviewed. Finally, the potential role of organ donation in the patient resuscitated from cardiac arrest is reviewed.

Key Words: AHA Scientific Statements ■ advanced cardiac life support ■ blood pressure ■ electroencephalography ■ heart arrest ■ hypothermia ■ percutaneous coronary intervention ■ survivorship

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TOP 10 TAKE-HOME MESSAGES FOR ADULT ADVANCED CARDIOVASCULAR LIFE SUPPORT

1. The section on neuroprognostication was updated to include predictors of favorable outcome, and neurofilament light chain (NfL) was added as a serum biomarker: When performed in combination with other prognostic tests, it may be reasonable to consider high serum values of neuron-specific enolase (NSE) or NfL within 72 hours after cardiac arrest to support the prognosis of unfavorable neurological outcome in patients who remain comatose.
2. It is reasonable that temperature control be maintained for at least 36 hours in adult patients who remain unresponsive to verbal commands after return of spontaneous circulation (ROSC).
3. It may be reasonable to perform computed tomography (CT) for adult patients after ROSC to investigate the etiology of cardiac arrest and complications from resuscitation, and it may be reasonable to perform echocardiography or point-of-care cardiac ultrasound for adult patients after ROSC to identify clinically significant diagnoses requiring intervention.
4. Coronary angiography is recommended prior to hospital discharge in adult cardiac arrest survivors

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with suspected cardiac etiology, particularly in the presence of an initial shockable rhythm, unexplained left ventricular systolic dysfunction, or evidence of severe myocardial ischemia.
5. Hypotension should be avoided in adults after ROSC by maintaining a minimum mean arterial pressure (MAP) of at least 65 mm Hg, though there is insufficient evidence to recommend a specific vasopressor to treat low blood pressure in adult patients after cardiac arrest.
6. In adult patients with cardiogenic shock (CS) after cardiac arrest and ROSC, temporary mechanical circulatory support (MCS) should not be routinely used, though in highly selected adult patients with refractory CS after cardiac arrest and ROSC, temporary MCS may be considered.
7. A new section dedicated to diagnosis and management of myoclonus after cardiac arrest was developed and includes the following: Treatment to suppress myoclonus without an electroencephalography (EEG) correlate is not recommended in adult survivors of cardiac arrest.
8. A therapeutic trial of a nonsedating antiseizure medication may be reasonable in adult patients who do not follow commands after ROSC with EEG patterns on the ictal-interictal continuum.
9. It is recommended that cardiac arrest survivors and their caregivers have structured assessment and treatment/referral for emotional distress after medical stabilization and before hospital discharge.
10. Interventions to address health care professional burnout may be beneficial.

INTRODUCTION

Scope of the Guidelines

This 2025 post–cardiac arrest care (PCAC) guideline from the American Heart Association (AHA) is based on the expert writing group review of the relevant International Liaison Committee on Resuscitation (ILCOR) Consensus on Science With Treatment Recommendations (CoSTR) documents and the studies included in the systematic reviews as well as new evidence updates conducted by the writing group. The writing group discussion and evidence reviews were conducted within the context of the clinical environments in which out-of-hospital and in-hospital resuscitations occur, with special consideration for the health care professionals who use these PCAC guidelines.

Organization of the Writing Group

The PCAC Focused Update Writing Group included a diverse group of experts with backgrounds in emergency medicine, neurocritical care, interventional and critical care cardiology, psychology, and pulmonary critical care. Group members were appointed by the AHA Emergency Cardiovascular Care Science Subcommittee and approved by the AHA Manuscript Oversight Committee. Writing group members were selected to represent diverse backgrounds in clinical medicine and research expertise as well as to form a group that was institutionally diverse.

The AHA has rigorous conflict of interest policies and procedures to minimize the risk of bias or improper influence during the development of guidelines. Before appointment, writing group members disclosed all relevant commercial relationships and other potential (including intellectual) conflicts. These procedures are described more fully in "Part 2: Evidence Evaluation and Guidelines Development" of the *2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care*.[1] Appendix 1 of this document lists the writing group members' relevant relationships with industry.

METHODOLOGY AND EVIDENCE REVIEW

The writing group members evaluated the current list of patient, intervention, comparison, and outcome questions included in current PCAC guidelines. Patient, intervention, comparison, and outcome questions with novel evidence were revisited by the writing group. For each targeted patient, intervention, comparison, and outcome question, writing group members created a search strategy or utilized a previously created ILCOR search strategy when available. Search strategies were internally peer reviewed. This search was executed in Medline and Excerpta Medica Database using the Ovid search interface and in the Cochrane Central Register of Controlled Trials. Final searches were executed in November 2024. Search results were not limited by language or year. Two writing group members performed dual screening of the titles and abstracts of all articles identified from each search and identified articles for full text review. Screening conflicts were resolved between the 2 writing group members and writing group leadership before full text review. Two writing group members reviewed the full text of all selected articles and applied the information contained to develop treatment recommendations appropriate for each clinical question. Each draft recommendation was created by a group of 2 or 3 writing group members and then reviewed and refined by all writing group members during regular virtual meetings. The final manuscript was reviewed and approved by all writing group members.

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Table 1. Applying American College of Cardiology/American Heart Association Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care (Updated December 2024)*

CLASS (STRENGTH) OF RECOMMENDATION

Class 1 (STRONG) — Benefit >>> Risk

Suggested phrases for writing recommendations:
- Is recommended
- Is indicated/useful/effective/beneficial
- Should be performed/administered/other
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is recommended/indicated in preference to treatment B
  - Treatment A should be chosen over treatment B

Class 2a (MODERATE) — Benefit >> Risk

Suggested phrases for writing recommendations:
- Is reasonable
- Can be useful/effective/beneficial
- Comparative-Effectiveness Phrases†:
  - Treatment/strategy A is probably recommended/indicated in preference to treatment B
  - It is reasonable to choose treatment A over treatment B

Class 2b (WEAK) — Benefit ≥ Risk

Suggested phrases for writing recommendations:
- May/might be reasonable
- May/might be considered
- Usefulness/effectiveness is unknown/unclear/uncertain or not well-established

Class 3: No Benefit (MODERATE) — Benefit = Risk (Generally, LOE A or B use only)

Suggested phrases for writing recommendations:
- Is not recommended
- Is not indicated/useful/effective/beneficial
- Should not be performed/administered/other

Class 3: HARM (STRONG) — Risk > Benefit

Suggested phrases for writing recommendations:
- Potentially harmful
- Causes harm
- Associated with excess morbidity/mortality
- Should not be performed/administered/other

LEVEL (QUALITY) OF EVIDENCE‡

Level A
- High-quality evidence‡ from more than 1 RCT
- Meta-analyses of high-quality RCTs
- One or more RCTs corroborated by high-quality registry studies

Level B-R (Randomized)
- Moderate-quality evidence‡ from 1 or more RCTs
- Meta-analyses of moderate-quality RCTs

Level B-NR (Nonrandomized)
- Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies
- Meta-analyses of such studies

Level C-LD (Limited Data)
- Randomized or nonrandomized observational or registry studies with limitations of design or execution
- Meta-analyses of such studies
- Physiological or mechanistic studies in human subjects

Level C-EO (Expert Opinion)
- Consensus of expert opinion based on clinical experience

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR 1 and 2a; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely-used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

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Class of Recommendation and Level of Evidence

As with all AHA guidelines, each recommendation in this focused update is assigned a Class of Recommendation (COR) based on the strength and consistency of the evidence, alternative treatment options, and the impact on patients and society (Table 1). The Level of Evidence (LOE) is based on the quality, quantity, relevance, and consistency of the available evidence. For each recommendation, the writing group discussed and approved specific recommendation wording and the COR and LOE assignments. In determining the COR, the writing group considered the LOE and other factors, including systems issues, economic factors, and ethical factors like equity, acceptability, and feasibility. These evidence-review methods, including specific criteria used to determine COR and LOE, are described more fully in "Part 2: Evidence Evaluation and Guidelines Development" of the 2025 guidelines.[1] The writing group members had final authority over and formally approved these recommendations.

Guideline Structure

The guidelines are organized into knowledge chunks, grouped into discrete modules of information on specific topics or management issues.[2] Each modular knowledge chunk includes a table of recommendations that uses standard AHA nomenclature of COR and LOE. A brief synopsis is provided to put the recommendations into context with important background information and overarching management or treatment concepts. Recommendation-specific supportive text clarifies the rationale and key study data supporting the recommendations. When appropriate, additional tables are included.

This 2025 document updates the recommendations for the use of MCS, vasopressor choice, ventilatory goals, coronary angiography and percutaneous coronary intervention (PCI), temperature control, seizure management (with a new section on postarrest myoclonus), and survivorship after cardiac arrest (Figure 1). This 2025 update is based on the evidence identified in systematic reviews performed by ILCOR and this writing group addressing novel data that has been published since the formal release of the 2020 AHA advanced life support guidelines for cardiopulmonary resuscitation and the 2023 AHA Focused Update on Adult Advanced Cardiovascular Life Support.[1,3]

Document Review and Approval

These guidelines were submitted for blinded peer review to 5 subject matter experts nominated by the AHA. Before appointment, all peer reviewers were required to disclose relationships with industry and any other conflicts of interest, and all disclosures were reviewed by AHA staff. Peer reviewer feedback was provided for guidelines in draft format and again in final format. All guidelines were reviewed and approved for publication by the AHA Science Advisory and Coordinating Committee and the AHA Executive Committee. Comprehensive disclosure information for peer reviewers is listed in Appendix 2.

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OXYGENATION TARGETS IN ADULT PATIENTS AFTER CARDIAC ARREST

Recommendations for Oxygenation Targets in Adult Patients After Cardiac Arrest		
COR	**LOE**	**Recommendations**
1	B-R	1. The use of 100% inspired oxygen is recommended until the arterial oxygen saturation (Spo_2) or the partial pressure of arterial oxygen (Pao_2) can be reliably measured in adult patients after ROSC.
1	B-NR	2. Hypoxemia should be avoided in adult patients after ROSC.
2a	B-R	3. Once reliable measurement of oxygen saturation is available, it is reasonable to avoid hyperoxemia and hypoxemia by titrating the fraction of inspired oxygen (Fio_2) to target oxygen saturation of 90% to 98% (Pao_2, 60–105 mm Hg) in adult patients after ROSC.
2b	C-LD	4. 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.

Synopsis

Delivery of oxygen to the brain and other vital organs is critical in resuscitation. There are theoretical risks associated with both hyperoxemia and hypoxemia.[1,2] Hyperoxemia may contribute to the development of reactive oxygen species in ischemic tissue, worsening oxidative injury and cell death.[3] Hypoxemia may

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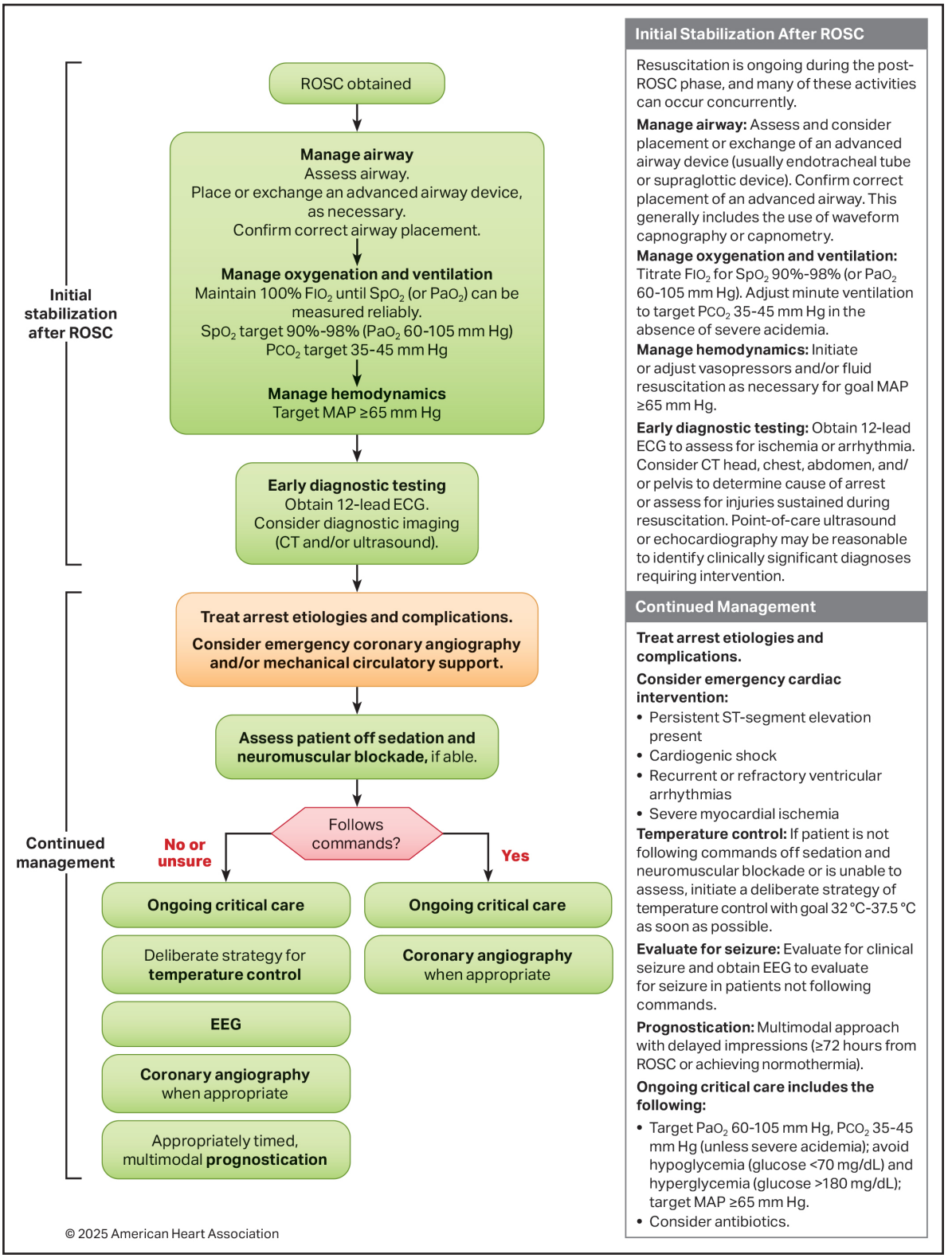

Figure 1. Adult Post–Cardiac Arrest Care Algorithm.
CT indicates computed tomography; MAP, mean arterial pressure; and ROSC, return of spontaneous circulation.

cause additional injury to end-organs and exacerbate the ischemic injury caused by the initial cardiac arrest.[4] Limitations in the ability to accurately measure oxygen saturation (Spo_2) after cardiac arrest can occur due to technological limitations in the prehospital setting and poor perfusion.[5] Additionally, pulse oximetry may be less accurate in patients with darker skin pigmentation.[6,7]

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Recommendation-Specific Supportive Text

1. In settings where accurate measures of Spo_2 or Pao_2 cannot be obtained, maintaining an Fio_2 of 100% until a reliable measure of oxygenation is obtained can help avoid hypoxemia. Administration of 100% oxygen immediately after ROSC until oxygen saturation can reliably be measured is supported by the EXACT (Reduction of Oxygen After Cardiac Arrest) randomized trial.[5] This study found an increase in hypoxemic events in the prehospital setting when Fio_2 was adjusted to maintain lower as compared to a higher Spo_2 target.[5]
2. Hypoxia increases the risk of end-organ damage, and hypoxemia is a widely available surrogate for hypoxia. Observational studies are mixed, with at least one study showing worse outcomes in patients experiencing post-ROSC hypoxemia.[8] These observational data are supported by the EXACT randomized trial, which demonstrated that lower oxygen targets in the prehospital and emergency department setting led to more hypoxemic episodes and lower survival.[5,9]
3. Several clinical trials have compared different Spo_2 and Pao_2 targets after ROSC in a variety of clinical settings with no superior or inferior target identified.[5,10,11] An Spo_2 target of 90% to 98% (Pao_2 target, 60–105 mm Hg) reflects the ranges studied in key randomized trials. In a prespecified subgroup of patients with hypoxic-ischemic encephalopathy in one clinical trial, patients randomized to a conservative oxygen therapy arm emphasizing protocolized reduction of Fio_2 had better outcomes than those in a usual care arm.[12] Observational studies have found an association between severe hyperoxemia (Pao_2 >250 mm Hg) and worse outcomes.[13]
4. Patients with darker skin pigmentation may develop "occult hypoxemia," wherein the Spo_2 on pulse oximeter reads in the normal range but the Pao_2 is in the hypoxemic range.[7,14–16]

VENTILATION TARGETS IN ADULT PATIENTS AFTER CARDIAC ARREST

Recommendations for Ventilation Targets in Adult Patients After Cardiac Arrest

COR	LOE	Recommendations
1	B-R	1. Arterial partial pressure of carbon dioxide ($Paco_2$) should be maintained within a normal physiologic range (generally 35–45 mm Hg) in adult patients who remain comatose after ROSC.
2b	B-NR	2. It may be reasonable to obtain a blood gas measurement to assess $Paco_2$ in mechanically ventilated adult patients after ROSC.

Synopsis

Management of carbon dioxide during the postarrest phase is necessary given its role in regulating cerebral blood flow. Hypocapnia-induced vasoconstriction may lead to cerebral ischemia, while hypercapnia may exacerbate elevated intracranial pressure (ICP) through increased cerebral blood volume associated with vasodilation.

Recommendation-Specific Supportive Text

1. Although a strategy of mild permissive hypercapnia (target $Paco_2$, of 50–55 mm Hg) might improve brain perfusion, observational studies have demonstrated mixed results on patient outcomes.[8,17–19] The TAME (Targeted Therapeutic Mild Hypercapnia after Resuscitated Cardiac Arrest) randomized trial compared the maintenance of normocapnia ($Paco_2$, 35–45 mm Hg) to mild hypercapnia ($Paco_2$, 50–55 mm Hg) for 24 hours in patients who remained comatose after cardiac arrest and found no difference in neurologic outcome at 6 months or in other secondary outcomes.[20] Although there was no outcome difference overall, the intervention in the TAME trial was stopped more often in the mild hypercapnia arm, possibly in response to severe acidemia because the protocol recommended suspending the intervention if pH <7.1 and base excess <—6 mmol/L. As a result, maintaining the $Paco_2$ within a normal physiologic range (generally, 35–45 mm Hg) is supported. Whether targets should be individualized based on individual patient physiology remains unknown.
2. The ability to measure $Paco_2$ after arrest is limited without blood gas measurement, and observational studies[21–24] suggest that end-tidal carbon dioxide levels may be falsely low and may not accurately reflect $Paco_2$ levels in post–cardiac arrest patients.

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BLOOD PRESSURE TARGETS IN ADULTS AFTER CARDIAC ARREST

Recommendation for Blood Pressure Targets in Adults After Cardiac Arrest		
COR	**LOE**	**Recommendation**
1	B-R	1. Hypotension should be avoided in adults after ROSC by maintaining a minimum MAP of at least 65 mm Hg.

Synopsis

Adequate blood pressure is important after cardiac arrest to maintain end-organ perfusion, including to the brain and heart. Determining the optimal blood pressure for an individual patient can be influenced by characteristics like the degree of myocardial dysfunction, the prearrest baseline blood pressure, the cause of hypotension, and the degree of neurologic injury.[1] The physiologic rationale for considering a higher MAP after cardiac arrest relates to impaired cerebral blood flow autoregulation, which can potentially impair the ability of the brain to maintain perfusion, even at normal MAP.

Recommendation-Specific Supportive Text

1. Hypotension and shock occur in at least two thirds of patients after cardiac arrest. Observational studies have associated hypotension with worse overall survival and lower rates of favorable neurologic outcome after cardiac arrest.[2–6] Four randomized trials including over 1000 patients compared lower (a cutoff of ≤70 mm Hg) to higher (≥71 mm Hg) MAP targets after out-of-hospital cardiac arrest (OHCA).[7–10] These studies did not demonstrate better overall survival or favorable neurologic outcome with higher MAP targets.[11] The median MAP achieved in the lower MAP arms was approximately 65 mm Hg, which is the standard minimum MAP recommended for other forms of critical illness, including CS and sepsis. Collectively, these trials do not provide evidence for a different MAP goal in patients after cardiac arrest.[11–13] The safety of a lower MAP target (eg, 60–65 mm Hg) has not been evaluated in post–cardiac arrest patients.[14] It is also unknown if a higher MAP target (eg, 80–100 mm Hg) may be beneficial for some

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patients. Because the referenced trials used MAP targets and not systolic blood pressure, the recommendation is updated to remove a previous systolic blood pressure target.

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DIAGNOSTIC STUDIES FOR ADULTS AFTER CARDIAC ARREST

Recommendations for Diagnostic Studies for Adults After Cardiac Arrest		
COR	**LOE**	**Recommendations**
1	B-NR	1. A 12-lead electrocardiogram (ECG) should be obtained as soon as feasible for all adult patients after ROSC.
2b	B-NR	2. It may be reasonable to perform head-to-pelvis CT for adult patients after ROSC to investigate the etiology of cardiac arrest and complications from resuscitation.
2b	C-LD	3. It may be reasonable to perform echocardiography or point-of-care cardiac ultrasound for adult patients after ROSC to identify clinically significant diagnoses requiring intervention.

Synopsis

Diagnosis and treatment of the underlying cause of cardiac arrest as well as identification and treatment of complications from cardiac arrest and cardiopulmonary resuscitation (CPR) are important considerations in postarrest care. Twelve-lead ECG, echocardiography, point-of-care cardiac ultrasound, and CT imaging are used in postarrest patients to identify clinically significant diagnoses requiring intervention. These diagnostic modalities are complementary, with patients often receiving multiple studies. While the majority of patients resuscitated from cardiac arrest have abnormal findings on these studies, these are not always diagnostic for the specific etiology of cardiac arrest and may not change clinical management.[1–7] The performance, timing, and interpretation of each study is guided by the clinical context. It is also important to note that the considerations regarding diagnostic imaging for an in-hospital cardiac arrest may differ from those in OHCA and that most of the available literature focuses on OHCA.

Recommendation-Specific Supportive Text

1. A 12-lead ECG obtained after ROSC can identify arrhythmia, ST-segment elevation myocardial infarction (STEMI), and other diagnoses associated with cardiac arrest for which treatment or monitoring is indicated. While the ECG is critical in identifying patients with STEMI or STEMI-equivalent patterns,[8,9] its accuracy for these diagnoses in the immediate post-ROSC period has limitations.[1,10–14] Electrocardiograms

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performed within the first 8 minutes following ROSC have been shown to have higher false positive rates for STEMI than those performed later.[1,10] In one study, approximately two thirds of STEMI patterns on the immediate post-ROSC ECG evolved to non-STEMI patterns on repeat ECG performed a median of 30 minutes later.[10] Optimal timing of an initial and repeat ECG following ROSC are not well defined. Furthermore, the absence of ST-segment elevation does not rule out an intervenable coronary lesion.[11,15–18]

2. Full body CT scan (ie, head to pelvis) can diagnose pathologies contributing to cardiac arrest, including but not limited to intracerebral hemorrhage, pulmonary embolism, cardiac tamponade, aortic dissection, and pneumothorax. A 2019 systematic review evaluating post–cardiac arrest imaging to determine arrest etiology included 17 observational studies and found that, despite heterogeneity in the CT protocols, the diagnostic yield of CT scans for clinically significant diagnoses and injuries ranges from 8% to 54%,[3] with several studies indicating an approximate yield of 30%.[7] This review was limited by the small number of patients included in the individual studies and the fact that few studies are prospective and that none were randomized.

   CT imaging can also identify complications of cardiac arrest or resuscitation, such as fractures, aspiration, pulmonary contusions, pneumothorax, and hemorrhage, which may inform subsequent medical interventions.[3–7,19,20] Small observational studies showed that patients resuscitated from OHCA may have CPR injuries identifiable by CT,[21–23] including a small proportion of time-critical injuries, such as liver/splenic lacerations and pneumothoraces.[6]

   CT imaging carries risks such as contrast-associated nephropathy. Transporting critically ill patients also carries the risks of hemodynamic instability, dislodging medical equipment, and delaying other interventions[24,25] that are weighed against the benefits of obtaining additional diagnostic information.[3–7]

   Head CT for neuroprognostication is discussed elsewhere.

3. Echocardiography and point-of-care cardiac ultrasound have been studied in the intra-arrest setting for a variety of purposes, including identification of a reversible cause for cardiac arrest. Available data suggest that these modalities can also contribute to elucidating the etiology of cardiac arrest in the postarrest setting. Diagnoses that have been evaluated with echocardiography or point-of-care ultrasound include pericardial effusion, pericardial tamponade, right ventricular dilation suggestive of pulmonary embolism, aortic dissection, cardiac regional wall motion abnormalities suggestive of myocardial infarction, cardiomyopathy, and hypovolemia.[3,26–35] An important limitation of most studies is that echocardiography or point-of-care ultrasound diagnoses were not compared to a reference standard[32]; thus, the accuracy of these studies for most diagnoses cannot be quantified.[3,36] Data are limited on whether cardiac regional wall motion abnormalities have an additional benefit when ECG and cardiac troponin results are considered.[29,37] Noncardiac point-of-care ultrasound protocols have been described, but limited data are available on their yield and accuracy.[38–40] The optimal time frame, operator, and technique for performing ECG or point-of-care cardiac ultrasound following ROSC remain uncertain.[36] Ultrasound is operator dependent, and recommendations for sonographer training and competencies are available from other organizations.[41–43]

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TEMPERATURE CONTROL AFTER CARDIAC ARREST IN ADULTS

Recommendations for Temperature Control After Cardiac Arrest in Adults

COR	LOE	Recommendations
1	B-R	1. A deliberate, protocolized strategy of temperature control is recommended for all adults who are unresponsive to verbal commands after ROSC, irrespective of arrest location or presenting rhythm.
1	B-R	2. Maintaining a temperature between 32 °C and 37.5 °C in patients unresponsive to verbal commands after ROSC is recommended for adults.
2a	B-R	3. It is reasonable that temperature control be maintained for at least 36 h in adult patients who remain unresponsive to verbal commands after ROSC.
2b	B-R	4. The benefit of strategies other than rapid infusion of cold intravenous fluids for prehospital cooling is unclear.
2b	B-R	5. It may be reasonable to avoid rapid (faster than 0.5 °C/h) rewarming in adult patients who have spontaneous hypothermia after ROSC or who are warming after hypothermic temperature control.
2b	B-NR	6. It is unclear if maintenance of a specific temperature (hypothermia versus normothermia) improves outcomes in subgroups of adult patients with higher illness severity.
3: No Benefit	B-R	7. Routine rapid infusion of intravenous fluids for prehospital hypothermic temperature control in adult patients after ROSC is not recommended.

Synopsis

Temperature control has been a focus of PCAC for several decades, reflecting strong physiologic rationale, evidence of benefit from preclinical and observational studies, and benefit in some randomized trials.[1–4] In 2023, the AHA published a focused update on temperature control that revised recommendations based upon newly published clinical trial data including the TTM2 (Targeted Temperature Management 2) trial and the CAPITAL CHILL (Moderate vs Mild Therapeutic Hypothermia in Comatose Survivors of OHCA) trial.[5–7] A recent systematic review and meta-analysis published in 2023 summarizes the multiple randomized trials conducted in various domains of temperature control.[8]

Temperature control refers to the period of active temperature management to a hypothermic target or to a normothermic target. In settings in which a hypothermic target is used, a period of fever prevention or temperature control to a normothermic target may follow the hypothermic period. The entire duration of active temperature management is considered temperature control.

Recommendation-Specific Supportive Text

1. Multiple randomized trials have tested various approaches to temperature control after cardiac arrest, including surface, intravascular, and intranasal cooling. Most of these trials specified deliberate temperature control strategies in both the intervention and control arms.[6,7,9–11]
2. A 2023 updated ILCOR systematic review[8] incorporates 6 additional randomized trials published between 2021 and 2023. All trial arms controlled temperature to between 31 °C and 37.7 °C. In the meta-analysis, there was no difference in survival when applying temperature control at 32 °C to 34 °C versus 36 °C or normothermia; however, the confidence intervals did not exclude a potential beneficial effect of temperature control at colder temperatures.[8] None of the included trials found worse outcomes with lower temperature goals. Observational studies have found that adopting higher temperature targets may result in an increased risk of fever and potentially worse outcomes, though confounders are likely present.[12–14]
3. The optimal overall duration of temperature control, including hypothermic temperature control (32 °C–34 °C) and normothermic or fever-prevention temperature control (36 °C–37.5 °C), is an important area of ongoing investigation. In one randomized trial, there was no difference in outcomes comparing hypothermic temperature control for 24 versus 48 hours, although the trial may have been underpowered and effect estimates favored longer temperature control durations.[10] In another recent randomized trial, there was no difference in outcomes comparing a period of device-based fever prevention of 12 versus 48 hours after an initial 24-hour period of temperature control to 36 °C (ie, 36 versus 72 total hours of temperature control, respectively).[15] The 2 large TTM randomized trials protocolized patients to 72 hours of total temperature control.[6,9] Recognizing evolution of evidence and definitions with respect to temperature control, 36 hours of total temperature control is the shortest recommended duration. Multiple observational studies have found strong associations between post–cardiac arrest fever and poor outcomes, including for fevers occurring after an initial 24-hour period of temperature control.[16–19] Results of the ICECAP (Influence of Cooling Duration on Efficacy in Cardiac Arrest Patients) trial, which aimed to identify the optimal duration of hypothermic temperature control for patients with both shockable and nonshockable rhythms, are pending after the study was stopped in June 2025.[20]
4. A randomized trial measured the impact of prehospital transnasal evaporative intra-arrest cooling

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versus postadmission temperature control on survival in 671 patients and found no difference in the primary outcome of neurologically favorable survival at 90 days (16.6% in the treatment group and 13.5% in the control group).[21] The ongoing PRINCESS-2 trial aims to study a similar approach in patients with shockable rhythm, a subgroup of interest in earlier trials.[22] Cooling through surface or intravascular methods are reasonable alternatives.

5. In one small, randomized trial, there was no difference in the primary outcome of interleukin-6 level or other outcomes comparing rewarming from temperature control at 33 °C at a rate of 0.25 °C per hour as compared to 0.5 °C per hour.[23] Recent randomized trials of temperature control used rewarming rates ranging from 0.25 °C to 0.5 °C per hour when transitioning out of temperature control to colder target temperatures.[6,7,9–11] Patients presenting with spontaneous hypothermia after ROSC may have more severe neurologic injury and be more susceptible to secondary injury with rewarming. In these cases, it is unclear whether passive, uncontrolled rewarming (potentially at rates above 0.5 °C per hour) results in worse outcomes as compared to slow, controlled rewarming. Approaches to warming of patients presenting at temperatures below target in randomized trials have varied from allowing either active or passive warming[6] to active, controlled warming at 0.25 °C to 0.5 °C per hour.[11]
6. Most patients enrolled in temperature control trials had shockable rhythms with primary cardiac causes of arrest, despite eligibility criteria including both shockable and nonshockable rhythms.[6,7,9,10] A patient level meta-analysis including patients with nonshockable rhythms from the TTM2 and HYPERION trials found no difference between hypothermic and normothermic temperature control.[24] Patients who do not meet eligibility criteria for randomized trials or who suffer cardiac arrest in the United States as compared to other parts of the world may have differences in important characteristics like arrest etiology, initial rhythm, witness status, bystander CPR, and downtime.[25,26] Some observational studies suggest benefit with temperature control to lower temperatures for patients with higher illness and brain injury severity.[27,28]
7. There was no clear benefit to prehospital initiation of temperature control with cold intravenous fluids and signals of potential harm in one large randomized clinical trial.[29]

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ADDITIONAL TREATMENTS IN ADULTS AFTER CARDIAC ARREST

Recommendations for Additional Treatments in Adults After Cardiac Arrest

COR	LOE	Recommendations
2b	B-R	1. The routine use of prophylactic antibiotics in adult patients after ROSC is of uncertain benefit.
2b	B-R	2. The effectiveness of agents to mitigate neurological injury in adult patients who remain comatose after ROSC is uncertain.

Recommendations for Additional Treatments in Adults After Cardiac Arrest (Continued)

COR	LOE	Recommendations
2b	B-R	3. The routine use of steroids for adult patients with shock after ROSC is of uncertain value.
2b	B-NR	4. In adult patients with ROSC after cardiac arrest, it may be reasonable to avoid hypoglycemia (glucose <70 mg/dL) as well as hyperglycemia (glucose >180 mg/dL).

Synopsis

Patients with cardiac arrest often remain critically ill in the immediate post–cardiac arrest period, though treatments for general critical care populations may not be universally applicable to the post–cardiac arrest patient population. One important area in post–cardiac arrest therapies where new observational data have emerged is glucose control for post–cardiac arrest patients, and this has also been studied more extensively in general critical care populations. Patients are at risk of developing pneumonia after cardiac arrest, which is often caused by aspiration during the cardiac arrest and resuscitation. Thus, there is rationale to evaluate whether empiric antibiotic treatment can improve outcomes. Steroids are also of physiologic interest in patients after cardiac arrest due to their broad effects, including reducing inflammation and possibly supporting hemodynamics. Similarly, neuroprotective agents that act through a broad range of possible mechanisms continue to be an area of clinical and research interest.

Recommendation-Specific Supportive Text

1. A 2020 ILCOR systematic review[1] identified 2 randomized controlled trials (RCTs) that found no difference in survival or neurological outcome[2,3] in patients treated with early prophylactic antibiotics after cardiac arrest. One RCT[2] did find lower incidence of early pneumonia in those who received prophylactic antibiotics, but this did not translate to a difference in other outcomes. Since then, one observational study similarly demonstrated a reduction of early ventilator-associated pneumonia with prophylactic antibiotics[4] but no differences in other patient-oriented outcomes (ie, short-term mortality, duration of mechanical ventilation, or intensive care unit length of stay). Given the need for general antibiotic stewardship and the findings of the above studies, there is insufficient evidence to suggest the use of antibiotics routinely after cardiac arrest.
2. A recent systematic review[5] evaluated neuroprotective drugs and their effect on mortality and functional outcome. Nineteen RCTs of drugs categorized as neuroprotective agents and 16 studies of drugs categorized as anti-inflammatory

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or antioxidant were included. Multiple agents, including magnesium, nimodipine, inhaled gases (hydrogen, nitric oxide, and xenon), coenzyme Q10 (ubiquinol), thiamine, and others, were evaluated. Most studies were single-center trials with low numbers of participants. The heterogeneity of intervention agents and trial designs limited the ability to perform meta-analyses, and there was overall low certainty of evidence, thus, limiting the ability to recommend any specific agent.

3. One small RCT including 50 patients compared steroids to placebo for post–cardiac arrest shock.[6] Time to shock reversal and other outcomes did not differ between groups. A large retrospective observational study found that steroid use after cardiac arrest was associated with survival.[7] A recent systematic review evaluating drug therapy compared with placebo[5] included 2 RCTs using hydrocortisone after arrest as part of a multidrug protocol.[8,9] There was insufficient evidence to perform a meta-analysis for steroids after ROSC and insufficient evidence to recommend any specific drug treatment after ROSC. This topic does not address intra-arrest steroids.
4. One small RCT evaluating strict versus moderate glucose control in patients resuscitated from cardiac arrest due to ventricular fibrillation (VF)[10] found no difference in survival, though the therapeutic ranges for their control and experimental arms are no longer congruent with current critical care management. Many subsequent observational studies have demonstrated an association between hyperglycemia or hypoglycemia in the post–cardiac arrest period and worse neurological outcomes and mortality, though these were not evaluating active glucose management interventions.[11–16] While no RCTs have evaluated glucose targets in broad populations of post–cardiac arrest patients, treatment of blood glucose using insulin in the general critical care population improves mortality and is recommended in other guidelines, acknowledging risks of hypoglycemia when lower blood glucose ranges are targeted.[17–19] Given the observational findings in post–cardiac arrest patients, the RCT findings in general critical care populations, and that post–cardiac arrest patients are often critically ill, this recommendation is updated to address avoidance of hypoglycemia and hyperglycemia without giving a specific target glucose range.

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USE OF VASOPRESSORS IN ADULTS AFTER CARDIAC ARREST

Recommendation for Use of Vasopressors in Adults After Cardiac Arrest		
COR	**LOE**	**Recommendation**
2b	B-NR	1. There is insufficient evidence to recommend a specific vasopressor to treat low blood pressure in adult patients after cardiac arrest.

Synopsis

Hypotension requiring vasopressors occurs in up to 75% of post–cardiac arrest patients.[1,2] After cardiac arrest, shock is often caused by multiple etiologies, and the shock phenotype may evolve from initial low-output CS from post–cardiac arrest myocardial dysfunction to a later vasodilatory shock from inflammatory vasoplegia.[2] Vasopressors are commonly used to support blood pressure and cardiac output in the setting of hypotension after cardiac arrest. Vasopressors have dose-dependent differences in cardiac (inotropic), vascular (vasoconstrictive), and adverse (tissue ischemia, cardiac arrhythmia) effects, which influence their efficacy and safety across individuals.[3]

Recommendation-Specific Supportive Text

1. No large-scale RCTs have compared clinical outcomes between different vasopressors in post–cardiac arrest patients.[4] A small prehospital RCT (n=40) comparing epinephrine and norepinephrine after cardiac arrest did not show a difference in safety or clinical outcomes.[5] Some, but not all, observational studies with a high risk of bias and residual confounding have suggested worse outcomes in postarrest patients who received epinephrine versus norepinephrine.[4,6] In patients with CS, many of whom had cardiac arrest, epinephrine and dopamine have been associated with a less favorable safety profile and potentially worse outcomes than norepinephrine; the presence of cardiac arrest did not influence this effect in one meta-analysis comparing epinephrine to other drug regimens.[7–9] In non–cardiac arrest patients with vasodilatory or septic shock, epinephrine was associated with more arrhythmias and metabolic abnormalities but similar survival while dopamine was associated with worse outcomes.[10] Accordingly, norepinephrine is suggested as the first-line vasopressor for patients with CS or septic shock, but whether this recommendation applies to undifferentiated post–cardiac arrest patients remains unproven.[11–13]

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PERCUTANEOUS CORONARY INTERVENTION IN ADULTS AFTER CARDIAC ARREST

Recommendations for PCI in Adults After Cardiac Arrest		
COR	**LOE**	**Recommendations**
1	B-NR	1. Coronary angiography should be performed emergently after cardiac arrest for all patients with suspected cardiac cause of arrest and persistent ST-segment elevation on ECG, regardless of the presence of coma.
1	B-NR	2. Coronary angiography is recommended prior to hospital discharge in adult cardiac arrest survivors with suspected cardiac etiology, particularly in the presence of an initial shockable rhythm, unexplained left ventricular systolic dysfunction, or evidence of severe myocardial ischemia.
2a	B-NR	3. Emergency coronary angiography is reasonable for selected adult patients after cardiac arrest with suspected cardiac etiology without ST-segment elevation on ECG in the presence of CS, recurrent ventricular arrhythmias, or evidence of significant ongoing myocardial ischemia, regardless of the presence of coma.
3: No Benefit	B-R	4. In adult comatose patients with ROSC after cardiac arrest, emergency coronary angiography is not recommended over a delayed or selective strategy in the absence of ST-segment elevation, shock, electrical instability, or evidence of significant ongoing myocardial ischemia.
3: No Benefit	B-R	5. In the setting of multivessel coronary artery disease (CAD) in adult patients with shock after cardiac arrest, immediate revascularization of non–infarct-related coronary lesions is not recommended over initial revascularization of only the infarct-related artery.

Synopsis

Coronary artery disease is identified in up to two thirds[1] of patients with OHCA from a presumed cardiac etiology who undergo invasive coronary angiography, including acute culprit lesions in one third of these patients; the prevalence is higher in patients with VF, particularly refractory VF receiving extracorporeal CPR (ECPR).[2] Identifying and treating unstable CAD has been shown to improve outcomes by stabilizing hemodynamics, preventing recurrent arrhythmias, and preserving myocardial function.[3] The ILCOR CoSTR[4] and the 2023 AHA Focused Update[5] on this topic were reviewed, and an independent literature search undertaken.

Observational studies have demonstrated higher overall and favorable neurologic outcome among OHCA patients who receive invasive coronary angiography with PCI performed within 24 hours of admission, recognizing that selection bias and confounding by indication can magnify this effect. Evidence regarding the optimal timing of coronary angiography after OHCA comes from multiple RCTs enrolling 1590 comatose hemodynamically stable OHCA patients without STEMI, the majority having a shockable rhythm.[6–12] Therefore, the certainty of data is limited for types of cardiac arrest patients excluded from these trials. Randomized data are also lacking for patients with ST-segment elevation or cohorts permitted to cross over in RCTs because of the presence of CS, signs of significant myocardial damage, electrical instability, or ongoing ischemia. A key challenge is the competing risk of poor outcome due to hypoxic-ischemic brain injury in patients who had cardiac arrest compared to those who have acute coronary syndromes but did not have cardiac arrest. Poor outcome due to the brain injury may mitigate and confound the potential benefit of coronary revascularization in this population.[13]

Recommendation-Specific Supportive Text

1. The presence of STEMI or STEMI-equivalent pattern on ECG after cardiac arrest implies transmural myocardial ischemia and a high probability of acute coronary occlusion, which can result in worsening cardiovascular instability if not promptly revascularized.[14] Multiple observational studies have demonstrated improved neurologically favorable survival when early coronary angiography is performed followed by PCI in patients with cardiac arrest who have STEMI.[15] This recommendation mirrors global recommendations for all patients with STEMI. Randomized controlled trials examining the optimal timing of coronary angiography after OHCA systematically excluded patients with STEMI.
2. Evaluating for CAD prior to hospital discharge with invasive coronary angiography in cardiac arrest survivors with a presumed cardiac etiology is supported by other cardiology-focused guidelines and scientific statements.[3,16–18] Randomized controlled trials examining the timing of coronary angiography after OHCA performed invasive coronary angiography in all patients with neurological awakening.[6–12]
3. Cardiogenic shock (hemodynamic instability) or recurrent ventricular arrhythmias (electrical instability) after cardiac arrest can be caused by severe myocardial ischemia. Patients with these unstable cardiovascular conditions are at high risk of rearrest if myocardial ischemia goes untreated. Randomized controlled trials examining the timing of coronary angiography after OHCA in comatose patients allowed crossover to the emergent timing arm for shock, recurrent VF, or evidence of severe myocardial ischemia. Elevated serum troponin levels[19–29] and ischemic ECG abnormalities (other than STEMI)[6,30–34] are common after OHCA but have inadequate sensitivity or specificity for unstable CAD and do not predict the benefit of invasive coronary angiography. This makes the optimal definition of severe myocardial ischemia uncertain, although the TOMAHAWK (Angiography After Out-of-Hospital Cardiac Arrest Without ST-Segment Elevation) trial

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used a serum troponin cut-off 70 times the upper reference limit. Patients with OHCA with refractory VF from a presumed cardiac etiology who receive ECPR have a high prevalence of unstable CAD, and early invasive coronary angiography was part of the ECPR bundle in RCTs.[2,35–37]

4. In multiple RCTs of stable comatose OHCA patients without STEMI, there was no evidence of improved overall survival or favorable neurologic outcome with early invasive coronary angiography (eg, within 2 hours) versus delayed or selective invasive coronary angiography (eg, after awakening), with some studies suggesting potential harm with early angiography.[38] In the delayed angiography group, up to 40% of patients did not receive invasive coronary angiography due to lack of awakening[12] and up to 17% crossed over to early intervention[8] due to hemodynamic or electrical instability or severe myocardial ischemia. Invasive coronary angiography can be safely deferred until after neurological awakening in comatose OHCA patients without any of the following: STEMI or STEMI-equivalent patterns, CS, recurrent ventricular arrhythmias, or evidence of significant myocardial ischemia. Cardiac arrest patients without coma were excluded from these RCTs.
5. There is substantial overlap between the OHCA and CS populations, as acute myocardial infarction is often the underlying pathophysiology in both.[3,39] Multivessel CAD is identified in up to 50% of patients receiving invasive coronary angiography after OHCA, as in patients with CS from acute myocardial infarction.[40,41] No RCTs have examined the optimal revascularization approach for patients with cardiac arrest and multivessel CAD, and RCTs examining multivessel revascularization in patients with STEMI have excluded patients with cardiac arrest.[42] The CULPRIT-SHOCK (Culprit Lesion Only PCI Versus Multivessel PCI in Cardiogenic Shock) trial[41] randomized patients with CS from acute myocardial infarction (including 55% OHCA patients) who had multivessel CAD and underwent culprit vessel PCI to either immediate multivessel PCI or delayed selective multivessel PCI. Patients randomized to immediate multivessel PCI had higher mortality and more complications, with similar findings of harm with initial multivessel PCI in the subgroup of patients with cardiac arrest.[43] Thus, immediate revascularization of nonculprit coronary lesions is not recommended over initial culprit-only revascularization in patients with multivessel CAD and shock after cardiac arrest and is supported by the 2021 AHA/ACC/SCAI Guideline for coronary revascularization and 2025 AHA/ACC Guideline for acute coronary syndromes.[14,44]

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TEMPORARY MCS FOR ADULTS AFTER CARDIAC ARREST

Recommendations for Temporary MCS for Adults After Cardiac Arrest		
COR	**LOE**	**Recommendations**
1	C-EO	1. In adult patients with cardiac arrest who have been placed on MCS, appropriate monitoring and management by a team with experience managing the device(s) and the potential associated complications is recommended.
2b	B-NR	2. In highly selected adult patients with refractory CS after cardiac arrest and ROSC, temporary MCS may be considered.
3: No Benefit	B-R	3. In adult patients with CS after cardiac arrest and ROSC, temporary MCS should not be routinely used.

Synopsis

Cardiogenic shock commonly occurs as either a cause or consequence of cardiac arrest.[1] Patients with CS are usually managed with vasopressors and inotropes, but treatment failures and drug toxicity are common with these therapies.[1] Temporary MCS devices have been developed to increase blood pressure and cardiac output in patients with CS as an alternative or adjunct to vasoactive drug therapy. These devices include the intra-aortic balloon pump, percutaneous ventricular assist devices (including the Impella and TandemHeart families of devices), and extracorporeal membrane oxygenator (ECMO). Temporary MCS devices can provide hemodynamic stabilization in refractory CS, allowing time for neuroprognostication and potential cardiac recovery. Balancing the aforementioned benefits with associated increased risk of bleeding and ischemic complications observed with percutaneous ventricular assist devices and ECMO is important. Temporary MCS is becoming more commonly used as a rescue strategy for patients with refractory CS despite initial vasoactive drug therapy. While few trials of temporary MCS have exclusively included cardiac arrest patients, many of the CS patients enrolled in clinical trials of temporary MCS had cardiac arrest. Accordingly, the evidence guiding the use of temporary MCS in CS more broadly may apply to patients with cardiac arrest in the absence of studies showing differential benefits in the cardiac arrest subgroup specifically.

Recommendation-Specific Supportive Text

1. Management of temporary MCS is nuanced and requires specific knowledge. Balancing hemodynamic needs with device management is often challenging because responses to interventions can be paradoxical or counterintuitive during MCS. Given these challenges, optimizing outcomes necessitates a team experienced in MCS management. Although specific team composition and training are not well defined, a volume-outcome relationship has been noted with the use of advanced temporary MCS devices whereby centers with higher volume have better patient survival, suggesting that greater familiarity with these devices may result in improved outcomes.[2,3]

2, 3. Temporary MCS devices, including intra-aortic balloon pump, percutaneous ventricular assist devices, and ECMO, can potentially improve hemodynamics for patients with CS refractory to vasopressor and inotrope therapy. No large-scale RCTs have specifically evaluated patient-centered outcomes with early routine use of MCS devices in cardiac arrest patients. One small (n=60) RCT showed no difference in mortality with early routine intra-aortic balloon pump in patients with acute coronary syndrome who had suffered an in-hospital cardiac arrest with ROSC.[4] Patients with cardiac arrest made up the majority (64%) of patients included in RCTs assessing MCS in CS, though the subgroup of patients with cardiac arrest ranged from <20% to >90% across studies.[4–18]

In a meta-analysis of 14 trials, there was no difference in survival for CS patients treated with routine MCS compared to standard of care (OR, 1.17; 95% CI, 0.97–1.42 [ILCOR meta-analysis]). A patient-level meta-analysis of 9 RCTs in acute myocardial infarction CS (n=1114) found no survival benefit for early routine use of percutaneous ventricular assist devices or ECMO in the 51.6% with prior cardiac arrest (HR, 0.91; 0.71–1.15).[19] Patient-level subgroup analysis of 816 resuscitated cardiac arrest patients from 11 RCTs (n=816) found no difference in survival with MCS (OR, 1.21; 95% CI, 0.91–1.60 [ILCOR meta-analysis]). The singular RCT that showed survival benefit with routine use of MCS in CS patients included 20% cardiac arrest survivors but systematically excluded OHCA patients who were comatose after ROSC.[16] Importantly, individual RCTs and meta-analyses demonstrate increased harm, including severe bleeding and ischemic vascular events, with the routine use of MCS.[13,15,16,18,19] Accordingly, routine

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use of MCS in cardiac arrest patients with CS is not likely to improve survival, however, selective use of MCS in cardiac arrest patients with refractory CS may be considered, particularly for those who are not comatose and have STEMI as represented in the DanGer Shock (Danish–German Cardiogenic Shock) trial.[16,20]

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ADVANCED NEUROMONITORING IN ADULTS AFTER CARDIAC ARREST

Recommendation for Advanced Neuromonitoring in Adults After Cardiac Arrest		
COR	**LOE**	**Recommendation**
2b	**C-LD**	1. The usefulness of monitoring ICP, cerebral blood flow, brain tissue oxygenation, or jugular venous oxygen saturation in adults after cardiac arrest is not well established.

Synopsis

Hypoxic-ischemic brain injury causes imbalance in physiological processes involved in cerebral homeostasis.[1] These disruptions place patients at risk for secondary brain injury, which may contribute to mortality

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and unfavorable neurologic outcomes. Causes of secondary brain injury are heterogeneous and vary temporally and between patients but include inadequate cerebral perfusion, oxygenation, and mismatch in metabolic supply and demand.[2] Conventional patient monitoring by clinical examination and vital signs can be insensitive to detecting secondary brain injury.[3,4] Advanced neuromonitoring refers to placing probes into or adjacent to brain tissue through a cranial burr hole or through jugular vein cannulation. These probes permit direct and frequent measurement of ICP, cerebral blood flow, brain tissue oxygen saturation ($Pbto_2$), jugular venous oxygen saturation, and neurophysiology (electrocorticography).[5,6] They also allow for sampling of the interstitial space (microdialysis) and calculation of cerebral autoregulation indices, such as pressure reactivity index and optimal cerebral perfusion pressure. These measurements can provide additional information about cerebral physiology and facilitate targeted interventions. While these techniques have been used in other types of acute brain injury populations, there has been limited investigation in hypoxic-ischemic brain injury. Limitations of previous studies in cardiac arrest populations include their observational nature; highly selected subpopulations; variability in the timing, duration, and methods of monitoring; and thresholds used to prompt interventions.

Recommendation-Specific Supportive Text

1. There are no RCTs comparing invasive neuromonitoring to no invasive neuromonitoring after cardiac arrest. Eleven nonrandomized observational studies[7–17] evaluated ICP monitoring. Five studies found an association between ICP elevation or lower intracranial compliance with poor functional outcomes.[7,10,13,16,17] Three observational studies using intracranial ICP monitoring evaluated cerebral autoregulation using pressure reactivity index.[8,13,18] The pressure reactivity index is a measure of cerebral autoregulation derived from the correlation of ICP and MAP. Two of these studies measured deviations from the optimal cerebral perfusion pressure, which was associated with mortality and lower $Pbto_2$.[8,18] Of 5 nonrandomized studies, 2 showed that cerebral hypoxia measured using $Pbto_2$ or arterio-jugular differences of oxygen was more common in patients with poor functional outcomes.[8,13–16] One single-center prospective nonrandomized interventional study evaluated functional outcomes with care guided by monitoring of ICP, $Pbto_2$, and jugular venous oxygen saturation.[8] The invasive monitoring group had superior functional outcomes at 6 months compared to a historical matched comparison group. All findings for ICP, cerebral autoregulation, $Pbto_2$, and jugular venous oxygen saturation were inconsistent across studies, and there was overall high risk of bias.

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SEIZURES, MYOCLONUS, AND OTHER EPILEPTIFORM ACTIVITY

Diagnosis and Management of Seizure and Other Epileptiform Activity in Adults After Cardiac Arrest

Recommendations for Diagnosis and Management of Seizure and Other Epileptiform Activity in Adults After Cardiac Arrest		
COR	**LOE**	**Recommendations**
1	C-LD	1. We recommend promptly performing and interpreting EEG for the diagnosis of seizures in adult patients who do not follow commands after ROSC.
1	C-LD	2. We recommend treatment of clinically apparent seizures in adult patients after ROSC.
2a	B-R	3. Treatment of nonconvulsive seizures (ie, diagnosed by EEG only) is reasonable in adult patients after ROSC.
2a	C-LD	4. Monitoring EEG repeatedly or continuously is reasonable for adult patients who do not follow commands after ROSC.
2b	C-LD	5. The same antiseizure medications used for treatment of seizures caused by other etiologies may be considered for seizures in adult patients after ROSC.
2b	C-EO	6. A therapeutic trial of a nonsedating antiseizure medication may be reasonable in adult patients who do not follow commands after ROSC with EEG patterns on the ictal-interictal continuum.
3: No Benefit	B-R	7. Routine seizure prophylaxis in adult patients who do not follow commands after ROSC is not recommended.

Synopsis

Seizures and status epilepticus are common acute neurologic complications in the post–cardiac arrest period, occurring in 10% to 35% of patients who do not follow commands after ROSC.[1–6] Cerebral hyperexcitability after cardiac arrest may exacerbate a mismatch between neuronal bioenergetic supply and demand, thereby contributing to secondary brain injury.[5] Post–cardiac arrest hyperexcitability can manifest as a wide range of electroclinical findings, from seizures with overt clinical manifestations, such as convulsions to periodic or rhythmic discharges on EEG and other abnormal EEG patterns.[7] Clinical or electrographic findings can manifest with or without impairment of consciousness and may or may not reach the criteria for seizures or status epilepticus (Table 2).[8]

The indications for and intensity of antiseizure medications vary in clinical practice and across studies. Although the occurrence of status epilepticus in post–cardiac arrest patients has been associated with poor outcomes in observational studies,[2,9,10] some patients survive with recovery of functional independence. Myoclonus is covered in a separate section because only a subset of patients with post–cardiac arrest myoclonus meets criteria for electroclinical seizures or status epilepticus. Marked heterogeneity in the definitions of seizures and status epilepticus across studies challenges the interpretation of available data.

Recommendation-Specific Supportive Text

1. In patients who are unable to follow commands after cardiac arrest, EEG can detect nonconvulsive seizures and status epilepticus (Table 3).[11–13] This recommendation is informed by the high prevalence of nonconvulsive seizures and other epileptiform activity in cardiac arrest survivors.[5] However, there is no direct evidence that detection of nonconvulsive seizures with EEG improves outcomes. An ILCOR systematic review from 2023 did not specifically address the timing and method of EEG monitoring in this setting.[14]
2. There are no nonrandomized trials or RCTs comparing the effect of treating clinical seizures versus no seizure treatment.[14] There is no widely accepted definition for clinically apparent seizure or status epilepticus after cardiac arrest, and previous literature has used a variety of clinical and EEG classifications. It remains unclear which seizures or status epilepticus represent an epiphenomenon of severe brain injury or treatment-responsive targets to prevent secondary brain injury. Despite the lack of high-certainty evidence, untreated clinically apparent seizure activity is thought to be potentially harmful to the brain; therefore, treatment of seizures or status epilepticus is recommended.[15]
3. Seizures or status epilepticus that have no clearly apparent clinical correlate, (ie, electrographic or nonconvulsive seizures or status epilepticus), emerge in 1% to 20% of post–cardiac arrest patients.[16] The American Clinical Neurophysiology Society (ACNS) has developed specific criteria for electrographic or nonconvulsive seizures or status epilepticus for critically ill patients (Table 2), though prior studies have used varying definitions. Given the limited evidence to support withholding treatment of nonconvulsive seizures after arrest, a similar approach to nonconvulsive seizure treatment for other etiologies is reasonable. The TELSTAR (Treatment of Electroencephalographic Status Epilepticus after

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Table 2. American Clinical Neurophysiology Society Criteria for Electrographic Seizures, Status Epilepticus, and Ictal-Interictal Continuum

Hyperexcitable phenomenon	Diagnostic criteria
Electrographic seizure	1. Epileptiform discharges averaging >2.5 Hz for ≥10 s* *or* 2. Any pattern with definite evolution† lasting ≥10 s*
Electrographic status epilepticus	1. Any pattern qualifying for electrographic seizure for ≥10 continuous min‡ or for a total duration of ≥20% of any 60-min‡ period of monitoring
Ictal-interictal continuum (ie, possible electrographic status epilepticus; if an unequivocal electrographic and clinical response is seen following therapeutic trial, that is diagnostic for electroclinical status epilepticus)	1. Any periodic discharges or spike/sharp-wave pattern averaging >1.0 and ≤2.5 Hz over 10 s *or* 2. Any periodic discharges or spike/sharp-wave pattern averaging ≥0.5 Hz and ≤1.0 Hz over 10 s with either a plus modifier§ or fluctuation‖ *or* 3. Any lateralized rhythmic delta activity averaging >1 Hz over 10 s with either a plus modifier§ or fluctuation‖

*The minimum duration of 10 s does not apply if a consistent clinical correlate is in lockstep to the electrographic pattern (ie, electroclinical seizure).
†Evolution: At least 2 unequivocal, sequential changes in frequency, morphology, or location
‡The minimum duration for bilateral motor activity with an electrographic correlate is 5 continuous minutes (ie, electroclinical convulsive status epilepticus).
§Plus modifier: Additional feature that renders the pattern more ictal in appearance (+F [superimposed fast activity], +R [superimposed rhythmic activity], +S [superimposed sharp waves or spikes, or sharply contoured])
‖Fluctuation: ≥3 changes, all within 1 min in frequency, morphology, or location but not qualifying as evolution
Data from Hirsch LJ et al (2021).[8]

Cardiopulmonary Resuscitation) trial[17] is the first RCT of protocolized tiered treatment targeting suppression of electrographic seizures, status epilepticus, or interictal patterns detected on continuous EEG in adults after arrest compared with standard care (Table 2). The trial randomized 172 subjects and the use of antiseizure medication was allowed but discouraged in the standard care group. The rate of unfavorable neurological outcome (defined as Cerebral Performance Category score of 3–5) did not differ at 3 months, but only 10% of patients in both treatment groups had electrographic seizures (the rate of clinically apparent and electroclinical seizures were not reported). Although the trial was not powered for subgroup analyses, patients with electrographic seizures (ie, periodic discharge frequencies surpassing 2.5 Hz), evolving patterns, or those with nongeneralized periodic discharges between 0.5 and 2.5 Hz had better outcomes with protocolized, tiered antiseizure treatment than standard care alone.

4. There are several approaches to EEG monitoring that vary in duration (ie, from short 20- to 40-minute recordings to continuous monitoring for several days) and electrode arrangement (ie, from full 21 electrodes to simplified 6–10 electrode montages). Seizures, epileptiform abnormalities, and clinical myoclonus may occur immediately after ROSC or emerge several days after initial resuscitation.[7,12,18] Continuous EEG after cardiac arrest, although more costly and labor intensive, increases sensitivity for seizures, status epilepticus, and epileptiform activity detection when compared with brief intermittent recordings given the variability in the timing these patterns occur and frequent lack of clinical correlation. However, use of continuous EEG was not associated with improvement in survival or functional outcome in observational cardiac arrest studies[19,20] or the CERTA (Continuous EEG Randomized Trial in Adults) trial,[21] a multicenter pragmatic study involving critically ill patients with impaired consciousness, of whom nearly one-third had been post–cardiac arrest patients.
5. Cardiac arrest as the etiology of seizures and status epilepticus has been an exclusion criterion in RCTs specific to status epilepticus[22,23]; consequently, therapeutic algorithms are extrapolated from other settings, including guidelines for generalized convulsive status epilepticus. The 2023 ILCOR CoSTR summary[14] recommended that seizures be treated when diagnosed in postarrest patients. No specific antiseizure medications were recommended.
6. The ACNS defines the ictal-interictal continuum as rhythmic or periodic patterns that may be consistent with possible nonconvulsive seizures or status epilepticus even without fulfilling strict electrographic criteria (Table 2).[8] Patients with patterns on the ictal-interictal continuum who exhibit both electrographic and clinical response to a therapeutic trial with a loading dose of a nonsedating antiseizure medication (ie, not benzodiazepines) are considered to have electroclinical status epilepticus; thus, therapeutic trials of antiseizure medication may be considered for interictal findings. Clinical response to a therapeutic trial may not be apparent on bedside examination in patients who are unresponsive to commands after ROSC, therefore, determination of an electroclinical response to a therapeutic trial may be challenging.
7. No new studies were identified in the updated ILCOR CoSTR summary from 2023.[14] Seizure

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prophylaxis did not improve outcomes after cardiac arrest in 2 prospective RCTs[24,25] and 1 nonrandomized prospective clinical trial with historical controls.[26] Prophylaxis was also not effective in preventing subsequent seizures in the post–cardiac arrest period.[24–26] However, these studies lacked systematic diagnosis of seizures with EEG monitoring, seizures reported were abstracted from clinical documentation, and the sample size was insufficiently powered for this outcome. Additionally, these studies were designed as therapeutic trials of neuroprotection with thiopental, magnesium and diazepam, or diazepam alone, with the primary outcome being functional neurologic outcome with the Cerebral Performance Category scale. Therefore, their study designs are inadequate to provide definitive evidence on the role of seizure prophylaxis in the prevention of acute symptomatic seizures and later development of epilepsy following cardiac arrest. Furthermore, the chosen therapeutic agents in these studies[24–26] are not commonly used as seizure prophylaxis in clinical practice in the current era, thus, precluding extrapolation of findings on seizure prophylaxis with other agents that might have a more favorable side effect profile with fewer sedating effects.

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Diagnosis and Management of Myoclonus in Adults After Cardiac Arrest

Recommendations for the Diagnosis and Management of Myoclonus in Adults After Cardiac Arrest		
COR	**LOE**	**Recommendations**
1	**C-LD**	1. We recommend promptly performing and interpreting EEG for the diagnosis of seizures in adult patients with myoclonus after ROSC.
3: No Benefit	**C-LD**	2. Treatment to suppress myoclonus without an EEG correlate is not recommended in adult survivors of cardiac arrest.

Synopsis

Myoclonus is a common clinical manifestation of hypoxic-ischemic brain injury, being observed in approximately 18% to 34% of post–cardiac arrest patients.[1–5] Myoclonus can present as diffuse or multifocal muscle jerks or more subtle focal motor movement involving the face and limbs.[6,7] Up to half of patients with myoclonus are found to have electrographic seizures or status epilepticus, and the clinical exam alone is insufficient to predict which patients are having electrographic seizures.[8–10] Myoclonus with a time-locked EEG correlate is a seizure (Table 2), although it is controversial whether this is an epiphenomenon of hypoxic-ischemic brain injury or if it is a seizure pattern that should be treated to prevent secondary brain injury.[8,10,11] Independent of the presence of a time-locked EEG correlate, myoclonus may interfere with supportive care and ventilatory mechanics.[12,13]

Post–cardiac arrest studies are limited by substantial heterogeneity in definitions and terminology used for describing and classifying myoclonus and its associated EEG findings, including the presence of electrographic seizures and status epilepticus or epileptiform discharges or other electrographic events time locked to the myoclonus[8,11,14–16] (Table 3).

Recommendation-Specific Supportive Text

1. There is no specific clinical exam pattern, timing of occurrence, or myoclonus pattern that is reliably associated with the presence or absence of seizures or status epilepticus on EEG after cardiac arrest.[4,6–8] Therefore, prompt EEG monitoring is necessary to diagnose whether myoclonus is associated with seizures, status epilepticus, or the presence of other EEG correlates (Table 3).[16] Back averaging of EEG and electromyography signals may be necessary to determine the precise relationship between EEG events (eg, spikes, bursts) and myoclonus.[8,17] Myoclonus can cause significant muscle artifact on EEG, which can be overcome with neuromuscular blockade under close monitoring.
2. There is no randomized or nonrandomized study evaluating the role of pharmacologic interventions for the management of myoclonus without an EEG correlate after cardiac arrest. Similarly, there is no evidence implicating myoclonus without an EEG correlate in the pathogenesis of secondary brain injury after cardiac arrest.[18] Myoclonus after cardiac arrest is often refractory to treatment, and multiple antiseizure medications or anesthetic agents may be needed for myoclonus control.[2,5,7,8,13,18–24] High risk of bias related to patient selection and confounding effects and inconsistent reporting of myoclonus and EEG characteristics in the literature preclude a specific treatment recommendation for myoclonus without an EEG correlate.[14] The risk of cardiovascular, neurological, and other medication side effects outweighs the unknown benefit of suppressing myoclonus without an EEG correlate on patient outcomes.

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Table 3. Commonly Used Terms and Definitions for Myoclonic Activity After Cardiac Arrest

Terminology	Definition	Note
Status myoclonus Clinical myoclonus without EEG evaluation	Repetitive myoclonic jerks that are diffuse or generalized, focal, or multifocal, occurring once every 10 s for at least 10 min or at least once every min for at least 30 min	Clinical diagnosis that is made without EEG evaluation Status myoclonus cannot be differentiated from myoclonic seizures without an EEG. This term is used only until the myoclonus is further characterized by EEG.
Electroclinical myoclonic seizure/status epilepticus Cortical myoclonus Myoclonus with EEG correlate	Clinical manifestation of myoclonic jerks with a consistent and unequivocal EEG correlate that is not confounded by muscle artifact on EEG	No definite distinguishable features on clinical exam May require back averaging EEG-EMG for confirmation Distinct electroclinical phenotypes have been identified, which may carry different prognostic implications.
Subcortical myoclonus Myoclonus without EEG correlate	Clinical manifestation of myoclonic jerks without EEG correlate	No definite distinguishable features on clinical exam Ascertaining lack of EEG correlate can be challenging in clinical practice and may be aided by use of neuromuscular blockade.

EEG indicates electroencephalography; and EMG, electromyography.

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NEUROPROGNOSTICATION

Introduction

Hypoxic-ischemic brain injury is the leading cause of morbidity and mortality in patients who achieve ROSC after OHCA and accounts for a significant portion of unfavorable outcomes after resuscitation from in-hospital cardiac arrest.[1,2] Most deaths attributable to brain injury after cardiac arrest are due to withdrawal of life support based on a predicted unfavorable neurological outcome. Prognostication is critically important as surrogates commonly make decisions relying on the perceived estimated likelihood of recovery that is shared by the treatment team. Accurate neuroprognostication is important to avoid inappropriate withdrawal of life support in patients who may otherwise achieve meaningful recovery and to avoid ineffective treatment when poor outcome is inevitable (Figure 2).[3]

Neuroprognostication frequently incorporates assessment of structural injury (eg, neuroimaging and biomarkers) or neurological function (eg, neurophysiologic tests and clinical examination). The ideal timing for neuroprognostic tests avoids the effects of confounding (eg, from temperature, medications, and systemic organ dysfunction). Multiple tests are incorporated to estimate the likelihood for recovery to a favorable or unfavorable state. Most neuroprognostic studies utilize dichotomized outcome scales, with a favorable functional outcome defined by the ability to achieve independence (ie, Glasgow-Pittsburgh Cerebral Performance Category scores of 1–2 or modified Rankin Scale scores of 0–3), although some studies have thresholds characterized by recovery of consciousness (ie, Cerebral Performance Category score of 1–3 or modified Rankin Scale score of 0–4). These studies do not capture granular details on the functional state of patients, nor do they consider their individual preferences or values, limiting their utility. Further guidance on best practices on the interpretation of outcomes with a patient-centered approach is included in "Part 3: Ethics."

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General Considerations for Neuroprognostication in Adult Patients After Cardiac Arrest

Recommendations for General Considerations for Neuroprognostication in Adult Patients After Cardiac Arrest		
COR	LOE	Recommendations
1	B-NR	1. In adult patients who remain comatose after cardiac arrest, we recommend that neuroprognostication involve a multimodal approach and not be based on any single finding.
1	B-NR	2. In adult patients who remain comatose after cardiac arrest, we recommend that neuroprognostic impressions be delayed until adequate time has passed to ensure avoidance of confounding by medication effect or a transiently poor examination in the early postinjury period.
1	C-EO	3. We recommend that teams caring for adult patients who remain comatose after cardiac arrest have early, regular, and transparent multidisciplinary discussions with surrogates about the anticipated time course for uncertainties around neuroprognostication.
2a	B-NR	4. In adult patients who remain comatose after cardiac arrest, it is reasonable to consolidate the interpretation of multimodal prognostic assessments at a minimum of 72 h after normothermia and discontinuation of sedatives.

Synopsis

Neuroprognostication relies on interpreting the results of tests and correlating those results with outcome. Given that a false positive test for unfavorable neurological outcome could lead to inappropriate withdrawal of life support from a patient who otherwise would have recovered, specificity is the most important test characteristic when predicting unfavorable outcome. In some instances, prognostication and withdrawal of life support may appropriately occur earlier because of nonneurologic disease, catastrophic brain herniation, patient's goals and wishes, or clearly nonsurvivable situations. Many of the tests considered are subject to error because of the effects of medications, organ dysfunction, and temperature. Importantly, many published neuroprognostic studies are impacted by self-fulfilling prophecy bias, given that practices of neuroprognostication are inherently part of PCAC, and in turn, outcomes are modulated by such practices. Furthermore, research studies have methodological limitations, including small sample sizes, single-center design, lack of blinding, failure (or inability) to account for unmeasured factors that impact the pace of recovery, and the use of outcome at hospital discharge rather than a time point associated with maximal recovery (typically 3–6 months after arrest).[3] Additionally, prognostic tests may yield discordant or inconclusive results, and in such instances, continued observation and serial assessment remains a treatment option.

Recommendation-Specific Supportive Text

1. Any single method of neuroprognostication has an intrinsic error rate and may be subject to confounding, therefore, multiple modalities should be used to improve decision-making accuracy.[4–9] The overall certainty in the evidence of neuroprognostication studies is low due to inherent biases that limit the internal validity of studies and limited generalizability that challenge their external validity. Neuroprognostication approaches employing multimodal testing aim at mitigating error rates; concordant results increase certainty when predicting outcomes.[3,5,6,8,10–19]
2. Early withdrawal of life support based on presumed poor neurological prognosis remains frequent, despite the risk for unreliable outcome prediction within 72 hours after ROSC.[20,21] Sedatives and neuromuscular blockers may be metabolized more slowly in post–cardiac arrest patients, and injured brains may be more sensitive to the depressant effects of various medications. Residual sedation or paralysis can confound the accuracy of clinical examinations.[22]
3. Establishing clear and cohesive communication with families is a key aspect of PCAC. Communication should be implemented early and maintained longitudinally, addressing major needs, including the uncertainty of neurological prognosis.[23,24] Difficulties in family-team communication dynamics may contribute to premature withdrawal of life support.[25] Discordance in goals of care between clinicians and families/surrogates has been reported in more than 25% of critically ill patients.[26] Regular multidisciplinary meetings may help improve communication.
4. Operationally, the timing for prognostic impressions is typically at least 5 days after ROSC for patients treated with hypothermic temperature control (approximately 72 hours after normothermia) and is conducted under conditions that minimize the confounding effects of sedating medications. Each neuroprognostic test has a specific time window in which it has optimal test performance. Prognostic impressions comprise results of tests integrated into the multimodality assessment synthesized at least 72 hours after normothermia.[11,13,27–35]

Use of the Clinical Examination in Neuroprognostication

Synopsis

Historically, neuroprognostic studies evaluated findings from clinical examination that correlated with unfavorable neurological outcome. More recently, the focus of neuroprognostication after cardiac arrest has shifted to include prognostication for both favorable and unfavorable outcome. Given that a test may perform better in predicting unfavorable but not favorable outcome or vice versa, specific recommendations are made depending on the finding and the outcome (ie, favorable versus

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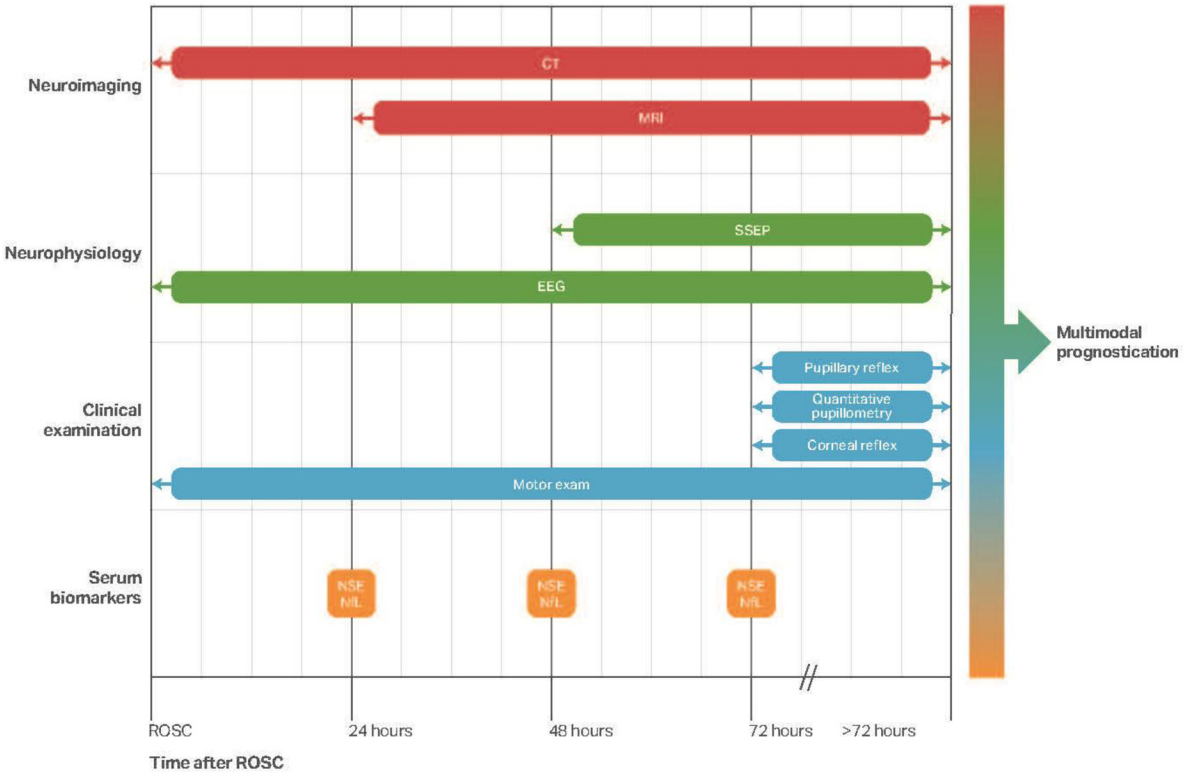

Neuroprognostic modality	Unfavorable outcome more likely	Favorable outcome more likely
Neuroimaging	• Reduced GWR on CT • Extensive areas of reduced ADC on MRI at 2-7 days after cardiac arrest • Extensive areas of restricted diffusion on MRI at 2-7 days after cardiac arrest	• Absence of restricted diffusion on MRI at 2-7 days after cardiac arrest
Neurophysiology	• Bilaterally absent N20 peaks on SSEP at 48 hours or more after cardiac arrest • Burst suppression at ≥72 hours after cardiac arrest in the absence of sedation • Status epilepticus ≥72 hours after cardiac arrest	• Continuous EEG background without discharges within 72 hours after cardiac arrest
Clinical examination	• Bilaterally absent pupillary light reflex at ≥72 hours after cardiac arrest • Bilaterally absent corneal reflexes at ≥72 hours after cardiac arrest • Decreased response on quantitative pupillometry at ≥72 hours after cardiac arrest	• Withdrawal or better motor response
Serum biomarkers	• High NSE within 72 hours after cardiac arrest • High NfL within 72 hours after cardiac arrest	• Normal NSE within 72 hours after cardiac arrest

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Figure 2. Recommended approach to multimodal neuroprognostication.
A multimodal approach to neuroprognostication is recommended, denoted by the multicolored arrow at the right of the figure. Neuroprognostic impressions are delayed until adequate time has passed to ensure avoidance of confounding by medications, temperature control, organ failure, or other sources. ADC indicates activated diffusion coefficient; CT, computed tomography; EEG, electroencephalogram; GWR, gray-white ratio; MRI, magnetic resonance imaging; NfL, neurofilament light chain; NSE, neuron-specific enolase; ROSC, return of spontaneous circulation; and SSEP, somatosensory evoked potential.

unfavorable outcome) with which it has correlated. Serial clinical examinations in comatose survivors of cardiac arrest assess the level of consciousness, pupillary light and corneal reflexes, and best motor response to noxious stimulation. The presence of myoclonus during the first week after cardiac arrest is also noted. Myoclonus

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describes repetitive jerk-like involuntary movements that can be generalized, focal, multifocal, synchronous, or asynchronous in their involvement of body parts and may or may not have an electroclinical correlate with discharges on EEG (refer to the Seizures, Myoclonus, and Other Epileptiform Activity section). Clinical examination findings that correlate with poor outcome are subject to confounding by temperature and medications.

Recent ILCOR systematic reviews included studies regardless of temperature control, and findings were correlated with neurological outcome at time points ranging from hospital discharge to 12 months after arrest.[10,36] A 2023 systematic review specifically evaluated the prognostic value of different test modalities for the prediction of favorable outcome.[37]

Clinical Examination for Neuroprognostication of Unfavorable Outcome in Adults After Cardiac Arrest

Recommendations for Clinical Examination for Neuroprognostication of Unfavorable Outcome in Adults After Cardiac Arrest		
COR	**LOE**	**Recommendations**
2b	**B-NR**	1. When performed with other prognostic tests, it may be reasonable to consider bilaterally absent pupillary light reflex at ≥72 h after cardiac arrest to support the prognosis of unfavorable neurological outcome in adult patients who remain comatose.
2b	**B-NR**	2. When performed with other prognostic tests, it may be reasonable to consider quantitative pupillometry at ≥72 h after cardiac arrest to support the prognosis of unfavorable neurological outcome in adult patients who remain comatose.
2b	**B-NR**	3. When performed with other prognostic tests, it may be reasonable to consider bilaterally absent corneal reflexes at ≥72 h after cardiac arrest to support the prognosis of unfavorable neurological outcome in adult patients who remain comatose.
2b	**B-NR**	4. The usefulness of undifferentiated myoclonus as a predictor of unfavorable neurological outcome in adult patients who remain comatose is uncertain, even when occurring within 72 h after cardiac arrest.
2b	**B-NR**	5. The usefulness of best motor response in the upper extremities of absent or extensor response as a predictor of unfavorable neurological outcome in adult patients who remain comatose after cardiac arrest is uncertain.

Recommendation-Specific Supportive Text

1. Twenty-seven retrospective studies demonstrated that absent pupillary light reflex evaluated immediately after ROSC and up to 7 days after arrest predicted unfavorable neurological outcome with specificity ranging from 48% to 100%[5–8,11,27,28,38–57]; these studies support the reliability of pupillary light reflex as a prognostic tool.[4,58,59] Studies with earlier time points for assessments of pupillary light reflex had lower specificity[43,46]; the highest specificity was seen at time points ≥72 hours after arrest[5,6,8,11,40,42] and when combined with absent corneal reflexes.[5,7,8,42] The false positive rates of bilaterally absent pupillary light reflex when assessed at least 72 hours after arrest in predicting unfavorable outcome were consistently low across studies. However, pupillary light reflex is vulnerable to the effect of medications and ambient light, subjective interpretation of the examiner, rigor of technique for assessment, individual factors, and self-fulfilling prophecy bias.
2. Quantitative pupillary light reflex of 0% is an objective finding that describes bilateral absence of pupillary light reflex as assessed by pupillometry.[49] The automated quantification of pupillary reactivity with pupillometry yields measurements of amplitude and velocity of constriction and dilatation. Four retrospective studies evaluated quantitative pupillary light response (ie, the percentage of reaction to light),[49,60–62] and 9 evaluated NPi (reactivity index from comparison with normal responses)[13,18,49,62–67] at time points ranging from immediately after ROSC[65] to 72 hours after arrest. Quantitative responses of 4% to 5% had higher sensitivity in predicting unfavorable neurologic outcome within 72 hours after arrest while maintaining 100% specificity. The NPi ≤2 threshold at 24 hours demonstrated 100% specificity for unfavorable neurological outcome in most studies.[13,18,49,66,67] NPi is nonspecific and may be affected by medications; thus, an absolute NPi cutoff that predicts unfavorable outcome remains unknown.[4,13,18,49,59,62–67]
3. Eighteen studies evaluated the bilateral absence of corneal reflexes at time points ranging from immediately after ROSC to 7 days after arrest with specificity ranging from 25% to 100%[5,7,8,27–29,35,40,42–45,48,50,53,54,68,69]; these studies support the reliability of corneal reflex as a prognostic tool. Studies with higher specificity evaluated corneal reflexes at time points ≥72 hours after arrest or in combination with bilaterally absent pupillary light reflexes.[5,7,8,42] Corneal reflexes are subject to confounding by medications and rigor of technique of the examiner, and few studies specifically evaluated the potential of residual medication effect or described the type of stimuli used for testing.
4. Marked heterogeneity in study definition of myoclonus after cardiac arrest challenge the interpretation of this finding as a neuroprognostic tool.[70] Eleven observational studies evaluated the presence of myoclonus (not otherwise specified) within 96 hours after arrest with specificities for unfavorable neurological outcome ranging from 77.8% to 100%,[11,13,27,29–35,68] yielding false positive rates up to 22.2% (and upper bound of 95% CI of 60%).[4] Six studies evaluated status myoclonus within 72 hours from ROSC with specificities for unfavorable outcome ranging from

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94% to 100%.[6,7,33,53,71,72] There were methodological limitations in all studies, including a lack of standard definitions, lack of blinding, incomplete data on EEG correlates, and the inability to differentiate between myoclonus subtypes. This imprecision may result in erroneous estimates of unfavorable outcome if undifferentiated myoclonus is used as a prognostic marker. Given these limitations in the interpretation of literature and the need for characterization of electroclinical subtypes of myoclonus after cardiac arrest, an expert consensus suggested avoiding using the term *status myoclonus*.[73]

5. Historically, the best motor examination in the upper extremities has been used as a prognostic tool, with extensor or absent motor responses being correlated with unfavorable outcome. Previous literature was limited by methodological concerns, including confounding for effects of hypothermic temperature control and medications, as well as self-fulfilling prophecy bias. The literature was so imprecise with higher-than-acceptable false positive rates (up to 75.1%)[4,7,58,59] that the finding of absent or extensor response as best motor response was considered potentially harmful when used alone for predicting a unfavorable neurological outcome.[74] Conversely, multimodal neuroprognostic studies using the Glasgow Coma Motor subscore as an entry point have demonstrated sensitivity ranging from 23% to 71% while maintaining high specificity.[5–9]

Clinical Examination for Neuroprognostication for Favorable Outcome

Recommendations for Clinical Examination for Neuroprognostication for Favorable Outcome		
COR	**LOE**	**Recommendations**
2b	**B-NR**	1. The usefulness of quantitative pupillometry to support the prognosis of favorable neurological outcome in adult patients who remain comatose after cardiac arrest is not well established.
2b	**B-NR**	2. It may be reasonable to consider withdrawal motor response or better to support the prognosis of favorable neurological outcome in adult patients who remain comatose after cardiac arrest.
3: No Benefit	**B-NR**	3. The finding of preserved pupillary light reflexes is not useful to support the prognosis of favorable neurological outcome in adult patients who remain comatose after cardiac arrest.
3: No Benefit	**B-NR**	4. The finding of preserved corneal reflexes is not useful to support the prognosis of favorable neurological outcome in adult patients who remain comatose after cardiac arrest.

Recommendation-Specific Supportive Text

1. Two retrospective studies evaluated the predictive performance of present pupillary light reflex to support a prognosis for favorable neurological outcome, when evaluated alone[12] or in combination with present corneal reflexes,[16] from admission[16] to up to 3 days following normothermia and discontinuation of sedatives.[12] Sensitivity when testing after mitigation of confounders reached 97.3%; however, specificities only surpassed 80% when both corneal and pupillary reflexes were present early after ROSC.[12]
2. Four observational studies evaluated the prediction performance of best motor responses (Glasgow Coma Motor subscores) from admission to 96 hours after arrest to support a prognosis of favorable neurological outcome.[7,12,16,75] Sensitivity ranged from 11.6% to 79.26% with specificity ranging from 71.7% to 97.7%; higher specificities were seen with higher motor scores (withdrawal or localizing responses, Glasgow Coma Motor subscores of 4 or 5, respectively).[37] This recommendation is supported by a 2022 ILCOR systematic review.[36]
3. Two retrospective studies evaluated the prediction performance of pupillometry when assessed at admission to up to 72 hours after arrest to support a prognosis for favorable neurological outcome.[12,13] In a post hoc analysis of the largest (n=456) neuroprognostic study evaluating the usefulness of pupillometry in cardiac arrest, the mean lowest NPi measured within 3 days after arrest in patients with a favorable outcome was 4.1.[13] The ideal thresholds and timing of testing for pupillometry derived metrics that predict favorable outcome is unknown.
4. Two retrospective studies evaluated the prediction performance of the presence of corneal reflexes to support a prognosis for favorable neurological outcome, when evaluated alone[12] or in combination with present pupillary light reflexes,[16] from admission[16] to up to 3 days following normothermia and discontinuation of sedatives.[12] Sensitivity when testing after mitigation of confounders reached 93.6%; however, specificities only surpassed 80% when both corneal and pupillary reflexes were present <72 hours after ROSC.[12]

Serum Biomarkers for Neuroprognostication of Favorable and Unfavorable Outcome in Adults After Cardiac Arrest

Recommendations for Serum Biomarkers for Neuroprognostication of Favorable and Unfavorable Outcome in Adults After Cardiac Arrest		
COR	**LOE**	**Recommendations**
2b	**B-NR**	1. When performed in combination with other prognostic tests, it may be reasonable to consider high serum values of NSE or NfL within 72 h after cardiac arrest to support the prognosis of unfavorable neurological outcome in adult patients who remain comatose after ROSC.

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Recommendations for Serum Biomarkers for Neuroprognostication of Favorable and Unfavorable Outcome in Adults After Cardiac Arrest (Continued)		
COR	**LOE**	**Recommendations**
2b	B-NR	2. When evaluated with other prognostic tests, it may be reasonable to consider normal levels of NSE within 72 h after cardiac arrest to support the prognosis of favorable neurological outcome in adult patients who remain comatose after ROSC.
2b	B-NR	3. The usefulness of other serum biomarkers for neuroprognostication in adult patients who remain comatose after ROSC is uncertain.

Synopsis

Serum biomarkers are blood-based tests that measure the concentration of proteins normally found in the central nervous system. These proteins are absorbed into blood in the setting of neurological injury, and their serum levels reflect the degree of brain injury. Limitations to their prognostic utility include variability in testing methods on the basis of site and laboratory, between-laboratory inconsistency in levels, susceptibility to additional uncertainty due to hemolysis, and potential extracerebral sources of the proteins. The 2020 and 2022 ILCOR systematic reviews evaluated studies that obtained serum biomarkers within the first 7 days after arrest and correlated serum biomarker concentrations with favorable and unfavorable neurological outcomes.[4,37] Other testing of serum biomarkers, including testing levels over serial time points after arrest, was not evaluated. The 2 most studied biomarkers were NSE and S100 calcium-binding protein B (S100B). Additional evidence for NfL in predicting favorable neurological outcomes and levels of other blood biomarkers for predicting favorable neurological outcomes has accumulated since these reviews. Prospective validation of different biomarkers and thresholds for both favorable and unfavorable neurological outcome in cohorts more broadly representative of resuscitated cardiac arrest patients is of high clinical importance.

Recommendation-Specific Supportive Text

1. For prediction of unfavorable outcome, 17 observational studies evaluated NSE collected within 72 hours after cardiac arrest,[4,13,18,72,76–86] and threshold levels for unfavorable outcome ranged from 17 to 106 µg/L with specificity for poor outcome of 44% to 100%. The evidence is limited because of a lack of blinding, laboratory inconsistencies, a broad range of thresholds needed to achieve 100% specificity, and imprecision. Data from only 2 observational studies assessing NfL for unfavorable outcome prediction were included in the 2020 ILCOR systematic review.[87,88] In the interim, 9 additional observational studies evaluated NfL within 72 hours after arrest for predicting unfavorable outcome.[81,82,89–95] Multiple studies directly compared NfL to NSE for prognostication of unfavorable outcome and found both improved sensitivity with NfL while maintaining high specificity. Many of the included studies are secondary analyses of RCTs. Strengths of these studies include multiple sites, blinding of clinical staff, and standardized, blinded outcome assessment, but the trial populations may not reflect the overall post–cardiac arrest population. SIMOA (Quanterix) was the most used assay. Values may differ among commercially available assays.[96] Studies reported multiple thresholds and collected samples at different times. In the postarrest period, the optimal threshold and timing for both NSE and NfL levels are unknown, but very high levels may inform multimodal prognostication.
2. For predicting favorable outcome, the 2022 systematic review identified normal levels of NSE (<17 µg/L) between 24 and 72 hours as a predictor of favorable neurological outcome.[37] Specificity was >80% in the included studies. The biomarkers S100B, NfL, ubiquitin carboxyl-terminal hydrolase-L1 (UCH-L1), glial fibrillary acidic protein (GFAP), and tau were also included. NfL and GFAP had the highest specificity for favorable outcome but had relatively fewer studies compared with NSE. Interval searches identified 5 studies of NSE,[8,16,76,97,98] 1 of NfL,[90] and 1 of both GFAP and tau[99] for predicting favorable neurological outcome. Specificity for favorable neurological outcome was >80% for each biomarker. Different threshold values and sample timing were reported between studies. While the evidence for favorable outcome prediction with biomarkers is less established than for prediction of unfavorable outcome, sustained low levels of biomarkers, in particular, NSE, may be an encouraging finding. Specificity may be lower when predicting favorable neurological outcome due to competing risks of nonneurological organ dysfunction or failure.
3. In addition to 2 prospective and 2 retrospective studies identified in the 2020 ILCOR systematic review,[4] 3 observational studies evaluated S100B levels within the first 72 hours after arrest.[84,85,93] The maximal level that correlated with unfavorable outcome ranged broadly depending on the study and the timing when it was measured after arrest. Interval studies do not clarify the optimal timing or threshold value to inform prognostication. Only 1 study of GFAP[100] and tau[101] were identified. Seven observational studies investigated other biomarkers, including UCH-L1, GFAP, and serum and cerebrospinal fluid tau.[89,93,95,99,102–104] In studies that included multiple biomarkers, performance was not consistently better than NSE. Given the low number of studies, the certainty of evidence was low and these biomarkers could not be recommended for clinical practice.

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Use of Electrophysiological Tests for Neuroprognostication

Synopsis

Electroencephalography is widely used in clinical practice to evaluate cortical brain activity and diagnose seizures. Its use as a neuroprognostic tool for predicting both unfavorable and favorable neurological outcome is promising, but the literature is limited by several factors, including lack of standardized terminology and definitions, relatively small sample sizes, lack of blinding, subjectivity in the interpretation, and lack of accounting for effects of medications. There is also inconsistency in definitions used to describe specific findings and patterns. The EEG patterns that were evaluated in the 2020 ILCOR systematic review for predicting unfavorable neurological outcome include unreactive EEG, epileptiform discharges, seizures, status epilepticus, burst suppression, and "highly malignant" EEG.[4] Unfortunately, studies define "highly malignant" EEG differently or imprecisely, limiting use of this finding. Use of standardized terminology from the ACNS avoids this heterogeneity and limits potential for misclassification. Several EEG patterns were observed in a 2022 systematic review for predicting favorable neurological outcome.[37] While studies had several operational definitions, most classifications assessed EEG continuity, voltage, and absence of epileptiform discharges.

Somatosensory-evoked potentials (SSEPs) evaluate the integrity of the dorsal column–lemniscal sensory pathway and are subject to less interference from medications than other modalities. In the context of neuroprognostication after cardiac arrest, SSEPs are obtained by stimulating the median nerve and evaluating for the presence of cortical N20 potentials, which are generated in the primary somatosensory cortex and demonstrate integrity of the thalamocortical pathway involved in cortical arousal and consciousness. The reliability of this modality is limited by technical challenges, including operator skill, interrater agreement, and impairment of signal to noise ratio from muscle and environmental contamination. Recommended technical standards are available.[105]

Electrophysiology for Neuroprognostication of Unfavorable Outcome in Adults After Cardiac Arrest

Recommendations for Electrophysiology for Neuroprognostication of Unfavorable Outcome in Adults After Cardiac Arrest		
COR	**LOE**	**Recommendations**
2b	**B-NR**	1. When evaluated with other prognostic tests, the prognostic value of seizures in adult patients who remain comatose after ROSC is uncertain.
2b	**B-NR**	2. When evaluated with other prognostic tests, it may be reasonable to consider status epilepticus continuing ≥72 h after cardiac arrest to support the prognosis of unfavorable neurological outcome in adult patients who remain comatose after ROSC.
2b	**B-NR**	3. When evaluated with other prognostic tests, it may be reasonable to consider burst suppression on EEG in the absence of sedating medications at ≥72 h after arrest to support the prognosis of unfavorable neurological outcome in adult patients who remain comatose after ROSC.
2b	**B-NR**	4. When evaluated with other prognostic tests, the usefulness of rhythmic or periodic discharges to support the prognosis of unfavorable neurological outcome in adult patients who remain comatose after ROSC is uncertain.
2b	**B-NR**	5. When evaluated with other prognostic tests, it may be reasonable to consider bilaterally absent cortical N20 waves on SSEPs at ≥48 h after cardiac arrest to support the prognosis of unfavorable neurological outcome in adult patients who remain comatose after ROSC.
3: No Benefit	**B-NR**	6. We recommend that the absence of EEG reactivity within 72 h after cardiac arrest not be used to support the prognosis of unfavorable neurological outcome in adult patients who remain comatose after ROSC.

Recommendation-Specific Supportive Text

1. No additional studies have been identified since the publication of the 2020 ILCOR systematic review.[4] The 2020 systematic review included observational studies focused on electrographic seizures, though some studies also included convulsive seizures and the definitions for seizures were nonstandardized across studies. The specificity of unequivocal seizures meeting ACNS critical care EEG criteria was 100%; however, the sensitivity of this finding was poor (0.3%–26.8%), and other studies that were not included in the review found patients with postarrest seizures who had favorable outcomes.[31,106,107] Additional methodological concerns include selection bias for which patients underwent EEG monitoring and inconsistent definitions of seizure. Further, critical care EEG terminology has been updated since the publication of these studies.[108] The term *seizure* encompasses a broad spectrum of pathologies that likely have different prognoses, ranging from a single brief electrographic seizure to refractory status epilepticus, and this imprecision justifies the more limited recommendation.
2. In the 2020 ILCOR systematic review, the specificity of status epilepticus for unfavorable outcome ranged from 82.6% to 100%.[4] No additional studies were identified that reported sensitivity or specificity of this finding. One retrospective study

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reported electrographic characteristics of patients with definitive or possible status epilepticus.[109] Of the 64 subjects included, 5 survived 30 days after arrest and 1 had a favorable outcome. The most common cause of death in decedents was withdrawal of life-sustaining therapies, which occurred a median of 8 days (IQR, 7–11) after arrest. Interestingly, although status epilepticus is a severe form of seizure the specificity of status epilepticus for unfavorable outcome was less than reported in the studies examining the seizures overall (as above). Additional concerns within the studies include the inconsistent definition of *status epilepticus*, lack of blinding, and the use of status epilepticus to justify withdrawal of life-sustaining therapies leading to potential self-fulfilling prophecies. The 72-hour timing is based on most studies reporting presence of status epilepticus within this period and case reports of good outcome when status epilepticus is successfully treated within this period.

3. The term *highly malignant EEG* was inconsistently applied in studies included in the 2020 ILCOR systematic review.[4] Twelve studies evaluated burst suppression or suppression on EEG monitoring.[6,8,9,40,69,72,81,110–114] Across these studies, *highly malignant EEG* was classified as burst suppression or suppression according to the ACNS critical care EEG terminology.[108,115] Specificity ranged from 90.7% to 100%, and sensitivity was 15% to 51%. The potential for self-fulfilling prophecies, interrater disagreement, and lack of control for medication effects limited the ability to make a stronger recommendation, despite the overall high specificity.[112] Further, in a preplanned analysis of the TTM2 trial, specificity of burst suppression or suppression for unfavorable outcome was lower (93%) compared to studies with specific centralized or expert EEG review.[114] Additional studies identifying subtypes of burst suppression, such as synchronous or identical bursts, are needed.[116] Burst suppression can be caused by medications, so it is particularly important that clinicians have knowledge about the potential effects of medication on this prognostic tool.
4. The 2020 ILCOR systematic review considered discharges as either rhythmic/periodic or nonrhythmic/periodic.[4] Sensitivity and specificity of rhythmic/periodic patterns for unfavorable outcome ranged from 0.5% to 50.8% and 77.7% to 100%, respectively, with wide confidence intervals. As the time from the cardiac arrest to test increased, the specificity of rhythmic/periodic discharges for unfavorable outcome improved. Nonrhythmic/periodic patterns had a similar range of sensitivity (0.5%–38.5%) and specificity (84.6%–100%). One observational study reported outcomes in patients with stimulus-induced rhythmic or periodic patterns recorded >36 hours after arrest.[117] Of the 142 included patients, 20 (14%) had stimulus-induced rhythmic or periodic patterns recorded on EEG monitoring. The rate of unfavorable outcome was not different between patients with (n=13, 65%) or without stimulus induced rhythmic or periodic patterns (n=88, 72%) (P=0.596). The literature of both rhythmic/periodic and nonrhythmic/periodic discharges are limited by lack of accounting for effects of medications and variable timing of EEG monitoring. Low specificity currently limits the use of these findings to support an unfavorable prognosis.
5. Bilateral absence of N20 peaks following median nerve stimulation is the most studied and well-accepted neuroprognostic predictor for SSEP testing. Twenty observational studies[5–8,11–13,27,35,38,39,41–43,47,49,50,55,57,69,72,118–130] evaluated bilateral absent N20 peaks assessed up to 6 days after arrest with specificity ranging from 50% to 100%. Six studies had specificity below 100%,[11,27,47,50,118,123] and additional methodological limitations included lack of blinding and potential for self-fulfilling prophecy bias. Newer studies evaluated the unilateral absence of N20 combined with amplitude thresholds, which may increase sensitivity for detection of unfavorable outcome.[6,57,131,132] While studies evaluated SSEPs obtained at any time starting immediately after ROSC, there is a high likelihood of potential confounding factors early after cardiac arrest, leading to the recommendation that SSEPs should only be obtained >48 hours after arrest.
6. A preplanned analysis of the TTM2 trial data reported the prognostic value of unreactive EEG between 24 hours to 14 days.[114] Specificity for unfavorable neurological outcome was 60% with a sensitivity of 79%. The study relied on local EEG reviewers to assess reactivity rather than a centralized expert review. Specificity was lower than in studies included in the 2020 ILCOR review, which ranged from 41.7% to 100% but was below 90% in most studies.[4] One study assessed EEG reactivity during hypothermia and normothermia intending to assess agreement for reactivity between raters and sensitivity for unfavorable outcome for reactivity to different stimulations.[35] Percent agreement ranged from 58% to 70%, and sensitivity ranged from 52% to 86% depending on stimulation type and whether assessment occurred during hypothermia or normothermia. Thus, the overall certainty of the evidence was rated as very low. There is interest in automated reactivity assessment and stimulation paradigms.

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Electrophysiology for Neuroprognostication of Favorable Outcome in Adults After Cardiac Arrest

Recommendations for Electrophysiology for Neuroprognostication of Favorable Outcome in Adults After Cardiac Arrest		
COR	LOE	Recommendations
2b	B-NR	1. When evaluated with other prognostic tests, it may be reasonable to consider a continuous EEG background without discharges within 72 h after cardiac arrest to support the prognosis of favorable neurological outcome in adult patients who remain comatose after ROSC.
2b	B-NR	2. The usefulness of the amplitude of the N20 wave on SSEP following medium nerve stimulation to support the prognosis of favorable neurological outcome in adult patients who remain comatose after ROSC is not well established.

Recommendation-Specific Supportive Text

1. The 2022 systematic review for prediction of favorable outcome found a continuous EEG background without discharges within 72 hours after cardiac arrest to predict a favorable neurological outcome.[37] Specificity ranged from 51% to 100%, with most studies reporting a specificity >80%. Specificity was higher in earlier (12 and 24 hours) compared to later time points (48 and 72 hours). One additional observational study evaluated continuous normal voltage background without discharges on EEG 24 hours after cardiac arrest.[16] Sensitivity and specificity for favorable neurological outcome at 6 months after arrest were 64% and 89%, respectively. When compared to unfavorable outcome, the specificity for predicting favorable outcome is overall less given the competing risk of nonneurological mortality and morbidity.
2. Quantitative characteristics of the N20 signal are of interest as prognostic indicators, and there are several methods for calculating the amplitude of the N20 wave. The threshold of >4 μV when measured as the peak-to-trough difference between the peak of the N20 wave and the trough of the subsequent P25 wave has achieved specificity above 90% with sensitivity above 40% in most studies using this finding to predict favorable neurological outcome.[16,36,37,72] One study found that patients sedated with midazolam had lower amplitudes (measured as N20/P25 peak-to-peak amplitude) when compared to propofol.[14] The ideal amplitude thresholds, measurement methods, and timing of N20 wave amplitude testing for SSEP that predict favorable outcome is unknown.

Use of Neuroimaging for Neuroprognostication

Synopsis

Neuroimaging may be helpful to detect and quantify structural brain injury after cardiac arrest. The most common modalities are CT and magnetic resonance imaging (MRI). The use of quantitative analysis modalities assessing the burden of hypoxic-ischemic brain injury in clinical practice is limited by the availability of quantitative methods outside research settings, while qualitative imaging results are often subjective and have lower sensitivity.[133,134] On CT, cytotoxic brain edema can be quantified as the gray-white ratio (GWR), defined as the ratio between the density (measured as Hounsfield units) of gray matter and white matter. Normal brain has a GWR of approximately 1.3. In the setting of cerebral edema, GWR declines, either due to decreased density of gray matter (representing cytotoxic edema) or decreased attenuation of white matter. On MRI, cytotoxic brain edema can be measured as restricted diffusion on diffusion-weighted imaging (DWI) and can be quantified by the apparent diffusion coefficient (ADC). The ADC is a sensitive measure of injury, with normal values ranging between 650 and 1000 × 10^{-6} mm^2/s and values decreasing with injury. Brain injury findings from CT and MRI evolve over the first several days after arrest, so the timing of the imaging study of interest is particularly important as it relates to prognosis.

Neuroimaging for Neuroprognostication of Unfavorable Outcome in Adults After Cardiac Arrest

Recommendations for Neuroimaging for Neuroprognostication of Unfavorable Outcome in Adults After Cardiac Arrest		
COR	LOE	Recommendations
2b	B-NR	1. When performed with other prognostic tests, it may be reasonable to consider reduced GWR on brain CT after cardiac arrest to support the prognosis of unfavorable neurological outcome in adult patients who remain comatose after ROSC.
2b	B-NR	2. When performed with other prognostic tests, it may be reasonable to consider extensive areas of restricted diffusion on brain MRI at 2 to 7 d after cardiac arrest to support the prognosis of unfavorable neurological outcome in adult patients who remain comatose after ROSC.
2b	B-NR	3. When performed with other prognostic tests, it may be reasonable to consider extensive areas of reduced ADC on brain MRI at 2 to 7 d after cardiac arrest to support the prognosis of unfavorable neurological outcome in adult patients who remain comatose after ROSC.

Recommendation-Specific Supportive Text

1. Forty-one observational studies[6,17,55,56,68,121,125,133–166] evaluated GWR—the most commonly studied method for quantification of hypoxic-ischemic brain injury on brain CT.[167] Whole-brain GWR (GWR average) and GWR in specific regions were evaluated with high specificity in predicting unfavorable neurological outcome; lower prediction performance was seen when using thalamus as a region of interest and with higher cutoffs for GWR.

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Thirty-four of the studies evaluated CT obtained within 24 hours after arrest,[6,17,55,56,68,121,133–139,141–143,145,147–153,155,156,158–161,163–166] and 6 studies included brain CTs obtained up to 10 days after arrest.[125,140,146,154,157,162] In retrospective studies, the predictive performance improved when images were obtained at 24 to 72 hours[134,140,151,155] and up to 10 days from ROSC.[154,162] There were methodological limitations, including selection bias, risk of multiple comparisons, and heterogeneity of measurement techniques, such as anatomic sites, equipment, and calculation methods. Thus, specific methods for calculation of and thresholds for GWR and ideal timing for CT acquisition that predict unfavorable prognosis with highest specificity remain unknown. Fewer studies have evaluated CT metrics as predictors of death by neurological criteria[148,150]; external validation and reproducibility of methods are lacking.

2. Ten observational studies[16,55,69,110,168–173] investigated DWI changes on MRI qualitatively within 2 to 7 days after arrest for unfavorable outcome prediction. The studies evaluated MRI qualitatively. And definitions of relevant findings differed between studies, such as use of "high signal intensity" and "positive findings." In some studies, only specific brain regions were examined, with or without using a standardized scoring system. Moreover, studies are limited by subjective thresholds and lack of blinding. The specificity ranged from 55.7% to 100%. In the context of multimodal prognostication, an extensive burden of reduced DWI on MRI may be correlated with unfavorable prognosis, but a broader recommendation could not be supported. The imprecise definition and short-term outcome in some studies led to significant uncertainty about how to use qualitative DWI MRI to predict unfavorable prognosis.
3. Ten observational studies investigated quantitative ADC on MRI within 2 to 7 days after arrest for unfavorable prognosis prediction.[17,69,158,164,170,171,174–177] The studies used custom-made computational tools to quantitatively determine the whole brain or region of interest volume below a specific ADC threshold for poor outcome prediction. The ADC thresholds used, ADC calculation methods used, and regions included for analyses varied among studies, with cutoffs for unfavorable outcome with 100% specificity using 650×10^{-6} mm^2/s or 450×10^{-6} mm^2/s varying from 20.5% to 42.2% and 1.3% to 5.2%, respectively. There is no standardization of quantitative measurements of ADC in cardiac arrest, and such analyses require expertise in advanced computational methods; hence, there are concerns about feasibility and reliability. In the context of multimodal prognostication, an extensive burden of decreased ADC on MRI may be correlated with unfavorable prognosis. A specific ADC threshold for global or regional brain injury that predicts unfavorable prognosis is not known.

Neuroimaging for Neuroprognostication of Favorable Outcome in Adults After Cardiac Arrest

Recommendations for Neuroimaging for Neuroprognostication of Favorable Outcome in Adults After Cardiac Arrest		
COR	**LOE**	**Recommendations**
2b	B-NR	1. The usefulness of GWR on brain CT after cardiac arrest to support the prognosis of favorable neurological outcome in adult patients who remain comatose after ROSC is not well established.
2b	B-NR	2. When performed with other prognostic tests, it may be reasonable to consider the absence of restricted diffusion on brain MRI at 2 to 7 d after cardiac arrest to support the prognosis of favorable neurological outcome in adult patients who remain comatose after ROSC.

Recommendation-Specific Supportive Text

1. Three observational studies evaluated the role of GWR on brain CTs performed within 6 hours up to 36 hours after arrest to identify patients with favorable outcomes.[56,142,158] In the largest cohort, patients who regained consciousness before hospital discharge had a median GWR 1.38. The ideal thresholds and methods of calculation for GWR and timing for CT acquisition that predict favorable prognosis are unknown.[36,37]
2. Six studies investigated the absence of qualitative DWI abnormalities within 2 to 7 days from arrest as a predictor of favorable outcome.[16,45,168–171] These studies had a sensitivity for favorable outcome prediction of 51% to 100%, but there was heterogeneity of DWI assessment methods and which regions were evaluated. In the context of multimodal prognostication, the absence of injury using DWI on MRI may be correlated with a favorable prognosis, but imprecise definitions and criteria for brain MRI assessment led to uncertainty about how to use DWI MRI to predict favorable prognosis.

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ORGAN DONATION AFTER CARDIAC ARREST IN ADULTS

Recommendations for Organ Donation After Cardiac Arrest in Adults		
COR	**LOE**	**Recommendations**
1	B-NR	1. Organ donation should be considered in all adult patients resuscitated from cardiac arrest who meet neurological criteria for death (ie, brain death).
1	B-NR	2. Organ donation should be considered in all adult patients resuscitated from cardiac arrest before planned withdrawal of life-sustaining therapies.
1	C-EO	3. Decisions about organ donation should follow local legal and regulatory requirements.
1	C-EO	4. Organ donation is an important outcome that should be considered in the development and evaluation of systems of care.
2b	C-LD	5. It may be reasonable to consider utilization of organs from adult patients resuscitated with ECPR who remain supported on ECMO and who meet neurological criteria for death (ie, brain death) or for whom withdrawal of life-sustaining therapies is planned.

Synopsis

Organ transplantation wait times in the United States are increasing as patients in need of transplant outpace available organs.[1] Thousands die annually waiting for transplantation.[1] Patients with cardiac arrest make up an important pool of potential donors because cardiac arrest is common and a substantial proportion of those who cannot recover are still able to donate.[2–7] However, organ donation is rarely reported as an outcome in cardiac arrest clinical trials or as a metric in large registry data.

Deceased organ donation may occur after death is determined by neurological criteria (donation after brain death) or circulatory criteria (donation after circulatory death [DCD]). After sudden cardiac arrest, DCD can be pursued in patients with ROSC after planned withdrawal of life-sustaining therapies and the transition to comfort- oriented care, called controlled DCD, or in patients who fail to achieve ROSC after unsuccessful resuscitation, called uncontrolled DCD. Uncontrolled DCD has unique logistic, ethical, and legal requirements—factors that hinder its widespread application in many settings.

The role of extracorporeal membrane support in organ donors is complex and evolving. Patients with cardiac arrest may receive extracorporeal membrane support either through ECPR or through having it placed in the postarrest period. Those patients who remain on extracorporeal membrane support and die by brain death or have a planned withdrawal of life-sustaining therapies represent a unique population of potential organ donors.

Recommendation-Specific Supportive Text

1, 2. Numerous observational studies demonstrate that allograft function and recipient outcomes are similar when transplanted organs are recovered from patients with cardiac arrest compared with other deceased donors[8–14]; this holds true for donation after brain death and controlled DCD.

3. Laws and regulations governing the determination of death and organ donation vary not only between countries[15,16] but also by state despite efforts to standardize death determined by neurological criteria worldwide.[15]

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4. A 2023 ILCOR CoSTR scientific statement focuses on the importance of increasing organ availability after cardiac arrest.[7] It recognizes organ donation as an important outcome of cardiac arrest and emphasizes the importance of research and clinical protocols incorporating this principle. Organ donation after cardiac arrest directly benefits recipient patients.
5. A 2024 meta-analysis[17] based mostly on retrospective observational studies, case reports, and one retrospective analysis of a prospective trial[18] demonstrated that organs donated from patients who were already on extracorporeal membrane support were viable for transplantation. In a subset of patients receiving ECPR, graft survival was high, reaching 89%. The most common organ donated was kidney, followed by liver and heart. The included studies indicate that patients who received ECPR are a potential source of donor organs and that organs donated from patients who received ECPR can have good graft survival.

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RECOVERY AND SURVIVORSHIP AFTER CARDIAC ARREST

Recommendations for Recovery and Survivorship After Cardiac Arrest		
COR	**LOE**	**Recommendations**
1	B-R	1. It is recommended that cardiac arrest survivors and their caregivers have structured assessment and treatment/referral for emotional distress after medical stabilization and before hospital discharge.
1	C-LD	2. It is recommended that cardiac arrest survivors have multimodal rehabilitation assessment and treatment for cognitive, physical, neurological, and cardiopulmonary impairments before hospital discharge.
1	C-LD	3. It is recommended that cardiac arrest survivors and their caregivers have multidisciplinary discharge planning, to include medical and rehabilitative treatment recommendations and return to activity/work expectations.
2b	B-R	4. Interventions to address health care professional burnout may be beneficial.
2b	C-LD	5. Debriefings and referral for follow-up for emotional support for lay rescuers, emergency medical services professionals, and hospital-based health care professionals after a cardiac arrest event may be beneficial.

Synopsis

Survivors of cardiac arrest experience emotional, social, physical, neurological, and cognitive sequalae, which can manifest during or after hospitalization.[1,2] Broadly defined, survivorship is the journey from stabilization through rehabilitation, recovery, and societal reintegration.[1] Improving cardiac arrest survivorship involves families, health

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care partners, and communities. Caregivers of cardiac arrest survivors also experience emotional and social challenges as they navigate survivorship issues.[1,2]

Optimizing survivorship for survivors and their caregivers involves in-hospital screening, treatment, referral, and postdischarge surveillance of postarrest sequalae.[1] Survivorship plans given at discharge can provide direction by including a summary of the inpatient course, individualized medical and rehabilitative treatment recommendations, and postdischarge recovery expectations.[1] All those impacted by cardiac arrest can be powerful advocates for informing community responses to cardiac arrest, tailored interventions, and relevant patient-/family-centered outcomes.[1]

Finally, lay rescuers, emergency medical services professionals, and hospital-based health care professionals who care for cardiac arrest patients often experience distress.[3,4] Debriefings after witnessing cardiac arrest events, identifying the natural stressors associated with caring for such patients, and offering well-being interventions or referrals for follow-up mental health services may provide opportunities to mitigate distress and burnout.

Recommendation-Specific Supportive Text

1. Approximately one fourth of cardiac arrest survivors and their caregivers experience emotional distress (including anxiety, depression, and posttraumatic stress).[1,5–8] Fatigue is also common and may be related to distress and physical and cognitive symptoms.[2,9–11] Often, these symptoms begin to manifest during hospitalization and can linger from months to years.[7,9,10]
   One RCT compared a psychosocial intervention between 2 groups; both groups included survivor-caregiver pairs, but in one group, only the survivors received the psychosocial intervention and in the other group, both the survivors and caregivers received the psychosocial intervention.[12,13] There were improvements in emotional distress for the survivors in both groups; however, those in the survivor-caregiver intervention group had the greatest benefit. Caregivers in the survivor-caregiver intervention group had more improvements in caregiver burden compared with the caregivers in the survivor-only intervention group.[12,13] Two other RCTs in survivors showed improvements in emotional distress in those receiving psychosocial intervention compared with control.[14–16] The evaluation before discharge is important to facilitate care coordination and referral.
2. Cognitive impairments, particularly in memory, attention, and executive function, are common in cardiac arrest survivors.[17–19] Physical, neurological, and cardiopulmonary impairments are also prevalent.[10,20–23]
   One RCT found improved quality of life in survivors enrolled in an early, cognitive-focused screening, self-management, and referral program compared to treatment as usual.[24] Three other preliminary trials demonstrated feasibility of a residential physical rehabilitation intervention, cardiac rehabilitation, and a telephone-based occupational therapy intervention in cardiac arrest survivors, with preliminary benefits in physical, cardiopulmonary, and quality of life outcomes.[25–27] The evaluation prior to discharge is important to facilitate care coordination and referral.
3. Community reintegration and return to work or other daily activities may be slow and depend on availability of social support and degree of postarrest sequelae.[27–31] Survivors and caregivers need direction on managing their postarrest challenges (eg, guidance on possibility of experiencing psychological, cognitive, physical, neurological, and cardiopulmonary symptoms and which professionals to seek out should they arise) and returning to daily activities.[1,2]
4. Burnout among health care professionals is common,[32] is not unique to those who provide care for patients with cardiac arrest, and is often characterized by emotional exhaustion, depersonalization/cynicism, and reduced sense of personal accomplishment.[33] Burnout negatively impacts health care professionals' productivity (eg, absenteeism, turnover) and patient care (eg, reduced patient satisfaction and increased clinician errors).[34,35]
   Seven RCTs targeting burnout in health care professionals all led to some improvement in at least one dimension of burnout or mental health outcome. Intervention mechanisms varied considerably, including yoga, mindfulness, gratitude journaling, various other positive psychology exercises, and individualized professional coaching. Benefits included improved well-being, work engagement, quality of life, perceived stress, and depressive and anxiety symptoms.[36–42]
   Although these results are promising, variability in intervention methods and outcome measures, considerable attrition, and high risk of bias inherent in behavioral trials limit the degree to which any single well-being intervention method can be recommended.
5. Rescuers and hospital-based health care professionals may experience emotional distress caring for a cardiac arrest patient.[3,4,43,44] Team debriefings may allow for quality improvement as well as recognition of the natural stressors associated with caring for a cardiac arrest patient. In one qualitative study of lay rescuers and one nonrandomized study of emergency department professionals, participants reported benefitting emotionally from

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debriefings[45,46]; however, a scoping review found that nurses may prefer to not discuss distress during debriefings and rather to pursue support later.[43]

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Disclosures

Appendix 1. Writing Group Disclosures

Writing group member	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
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Patrick J. Coppler	University of Pittsburgh	NIH*	None	None	None	None	None	None
Ian R. Drennan	University of Toronto Ornge Critical Care and Transport Medicine Sunnybrook Health Sciences (Canada)	ZOLL†	None	ZOLL†	None	None	None	None
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Jacob C. Jentzer	Mayo Clinic	None	None	None	None	None	None	None
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Writing group member	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
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Amber J. Rodriguez	American Heart Association National Center	None	None	None	None	None	None	None
Albert Yen	University of California	None	None	None	None	None	None	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

‡Author chose not to endorse the final Post-Cardiac Arrest Care chapter or be listed with the writing group.

Appendix 2. Reviewer Disclosures

Reviewer	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
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Teresa L. May	MaineHealth	NINDS (PRECICEAP co-I)*	None	None	None	None	None	None
Mary Ann Peberdy	Virginia Commonwealth University	American Heart Association (drone delivery of AEDs)*	None	None	None	None	None	None
Janice Zimmerman	The Methodist Hospital Physician Organization	None	None	None	None	None	None	None

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Part 12: Resuscitation Education Science: 2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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ABSTRACT: Developed by the American Heart Association, these Guidelines represent the first comprehensive update of education recommendations since 2020. Incorporating the results of structured evidence reviews from the International Liaison Committee on Resuscitation, these are guidelines for the design and delivery of resuscitation training for health care professionals and lay rescuers. This update emphasizes the continuous evolution of evidence evaluation and the necessity of adapting educational strategies to local needs and diverse community demographics. Existing guidelines remain relevant unless specifically updated in this publication. Key topics that are new, are substantially revised, or have significant new literature include the use of cardiopulmonary resuscitation feedback devices in training, rapid-cycle deliberate practice, teamwork and leadership training, manikin fidelity, gamified learning, virtual and augmented reality, use of cognitive aids, stepwise training, blended learning, scripted debriefing, instructor training, alternative objects for lay rescuer chest compression training, and special considerations for training in the management of opioid overdose. How certain personal considerations may influence the overall impact of education are also reviewed, including disparities accordingly related to gender, race, socioeconomic status, and language; the impact of training for school children; and factors that act as barriers or facilitators to lay rescuer willingness to perform cardiopulmonary resuscitation. We conclude with a summary of current knowledge gaps in resuscitation education science and a discussion of future directions for optimizing the impact of resuscitation training programs.

Key Words: AHA Scientific Statements ■ cardiopulmonary resuscitation ■ disparities ■ education ■ educational design ■ health care professionals ■ lay person ■ training

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TOP 10 TAKE-HOME MESSAGES

1. Effective resuscitation education for lay rescuers and health care professionals is an essential component of the formula for survival from cardiac arrest.
2. The use of cardiopulmonary resuscitation (CPR) feedback devices leads to improved skill performance and is recommended during skill training for lay rescuers and health care professionals.
3. Disparities in public awareness, knowledge, and access to CPR education affect specific populations differently. It is recommended to focus efforts on public awareness campaigns and training availability in areas where these discrepancies are greatest.
4. Children 12 years of age and older should be taught to perform effective CPR and defibrillation; children younger than 12 years of age should be trained in emergency response and CPR to improve confidence and willingness when they are older.
5. Virtual reality (VR) and augmented reality (AR) can increase realism during resuscitation training. However, while VR can improve knowledge

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acquisition, AR should not be used to teach CPR skills.

6. Gamified learning has been shown to improve learner engagement and enhance knowledge acquisition.
7. The use of a script to guide debriefing during resuscitation training can help instructors by guiding discussions and enhancing consistency.
8. Rapid-cycle deliberate practice (RCDP) during CPR training can lead to better skill performance after training.
9. Alternative objects (eg, a pillow) have been studied as an inexpensive and accessible alternative to manikins for chest compression training, but more data is needed to determine their effectiveness.
10. Goals for future research in resuscitation education include studies demonstrating impact on clinical outcomes, cost-effectiveness of instructional design elements, and improvement in the uniformity and quality of outcome measures across studies.

PREAMBLE

Every year, millions of health care professionals and thousands of laypeople undergo basic life support (BLS) and advanced life support (ALS) training, aiming to improve patient outcomes in cases of cardiac arrest. Resuscitation training programs integrate evidence-based content with the opportunity to practice critical lifesaving skills in both individual and team-based clinical settings. While such training is widespread, it often falls short in achieving optimal performance for various reasons, with learners struggling to consistently apply acquired skills in public/out-of-hospital events as well as in patient care.[1,2]

The International Liaison Committee on Resuscitation (ILCOR) Formula for Survival (Figure) emphasizes 3 essential components influencing survival outcomes from cardiac arrest: guidelines based on current resuscitation science, effective education of lay rescuers and health care professionals, and local implementation of guidelines.[3] The provision of an effective education component is highly dependent on the instructional design of the educational endeavor because design strongly determines how content is delivered to and ultimately taken up by the learner. Placing greater emphasis on our understanding of how to increase the effectiveness of education programs will improve performance and lay rescuer confidence and enhance local implementation, all of which lead to the ultimate goal of increasing survival from sudden cardiac arrest.

These Guidelines contain recommendations for the design and delivery of resuscitation training for both lay rescuers and health care professionals. In Part 12, we explore the evidence informing different instructional design features and discuss how factors related to individuals, both lay rescuers and health care professionals,

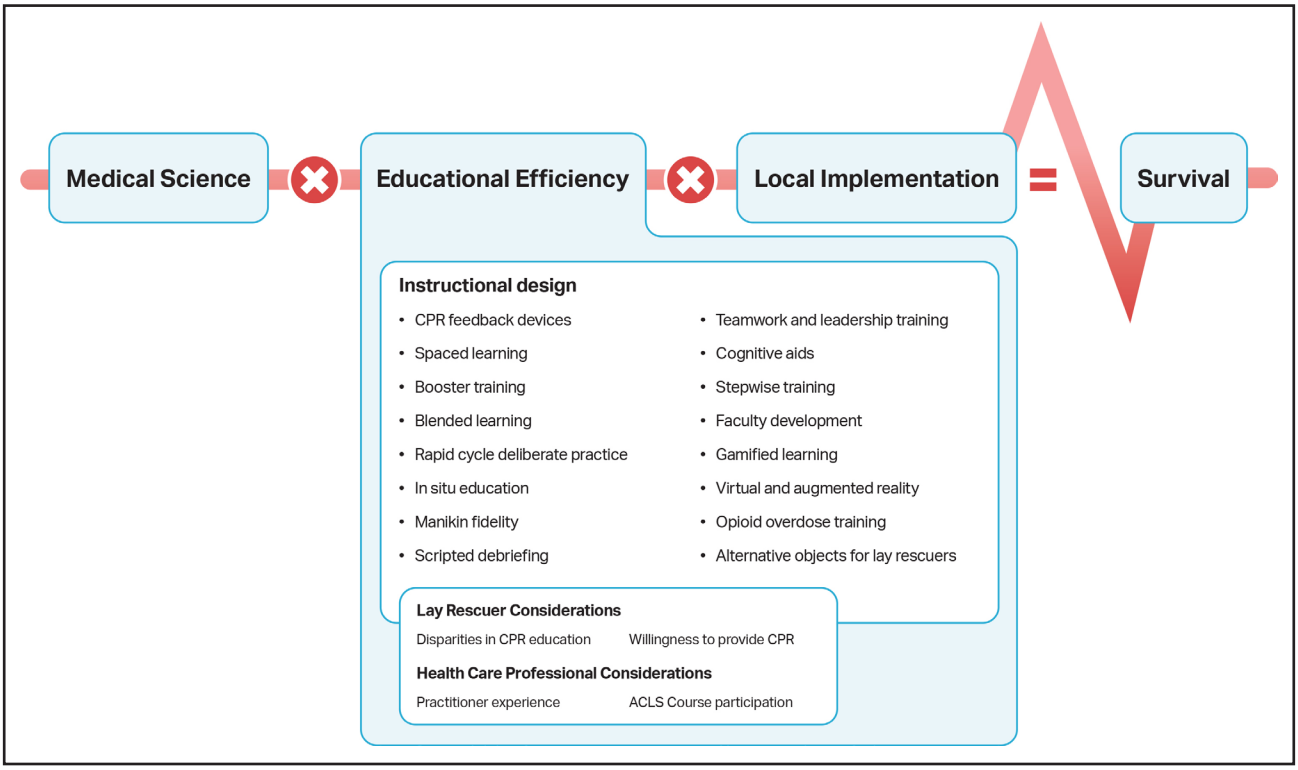

Figure. Formula for survival in resuscitation: key elements contributing to educational efficiency.
ACLS indicates advanced cardiovascular life support; and CPR, cardiopulmonary resuscitation.

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may influence CPR training, willingness to perform CPR, and quality of CPR performance.

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INTRODUCTION

Scope of Guideline

Cardiac arrest remains a major public health problem, with more than 600 000 cardiac arrests per year in the United States, both in and outside the hospital.[1,2] Survival rates of patients who experience cardiac arrest remain low despite significant advancements in resuscitation science and treatment; however, it is clear that timely CPR and use of an automated external defibrillator (AED) can double survival.[3] Each year, millions of people receive BLS and ALS training in an effort to improve the quality of CPR delivered to people experiencing cardiac arrest.[4] Resuscitation training programs are designed to convey evidence-based content and provide opportunities for learners (ie, those enrolled in resuscitation training programs) to apply knowledge and practice critical skills. These programs, however, frequently fall short of achieving the desired learning outcomes (eg, knowledge and skill acquisition), with performance that does not consistently translate over to real-world environments.[4,5] For example, CPR skills that are acquired immediately after BLS training often show decay by as early as 3 months, resulting in many BLS-trained lay rescuers and health care professionals—such as physicians, nurses, respiratory therapists, and emergency medical responders—challenged to perform Guideline-compliant CPR during simulated and real cardiac arrests.[6–14] Additionally, current research on lay rescuer CPR (LR-CPR) training lacks evidence describing how to train lay rescuers to consistently recognize cardiac arrest, initiate CPR, and use AEDs appropriately.[15–17] A dedicated focus on instructional design rooted in human psychology and behavior and learning science is essential to ensure that knowledge and skills acquired during training are easily and habitually applied in real-life cardiac arrest.[4]

Improving survival from cardiac arrest is highly dependent on the quality and timeliness of resuscitative care. Many key determinants of a higher chance of survival, such as immediate recognition of cardiac arrest, early initiation of CPR, early defibrillation, and high-quality chest compressions, are variables that can be targeted by resuscitation training programs. Instructional design features are the key elements, or "active ingredients," of resuscitation training programs that determine how content is delivered to the learner.[18] A better understanding of the impact of instructional design features, including the effectiveness of training aids, on learning outcomes will enable educators to design training programs that translate into outstanding skill performance during cardiac arrests. Furthermore, appreciating how social determinants of health (eg, SES, race) and individual factors (eg, practitioner experience) influence the impact of resuscitation education will help inform future policy and implementation strategies. In this Part, we describe the evidence supporting key elements of resuscitation education and provide recommendations aimed at improving learner outcomes and patient outcomes from cardiac arrest. The following sections briefly describe the process of evidence review and guideline development. See "Part 2: Evidence Evaluation and Guidelines Development" in the *2025 American Heart Association* (AHA) *Guidelines for CPR and Emergency Cardiovascular Care* (ECC) for more details on this process.

Organization of the Resuscitation Education Science Writing Group

The Resuscitation Education Science Writing Group comprised a diverse team of experts with backgrounds in resuscitation education, clinical medicine (ie, pediatrics, intensive care, emergency medicine), nursing, prehospital care, health services, and education research. Writing group members are AHA volunteers with an interest and recognized expertise in resuscitation and are selected by the AHA ECC Committee. The AHA has rigorous conflict-of-interest policies and procedures to minimize the risk of bias and improper influence during development of the Guidelines.[19] Before appointment, writing group members and peer reviewers disclosed all commercial relationships and other potential (including intellectual) conflicts. Disclosure information for writing group members is listed in Appendix 1.

METHODOLOGY AND EVIDENCE REVIEW

Part 12 of the 2025 Guidelines is based on the extensive evidence evaluation performed in conjunction with

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Table 1. Applying American College of Cardiology/American Heart Association Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care (Updated December 2024)*

CLASS (STRENGTH) OF RECOMMENDATION	LEVEL (QUALITY) OF EVIDENCE‡
Class 1 (STRONG) — Benefit >>> Risk **Suggested phrases for writing recommendations:** • Is recommended • Is indicated/useful/effective/beneficial • Should be performed/administered/other • Comparative-Effectiveness Phrases†: - Treatment/strategy A is recommended/indicated in preference to treatment B - Treatment A should be chosen over treatment B	**Level A** • High-quality evidence‡ from more than 1 RCT • Meta-analyses of high-quality RCTs • One or more RCTs corroborated by high-quality registry studies
Class 2a (MODERATE) — Benefit >> Risk **Suggested phrases for writing recommendations:** • Is reasonable • Can be useful/effective/beneficial • Comparative-Effectiveness Phrases†: - Treatment/strategy A is probably recommended/indicated in preference to treatment B - It is reasonable to choose treatment A over treatment B	**Level B-R (Randomized)** • Moderate-quality evidence‡ from 1 or more RCTs • Meta-analyses of moderate-quality RCTs
Class 2b (WEAK) — Benefit ≥ Risk **Suggested phrases for writing recommendations:** • May/might be reasonable • May/might be considered • Usefulness/effectiveness is unknown/unclear/uncertain or not well-established	**Level B-NR (Nonrandomized)** • Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies • Meta-analyses of such studies
Class 3: No Benefit (MODERATE) — Benefit = Risk (Generally, LOE A or B use only) **Suggested phrases for writing recommendations:** • Is not recommended • Is not indicated/useful/effective/beneficial • Should not be performed/administered/other	**Level C-LD (Limited Data)** • Randomized or nonrandomized observational or registry studies with limitations of design or execution • Meta-analyses of such studies • Physiological or mechanistic studies in human subjects
Class 3: HARM (STRONG) — Risk > Benefit **Suggested phrases for writing recommendations:** • Potentially harmful • Causes harm • Associated with excess morbidity/mortality • Should not be performed/administered/other	**Level C-EO (Expert Opinion)** • Consensus of expert opinion based on clinical experience

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR 1 and 2a; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely-used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

ILCOR and affiliated ILCOR member councils. Four different types of evidence reviews (systematic reviews, scoping reviews, evidence updates, and writing group evidence evaluations) were used in the 2025 process. Each of these resulted in a description of the literature that facilitated Guideline development.[20–24]

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Class of Recommendation and Level of Evidence

The AHA Resuscitation Education Science Writing Group reviewed all relevant and current AHA Guidelines for CPR and ECC[5,25–35] and the relevant ILCOR Consensus on Science With Treatment Recommendations[27] to determine if current guidelines should be reaffirmed, revised, or retired and whether new recommendations were needed. The writing group then drafted, reviewed, and approved recommendations, assigning to each a Level of Evidence (LOE; ie, quality) and Class of Recommendation (COR; ie, strength) (Table 1).

Importantly, applying Grading of Recommendations Assessment, Development, and Evaluation[36] to educational studies yields greater challenges than its application to clinical studies. Specific considerations for studies involving educational outcomes (eg, improved outcomes in simulated patient settings or improved performance on summative assessment tools) are not provided in Grading of Recommendations Assessment, Development, and Evaluation methodology; instead, the writing group frequently assigned LOE to these studies according to a combination of a typical review of study quality, perceived importance of underlying constructs in the context of educational science, and, where possible, extrapolation of findings to analogous clinical phenomena (eg, outcomes in real patients as opposed to simulated ones).

Guideline Structure

The 2025 Guidelines are organized into knowledge chunks grouped into discrete modules of information on specific topics or management issues.[37] Each modular knowledge chunk includes a table of recommendations using standard AHA nomenclature of COR and LOE. A brief introduction or short synopsis puts the recommendations into context with important background information and overarching management or treatment concepts. Recommendation-specific supportive text clarifies the rationale and key study data supporting the recommendations. Hyperlinked references are provided to facilitate quick access and review.

Document Review and Approval

These Guidelines were submitted for blinded peer review to subject matter experts nominated by the AHA. Peer reviewer feedback was provided for the Guidelines in draft format and again in final format. The Guidelines were reviewed and approved for publication by the AHA Science Advisory and Coordinating Committee and the AHA Executive Committee. Disclosure information for peer reviewers is listed in Appendix 2.

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MAJOR CONCEPTS

This Part is divided into 3 main sections: (a) instructional design and aids, (b) individual learner considerations, and (c) knowledge gaps and future research. Instructional design refers to the way in which curricula are designed and structured to help learners meet their objectives. When optimally implemented, instructional design involves recognizing the needs and contexts of individual learners and aligning the objectives of a given curriculum to best meet those needs.[1–3] Instructional design features take many forms, including features related to content (eg, team training), manikins or equipment (eg, manikin fidelity), methods of content delivery (eg, blended learning, spaced practice, RCDP), methods of content presentation (eg, VR, gamified learning), and other aspects of instruction. Resuscitation training programs may incorporate a key instructional design feature, or multiple features may be blended in an effort to optimize learning outcomes. In the first section, we offer recommendations related to the use of CPR feedback devices during training, RCDP, spaced learning and booster training, teamwork training, in situ training, levels of manikin fidelity, use of cognitive aids, gamified learning, VR and AR, blended

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learning, stepwise learning, scripted debriefing, and lay rescuer training in the management of opioid overdose.

In the second section, we describe how certain learner considerations may influence the overall impact of education. These include disparities related to gender, race, SES, and language; training of school-age children; as well as factors that act as barriers or facilitators to lay rescuer willingness to perform CPR. All of these considerations feed into the potential impact of instructional design and ultimately influence the educational efficiency component of the Formula for Survival (Figure).[4]

We conclude Part 12 of the 2025 Guidelines with a summary of current systematic shortcomings in resuscitation education research, a discussion of knowledge gaps in resuscitation education science, and future directions for optimizing the impact of resuscitation training programs.

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INSTRUCTIONAL DESIGN

Feedback Devices During CPR Training

Recommendations for the Use of Feedback Devices During CPR Training		
COR	**LOE**	**Recommendations**
1	A	1. Feedback devices are recommended for use during CPR training for health care professionals.
1	A	2. Feedback devices are recommended for use during CPR training for lay rescuers.

Synopsis

Accurate and reliable feedback is crucial for enabling learners to improve their performance. Prior studies demonstrate that visual assessment of CPR quality is often unreliable,[1,2] making it challenging for instructors to consistently deliver accurate feedback during training. Feedback devices for CPR help overcome this limitation by providing objective, real-time data to learners during training. Recent scientific statements have emphasized the importance of using CPR feedback devices during resuscitation training.[3] While earlier reviews indicate that these devices can enhance short-term educational outcomes,[4] there is a scarcity of studies objectively assessing CPR quality after training. No studies reported on cost-effectiveness, quality of CPR during real resuscitation, or patient survival.

Recommendation-Specific Supportive Text

1. Seventeen randomized controlled trials (RCTs) assessed the impact of using feedback devices during training on the quality of CPR compressions performed by health care professionals.[5–21] The meta-analyses demonstrated that CPR feedback devices had a moderate to large effect on all CPR quality metrics. Specifically, the use of feedback devices significantly increases mean compression depth, reduces deviations from the guideline-compliant compression rate, and improves compression depth, rate, and recoil compliance.
2. Three RCTs[22–24] conducted with lay responders demonstrated that feedback devices were effective in increasing mean compression depth,[22,23] improving compression depth,[22–24] and rate compliance,[22] and reducing deviations from the Guidelines for mean compression rate.[22–24] The effect on recoil compliance was not statistically significant in lay rescuers.[22,23]

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Spaced Learning and Booster Training

Recommendations for Spaced Learning and Booster Training		
COR	**LOE**	**Recommendations**
1	B-R	1. It is recommended to implement booster sessions when utilizing a massed learning approach for resuscitation training.
2a	B-R	2. It is reasonable to use a spaced learning approach in place of a massed learning approach for resuscitation training.

Synopsis

Traditional resuscitation courses typically follow a massed learning approach, consisting of a single training event that lasts several hours or days, with retraining occurring every 1 to 2 years.[1] In contrast, some resuscitation courses adopt a spaced learning approach, where training is divided into multiple sessions lasting from minutes to hours, dispersed weeks or months apart.[2–5] Each session in a spaced learning format either introduces new content or reinforces material from previous sessions. Another instructional strategy is booster training, which involves brief weekly or monthly sessions designed to reinforce content initially taught in a massed learning course.[6–19]

For advanced pediatric resuscitation training, spaced learning courses have been found to be at least as effective or more effective than massed learning courses.[3–5] No studies have directly compared spaced learning with massed learning for BLS, neonatal resuscitation (eg, the Neonatal Resuscitation Program), or advanced cardiovascular life support (ACLS) courses. Frequent booster training sessions conducted at 1- to 6-month intervals[6–12] as well as implementation of weekly booster sessions for Neonatal Resuscitation Program training reduced infant mortality.[13] However, a study found increased booster frequency reduced attendance rates, with the highest attrition.[6] No studies have evaluated booster training for pediatric advanced life support or ACLS courses.

Recommendation-Specific Supportive Text

1. Seven RCTs compared booster CPR training at intervals of 1 to 6 months with no booster training.[6–12] In 1 RCT, nurses who received more frequent CPR booster training showed a dose-dependent improvement in 1-year CPR skills. The proportion of participants achieving excellent CPR at 12 months was highest in those receiving monthly boosters.[6] Another RCT found that emergency department professionals who received monthly booster training had higher rates of excellent 12-month CPR performance compared to those who received no boosters.[7] One study reported improvements in CPR knowledge and skills following 30-minute booster sessions at 1, 3, and 6 months.[8] Another found enhanced ventilation and compression quality after monthly

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booster sessions.[9,10] One study observed shorter times to chest compressions and defibrillation following 15-minute booster sessions administered every 2, 3, or 6 months.[11] A lay rescuer study found every 6-month booster training demonstrated better CPR skill retention.[14] For neonatal resuscitation, 3 RCTs indicated that more frequent Neonatal Resuscitation Program booster sessions (ranging from weekly to 9 months) were associated with sustained improvements in skill performance.[15,16,18] One observational study reported both improved clinical performance and reduced infant mortality following implementation of 3- to 5-minute weekly booster sessions.[13]

2. Two RCTs and 1 observational study have compared spaced learning with massed learning for pediatric resuscitation training.[3–5] In 1 RCT, emergency medical services (EMS) professionals were randomized to either a spaced learning format (4 weekly sessions) or a massed learning format (2 consecutive days).[3] At 3 months, the spaced learning group demonstrated superior retention of infant bag-mask ventilation and infant intraosseous insertion skills compared to the massed learning group; no significant difference was observed in chest compression skills. Additionally, knowledge decay was noted in the massed learning group but not in the spaced learning group.[3] In another RCT, pediatric nurses and respiratory therapists were assigned to either a spaced learning approach (6 sessions over 6 months) or a massed learning format (a single day) for pediatric advanced life support recertification.[4] Clinical performance scores improved in the spaced learning group, while both groups showed similar improvements in teamwork at course completion. An observational study examined medical students who completed pediatric resuscitation training through either a spaced learning format (4 weekly sessions) or a massed learning session (a single session).[5] At 4 weeks after training, no significant differences were found between the groups in knowledge or skills.

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Rapid-Cycle Deliberate Practice

Recommendation for RCDP		
COR	LOE	Recommendation
2b	C-LD	1. It may be reasonable to incorporate RCDP as part of BLS or ALS training for health care personnel.

Synopsis

Rapid-cycle deliberate practice is a simulation-based training method that incorporates within-event debriefing.[1,2] RCDP is defined by rapid cycling between deliberate practice and directed feedback until skill mastery is achieved.[3] In simulations incorporating RCDP, the scenario is stopped at specific points (eg, time-outs), during which the facilitator gives learners feedback on performance. After the pause, the simulation is restarted and allowed to continue until another pause. Thus, the debriefing in RCDP is done in small chunks during the scenario and not after the scenario is completed. By the end of an RCDP session, learners have repeated several steps of the scenario multiple times. RCDP typically occurs in the context of a single learning session and thus can be incorporated into BLS and ALS courses.

Several randomized and nonrandomized studies with very low quality of evidence involving predominantly trainees incorporated RCDP as part of BLS or ALS training.[3–10] Knowledge gaps exist regarding the use of RCDP in lay rescuers and experienced health care professionals, the long-term impact of RCDP training, and the resources required to implement RCDP into life support training. Further research is needed to examine the effects of RCDP on clinical outcomes and patient survival.

Recommendation-Specific Supportive Text

1. One randomized[7] and 1 observational[3] study found that time to chest compressions was faster in the RCDP groups. Two studies reported higher compression fractions in the RCDP groups.[3,10] Studies show that the time to ventilate,[3,6] to deliver a shock,[3,7,10] and to the administration of epinephrine[6] were all shorter in the RCDP groups. Two studies found that RCDP groups had better odds of performing defibrillation within 2 and 3 minutes.[3,4] Two studies found that defibrillation before pause was significantly shorter in RCDP groups.[3,10] One randomized study showed lower NASA Task Load Index workload scores in RCDP participants compared to controls.[7] One study reported differences in teaching effectiveness as reported by learners in favor of controls.[5]

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Teamwork Competencies in Life Support Training

Recommendation for Teamwork Competencies in Life Support Training		
COR	LOE	Recommendation
1	B-R	1. It is recommended that life support training for health care professionals includes a specific emphasis on teamwork competencies.

Synopsis

Lapses in teamwork are a major contributor to unintended harm across health care.[1] Cardiac arrest outcomes are dependent on effective teamwork, given the need for the simultaneous delivery of several time-sensitive interventions.[2–4] Thus, in addition to training focusing on technical skills such as delivering high-quality CPR, life support training commonly includes training specifically targeting teamwork competencies including communication, leadership, decision-making, and workload management. The addition of teamwork training to life support courses may represent an opportunity to enhance patient safety.

Recommendation-Specific Supportive Text

1. Sixteen studies (14 RCTs and 2 observational studies) examined the impact of a specific emphasis on teamwork competencies in life support training on teamwork performance measures. Twelve of 14 RCTs demonstrated superior performance after specific teamwork training in outcomes related to

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communication,[1–7] leadership behavior,[4,8,9] nontechnical skills,[10,11] workload management,[6,7] and overall teamwork[12] at course completion. One observational study[13] reported higher scores on overall teamwork measures, while the other[14] found no difference in teamwork or leadership measures. Two[5,12] of the 3[5,12,15] RCTs reporting outcomes beyond course completion demonstrated improvement in teamwork measures.

Thirteen studies, 12 RCTs, and 1 observational study examined the impact of teamwork training on the performance of various technical skills such as adherence to guidelines,[3] time to specific behaviors,[5,6,10,11,13] completion of tasks such as intubation or medication administration,[8,11–13,15–17] or CPR quality parameters,[2–5,8] Of these 13 studies, 7 demonstrated improvement in at least one measure of technical skills performance either at[2,3,10,11,13] or beyond course completion.[5,12]

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Gamified Learning

Recommendations for Gamified Learning		
COR	**LOE**	**Recommendations**
2b	**C-LD**	1. It may be reasonable to use gamified learning elements as a component of resuscitation training for health care professionals.
2b	**C-LD**	2. It may be reasonable to use gamified learning elements as a component of CPR instruction for lay rescuers.

Synopsis

Gamified learning involves the use of game-like elements during resuscitation training. These elements can include competition, point systems, scaffolded levels of difficulty, and leaderboards. Gamified learning has been shown to increase learner engagement and enhance recall of content.[1] Gamified learning elements, both digital and nondigital, have been included in resuscitation training in an effort to create a greater degree of stimulation and engagement using active participation with and alongside peers, particularly for younger generations.

Significant heterogeneity exists in the literature regarding definitions of gamification, learning platforms, and assessment methods and metrics. More robust data are needed regarding generalizability and implementation, as well as understanding learner responses to gamification and possible patient outcomes.

Recommendation-Specific Supportive Text

1. Eleven studies in health care professionals evaluated outcomes of CPR skill performance, knowledge, and attitudes. One RCT using an online competitive platform showed improved CPR performance,[2] but multiple studies using leaderboards

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to monitor competition showed mixed results.[3,4] One RCT comparing smartphone-based games before and during the ALS course to no gaming showed no difference in ALS skills.[5] In contrast, an online gaming portal improved neonatal resuscitation scores in an observational study.[6] Multiple observational and RCT studies showed improved knowledge scores following a board game, a point-based screen game, a leaderboard, and smartphone-based games.[2,5,7,8] Self-reported confidence was higher among smartphone-based game users than nonusers[5] and players of a card game designed for neonatal resuscitation knowledge training reported high levels of perceived usefulness following the training.[9] Overall, for health care professionals, the evidence suggests that gamified learning was associated with improved CPR skill performance, knowledge, and self-confidence; however, because of low quality and heterogeneity among these studies, the recommendation remains weak.

2. Two studies in high school students examined CPR skill following a CPR tournament or a screen-based competition. Both studies showed immediate and 3-month to 6-month posttraining improvement in CPR skills compared with baseline or control group.[10,11] No studies evaluated CPR knowledge as an outcome. One RCT of a screen-based competition compared to standard training reported a higher proportion of learners in the competition group feeling emotions reported by lay rescuers such as afraid, nervous, or upset.[11] For laypersons, the evidence suggests gamified learning was associated with improved CPR skill performance and an emotional response similar to actual lay rescuers. Because of low quality and heterogeneity among these studies, the recommendation remains weak.

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Virtual and Augmented Reality

Recommendations for Virtual and Augmented Reality		
COR	**LOE**	**Recommendations**
2b	B-R	1. It may be reasonable to use VR to support knowledge acquisition in BLS and ALS training for lay rescuers and health care professionals.
2b	C-LD	2. The use of AR to provide real-time CPR feedback may be considered for BLS training of lay rescuers and health care professionals.
3: Harm	B-R	3. VR should not be used for CPR skill acquisition in lay rescuers and health care professionals.

Synopsis

VR environments allow users to engage with simulated patients via interactive scenarios within 3-dimensional computer-generated spaces that attempt to replicate real world interactions,[1] without overlaying objects from the real environment. In contrast, AR generates holographic images overlaid into the real clinical environment, allowing the user to interact with real objects and holograms in an integrated fashion.[1,2] AR has been used to provide clinical guidance and real-time feedback during technical skills such as CPR and patient care.[2–5] VR has been used to engage learners in immersive learning with the advantages of realism, reproducibility, and time-effectiveness,[6,7] with prior AHA Guidelines recommending VR as an option for BLS or ALS training.[8] Augmented reality has not been described in prior AHA Guidelines.

Recommendation-Specific Supportive Text

1. Thirteen studies[9] explored the use of VR for BLS training[10–19] and 2 described the use of VR for ALS training.[20,21] These studies utilized VR as the primary instructional methodology, either alone[10–12,14–19] or in combination with other methods.[13,22,23] Four studies showed improved

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knowledge acquisition with VR training compared to other forms of non-VR training (eg, personal computer or tablet-based serious games,[24] e-learning modules,[13] video-based training,[14] or flipped classroom training[19]), while other studies showed either no difference (compared to traditional training[16] or video-based training[15]) between groups or favored non–VR-based training methods.[18] Comparison of VR-based neonatal life support training to traditional training showed no difference in knowledge or clinical performance after training.[20,21]

2. Four RCTs involving health care professionals and lay rescuers examined CPR performance comparing AR to standard training.[2–5,9] These studies demonstrated mixed results for CPR performance when comparing AR-assisted feedback to other forms of CPR feedback or guidance from instructor.[2,4,5] There was no significant difference in mean CPR depth or CPR rate between the AR groups.[2,4,5]
3. Several studies quantitatively assessed CPR performance parameters (ie, mean CPR depth,[10,12] CPR depth compliance,[12,18] CPR rate compliance,[12,18] chest recoil compliance[16–18]) in VR-based training. VR-based training was found to be either inferior to or no different than other forms of CPR training. Results for overall CPR performance were mixed, with 1 study favoring VR training[19] and 3 others showing no difference or favoring non-VR training.[15,17,18] Participants receiving instructor-led training were more willing to perform CPR at 6 months after training[11] compared to those who received VR-based training.

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Manikin Fidelity

Recommendations for Manikin Fidelity		
COR	LOE	Recommendations
2b	B-R	1. The use of higher-fidelity manikins for BLS and ALS training can be beneficial for learners in training settings with available infrastructure.
2b	C-LD	2. The use of lower-fidelity manikins during BLS and ALS training may be considered in training settings where higher-fidelity manikins cannot be used for any reason.
2b	C-EO	3. It may be reasonable for instructors to use manikins and manikin features in a manner that allows for alignment of learning objectives to the specific needs of learners.

Synopsis

The term *fidelity* is used to describe features in a simulation setting that improve realism and allow learners to suspend disbelief to a greater extent. When the term fidelity is applied to manikins, it refers to the presence of physical features (visible, audible, palpable, etc.) and physiologic responses that make the manikin more closely resemble an actual patient. This increased physical realism may theoretically lead to greater engagement of learners, with the goal of improving educational outcomes. Limitations to higher-fidelity manikin use include high costs, availability of personnel and infrastructure to operate and maintain them (eg, technological resources), and limitations to manikin design in terms of physical features and their optimal applicability to learning objectives.[1,2] Data are lacking comparing manikin fidelity on patient outcomes and the effects of fidelity level on lay rescuer training.

Recommendation-Specific Supportive Text

1. A meta-analysis of 8 RCTs examining the effect of higher manikin fidelity on learning outcomes found modest improvement in psychomotor skill performance during immediate post-training assessment using simulated clinical scenarios. Another meta-analysis of 7 RCTs found no impact of manikin fidelity on immediate posttraining knowledge assessment.[3] Three RCTs examined teamwork performance between groups trained on higher- versus lower-fidelity manikins; 2 of the RCTs found positive effect of higher fidelity, while one found no difference.[4–6] Three RCTs examined psychomotor skill at 3 months or greater after training with mixed results.[7–9] Three RCTs examined knowledge at 6 months or longer after training based on higher- versus lower-fidelity manikin use, with mixed results.[7,9,10] Two studies reported exclusively on learner satisfaction and confidence; both demonstrated high levels of positive responses from learners.[11,12]
2. In a recent systematic review, 4 RCTs comparing higher- versus lower-fidelity manikins found no significant difference in learning outcomes across a variety of life support curricula, while at the same time demonstrating that both high- and low-fidelity manikins resulted in significant improvement in skill or knowledge compared to a pretraining baseline assessment.[4,13–15]
3. Because physical features of manikins vary, it may be reasonable for instructors to train learners using manikins and manikin features that are optimally realistic based on the learning objectives of a given training session (eg, manikin with compressible chest wall for CPR training).[1,2]

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Use of Cognitive Aids

Recommendations for Use of Cognitive Aids		
COR	LOE	Recommendations
2a	C-LD	1. It may be reasonable for health care professionals to use cognitive aids during resuscitation.
3: No Benefit	C-LD	2. It is not recommended for lay rescuers to use cognitive aids during resuscitation.

Synopsis

Cognitive aids are resources that provide prompts aimed to encourage recall of information and increase the likelihood of correct performance/behaviors. Cognitive aids can be divided into interactive (bidirectional flow of data, eg, digital app) or noninteractive (unidirectional flow of data, eg, algorithm card). There is significant heterogeneity in the literature in terms of study design, cognitive aid tool (eg, checklist, mobile device app, voice prompts, or pictures/flowsheet), and assessment methods/metrics. Published simulation data suggests that cognitive aid use by health care professionals and lay rescuers during resuscitation efforts have different impacts on the effectiveness of the resuscitation process, leading to opposing recommendations for these different groups.

Recommendation-Specific Supportive Text

1. Nineteen small simulation-based studies in health care professionals (physicians, nurses, multidisciplinary teams, and medical students) evaluated the outcomes of CPR quality, and adherence to protocols/process during resuscitation. For CPR quality, 1 RCT of noninteractive cognitive aid showed improved chest compression quality,[1] 1 RCT of interactive cognitive aid showed improved CPR performance score,[2] and 1 RCT showed no difference.[3] Studies of interactive cognitive aids included 4 non-RCTs[4–7] and 6 RCTs[8–14] showing improved adherence to protocol or procedure compared to controls. Two RCTs of noninteractive cognitive aids showed no difference in protocol adherence compared to control,[15,16] and 3 RCTs showed improved protocol adherence.[17–19] Overall, for health care professionals the evidence suggests that use of cognitive aids during simulated resuscitation efforts may lead to improved adherence to protocols and may improve CPR quality.
2. Ten small simulation-based studies in lay rescuers evaluated the outcomes of CPR quality and adherence to protocol/process during simulated resuscitation. For the outcome of CPR quality, 1 RCT using a noninteractive flowchart showed reduced hands-off time during CPR,[20] 1 RCT using a noninteractive smartphone app improved compression rate and depth,[21] and 1 RCT using an interactive cognitive aid showed improved adherence to 30:2 CPR ratio.[22] One observational study using chatbot guidance described low rates of high-quality CPR achieved, but had no comparison group.[23] One RCT comparing various-length noninteractive checklists showed no difference in CPR quality.[24] For the outcome of adherence to protocol/process, 3 RCTs (both interactive and noninteractive cognitive aids) showed improved adherence,[21,25,26] 1 RCT of noninteractive showed no improvement,[27] and 1 RCT and 1 observational study of noninteractive cognitive aids showed improved adherence to protocol.[28,29] However, 2 RCTs of interactive[20,22] and 1 RCT of noninteractive cognitive aids[26] showed significant delays (30–70 seconds) in calling emergency services and initiating chest compressions. Although studies demonstrated some improved CPR quality, this is outweighed by the statistically significant and clinically relevant delays to critical actions in the Chain of Survival.

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Stepwise Approach in Resuscitation Training

Recommendation for Stepwise Approach in Resuscitation Training		
COR	**LOE**	**Recommendation**
2b	**C-LD**	1. It may be reasonable to use a stepwise approach for skills-teaching in resuscitation training.

Synopsis

The ideal approaches for teaching resuscitation skills, considering learner performance, retention, confidence, and preference are not currently known and various stepwise approaches exist amongst courses developed by the world's leading resuscitation organizations. A stepwise approach is a deliberate skills-teaching methodology, including 2 or more steps (eg, Halsted's "see one, do one" approach). Stepwise approaches can vary considerably in number and order of steps, instructor/learner presence (eg, in-person or virtual), skills demonstration modality (eg, live versus prerecorded), and whether feedback is, or is not, provided by the instructor. Other stepwise approaches include Peyton's 4-step approach, which uses well-defined serial steps including demonstration, deconstruction, comprehension, and learner performance and practice.

Recommendation-Specific Supportive Text

1. Data primarily supported from a systematic review of 17 studies, including 14 RCTs[1–17] and 3 non-RCTs.[17–19] Skills were heterogeneous, ranging from very basic, such as nasogastric tube insertion,[8,10] to very advanced, such as endotracheal intubation and cricothyrotomy.[6,18] Most studies assessed chest compressions,[2,3,5,7,9,11,13,16,19] AED use,[2,3,7] and basic airway management.[2,3,5,7,11,14] The majority of studies included medical students,[1,5–10,13,14,16–19] 2 studies included nursing students,[11,15] and 2 studies involved lay rescuers.[2,3] Regarding end-of-course skills performance (up to 3 months after the course), only 2 studies demonstrated superiority utilizing Peyton's stepwise approach.[5,18] The remaining studies showed no differences between stepwise approaches versus non-stepwise approaches. Skills retention, reevaluated 2 to 3 months after the course, was unaffected by a stepwise approach.[13,14,19] One study demonstrated significantly increased BLS/AED skill and confidence with live instructor-performed skills demonstration compared to recorded video demonstration.[7] There was a trend toward learners preferring a stepwise approach, with 2 studies demonstrating higher overall learner satisfaction.[1,18] Two studies showed no difference in learner preferences[2,7]; instructor preference was not analyzed in the studies.

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In Situ Training

Recommendations for in Situ Training		
COR	**LOE**	**Recommendations**
2a	**C-LD**	1. It is reasonable to conduct in situ simulation-basedresuscitation training in addition to traditional training.
2b	**B-R**	2. It may be reasonable to conduct in situ simulation-based resuscitation training in place of traditional training.

Synopsis

In situ simulation refers to a subset of simulation activities occurring in actual patient care areas (ie, real clinical environment).[1] In situ simulation can be used as a strategy to train individuals or health care teams.[2,3] The objectives for in situ training can be individual technical skills or team-based skills, including communication, leadership, role allocation, and situational awareness.[2,3] One distinct advantage of in situ training is that it provides learners with a more realistic training environment. We explored if in situ, simulation-based resuscitation training for health care professionals leads to improved learning, performance, and patient outcomes.

Studies comparing in situ training to traditional training (ie, classroom or laboratory-based training) have demonstrated mixed results in learning outcomes.[4–7] Compared with no intervention, in situ training added to other educational strategies has a positive impact on learning outcomes (eg, improved team performance, improved time to critical tasks),[8–15] performance change in the real clinical environment (eg, improved team performance, recognition of deteriorating patients),[8,16,17] and patient outcomes (eg, improved survival, neurological outcomes).[15,16,18–21]

Recommendation-Specific Supportive Text

1. Four observational studies demonstrated that regular in situ simulation training, in combination with or in addition to other educational strategies (ie, standard classroom training, refresher of BLS/pediatric advanced life support training, introduction of code teams, distributed practice), is effective at improving team performance, time to recognize deteriorating patients, and code documentation.[8,16,17,22] Four additional observational studies assessing bundled interventions including in situ training demonstrated significant improvements in cardiac arrest survival.[16,18–20] Because in situ training was tested as part of a bundled intervention in these studies, the individual contribution of in situ training cannot be clearly elucidated. Two RCTs demonstrated that in situ cardiac arrest training coupled with spaced learning yields better learning outcomes (ie, improved clinical performance, decreased time to initiate compressions and defibrillation) compared with training conducted in a massed-delivery format in the classroom.[11,14] One RCT and 4 prospective observational studies demonstrated that in situ simulation training results in improved clinical performance in simulated environments.[8–10,12,13] Two observational before-and-after studies of neonatal resuscitations found incorporating in situ simulations improved specific task performance (time to heart rate) and teamwork,[15] as well as improved clinical outcomes.[21] Most observational studies are

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limited by a lack of parallel control groups, a lack of performance measures with supportive validity evidence, and potential confounding factors.

2. Three RCTs and 1 observational study compared learning outcomes (ie, team performance, technical skills) of in situ simulation training with standard classroom or laboratory-based training settings. One RCT demonstrated improved performance in the in situ group while the other studies demonstrated no significant differences between the 2 settings.[4–7]

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Scripted Debriefing

Recommendation for Scripted Debriefing		
COR	**LOE**	**Recommendation**
2b	**C-LD**	1. It may be reasonable for an instructor to use a debriefing script during resuscitation education.

Synopsis

Scripted debriefing involves the creation of a written plan for debriefing learners during or following life support training. It may include such elements as specified sets of topics or subtopics for the debriefing, suggested words or phrases to guide the discussion, and a framework to structure the debriefing. These scripts aim to standardize debriefing during resuscitation training, supporting facilitators with a clear plan and guiding discussion. Standardized debriefing helps to maintain consistency in the delivery of debriefings across training centers and resuscitation programs. Six studies were identified with varying outcomes.[1–6] Despite the limited and mixed data, scripted debriefing holds significant potential to enhance CPR training. The integration of quantitative data, such as CPR quality, into debriefings is particularly promising. Further exploration is necessary as we integrate these principles into clinical event debriefings. Future research should concentrate on optimizing debriefing script designs to achieve the best learning outcomes across different learner groups.

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Recommendation-Specific Supportive Text

1. Six studies used simulation scenarios to evaluate scripted debriefing.[1–6] A multicenter RCT with 453 health care professionals found scripted debriefing improved team leadership skills and knowledge acquisition but no difference in clinical performance.[2] Another study found no difference in teamwork performance or learner satisfaction among medical and nursing students using scripted debriefing.[3] In an RCT of 80 health care professionals, data-informed scripted debriefing improved CPR quality metrics, such as overall excellent CPR, depth, chest compression fraction, and perishock pause duration, but no difference in time to critical interventions, time to initiate CPR, time to first defibrillation, and time to the first dose of epinephrine.[1] Another nonrandomized study found no significant difference in clinical judgment using scripted or nonscripted debriefing among nursing students.[6] A multicenter, cluster-randomized trial with novice and expert instructors and 70 participants found scripted debriefings improved debriefing quality, especially for novice instructors, but not for experts.[5] A single-center RCT found no difference in the debriefing quality of novice instructors when using a script.[4] One RCT studying novice debriefers' cognitive load and workload while debriefing trained actors in video-recorded simulated resuscitations using a debriefing script found reduced debriefer cognitive load in the scripted debriefing group but no difference in debriefer workload.[4]

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Blended Learning in Resuscitation Training

Recommendation for Blended Learning in Resuscitation Training		
COR	**LOE**	**Recommendation**
2b	**B-NR**	1. A blended learning educational approach may be considered for teaching guideline-based life support courses.

Synopsis

Blended learning combines traditional classroom instruction with electronic or online methods. Blended learning incorporates various attributes from 4 domains: communication synchronicity, location, delivery method, and educational philosophy. Traditional educational methods (eg, in-class learning) in resuscitation courses have transformed due to technological advancements, evidence-based educational science, and time and financial constraints for learners, faculty, and sponsoring organizations. Nontraditional education methodologies, including blended learning, have numerous advantages, which became more obvious during the COVID-19 pandemic, and have become widely implemented and adopted for the long term. This recommendation addresses whether blended learning, for lay rescuers and health care professionals taking an accredited life support course, affects knowledge, skill acquisition and retention, participant satisfaction, and resource outcomes.

Recommendation-Specific Supportive Text

1. Data are primarily extracted from a systematic review encompassing 13 courses.[1] In comparing blended learning to traditional courses, knowledge[1–11] acquisition was mixed while skills acquisition studies[2–4,6–10,12–19] predominantly found no differences, though a few showed blended learning superiority in various specific resuscitation skills.[2,13,18,19] Knowledge retention consistently demonstrated no differences between blended learning and traditional courses.[2–4,8] Skills retention was more variable, with 5 of the studies demonstrating no differences,[3,4,14,15,17] and the remaining 4 studies[3,5,10,11,19] reporting mixed findings.[2,8,19] Learner satisfaction toward blended learning in BLS studies were equally split between those observing no differences[9,17] and those demonstrating more favorable attitudes.[19] Among ALS-based studies, 3 studies[6,10,12] showed more favorable attitudes toward the blended learning approach while 2 studies[3,5] demonstrated learner preference for traditional educational methods. Of the 4 studies (2 BLS and 2 ALS)[6,11,23,24] evaluating costs, blended learning demonstrated long-term cost savings through fewer employment absences for learners and faculty, despite the initial higher set-up costs for Guideline-based life support courses.[7,9,20]

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Instructor Training and Development

Recommendations for Instructor Training and Development		
COR	**LOE**	**Recommendations**
1	B-R	1. Initial instructor training is recommended for individuals teaching BLS and ALS courses.
2a	B-R	2. Ongoing instructor development is reasonable for individuals teaching BLS and ALS courses.

Synopsis

The educational effectiveness of life support courses is one of several factors that can enhance CPR quality. The effectiveness of CPR education is heavily dependent on the quality and ability of life support course instructors who are responsible for delivering both basic and advanced resuscitation courses. Many resuscitation training organizations have developed initial instructor training for instructor candidates and ongoing instructor development opportunities for current instructors. A 2018 AHA scientific statement on resuscitation education suggested a variety of approaches to improve the competency of life support course instructors.[1] A 2022 ILCOR scoping review on faculty development identified 4 general themes to improve the quality and ability of life support course instructors, which included instructor qualification and training, assessment tools, teaching skill enhancement, and additional instructor courses.[2]

Recommendation-Specific Supportive Text

1. Ten studies examined initial instructor training with heterogeneous outcomes of interest.[1–10] Five studies used a train-the-trainer instructor course design and reported improvements in knowledge, comfort levels, and resuscitation skills after train-the-trainer participation.[1–3,5,9] In a study of a systemwide instructor training course, instructor candidates had a high pass rate on theoretical and practical tests.[7] Multiple studies examined instructor development with mixed results.[6,11–21]
2. One RCT examining the impact of additional instructor training found students taught by trained instructors performed worse on 2 clinical examinations sections and teaching quality was rated worse.[14] In an RCT where ALS instructors were taught to identify team leader errors, the intervention group found and documented more errors and

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made more correct grade assignments.[15] Two studies examining the assessment training program found participants incorrectly failed candidates less and were more confident in their assessments.[18,19] After an instructor program involving lectures, scenario development, and video reviewing, participants reported improved ability to conduct simulations, recognize warning signs, and debrief.[12] In summary, evidence supports ongoing instructor development with targeted training programs and structured assessment techniques that improve instructor confidence, error detection, and teaching abilities.

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Alternative Objects for Chest Compression Training in Lay Rescuers

Recommendation for Alternative Objects for Chest Compression Training in Lay Rescuers		
COR	**LOE**	**Recommendation**
2b	**C-LD**	1. The usefulness of alternative objects to train laypeople in chest compressions, when compared to a manikin, is not well established.

Synopsis

Barriers to CPR training in low-resource settings include cost, access to training centers, and time constraints. Preliminary data about the feasibility of the use of common household objects to train and practice chest compressions have been recently described.[1–6] The goal of these studies is to find low-cost, easy-access alternatives to manikins to allow laypeople in low resource settings to receive chest compression training at home without attending training courses.[1–4,6,7,8] The underlying assumption is that such training is preferable to having no psychomotor training.

Recommendation-Specific Supportive Text

1. Seven studies were identified where learners used alternative objects (eg, pillow, toilet paper rolls, foam blocks) to practice chest compressions.[1–4,6,7,8] Four RCTs compared use of these objects to a standard manikin and assessed chest compression performance after training using a feedback-enabled manikin.[2,3,6,8] Results were mixed, with 2 RCTs finding no difference in compression rate or depth[2,3] and 2 finding worse compression depth with the alternative objects.[6,8] One study found better chest wall recoil during manikin-based post-training assessment in learners who trained on a pillow compared with a manikin.[2] Two observational studies found favorable responses after training

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using these objects to surveys of usefulness and confidence.[1,4]

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Lay Rescuer Training for Opioid Overdose

Recommendations for Lay Rescuer Training for Opioid Overdose		
COR	**LOE**	**Recommendations**
1	B-NR	1. It is recommended that lay rescuers receive education on recognition and initial treatment steps for persons experiencing opioid-associated out-of-hospital cardiac arrest (OHCA).
2b	C-LD	2. The optimal training method for lay rescuers in recognizing and intervening on opioid overdose has not been established.

Synopsis

According to the Centers for Disease Control and Prevention, opioid overdose deaths in the United States have more than doubled in the past decade, from 18 515 in 2007 to 47 600 in 2017.[1] Improving recognition of opioid-associated OHCA and increasing lay rescuers' willingness and ability to administer naloxone has the potential to improve outcomes.[2] Systematic and scoping reviews on education for lay rescuers to recognize and intervene in opioid-associated OHCA have generally shown that training can increase knowledge and confidence, including a review specific to virtual instructional interventions.[3–5] For the present review, studies comparing at least 2 instructional methods are included. There is a high degree of variability in study design, intervention, and outcome measures used, and several studies use self-reported outcome measures that may be particularly subject to bias.[6–8] More research is required to determine which educational interventions provide the greatest benefit by measuring both learner and patient outcomes.

Recommendation-Specific Supportive Text

1. Three recent systematic reviews summarized the impact of lay rescuer training in opioid overdose recognition and treatment.[3–5] A systematic review of 87 studies found that lay rescuer training led to improved knowledge, improved willingness to respond, and increased likelihood of naloxone use[3] A scoping review of 59 studies reported a correlation between naloxone distribution and survival, but acknowledged the heterogeneity in studies and difficulty summarizing specific recommendations for training.[4] A scoping review of virtual training methods for lay rescuers found that such programs appear effective in increasing knowledge, confidence, and preparedness to respond.[5]
2. Eight studies compared the impact of opioid training using 2 instructional methods. Comparisons included training with and without providing naloxone,[6,8] computer- or video-based training versus instructional sheet,[7,9,10] different duration of training session,[11] inclusion of a peer support intervention,[12] and a novel local program versus standard training.[9] Outcomes were also heterogenous and included knowledge assessments,[6,7,9,11,12] surveys of confidence,[6] performance assessment in a simulated opioid overdose,[9] and proportion of subjects who filled a prescription for naloxone.[10]

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CONSIDERATIONS FOR LEARNERS

Disparities in Education

Recommendations for Disparities in Education		
COR	**LOE**	**Recommendations**
1	B-NR	1. It is recommended to focus and tailor layperson CPR training to specific racial and ethnic populations as well as neighborhoods and to incorporate awareness efforts in these areas.
1	B-NR	2. It is recommended to focus on low SES populations and neighborhoods for layperson CPR training and awareness efforts.
1	B-NR	3. It is recommended to address barriers in performing layperson CPR on females through educational training and public awareness efforts.
2a	C-LD	4. It is reasonable to address barriers to linguistically isolated communities by increasing availability and access to CPR training materials in diverse languages.
2a	C-LD	5. It is reasonable to consider cost-effective methods for CPR training and to promote safe access to CPR training for low SES populations and neighborhoods.

Synopsis

Health disparities adversely affect groups who systematically experience greater obstacles to health based on race, ethnicity, gender identity, geography, and SES. Historically, race, ethnicity, SES, and gender are associated with different rates of layperson CPR.[1–17] People experiencing cardiac arrest in racial and ethnic populations who have historically experienced inequity or prejudice, such as Black and Hispanic/Latino persons, and linguistically isolated communities with limited English proficiency have had lower rates of layperson CPR.[18–23] Focusing and tailoring CPR training for these populations is needed, as well as those that consider cost-effectiveness and safe access to training in low SES settings.

Recommendation-Specific Supportive Text

1. Retrospective cohort studies and 1 cross-sectional study found that residents of Black and Hispanic/Latino neighborhoods were less likely to receive CPR and that Black persons were less likely to be CPR trained.[1,3–6,24,25] To address this, retrospective studies have demonstrated the feasibility of using neighborhood mapping to identify racial and ethnic neighborhoods for focused training.[13,26]
2. Several retrospective cohort studies and 2 systematic reviews have demonstrated that low SES is associated with a lower likelihood of receiving LR-CPR.[7–16,27] In addition, recent cross-sectional studies and 2 systematic reviews found that low SES is associated with a lower likelihood of CPR training.[1,28–32] Additionally, individuals from low SES communities are less likely to report comfort performing CPR.[33–35] To address this, retrospective studies have demonstrated the feasibility of using neighborhood mapping to identify low SES neighborhoods for focused training.[13,26]
3. Studies examining sex differences in delivery of CPR found that adult females were less likely than males to receive LR-CPR in public locations.[2,17,36] Cross-sectional survey studies suggest that layperson responders are fearful of being accused of inappropriate touching, sexual assault, and causing injury to females in need of LR-CPR.[37,38] A randomized simulation study found that subjects were less likely to remove the clothing of a female manikin than a male manikin.[39] The gender of the lay rescuer may impact receipt of CPR.[40] Female respondents were less comfortable performing CPR than males.[33,34,41]
4. A descriptive investigation found few high-quality CPR educational resources for Spanish-speaking populations.[19] Mixed qualitative studies suggest that language barriers, financial considerations, and lack of information are associated with low rates of LR-CPR in linguistically isolated communities.[18–23]
5. Financial costs of training, lack of information, and fear of risking one's own life or safety are common barriers to CPR training in low SES neighborhoods.[13,18,21,22,42]

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CPR Training for Schoolchildren

Recommendations for CPR Training for Schoolchildren		
COR	**LOE**	**Recommendations**
1	**B-NR**	1. It is recommended to train middle school- and high school-age children to perform high-quality CPR.
1	**C-LD**	2. It is recommended to start CPR training under 12 y of age in order to increase willingness and self-confidence in later years.

Synopsis

Immediate CPR can double or triple survival rates after cardiac arrest.[1,2] The primary goal of resuscitation training for lay rescuers (ie, non–health care professionals) is to increase immediate layperson CPR rates, AED use, and timely emergency response system activation during an OHCA. Enhancing willingness of children to perform CPR may have a direct impact on survival rates for OHCA by improving socialization of the need for CPR early.[3,4] For this recommendation, schoolchildren are considered those who attend middle and high school, approximately 12 to 18 years of age.

Effective chest compression depths and ventilation volumes can be achieved on training manikins by 10 to 12 years of age. However, starting to introduce the concepts of emergency calls and the need for CPR and AEDs earlier in younger children improves socialization of the importance of timely lay rescuer response. Annual repetition of messaging and training in all children may increase willingness and self-confidence in later years. Schoolchildren also serve as multipliers by passing on BLS skills to others.[5]

Recommendation-Specific Supportive Text

1. Multiple studies have found that middle school- and high school-age children are capable of learning, recalling, and performing high-quality CPR skills.[4–21] Evidence suggests that schoolchildren can only achieve effective resuscitation attempts with sufficiently deep and rapid chest compressions or adequate ventilation volumes at age 12 years of age or older.[22–26]
2. Schoolchildren from 4 to 7 years of age can make an emergency call[27–30] or follow the instructions of an automatic external defibrillator.[27–29,31] In schoolchildren under 12 years of age, a playful approach in terms of CPR at early ages promotes motivation and interest.[27–29,31–33] Annual repetition leads to a consolidation of practical CPR skills, which sustainably increases the willingness and self-confidence in initiating resuscitation measures in later years.[28]

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Lay Rescuer Willingness to Perform CPR

Recommendations for Lay Rescuer Willingness to Perform CPR		
COR	**LOE**	**Recommendations**
2a	**C-LD**	1. It is reasonable to increase lay rescuer willingness to perform CPR through CPR training, mass CPR training, CPR awareness initiatives, promotion of Hands-Only (compression-only) CPR, and mobile apps alerting lay rescuers to emergency events.
2b	**C-LD**	2. It may be reasonable for lay rescuer CPR training programs to raise awareness of physical barriers that may affect lay rescuers' willingness to perform CPR.
2b	**C-LD**	3. It may be reasonable for lay rescuer CPR training programs to address emotional barriers that may impact lay rescuers' willingness to perform CPR.

Synopsis

Prompt lay rescuer CPR (LR-CPR) delivery doubles survival for persons experiencing sudden cardiac arrest, yet fewer than 40% of these individuals receive LR-CPR.[1,2] Given the relatively low LR-CPR rate, facilitator and performance barrier assessment of LR-CPR is warranted. Individual-level facilitators that increase willingness to perform LR-CPR include previous CPR training, younger age, and family relationship to the person experiencing cardiac arrest.[3–6] Community-level facilitators include Hands-Only CPR training, mass CPR training (ie, training large numbers), CPR awareness initiatives to increase lay rescuer performance, and mobile apps to alert lay responders to emergency events.[4,7–11] Barriers to lay rescuers initiating CPR include individual-level emotional barriers such as perception of the person's physical characteristics (eg, vomit, blood), perceived futility of the situation, and difficulty or limitations with positioning of the patient.[3,8,12–15]

Recommendation-Specific Supportive Text

1. A cohort study demonstrated that lay rescuers with previous CPR training were 3 times more likely to perform CPR.[4] A 40-minute mass, Hands-Only CPR training of more than 5500 university students was found to promote LR-CPR.[8] Community-level promotion of Hands-Only CPR training was associated with increased LR-CPR and an increased incidence of survival with favorable neurological outcome.[7]

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Communities with a higher proportion of residents identifying as having CPR awareness, prior CPR training, and higher self-efficacy were associated with an increased likelihood of LR-CPR.[9] Two studies of previously enlisted community first responders using a cellphone app which alerted them to emergencies found that responders to OHCA were facilitated to assist with LR-CPR with the information from the app (eg, location).[10,11] Some studies were limited by prior CPR training and ecological community-level measurements.

2. Several survey-based studies of lay rescuers described vomit, alcohol on the person's breath, and visible blood as physical barriers to initiating CPR.[12,15] Analyses of telecommunicator-assisted CPR tapes found that inability to move patients to a hard, flat surface was associated with reduced rates of CPR.[13,14]
3. Observational studies found that panic, lack of confidence, perceptions of futility, and fear of injury were emotional barriers to initiating CPR.[3,12] A survey of lay responders using a mobile app for emergency alerts cited logistical obstacles (eg, smartphone difficulties) and cognitive-emotional obstacles as barriers to accepting dispatch alerts.[11] A survey of university students cited burden of responsibility and difficulty in judging a cardiac arrest as additional barriers.[8] These studies suggest that tailored CPR training to address these emotional barriers and providing general awareness of these barriers may improve lay rescuer willingness to perform CPR.

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ACLS Course Participation

Recommendation for ACLS Course Participation		
COR	**LOE**	**Recommendation**
2a	**C-LD**	1. It is reasonable for health care professionals to take an adult ACLS course or equivalent training.[1–9]

Synopsis

Resuscitation councils have offered adult ALS courses (eg, ACLS offered by the AHA, Advanced Life Support offered by the European Resuscitation Council) for more than 3 decades, providing the knowledge and skills required to recognize and treat critically ill adult patients.[10] These courses are intended for health care professionals likely to manage adult patients with cardiac arrest. Advanced cardiovascular life support course content and instructional design is updated to reflect the most current resuscitation guidelines, and recent versions have focused on interprofessional, team-based care via simulation-based training.[10–12]

Recommendation-Specific Supportive Text

1. A systematic review found evidence from 6 observational studies[3–8] enrolling 1461 patients with higher rates of return of spontaneous circulation (ROSC) for adult in-hospital cardiac arrest cared for by a resuscitation team with at least 1 member completing an accredited ACLS course compared with patients cared for by a team without members with prior ACLS training.[9] The systematic review found evidence from 7 observational studies[1–3,5–8] enrolling 1507 adult

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in-hospital cardiac arrest patients for improved survival to hospital discharge or survival to 30 days for patients cared for by a team with at least 1 member completing an accredited ACLS course.[9] Pooled data from 2 observational studies[5,6] enrolling 455 patients showed no significant association between 1-year survival and ACLS training.[9] Additional benefits of ACLS training include faster time to ROSC,[5] decreased treatment errors (eg, incorrect rhythm assessment),[4] and an association between the number of team members trained and ROSC.[5] No studies report the impact of ACLS training on intact neurological survival or the impact of course components on patient outcomes. Among the studies reviewed, there was a high risk of selection bias due to differences between study populations. Most studies were conducted before 2010 and may not accurately reflect current standards of care and current ACLS course design, which has a greater focus on team-based care and simulation-based learning.

EMS Practitioner Experience and Exposure to OHCA

Recommendation for EMS Practitioner Experience and Exposure to OHCA		
COR	**LOE**	**Recommendation**
2a	**C-LD**	1. It is reasonable for EMS systems to monitor clinical personnel's exposure to resuscitation events to ensure treating teams have members competent in the management of cardiac arrest cases.

Synopsis

Appropriate provision of prehospital resuscitative care is an important element in determining outcomes from OHCA.[13] Understanding the impact of ongoing exposure (ie, caring for actual patients in cardiac arrest) or general experience (ie, time on the job) on patient outcomes from OHCA may inform staffing and training strategies. A systematic review suggests that EMS professional exposure—both the number of cardiac arrest cases managed over time and the most recent exposure to cardiac arrest (less than 6 months)—is associated with improved ROSC[14,15] and survival to hospital discharge.[16,17] Results of the individual studies were inconsistent, but those of higher quality that adjusted for known predictors of survival demonstrated improved short-term survival outcomes with higher EMS professional exposure.[16] Emergency medical service professional experience was not associated with improved survival to discharge.[16]

Recommendation-Specific Supportive Text

1. Results of a systematic review identified 2 observational studies that evaluated an impact of professional exposure.[15,16] The larger study reporting adjusted outcomes found improved survival to discharge with higher team exposure (number of cardiac arrests in the preceding 3 years). Compared with teams with fewer than 6 exposures, the likelihood of survival was higher in groups with more than 6 to 11 exposures, 11 to 17 exposures, and >17 exposures, suggesting a dose-response relationship with exposure.[16] The remaining observational study reporting unadjusted outcomes found no association between exposure and survival to hospital discharge. One observational study found lower survival to discharge in patients treated by teams with no exposure in the preceding 6 months compared with those with recent (<1 month) exposure.[16] Additional studies found no association between team leader cardiac arrest exposure and event survival[15] and no association between years of clinical experience of the EMS professional or EMS team and survival to hospital discharge.[16,18,19] Two studies reported improved ROSC with higher prior exposure to resuscitation events in the primary treating paramedic.[14,15]

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KNOWLEDGE GAPS AND FUTURE RESEARCH

Conducting impactful research on resuscitation education carries its own set of challenges, some of which are very different from the challenges of clinical research. The Grading of Recommendations Assessment, Development, and Evaluation system for evidence review, used throughout these Guidelines, has massive shortcomings in its applicability to educational research.[1] The certainty assessment of evidence in Grading of Recommendations Assessment, Development, and Evaluation terms is reduced in the presence of risk of bias, imprecision, and indirectness. When one considers that blinding of assessors and participants in simulation studies is often impossible, that the majority of these studies are small and conducted with specific learner groups, and that virtually all of the studies reviewed for Part 12 were not associated with clinical outcomes, it is easy to see how rare it is for the certainty of the evidence to be any higher than moderate, and much more commonly low or very low. Larger, more generalizable studies featuring multicenter collaboration would help to address this problem. Education research networks provide the infrastructure necessary to support mentorship, grant applications, study design and implementation, and provide knowledge dissemination.[2] Similarly, outcome measures that are reliable, reproducible, and clinically relevant are a goal to work toward with education research. When the selection of patient outcomes is not feasible, we encourage educational researchers to select quantitative measures that have a known association with improved clinical outcomes from cardiac arrest (eg, chest compression depth). Doing so will allow researchers to establish causal links among outcomes that are similarly reported in simulation-based and clinical studies.[3]

Very few of the recommendations in Part 12 are based on robustly conducted meta-analyses, and the ones that are (eg, feedback devices, manikin fidelity) exhibit very large degrees of heterogeneity. This too should not be surprising, given that these studies may involve many different learner groups (eg, students, nurses, physicians, paramedics, laypersons) and surrogate outcomes that can be measured and reported in a variety of ways (eg, overall chest compression quality, specific compression parameters such as depth and rate, timing considerations, etc.). The establishment of standardized reporting guidelines for outcomes from resuscitation education research would address this issue and enable meta-analysis of key questions in the future. Because very few studies link educational interventions to patient outcomes, additional research is needed to examine the connections between educational outcomes and survival from cardiac arrest, as well as from other intermediate clinical outcomes known to be contributors to survival, such as high-quality CPR. The growth and evolution of technology and its incorporation into educational design has implications that these Guidelines do not fully address. Perhaps most notably, well-conducted research evaluating the cost-effectiveness of the various technology-dependent elements of instructional design (eg, high-fidelity manikins, VR, AR, gamified learning, and cognitive aids on digital platforms, etc) is lacking in current literature. In addition to cost, implementing technologies such as these also requires personnel with appropriate training to use and maintain such devices. Training centers also require significant infrastructure such as physical space, basic equipment, and information technology support. The balance between cost and benefit will vary among institutions, regions, and nations. For example, a recent systematic review examining the effect of higher physical realism in training manikins for learners in low-resource settings failed to demonstrate any difference in skill or knowledge acquisition when compared with lower-realism devices; the authors of this review made a recommendation against the use of manikins with higher realism, presuming that the cost would outweigh the benefit.[4] Future research should include elucidating the cost-benefit ratio of these evolving technologies. At the same time, we recognize the importance of incorporating digital

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and technologic advances to improve training quality and accessibility. We believe this will be an area where recommendations for resuscitation education may change most rapidly. In the section of Part 12 summarizing published data on VR, the writing group assigned a COR 3 (possible harm) for the use of VR for CPR skill training. This recommendation is based on the best available evidence, but we believe its implication may be different than for that of a COR 3 in another section of these Guidelines. For example, if a clinical intervention were found to have a negative association with patient outcomes from cardiac arrest and a COR 3 recommendation was assigned to it, it is easy to imagine that such an intervention would be abandoned from common clinical use. For an educational intervention—particularly one dependent on rapidly evolving technology—this is not necessarily the case, and with continual progress in VR and other technologies, we expect that ongoing reassessment of this literature will remain necessary, and that such recommendations may change over time. We continue to encourage the exploration and optimization of technology for resuscitation training.

Table 2 contains an exemplar list of knowledge gaps in resuscitation education from the various areas covered in Part 12. This list is far from complete but is meant to

Table 2. Specific Knowledge Gaps in Resuscitation Education by Topic

Topic area	Sample research topics
General underexplored areas of research in resuscitation education	Synergy between combinations of instructional design phenomena
	Educational impact over longer time periods
	Cost-effectiveness
	Consistency and generalizability of study outcomes
	Link to patient clinical outcomes
Feedback devices in training	Further studies exploring effects of training with feedback devices on CPR skill retention and transfer of CPR skills to the real clinical environment (eg, CPR quality during cardiac arrest events) to clarify the clinical effectiveness
Rapid-cycle deliberate practice	Consistent definitions of passing standard (eg, mastery) during RCDP-based training
Spaced learning	Optimal training frequency for specific provider groups, including selected lay rescuer populations (eg, coaches, lifeguards) and health care professionals
Team training	Evidence regarding the most efficacious training methods to improve teamwork competencies
	Guidance regarding the outcome measurement of teamwork competencies
	Evidence regarding which teamwork competencies have the greatest impact on technical skill performance and overall resuscitation performance in simulated and real cardiac arrests
	Evidence linking teamwork performance to clinical outcomes and patient safety
Manikin fidelity	Identifying simulation features most associated with learner engagement
Gamified learning	Consistent definition of *gamification*
	Impact of gamification on cognitive load and stress levels
Virtual and augmented reality	How AR and VR are best employed (eg, real-time feedback, gamification, knowledge delivery)
	Clarification of the instructor role when immersive technology is being used (eg, when is it beneficial for the instructor to provide feedback, and what type of training is needed when this technology is used?)
Blended learning	Defining the combination/sequence/timing of blended content delivery methods to yield the best outcomes
Scripted debriefing	Assessing the impact of scripted debriefing on knowledge and skill retention
	Defining the importance of debriefer adherence to debriefing scripts and its influence on learning and performance outcomes
	Assessing debriefer experience and learner characteristics on the impact of debriefing scripts
Disparities in CPR education	Evidence-based initiatives to focus and tailor layperson CPR training to underrepresented racial, ethnic, and low SES populations and neighborhoods
	Methods to remove barriers to performing CPR on female persons
	Enhanced diversity and culturally competent CPR training, including diversity in manikin design and appearance
Willingness for lay rescuers to provide lay rescuer CPR	Assessing effectiveness of public awareness interventions on CPR training participation and willingness to perform CPR
	Identifying simple adjuncts (eg, pocket masks, hand/eye protection) and strategies for their dissemination to improve willingness to perform CPR
CPR training for schoolchildren	School-based training frequency to optimize educational outcomes
Cognitive aids	Comparison of method (eg, card versus smartphone versus mnemonic use) for cognitive aid
	Measurement of stress and/or cognitive load in learners and determining the impact of aids on these outcomes
	Effective design and dissemination of cognitive aids for lay rescuers

AR indicates augmented reality; CPR, cardiopulmonary resuscitation; RCDP, rapid-cycle deliberate practice; and VR, virtual reality.

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provide more focused ideas than the overarching concerns with education research discussed earlier. We are encouraged that Part 12, compared with that from the 2020 Guidelines,[5] has a greater number of topics and many new recommendations, as well as some existing recommendations, yielding enough good-quality evidence to be strengthened to higher COR levels. We call on researchers to continue this progress toward higher-quality evidence for educational outcomes and to continue to strive for the elusive link to patient outcomes. Accordingly, we also urge research funding agencies to provide support to these critical endeavors. We call on educators to continue to interrogate the optimal means of implementation and dissemination of existing knowledge while determining the economic impact of recommended approaches. A multifaceted approach will be essential in strengthening this element of the formula for survival and thus improving outcomes from cardiac arrest.

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Disclosures

Appendix 1. Writing Group Disclosures

Writing group member	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
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Kelly D. Kadlec	Children's Hospital and Medical Center	None	None	None	None	None	None	None
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Appendix 1. Continued

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Jaylen I. Wright	American Heart Association	None	None	None	None	None	None	None
Stephen M. Schexnayder	University of Arkansas/ Arkansas Children's Hospital	None	None	None	None	None	American Heart Association†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix 2. Reviewer Disclosures

Reviewer	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
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2025 AMERICAN HEART ASSOCIATION

GUIDELINES FOR CPR AND ECC

摘要

American Heart Association.

2025 摘要

2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care 摘要

American Heart Association (AHA) 特此感謝下列人員對於本刊物擬定之貢獻：
Ian R. Drennan, ACP, PhD；Stephen M. Schexnayder, MD；Jason Bartos, MD, PhD；Marina Del Rios, MD；Melissa Mahgoub, PhD；Ashish R. Panchal, MD, PhD；Amber J. Rodriguez, PhD；Julie Sell, MSN, RN；Comilla Sasson, MD, PhD；Jaylen Wright, PhD；以及 AHA Guidelines 摘要專案團隊; Tsai Weide; Shen Chingyi; Chen Tse-Hao。

簡介

本摘要概述了 *2025 AHA Guidelines for Cardiopulmonary Resuscitation* (CPR) *and Emergency Cardiovascular Care* (ECC) 的關鍵議題與主要變更。[1]2025 年指引是 AHA 針對成人、小兒和新生兒救命術，復甦教育科學，照護體系及復甦倫理等專題的全面修訂。這份摘要專為復甦專業人員及AHA講師整理，旨在幫助他們聚焦復甦科學中最重要、最具爭議或最可能改變復甦訓練與實踐的指引建議。每項建議的依據已在指引中作出說明。

由於本摘要為概要彙編，未引用相關已發表研究，也未列出建議類別或證據等級。如需獲取更詳盡的資訊及參考文獻，請查閱將於 2025 年 10 月在 *Circulation* 發表的 2025 年指引（含執行摘要），以及由國際復甦聯絡委員會 (ILCOR) 制定並於 2025 年 10 月在 *Circulation* 和 *Resuscitation* 同步發表的 *2025 ILCOR Consensus on Science With Treatment Recommendations*[2]中的復甦科學詳細摘要。ILCOR 的證據評估方法，以及 AHA 將這些評估結果（包括對 ILCOR 未覆蓋專題的評估）轉化為復甦指引的方法，均已詳盡發表。

2025 年指引採用了 AHA 最新版的各項建議類別和證據等級定義（圖 1）。指引在成人、小兒和新生兒救命術，復甦教育科學及照護體系等領域共提出 760 項具體建議。其中，1 級建議共 233 項，2 級建議共 451 項（圖 2）。此外，3 級建議共有 76 項，其中 55 項為無益證據，21 項為有害證據。

1. Del Rios M, Bartos JA, Panchal AR, et al. Part 1: executive summary: 2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation.* 2025;152(suppl 2):In press.
2. International Liaison Committee on Resuscitation. 2025 ILCOR Consensus on Science With Treatment Recommendations. *Circulation*. 2025;152(suppl 1):In press.

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圖 1. 針對病人的臨床策略、介入措施、治療或診斷中使用 ACC/AHA 建議類別和證據等級*(更新於 2024 年 12 月)。

建議類別(強度)

1 級(強) **益處 >>> 風險**

撰寫指引建議時推薦採用的表述:
- 建議
- 需要/有用/有效/有益
- 應實施/執行/其他
- 相對有效性的表述 †:
  - 建議/需要使用治療方案/策略 A 而不是治療方案 B
  - 應該優先選擇治療方案 A 而非治療方案 B

2a 級(中) **益處 >> 風險**

撰寫指引建議時推薦採用的表述:
- 是合理的
- 可能有用/有效/有益
- 相對有效性的表述 †:
  - 可能建議/需要使用治療方案/策略 A 而不是治療方案 B
  - 優先選擇治療方案 A 而非治療方案 B 是合理的

2b 級(弱) **益處 ≥ 風險**

撰寫指引建議時推薦採用的表述:
- 可能/或許合理
- 可能/或許可考慮
- 有用性/有效性尚未知/不明確/不確定或未得到充分證實

3 級:無益(中) **益處 = 風險**
(通常僅用 LOE A 或 B)

撰寫指引建議時推薦採用的表述:
- 不建議
- 不需要/無用/無效/無益
- 不應實施/執行/其他

3 級:有害(強) **風險 > 益處**

撰寫指引建議時推薦採用的表述:
- 可能有害
- 導致危害
- 與發病率/死亡率上升相關
- 不應實施/執行/其他

證據等級(品質) ‡

A 級
- 來自 1 項以上 RCT 的高品質證據 ‡
- 高品質 RCT 的統合分析
- 一項或以上由高品質登錄研究證實的 RCT

B-R 級 **(隨機)**
- 來自 1 項或以上 RCT 的中等品質證據 ‡
- 中等品質 RCT 的統合分析

B-NR 級 **(非隨機)**
- 來自 1 項或以上設計良好、執行良好的非隨機研究、觀察性研究或登錄研究的中等品質證據 ‡
- 這類研究的統合分析

C-LD 級 **(有限數據)**
- 設計或執行存在局限性的隨機或非隨機觀察性或登錄研究
- 這類研究的統合分析
- 對人類受試者的生理或機理研究

C-EO 級 **(專家意見)**
- 基於臨床經驗的專家意見共識

COR 與 LOE 均獨立確定(COR 與 LOE 可隨意匹配)。

如果某建議的證據等級為 LOE C,並不代表其為弱建議。本指引中提到的許多重要臨床問題缺乏臨床試驗支援。儘管沒有 RCT,但可能存在非常明確的臨床共識,認為某一特定檢查或治療有用或有效。

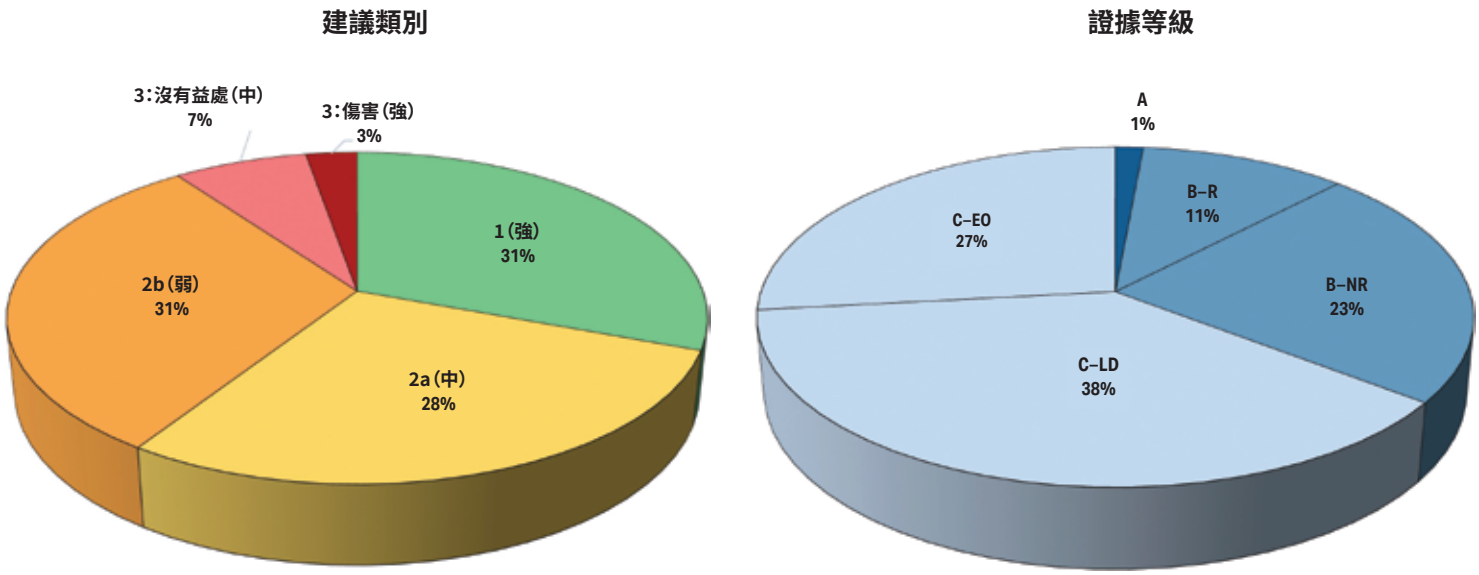
* 介入措施的結果或效果應該具體明確(臨床效果改善或診斷精度提高或預後資訊增加)。

† 對於比較療效建議(僅限 COR 1 和 2a;LOE A 和 B),支援使用比較性措辭的研究應當直接對比所評估的治療方法或策略。

‡ 品質評估方法正在不斷演進,包括採用標準化、廣泛使用且最好經過驗證的證據分級工具;對於系統綜述,還引入了證據審查委員會。

COR 指推薦級別;EO,專家意見;LD,有限數據;LOE,證據級別;NR,非隨機;R,隨機;以及 RCT,隨機對照試驗。

圖 2. ***2025 AHA Guidelines for CPR and ECC*** **760 項建議中各 COR 和 LOE 的百分比分佈*。**



縮寫說明：COR，推薦級別；EO，專家意見；LD，有限數據；LOE，證據級別；NR，非隨機；R，隨機。

*結果反映成人基本及高級救命術 (ALS)、小兒基本及高級救命術、新生兒救命術、心跳停止後照護、復甦教育科學、特殊情境及照護體系等領域 760 項建議的百分比分佈。

關於建議

在這 760 項建議中，只有 11 項 (1.4%) 基於 A 級證據，即至少 1 項高品質隨機對照試驗 (RCT)，並由第二項高品質試驗或登錄研究加以證實。這一現象凸顯了開展高品質復甦研究的持續挑戰。國內外需協力為復甦研究提供經費及其他支援。

ILCOR 的證據評估流程與 AHA 的指引制定流程均遵循嚴格揭露政策，以確保與業界的關係及其他潛在利益衝突完全透明，並防止流程受到不當干擾。AHA 工作人員已處理所有參與者的利益衝突揭露。所有指引編寫組主席及至少 50% 的組員須無任何利益衝突，且所有相關關係已在對應指引出版物中揭露。

倫理

重點議題與主要變更摘要

心肺復甦 (CPR) 和緊急心血管照護 (ECC) 往往在高風險的突發情境中開展。專業醫護人員和組織無論在個體層面還是系統層面，都面臨艱難抉擇。本章概述了多種倫理框架，闡明了專業醫護人員和組織共同承擔的義務，並提出可用來分析困難決策的架構。以往指引側重於倫理治療建議（如推薦特定診斷檢測以指導心跳停止後預後），但並未深入探討其背後的倫理原則與考量。2025 年指引倫理章節

- 針對倫理問題進行深度的敘述性探討，使讀者能夠應對該領域中最常見的挑戰
- 多個倫理框架、大量學術研究以及本寫作組的專家共識支持醫護人員 (HCP) 及其組織應積極解決健康方面社會決定因素中的不平等現象，從而消除由此導致的心跳停止和緊急心血管護理中的差異。
- 回顧復甦過程的諸多複雜情境，包括病人無法參與決策，以及從新生兒到年長病人各年齡段所面臨的挑戰，並探討 CPR 對病人、家屬及專業醫護人員的長期影響

撰寫小組進行了一系列完整的結構化文獻回顧。與以往指引相比，本章內容均為新增，但其背後的倫理考量與之前指引的依據基本一致。

基本倫理原則

原則主義是醫學倫理領域的主流框架。該框架以 4 項同等重要的道德原則——受益、不傷害、尊重自主和公正——為核心，透過審議過程引導決策。可從各原則視角評估倫理問題，進而提供多元視角，並將其融為綜合方法。受益原則指導制定有利於病人的決策。不傷害原則即醫者不應對病人造成傷害的倫理義務。尊重自主原則強調尊重個體在醫療決策中的知情權。公正原則即公平，對個體進行公平、平等及適當的對待。

其他倫理原則和框架同樣相關，包括敘事倫理學、危機醫療標準、美德倫理學和尊嚴原則。這些提供互補的觀點；通常，倫理架構和原則的結合能夠更有效解決倫理衝突。

努力實現健康和復甦的公平性

只有消除導致醫療結果差異的不平等現象，AHA 改善所有人心血管健康的目標才能完全實現。健康不平等現象源于健康的社會決定因素，在很大程度上是可以預防的，並且深深植根於社會結構。如果不承認和解決這些差異，系統性的不平等現象就會繼續存在，醫療差異也會持續存在。因此，HCP 及其組織應積極解決健康方面社會決定因素中的結構性不平等現象，從而消除由此導致的心跳停止和緊急心血管護理中的差異。

復甦倫理決策

在復甦過程中，常常需要決定是否啟動復甦措施，以及啟動後是繼續還是停止治療。在許多情境中，預設做法是立即啟動治療。若病人希望在緊急情況下放棄這些介入治療，務必記錄在預立醫療照護計劃。隨身攜帶的維持生命治療醫囑是最優途徑。當病人意願未被記錄且病人無法自行決策時，代理人將根據替代判斷替其決定。

在面對多個醫學合理選項時，應優先採用共同決策。這要求：(1) 專業醫護人員確保病人和 (或) 代理人瞭解病人當前病情；(2) 專業醫護人員說明可選醫療方案；(3) 專業醫護人員瞭解病人的目標、價值觀和偏好；(4) 專業醫護人員提出與病人目標和價值觀一致的建議；(5) 專業醫護人員支持病人和 (或) 代理人的決定。

對於成人心跳停止病人，預設做法是啟動 CPR，除非該操作會對專業醫護人員造成嚴重身體傷害風險，或出現不可逆死亡的客觀體徵，或已有拒絕治療的預立醫囑。在某些情境下，復甦啟動後接受家屬口頭放棄 CPR 或是知情告知無異議的做法是符合倫理的。復甦啟動後，預先定義好的停止復甦規則可以減少醫療上無效的治療，並促進資源分配正義。小兒和新生兒病人為專業醫護人員提出了獨特的倫理挑戰。有關小兒和新生兒病人的詳細討論，請參閱相應指引章節。

在特定情況下，一種或多種治療對病人可能無實際益處。即便代理決策者提出要求，專業醫護人員在倫理上也無需提供此類治療。此類判斷具有挑戰性且帶有一定主觀性，可能引發衝突。為盡量減少專業醫護人員個人觀點和偏見對獲益評估的影響，以及保護專業醫護人員免於道德困擾，應盡可能交由機構委員會或倫理顧問，並依照機構政策作出判斷。

其他倫理議題

復甦研究面臨獨特挑戰。在急救復甦的情境下，病人往往無法自行決定同意，治療的時間窗口非常狹窄，且代理人的情緒反應常干擾一般知情同意程序的執行。在此情境下，研究倫理路徑包括免除知情同意、豁免知情同意以及前瞻性知情同意。適當的監管途徑應由機構審查委員會而非研究者來確定。對符合公認臨床研究定義的活動，繞過這些要求是不道德的。

ECC 可能對專業醫護人員的身心健康產生持久影響。AHA 認為，必須保護執行復甦

的專業醫護人員免遭身體傷害。同時，專業醫護人員亦承擔提供治療的專業義務。實證建議無法涵蓋所有臨床情境或情況。在特定情境下解讀指引時，專業醫護人員應警惕潛在偏見，審慎決策，並系統地權衡現有證據。在實施 CPR 時，尤其當專業醫護人員認為 CPR 嘗試不當時，可能產生道德困擾。機構應制定復甦政策和指導，幫助專業醫護人員化解爭議並應對道德困擾。應對這些複雜情境不應僅依賴個別人員。

CPR 倖存的病人常會出現長期後遺症。醫療機構有責任構建照護體系，以最佳化病人的長期健康和福祉。心跳停止也可能對非專業施救者產生持久影響。儘管專業醫護人員首要職責在於病人，但其倫理義務亦延伸至支援病人的家屬、照護者及病人周遭人員。對於家屬而言，親臨 CPR 現場可減輕複雜性悲傷並改善心理健康結局。醫療機構應制定相關政策，明確規範在何種情況下可限制家屬在場，並確保有足夠的資源與訓練來支持此作法。

危機時的醫療標準是在災難事件中對常規醫療標準的調整。危機標準並不改變或削弱專業醫護人員對病人的職責，其法律和倫理責任仍是存在類似情境中，專業醫護人員會採取合理的做法。功利主義和公正原則的倫理規範指導危機標準的設計與實施，旨在實現資源公正分配並促進健康結局均等。

體外 CPR (ECPR) 是一種先進療法，可用於救治經過嚴格篩選的病人。相關倫理議題包括：用於病人篩選的指導數據有限、知情同意難以獲得、高昂成本及大量資源消耗所引發的公平分配問題，以及在復甦失敗後，這些療法可能轉為器官捐獻或撤除生命維持治療的應用。

對於所有心跳停止後按神經學標準判定為死亡或計劃撤除生命支援的病人，均應考慮器官和組織捐獻。關於臨終關懷的決策應首先以病人利益為核心，並在向病人或其代理人提出器官捐獻選項前獨立完成。機構應制定流程，以增進公眾信任並避免利益衝突。

照護體系

心跳停止後的生存依賴於人員、方案、政策和資源的一體化體系，並需持續進行數據收集與審查。照護體系指引遵循統一的心跳停止生存鏈（圖 3），從預防與復甦準備開始，繼而早期辨識心跳停止，再到有效復甦，直至心跳停止後照護、生存者管理及康復。要最佳化心跳停止後的結局，需院內外均高效運作的照護體系，並持續收集與分析數據，以改進生存之鏈每個環節的品質。

重點議題與主要變更摘要

- 單一化的生存之鏈設計同時適用於成人與小兒的院內心跳停止（IHCA）及院外心跳停止（OHCA）。在構建這一生存之鏈時，我們認識到心跳停止前的預防與準備既可避免復甦需求，也能最佳化復甦效果。
- 多項建議已整合成一個知識模組，專注於社區行動方案，以提升一般救援者（非專業醫療人員）對院外心跳停止（OHCA）的反應能力。在此，讀者可見系統性方法的建議，旨在提高社區對心跳停止的認識，並強調一般民眾施救者實施僅按壓 CPR 及使用自動體外心臟去顫電擊器的重要性。
- 小兒與成人使用早期預警系統和快速反應或急診醫療團隊預防 IHCA 的建議已合併，並新增使用安全交接會議預防 IHCA 的一項建議。
- 現在建議推動政策，使大眾更容易取得納洛酮（naloxone）及自動體外心臟去顫器（AED），因為兩者都具有挽救生命的潛力。

圖 3. 心跳停止生存之鏈。

- 現已為通訊調度員提供成人與兒童 CPR 指導的差異化建議；他們應指導一般民眾施救者對成人實施僅按壓 CPR，對兒童實施包含人工呼吸的常規 CPR。重申「無反應–無呼吸–立即施救」框架是識別 OHCA 的有效方法。
- 重申臨床事後檢討的建議，並新增在 CPR 事件後結合即時（熱）與延時（冷）事後檢討的做法。
- 對院內外復甦團隊的組成提出新建議。
- 對於仍在進行復甦及自發性循環恢復 (ROSC) 後的病人，其轉送時機仍存不確定性。這一問題在多個知識模組中探討，涵蓋現場復甦（而非持續 CPR 中轉送）、為 ECPR 進行的轉送以及向心跳停止中心的跨機構轉送。後續知識模組旨在探討心跳停止中心與 ECPR 中心的關鍵系統性考量。
- 提出構建照護體系以確保心跳停止倖存者獲得最佳復甦後康復的新建議。

主要新增與更新建議

預防 IHCA

2025（新增）：實施安全交接會議可提升高風險住院病人場景下的情況感知並減緩病情惡化，進而有效降低心跳停止發生率。

理由：兩項多中心觀察性品質改進研究顯示，在小兒心臟加護病房和綜合加護病房實施包含高風險病人安全交接會議的心跳停止綜合方案，可降低 IHCA 發生率。

公眾獲取納洛酮

2025（新增）：公共政策應允許一般民眾施救者持有和使用納洛酮，並對其善意使用行為免除民事和刑事責任。

2025（新增）：納洛酮分發計畫有助於提升一般民眾施救者獲取納洛酮的可及性，並可降低鴨片類藥物過量所導致的死亡率。

理由：觀察性研究顯示，使納洛酮更易獲得並在立法上保護一般民眾施救者持有或善意使用免受起訴的措施，以及社區納洛酮分發計劃，通常與死亡率下降相關。

改善一般民眾施救者回應 OHCA 的社區行動方案

2025（更新）：實施社區綜合措施是改善一般民眾施救者對 OHCA 回應的合理策略。

2025（新增）：提高社區由導師引導訓練的可及性，可有效改善一般民眾施救者施救者對 OHCA 的回應。

2025（新增）：可考慮透過大眾媒體宣導，來推廣全民學習 CPR 技能。

2025（新增）：社區推行政策，要求公眾持有 CPR 證書可能合理。

理由：改善一般民眾施救者的回應需多管齊下的綜合策略，現有證據表明多種介入措施均有效。

臨床事後檢討

2025（新增）：將即時事後檢討與延時事後檢討結合採用是合理的，並有助於發現不同的系統改進機會。

理由：事後檢討研究既採用即時事後檢討，也採用延時事後檢討，雖尚無證據顯示孰優，二者並用或可兼得優勢。

OHCA 團隊構成

2025（新增）：對疑似 OHCA 病人進行復甦時，若有一名具備高級救命術 (ALS) 水準的臨床醫生在場，可能更為有利。

2025（新增）：確保緊急醫療服務 (EMS) 系統具備足夠規模的團隊是合理的，以便團隊成員能明確分工、執行各自職責。

理由：研究顯示，最佳化 OHCA 復甦需足夠規模的團隊以執行關鍵角色，並需充分訓練以實施高級管理。

院內搶救團隊組成

2025（新增）：院內搶救團隊應由具備 ALS 訓練的成員組成。

2025（新增）：設立具明確分工、專業多元，並接受充足模擬訓練的專責急救團隊，將有助於提升 IHCA 病人的預後。

理由：類似於 OHCA 團隊，IHCA 搶救團隊亦受益於高級訓練與明確角色，並應透過模擬訓練支援團隊成員履行職責。

OHCA 現場復甦

2025（新增）：EMS 系統應具備現場終止復甦的能力；其中包括 EMS 專業人員接受死亡告知訓練。

2025（新增）：對大多數 OHCA 的成人和兒童而言，若無特殊情形，優先進行現場復甦並在轉運前實現持續 ROSC，可取得更佳效果。

理由：若整場復甦都留在現場，難免出現大量死亡。因此訓練急救人員掌握何時終止復甦及如何向家屬告知，對提供富有同情心的照護與防止職業倦怠至關重要。而在 CPR 持續進行時嘗試轉送病人，不僅會降低 CPR 品質，還可能危及救援人員安全，因此僅應在明顯有助於提升病人存活率的情況下才考慮。

體外照護體系

2025（新增）：對於開展 ECPR 計劃的中心，制定並定期評估病人篩選標準，以最大化心跳停止生存率、確保公平可及並減少無效介入措施，是合理的。

2025（新增）：執行成人周邊 ECPR 管路建置的臨床醫師應具備熟練的經皮穿刺操作經驗，是合理的。

2025（新增）：區域化 ECPR 服務以最佳化療效與資源利用是合理的。

2025（新增）：對於少數經嚴格篩選的成人 OHCA 病人，可以考慮在心臟停止持續期間進行快速轉送以施行 ECPR。

理由：ECPR 是高度耗用資源的技術，需要專業化且高水準訓練的團隊。這些因素使區域化服務頗具吸引力，但是在 OHCA 的情況下，心跳停止期間進行轉送及高資源需求，均須嚴格篩選病人。

器官捐獻

2025（新增）：機構應依據當地法律法規，建立促進並評估心跳停止後器官捐獻的照護體系。

理由：各國旨在促進器官捐獻的政策存在差異，且與當地價值觀和文化密切相關。

改善心跳停止後康復

2025（新增）：對於心跳停止倖存者而言，透過整合式照護系統，在出院前進行評估、出院後持續追蹤並定期處理需求，可改善康復過程及長期功能性預後。

理由：心跳停止倖存者的復健有助於提升長期預後，但其推動需仰賴跨專科醫療團隊的協作，涵蓋院內與院外照護。

新生兒救命術

美國和加拿大每年約有 400 萬例新生兒出生。每 10 到 20 名新生兒就有 1 名需要協助，才能順利從充滿羊水的子宮環境過渡到空氣環境。對於每名需要此類照護的新生兒，必須配備一名專職、經訓練且裝備齊全的專業醫護人員協助完成這一過渡。

重點議題與主要變更摘要

- 新生兒照護鏈始於產前照護，延伸至產後康復和相應隨訪。
- 新生兒復甦需專業醫護人員提前預判並做好準備，包括個人和團隊訓練。
- 大多數新生兒可在延遲鉗夾臍帶 60 秒或以上期間接受評估與監測，並在出生後與父母保持皮膚接觸。
- 對需復甦的新生兒，首要任務是確保有效肺部通氣。
- 多項新增建議（如胸部按壓體位擺放、脈搏血氧機放置時機及通氣糾正步驟）雖可能已成常規，均基於最新證據綜述新增。
- 若以面罩通氣後心跳速率仍未改善，可能需要採取通氣矯正步驟，包括使用喉罩或氣管內插管等替代性氣道。

流程圖和視覺輔助工具

新生兒復甦流程圖（圖 4）已更新，凸顯出生時臍帶管理的重要性。目標血氧飽和度表從 2 分鐘開始適用，因為延遲夾閉臍帶 60 秒或以上無法常規獲取 1 分鐘時的血氧飽和度。建議在胸部按壓前先行心電圖監測。

新生兒預後受到新生兒復甦整體環境影響，包括出生前、中、後各階段的照護體系。新生兒照護鏈（圖 5）為整合醫療系統核心要素、提升新生兒健康提供框架。

主要新增與更新建議

臍帶管理

2025（更新）：對無需立即復甦的足月新生兒，延遲夾閉臍帶至少 60 秒比即時鉗夾更具益處。

理由：統合分析結果顯示，延遲鉗夾臍帶能改善嬰兒期的血液學指標及鐵儲備。與較早鉗夾臍帶相比，近期的研究將延遲時間延長至 60 秒，進一步證實了上述結論。

2025（新增）：對無活力足月及胎齡 35 週或以上的晚期早產兒，與即時鉗夾相比，完整臍帶擠捏可能合理。

理由：一項針對胎齡 35 至 42 週無活力嬰兒的大型 RCT 顯示，完整臍帶擠捏較早期鉗夾可降低心肺支援需求、中重度缺氧缺血性腦病發生率及治療性低體溫使用率。

2025（更新）：對胎齡不足 37 週且無需立即復甦的新生兒，與即時鉗夾臍帶相比，建議延遲鉗夾臍帶至少 60 秒。

理由：統合分析結果顯示，延遲鉗夾 60 秒或以上的早產兒與即時鉗夾者相比，死亡率顯著降低。

通氣與持續氣道正壓通氣

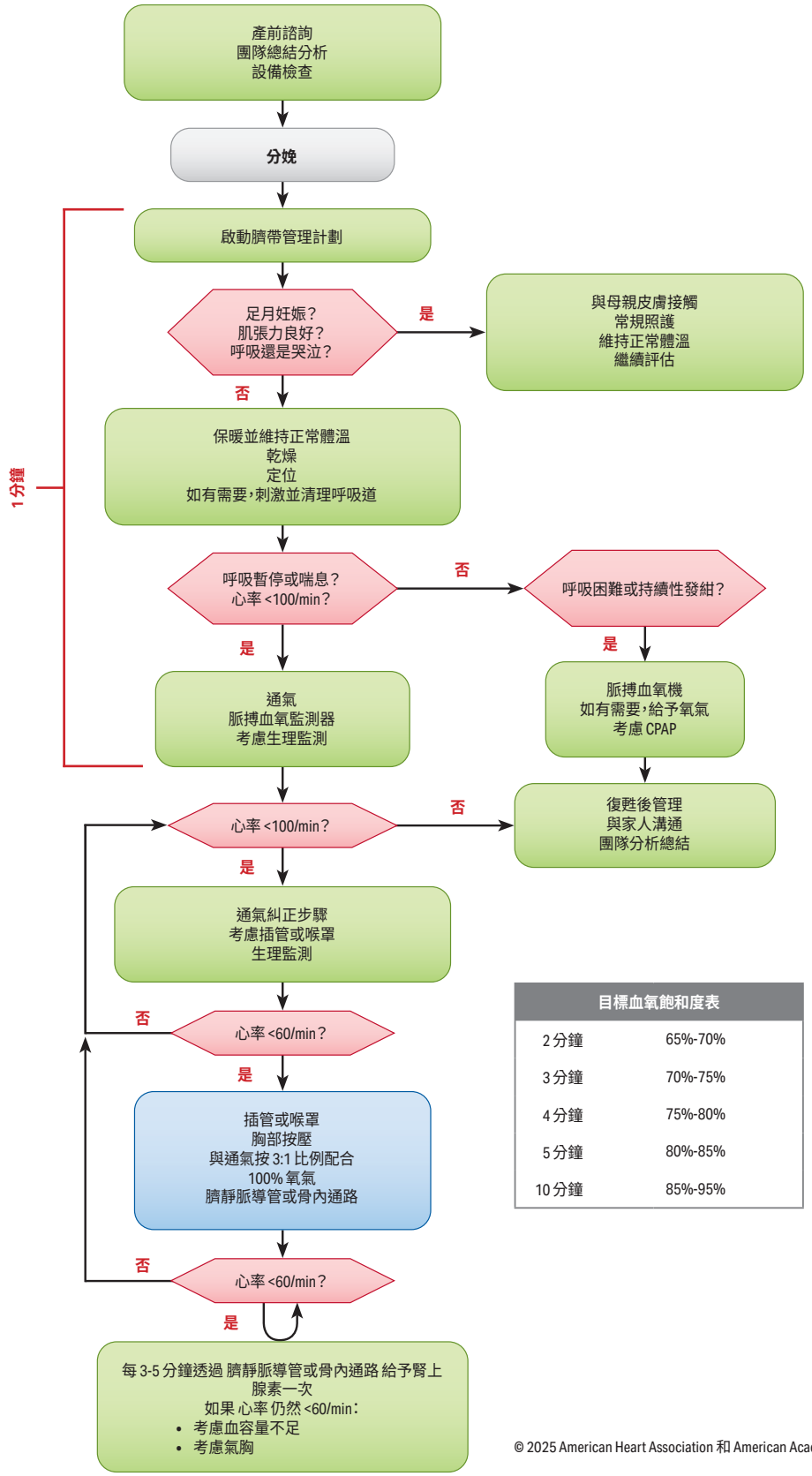
2025（更新）：對新生兒，初始峰值吸氣壓設為 20 至 30 cm H_2O 是合理的，並可根據通氣效果調整峰值吸氣壓。

理由：早產和足月新生兒觀察性研究報告峰值吸氣壓可達 30 cm H_2O 或以上，對應潮氣量足以滿足新生兒通氣需求。達成有效通氣後，可適度調整壓力設置。

2025（更新）：新生兒通氣頻率為 30 至 60 次/分鐘是合理的。

理由：觀察性研究顯示，30 至 60 次/分鐘通氣可輸送 5 mL/kg 至 10 mL/kg 潮氣量。針對晚期早產兒及足月新生兒的觀察

圖 4. 新生兒復甦流程圖。



目標血氧飽和度表	
2 分鐘	65%-70%
3 分鐘	70%-75%
4 分鐘	75%-80%
5 分鐘	80%-85%
10 分鐘	85%-95%

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圖 5. 新生兒照護鏈。

性研究表明，30 次/分鐘通氣頻率對二氧化碳清除最優。

2025（新增）：對需氣管內插管的新生兒，視覺輔助喉鏡有助於提高成功率。

理由：統合分析（6 項涉及插管的 RCT）顯示，視覺輔助喉鏡較傳統喉鏡能提升插管成功率。但傳統喉鏡仍不失為合理的氣管內插管方式。

2025（新增）：對胎齡 34 週 0 至 7 天或以上且面罩通氣失敗的新生兒，使用喉罩替代氣管內插管是合理的。

理由：在 4 項 RCT 中，面罩通氣失敗後，喉罩（聲門上氣道）替代二線插管在置入時長和首嘗成功率上與氣管內插管無顯著差異。在 1 項觀察性研究中，使用喉罩替代氣管內導管與降低新生兒加護病房入院率相關。

2025（新增）：對胎齡 34 週 0 至 7 天或以上的新生兒，選擇喉罩而非面罩作為首選通氣介面可能合理。

理由：一項涵蓋 6 項 RCT 的統合分析發現，使用喉罩相較於面罩，可降低裝置通氣失敗及需進行氣管內插管的比例；同時，使用喉罩可縮短通氣時間以及病人心率恢復 >100 次/分鐘的時間。

氧氣

2025（新增）：對於需要呼吸支持或氧氣補充的新生兒，應儘快置放脈搏血氧監測器。

理由：在復甦早期貼戴脈搏血氧機，可更早獲取血氧飽和度指數以指導治療。觀察性研究表明，獲取脈搏血氧飽和度指數的中位時間為 238 至 260 秒，且早產兒所需時間長於足月兒。

2025（更新）：對胎齡不足 32 週且出生時需呼吸支援的早產兒，初始氧濃度設為 30% 至 100% 可能合理。

理由：針對該人群的現有研究分析結果與一項納入 10 項 RCT 的研究級統合分析結論不一致。後者顯示，與高初始氧濃度相比，低初始氧濃度下的短期死亡率沒有差異（在這些研究中，低氧通常被認為是 21%-30%，高氧為 60%-100%）。近期一項個別病人數據統合分析顯示，與 21% 至 30% 的低初始氧濃度相比，90% 至 100% 的高初始氧濃度可降低死亡率。在達成目標飽和度後，可逐步下調氧濃度。

胸部按壓

2025（新增）：為新生兒實施胸部按壓時，可在胸骨下三分之一處施力，避免壓到劍突，這可能是合理的。

理由：一項嬰幼兒屍檢研究發現，胸骨中段按壓並不增加肝破裂風險。但若壓到劍突，可導致肝包膜淺表撕裂；同時進行胸腹或僅腹部按壓者均出現肝破裂。胸部放射線影像顯示，大多數嬰兒心臟位於胸骨下三分之一處的正下方。

2025（新增）：為新生兒實施胸部按壓時，每 2 至 5 分鐘更換一次按壓員，並在評估心率時換人，可能合理。

理由：高品質胸部按壓需兼顧最佳按壓-通氣比、適當頻率、足夠按壓深度及按壓間隙完全回彈等要素。新生兒模擬人研究表明，單一臨床醫生持續按壓 2 至 5 分鐘後，按壓品質會下降。

小兒基本救命術

在美國，每年嬰幼兒 OHCA 超 7,000 例，IHCA 約 20,000 例。儘管小兒 IHCA 的存活率與良好神經功能預後已有改善，小兒 OHCA 的存活率仍偏低，尤以嬰兒為甚。生存之鏈的實施需各學科專業醫護人員協同，在 OHCA 中，還需非專業施救者、通訊調度員及急救人員配合。

重點議題與主要變更摘要

- 嬰幼兒心跳停止多繼發於進行性呼吸衰竭或休克，而非原發性心臟病。
- 鑒於大多數兒童心跳停止屬繼發性，照護者早期辨識危急重症的嬰幼兒一般民眾施救者接受 CPR 訓練和及時急救，對於改善預後至關重要。
- 高品質 CPR 與針對可電擊心律的早期去顫，是小兒心跳停止治療的基礎，必須優先執行，才能確保後續治療有效。

主要新增與更新建議

高品質 CPR 組成要素

2025（新增）：對心跳停止的嬰幼兒，須盡量減少 CPR 中斷，胸部按壓暫停時間應在 10 秒以內。

理由：一項多國多機構觀察性隊列登錄研究的證據顯示，CPR 中斷頻率及時長的增加與降低 ROSC 概率顯著相關。

復甦順序

2025（更新）：對於嬰兒，建議施救者採用單手掌根或雙拇指環抱胸廓法按壓胸骨。若施救者無法雙手環抱胸部，建議採用單掌根按壓。

理由：模擬研究的系統綜述和統合分析顯示，相較於雙指按壓，雙手環抱拇指按壓更適用於嬰兒按壓，尤其更易達到足夠深度。一項多中心前瞻性觀察登錄研究發現，單掌根按壓在嬰兒中產生的胸部按壓深度優於雙拇指環抱按壓，兩種手法的胸部按壓頻率無差異。雙手指按壓技巧險少在此研究使用，但一經使用，其所有胸部按壓部分均不符合 AHA 指引要求。因此，建議對嬰兒採用單掌根或雙手環抱拇指按壓法。長期沿用的嬰兒 CPR 雙指按壓法已不再推薦。

氣道異物梗塞

2025（更新）：對嚴重氣道異物梗塞 (FBAO) 兒童，應循環進行 5 次背部拍擊與 5 次腹部快速推壓，直至異物排出或兒童無反應（見更新流程圖）。

理由：多數 FBAO 可透過讓病人咳嗽緩解；在嚴重病例中，一般民眾施救者可施行胸部或腹部快速推壓予以排除。近期一項成人及兒童 FBAO 的觀察性研究表明，背部拍擊較腹部快速推壓更能有效清除異物。為保持教學一致，且在無兒童資料顯示背部拍擊效果遜色的前提下，兒童嚴重 FBAO 的初始處置改為先行背部拍擊而非腹部快速推壓。重複進行 5 次背部拍擊與 5 次腹部快速推壓的循環，直至梗塞清除或兒童無反應。

2025（更新）：對於嚴重 FBAO 的嬰兒，應重複循環執行 5 次背部拍擊與 5 次胸部推壓。

理由：因可能造成腹部器官損傷，不建議對嬰兒施行腹部快速推壓。現建議對嚴重 FBAO 嬰兒採用單掌根法進行胸部推壓。儘管單掌根胸部推壓與 CPR 中的胸部按壓相似，但其不強調高品質 CPR 胸部按壓的頻率和回彈等要素，故不沿用「胸部按壓」一詞。

成人基本救命術

在美國，每年有數十萬人經歷 OHCA 和 IHCA。不同地區在一般民眾施救者 CPR 覆蓋率、公共自動體外心臟去顫電擊器 (AED) 使用率、EMS 回應時效及出院存活率等方面差異顯著。COVID-19 大流行期間，成人 OHCA 及 IHCA 的存活率均有所下降。

重點議題與主要變更摘要

- 及早施行高品質 CPR 及立即去顫，是改善成人心跳停止預後的最關鍵介入措施。
- 對頭頸部創傷成人，若下頜推出法與氣道輔助器無法打開氣道，施救者應改用壓額抬頦法。
- 對成人心跳停止者，施救者應在堅硬平面上對病人實施胸部按壓，並使病人軀幹高度與施救者膝部大致齊平。
- 對呼吸停止成人病人進行通氣時，專業醫護人員每 6 秒給予 1 次通氣（或每分鐘 10 次人工呼吸），每次通氣應能見胸部起伏是合理的。
- 對肥胖成人心跳停止病人，應按與非肥胖者相同的方式實施 CPR。
- 不建議對成人心跳停止常規使用機械 CPR 裝置。
- 對嚴重 FBAO 成人，應循環進行 5 次背部拍擊與 5 次腹部快速推壓，直至異物排出或病人無反應。

流程圖和視覺輔助工具

專業醫護人員基本救命術 (BLS) 流程圖已更新，強調鴉片類受體拮抗劑（如納洛酮）在疑似鴉片類藥物過量引發呼吸或心跳停止中的應用。為一般民眾施救者設計的簡化視覺化工具強調，除啟動胸部按壓外，還應盡早啟動 EMS 系統並獲取自動體外心臟去顫電擊器。

新增成人 FBAO 處理流程圖（圖 6），示範先行背部拍擊再施腹部快速推壓的操作流程。對嚴重梗塞病人，應指示施救者啟動應急反應系統，因為病人一旦失去意識，即可迅速轉為心跳停止。

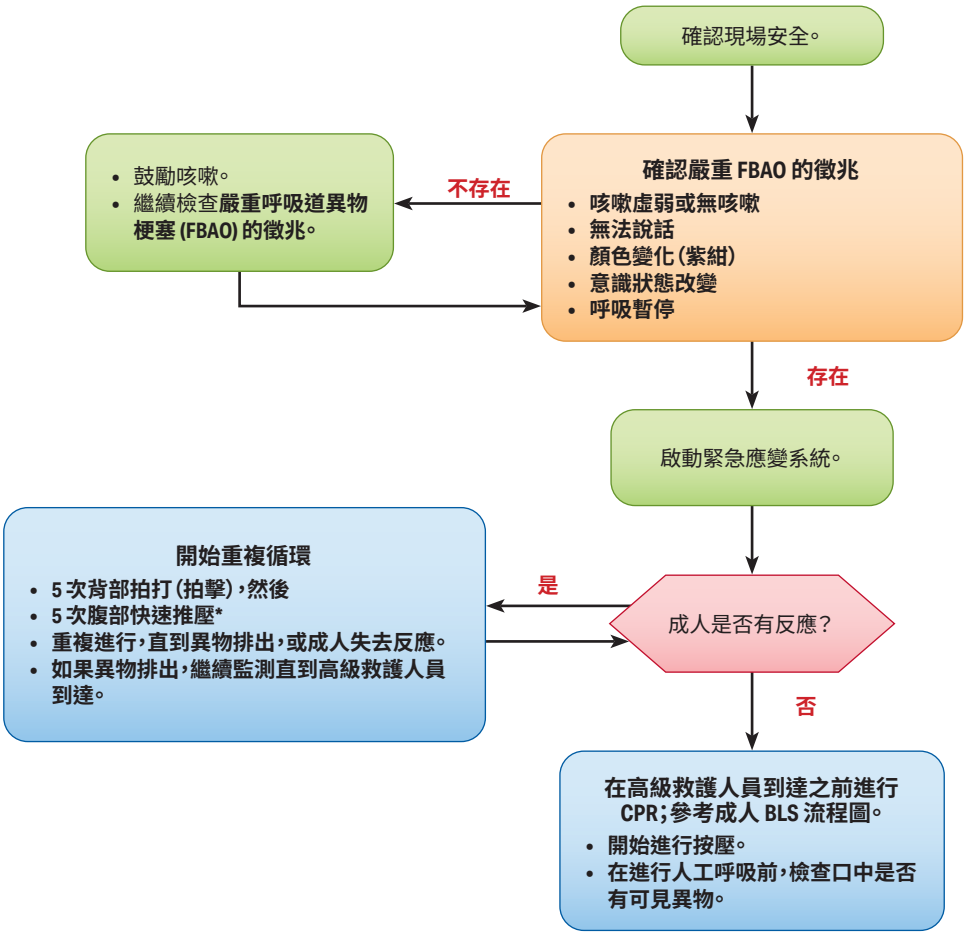
主要新增與更新建議

氣道管理

2025（更新）：對於頭頸部創傷的成人，若無法透過下頜推出法或輔助氣道裝置維持通暢，受過訓練的救援人員可改採壓額抬頦法來打開氣道。

理由：為創傷病人打開氣道是首要任務。雖頭頸外傷時首選下頜推出法，但對於創傷病人，關鍵在於確保氣道通暢以實現氧合和通氣。

圖 6. 成人 FBAO 流程圖。



*對於在懷孕後期的病人,或者當施救者無法環繞病人腹部時,應改用 5 次胸部推壓。

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通氣

2025(更新):對成人心跳停止病人通氣時,給予能產生胸部明顯起伏的潮氣量是合理的。

2025(更新):對心跳停止成人進行人工呼吸時,施救者應避免通氣不足(頻率過低或潮氣量不足)和過度通氣(頻率過高或潮氣量過大)。

理由:近期研究顯示,施救者常未能按指引正確通氣。研究表明,同時實施有效通氣與胸部按壓的 CPR 與較佳的預後相關。

按壓-通氣比

2025(更新):在放置高級呼吸道(如聲門上氣道或氣管內管)前,一般民眾施救者和專業醫護人員採用 30:2 按壓-人工呼吸循環實施 CPR 是合理的。

理由:多數研究顯示,含有通氣間隔的 間歇性 CPR 與單純連續胸部按壓,在病人的預後上並沒有顯著差異。然而,近期證據表明通氣往往不足以達到效果;與持續胸外按壓相比,30:2 按壓-人工呼吸循環實施 CPR 可使施救者監測胸部起伏,進而評估通氣是否充分。

去顫電極片

2025(新增):為成人心臟停止病人貼上去顫電擊片時,調整胸罩位置而非脫除或許合理。

理由:女性在公共場所接受去顫的比例顯著低於男性。需將去顫電擊片直接貼於裸露胸壁,可能影響施救者意願。透過調整而非移除胸罩,可減少施救者因暴露女性胸部而產生的不適。

肥胖成人 CPR

2025（新增）：對肥胖成人心跳停止病人，應採用與非肥胖者相同的 CPR 技術。

理由：2024 年 ILCOR 範圍審查納入 34 項肥胖成人心跳停止觀察性研究，未見支持修改標準 CPR 的證據。

CPR 替代技術

2025（更新）：不建議對成人心跳停止病人使用機械 CPR 裝置。

2025（新增）：在成人心跳停止的特定場景中，若人工按壓難以保證品質或存在風險，專業醫護人員可考慮使用機械 CPR 裝置，前提是部署和移除裝置時嚴格限制 CPR 中斷。

理由：多項 RCT 顯示，手動 CPR 與機械 CPR 在存活率方面無差異。但在某些情況下，機械 CPR 裝置或可提供後勤與安全優勢。這些場景尚未在現有臨床試驗中有所呈現。

氣道異物梗塞

2025（更新）：對嚴重 FBAO 成人，應循環進行 5 次背部拍擊與 5 次腹部快速推壓，直至異物排出或病人無反應。

理由：成人 FBAO 研究顯示，背部拍擊較腹部快速推壓可提高 FBAO 解除率並減少損傷。交替 5 次背部拍擊與 5 次腹部快速推壓的建議，旨在與現有採用此方法的嬰幼兒指引保持一致。

小兒高級救命術

鑒於先前指出的小兒 OHCA 預後不佳，各照護階段仍有大幅提升復甦效果的空間。院內外復甦網路中兒童復甦研究持續推進，為知識增長做出重要貢獻，並促成 2025 年指引的多項修訂。

- 本章更新心跳停止期間的用藥指引，並修改多種藥物的建議類別。
- 隨著心跳停止後照護監測資料的累積，指引提出了新的建議。
- 本指引首次納入心跳停止後神經功能預測（neuroprognostication），涵蓋良好與不良預後的評估。

主要新增與更新建議

心跳停止期間給予藥物

2025（更新）：對初始心律為不可電擊的心臟停止嬰幼兒，盡早給予首劑腎上腺素是合理的。

理由：一項納入 7 項觀察性研究的系統綜述顯示，在 OHCA 與 IHCA 中，越早給予腎上腺素與較佳的預後有關。特別是首劑在 3 分鐘內給予時，與較高的良好預後有關。儘管首次腎上腺素給藥時間的不同時間區間（如 <5 分鐘、<10 分鐘）之間未作直接對比。

CPR 期間生理監測

2025（更新）：對 CPR 期間置入侵略性氣道的嬰幼兒，可考慮採用呼氣末二氧化碳（$ETCO_2$）監測，以評估 CPR 品質。

2025（新增）：不應僅以特定 $ETCO_2$ 臨界值作為終止嬰幼兒復甦的唯一依據。

理由：監測 CPR 期間侵略性氣道病人的呼氣末二氧化碳水準十分重要，因為 $ETCO_2$ 既反映心輸出量和通氣效率，又能回饋 CPR 品質。近期一項針對兒童院內 CPR 前 10 分鐘平均 $ETCO_2$ 的多中心前瞻性研究發現，CPR 期間 $ETCO_2$ 為 20 mmHg 或以上與更高的 ROSC 率、出院存活率及心跳停止期血壓升高相關。這一指標與胸部按壓頻率和按壓深度等 CPR 品質參數無關聯。然而，施救者在考慮復甦終止時，應避免僅依賴特定 $ETCO_2$ 臨界值，因為 $ETCO_2$ 低於 20 mmHg 的病人也有存活記錄，這一點至關重要。

2025（新增）：對 CPR 期間有放置持續型侵入性動脈血壓監測的嬰幼兒，專業醫護人員將嬰兒舒張壓目標設為 25 mmHg 或以上；對 1 歲及以上兒童，目標設為 30 mmHg 或以上，可能合理。

理由：一項新研究顯示，接受 CPR 且置入動脈導管的小兒病人中，嬰兒舒張壓至少為 25 mmHg、兒童舒張壓至少為 30 mmHg 與更高良好神經功能結局存活率相關。

有脈搏上心室心搏過速治療

2025（更新）：對於嬰幼兒合併心肺功能受損之上心室心搏過速，若對迷走神經刺激、adenosine, 及同步心律整流皆無反應，且無法取得專科醫師會診時，考慮靜脈注射 procainamide、amiodarone或 sotalol 是合理的做法。

理由：Procainamide 和 amiodarone 對具有adenosine 抗藥性的上心室心搏過速中度有效，但均可能引發不良反應。Sotalol 自 2009 年獲批用於室上性心動過速治療，多項研究顯示在小兒電生理專家指導下於急症環境應用時，急性同步整流電擊上心室心搏過速有效且不良事件罕見。

心跳停止後管理

2025（更新）：嬰幼兒心跳停止後，建議將收縮壓與平均動脈壓維持在同齡第 10 百分位以上。

理由：因心跳停止後血壓波動大，及時辨識低血壓（低於同齡同性第五百分位）至關重要。心跳停止恢復循環後，低血壓很常見，發生率在嬰幼兒中為 25% 至 50%。兩項觀察性研究表明，心跳停止後前 12 小時內收縮壓低於同齡第五百分位與出院存活率下降相關。此外，ICU 復甦兒童 IHCA 試

驗二次分析顯示，心跳停止後前 6 小時內，若血壓目標值均高於閾值，即收縮壓大於同齡第 10 百分位且舒張壓大於同齡第 50 百分位，則出院存活率及出院良好神經功能預後存活率更高。

心跳停止後預後評估

2025（更新）：建議醫護人員考量多種評估方式進行神經功能預測（在嬰幼兒心臟停止復甦後的良好或不良預後）。

2025（新增）：在嬰幼兒心跳停止後任何時間點，僅憑咳嗽或嘔吐反射及疼痛反應來預測神經功能預後（良好或不良）的有用性目前尚未有充足證據。

2025（新增）：結合其他預後指標解讀時，在嬰幼兒心跳停止後 72 小時內使用腦波圖 (EEG) 以輔助判斷神經功能預後（良好或不良），是合理的。

理由：兩項系統性回顧評估了兒童心跳停止後復甦的神經學檢查、生物標記、腦波圖與神經影像學檢查，與良好或不良預後之間的關聯。這些評估手段未曾單獨驗證，且均未在任一時間點達到可作為唯一預後標準的準確度。因此，雖針對各項檢查有相應建議，但不應單獨使用任何一種來預測結局。基於大量研究，腦波圖是一種可與其他檢查結合使用以預測結局的方式。然而，目前尚無數據支援單憑咳嗽或嘔吐反射預測良好或不良結局。臨床醫生在評估心跳停止倖存者神經功能預後時，應綜合多種評估方式。

心臟停止後復原與倖存者照護

2025（更新）：對心跳停止倖存嬰幼兒進行身體、認知和情感需求評估，以指導心跳停止後首年內的後續照護，是合理的。

理由：目前普遍認為，心跳停止後的復原會持續到初次住院後很久。倖倖存者在心跳停止後數個月甚至數年內，可能需要持續整合性的醫療、復健、照護與社區支持。AHA 近期發布的科學聲明強調，在這段期間為病人與家屬提供支持，對於達成最佳的長期預後至關重要。

成人高級救命術

經 EMS 處置的 OHCA 病人出院存活率仍僅約 10%；而 IHCA 病人出院存活率約為 24%。出院倖存者中約 85% 病人具有良好神經功能預後。建議醫護人員在評估嬰幼兒心跳停止後神經功能預後（良好或不良）時，應考量多種評估方式。然而，高級心臟救命術 (ALS) 介入措施——包含高級呼吸道處置、藥物治療，以及院前與院內協調一致的復甦後照護——對於改善病人預後仍然至關重要。

重點議題與主要變更摘要

- 心律不整 (例如心搏過速) 既是臨床不穩定的原因，也可能是其表現。評估導致不穩定的直接原因，可幫助專業人員更審慎應用本指引。
- 針對心房顫動 (AF) 與心房撲動進行同步電擊整流時，首次電擊能量設定較高 (≥200 J) 優於較低設定。
- 除了雙重序列性去顫電擊的建議更新外，也根據新文獻新增了向量改變去顫電擊的建議。

流程圖和視覺輔助工具

復甦終止流程圖已更新，納入 BLS 及通用復甦終止規則。新增適用於有脈搏成人的心搏過緩處理流程圖（更新版）。

主要新增與更新建議

向量改變去顫電擊與雙重序列性去顫電擊

2025（新增）：針對心跳停止且在連續 3 次或以上電擊後，仍持續心室顫動或無脈搏心室頻脈的成人，向量改變去顫電擊的有效性尚未證實。

2025（更新）：對於心跳停止且經連續 3 次或以上電擊後仍持續心室顫動/無脈搏心室頻脈的成人，雙序列去顫的有用性尚未證實。

理由：2023 年 ILCOR《涵蓋治療建議的國際 CPR 與 ECC 科學共識》指出，僅有一項小型 RCT 支援向量改變去顫和雙序列去顫用於頑固性心室顫動。關於這些介入措施的效果，尚存諸多疑問有待進一步研究。

初始血管通路建立

2025（更新）：建議專業醫護人員首先嘗試為成人心跳停止病人建立靜脈管路以給藥。

2025（更新）：若成人心跳停止病人靜脈管路路初試失敗或不可行，建立骨內 (IO) 管路合理的。

理由：ILCOR 2025 年系統綜述及統合分析（含 3 項近期大型 RCT）發現，骨內管路與靜脈管路相比，在結局上無統計學顯著改善。該系統綜述指出，骨內管路在達到持續性ROSC的機率，低於靜脈管路。

血管升壓藥物

2025（更新）：關於給藥時機，對可電擊心律的成人心跳停止病人，初步去顫電擊失敗後給予腎上腺素是合理的。

理由：文獻支持對可電擊心律病人優先快速去顫，並在初步 CPR 與去顫嘗試失敗後再行腎上腺素給藥。

2025（更新）：對成人心跳停止病人，單用血管升壓劑或血管升壓劑與腎上腺素並用，均不優於單用腎上腺素。

理由：多項 RCT 與觀察性研究的系統綜述與統合分析均顯示，單用血管升壓劑或血管升壓劑和腎上腺素並用，與單用腎上腺素相比在存活率上無差異。

非升壓藥物

2025（新增）：對於心跳停止的成人病人，使用乙型交感神經阻斷劑 (beta-blockers)、bretylium、procainamide 或 sotalol 來治

療對去顫電擊無反應的心室顫動或無脈搏心室頻脈，其益處仍不確定。

理由：ILCOR 2025 年證據更新未提供其他非口服抗心律不整藥物在心跳停止時應用的新證據，其中包括bretylium tosylate（該藥近期重返美國市場，尚缺療效與安全性新證據）。

CPR 輔助措施

2025（新增）：除臨床試驗環境外，不建議對成人心跳停止病人進行頭高位 CPR。

理由：ILCOR 近期系統綜述未發現任何 RCT，僅擷取到 3 項觀察性研究，且均存在顯著方法學局限。因此對於存活至出院，以及存活至出院且神經功能預後良好這兩項結果的證據確定性等級極低（存在嚴重的偏差風險），並建議未來需進一步研究評估該輔助措施。

復甦終止措施

2025（更新）：在同時配備 ALS 與 BLS 專業人員的分級 EMS 系統中，對 OHCA 成人病人採用通用復甦終止規則是合理的。

理由：通用復甦終止規則採用與 BLS 規則相同的標準（EMS 專業人員未目擊心跳停止；未給予電擊；無 ROSC），並且已在BLS/ALS整合模式或分級應變的EMS機構中獲得前瞻性驗證。

寬波群心搏過速

2025（更新）：對於血行動力學不穩定的寬波群心搏過速成人病人，建議實施同步整流進行急性治療。

理由：在血行動力學不穩定的寬波群心搏過速病人中，盡速恢復竇性心律至關重要。同步整流終止寬波群心搏過速的成功率高。

2025（更新）：對於血行動力學穩定的寬波群心搏過速成人病人，當迷走神經刺激術和藥物治療無效或有禁忌時，建議實施同步整流進行急性治療。

理由：在血行動力學穩定的寬波群心搏過速病人中，可先嘗試迷走神經刺激術或 adenosine；然而，若病人在這些治療後仍持續寬波群心搏過速，則建議實施同步整流來恢復竇性心律。

伴隨快速心室速率的心房顫動或撲動

2025（更新）：對成人心房顫動實施同步整流時，若使用現行美國核准的的任一雙相波去顫器，初始能量設定至少 200 J 是合理的；如電擊失敗，可依據雙相波去顫器特性逐步增量。

理由：近期多項隨機試驗及一項納入逾 3,000 例心房顫動病人的網路統合分析結果顯示，使用美國目前全 3 種雙相波平臺時，200 J 電擊累積同步整流成功率均超 90%。與 200 J 或以上的設定相比，低能量的單相電擊在對心房顫動或心房撲動進行整流時，顯著更容易誘發心室顫動。

2025（新增）：將雙重同步整流作為心房顫動成人病人的初始治療策略，其有效性仍不確定。

理由：基於當前可用資料，並鑒於採用雙相波最佳化同步整流的成功率已很高，雙重同步整流的增量獲益似乎有限。

2025（更新）：對成人心房撲動實施同步整流時，初始能量設定 200 J 可能合理；若電擊失敗，可依據雙相波去顫器特性逐步增量。

理由：近期研究顯示，使用在美國銷售的任一雙相波去顫器進行撲動同步整流時，以 200 J 作為起始能量，並在電擊整流失敗時依據去顫器特性逐步遞增，能在不增加安全疑慮的前提下，提高其有效性、效率與簡易性。

心搏過緩初始處置

2025（新增）：對藥物治療無效且血流動力學持續不穩的心搏過緩成人病人，暫時性經靜脈心律調節以增快心率、改善症狀是合理的。

理由：當藥物無法改善心率且休克持續存在時，經靜脈心律調節可提供臨時心率支持和症狀緩解，直至實施根本性治療（如治療病因或植入永久心律調節器）。

心跳停止後照護

心跳停止後照護側重於減少神經後遺症和器官功能障礙，並辨識處理心跳停止的任何可逆病因。神經功能預後是心跳停止後照護的關鍵環節，旨在確保資源合理利用、恰當撤除生命支持治療並最佳化病人預後。成人心跳停止後照護流程圖（圖 7）已更新，以體現該領域最新科學進展。

重點議題與主要變更摘要

- 神經功能預後評估的章節已更新，新增了良好預後的預測因子，並將 neurofilament 輕鏈納入作為血清生物標誌。
- 對 ROSC 後仍無言語反應的成人病人，至少維持體溫調控 36 小時是合理的。
- ROSC 後應避免成人低血壓，需將最低平均動脈壓 (MAP) 維持至少 65 mmHg；但尚無足夠證據建議特定血管升壓劑用於心跳停止後成人病人的低血壓治療。
- 對心跳停止倖存者及其照護者的新建議，強調在病情穩定且出院前，對情緒困擾進行結構化評估，並提供相應治療或轉診。

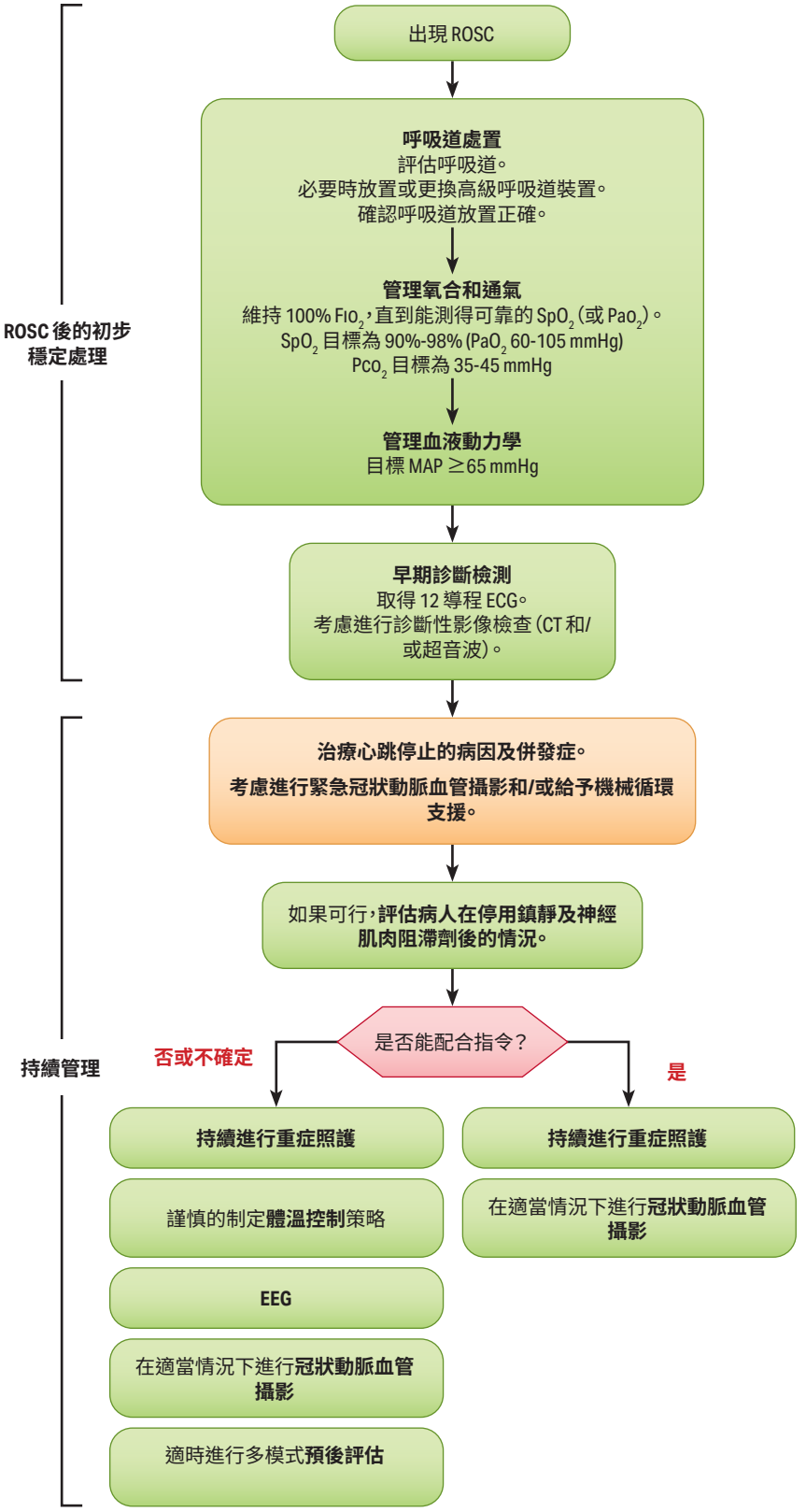
主要新增與更新建議

心跳停止後成人血壓管理

2025（更新）：ROSC 後應避免成人低血壓，將最低 MAP 維持至少 65 mmHg。

理由：四項隨機試驗比較了 OHCA 後 MAP 低目標與高目標的效果。這些研究未顯示高 MAP 目標可提升總體存活率或改善神經功能預後。

圖 7. 成人心跳停止後照護流程圖。



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ROSC 後的初步穩定處理

ROSC 後期間持續施行心肺復甦，這些活動多數可以同時進行。

呼吸道處置：評估並考慮放置或更換高級呼吸道裝置（通常為氣管內管或聲門上呼吸道裝置）。確認高級呼吸道放置正確。通常需使用波形二氧化碳圖或二氧化碳監測器。

管理氧合和通氣：調節 FIO_2，使 SpO_2 維持在 90%-98%（或使 PaO_2 維持在 60-105 mmHg）。在無嚴重酸血症的情況下，調整分鐘通氣量，目標是使 PCO_2 維持在 35-45 mmHg。

管理血液動力學：使用或調整血管升壓劑和/或輸液復甦處置，使目標 MAP ≥65 mmHg。

早期診斷檢測：取得 12 導程 ECG，評估是否存在缺血或心律不整。考慮進行頭部、胸部、腹部和/或骨盆 CT，以明確心跳停止的原因或評估復甦過程中造成的損傷。可以考慮使用床邊超音波或超音波，以發現需要介入措施的關鍵臨床診斷。

持續管理

治療心跳停止的病因及併發症。

考慮緊急心臟介入性治療：

- **持續存在 ST 段上升**
- **心源性休克**
- **復發或難治性室性心律不整**
- **嚴重心肌缺血**

體溫控制：若病人在停用鎮靜及神經肌肉阻滯劑後仍無法配合指令，或無法評估病人，應盡快啟動以 32°C-37.5°C 為目標的體溫控制策略。

評估是否存在癲癇發作：評估是否存在臨床癲癇發作，並對無法遵循指令的病人進行 EEG 檢查，以進一步評估癲癇活動。

預後評估：採用多模式評估，多模態方法與延遲判斷（ROSC或恢復到正常體溫後≥72小時）。

持續的重症照護包括以下內容：

- **目標是 PaO_2 為 60-105 mmHg，PCO_2 為 35-45 mmHg（除非存在嚴重酸血症）；避免低血糖症（血糖 <70 mg/dL）和高血糖症（血糖 >180 mg/dL）；目標 MAP ≥65 mmHg。**
- **考慮使用抗生素。**

心跳停止後成人診斷性檢查

2025（新增）：ROSC 後成人病人接受頭至盆腔電腦斷層掃描 (CT)，評估心跳停止病因及復甦併發症可能合理。

2025（新增）：對於成人病人在恢復自主循環後，進行心臟超音波或床邊心臟超音波檢查，可能是合理的作法，可用來辨識需要進一步處置的臨床重大診斷。

理由：因此，對病人預後而言，抑制無相關電位變化的肌陣攣所帶來的副作用風險，可能大於其未知的效益。

心跳停止後成人體溫管理

2025（更新）：對 ROSC 後仍無言語反應的成人病人，至少維持體溫調控 36 小時是合理的。

理由：體溫管理涵蓋低體溫控制 (32-34 °C) 及正常或預防發燒控制 (36-37.5 °C)。鑒於體溫管理方面的證據與定義演變，總計 36 小時體溫管理為建議最短時長。

心跳停止後成人經皮冠狀動脈介入

2025（更新）：對疑似心因性心跳停止成人倖存者，建議出院前進行冠狀動脈血管攝影，尤其有初始可電擊心律、不明左室收縮障礙或重度心肌缺血者。

理由：冠狀動脈病在 OHCA 病人中常見。辨識並治療不穩定冠狀動脈疾病已證明可改善預後。

心跳停止後成人臨時機械循環支持

2025（新增）：心跳停止及 ROSC 後頑固性心因性休克、經嚴格篩選的成人病人可考慮臨時機械循環支持。

理由：心因性休克常為心跳停止的病因或後果。臨時機械循環支援可為頑固性心因性休克提供血流動力學穩定。

心跳停止後成人肌陣攣診斷與管理

2025（新增）：對於電生理圖 (EEG) 上沒有相關電位變化肌陣攣的心跳停止成人倖存者不建議進行肌陣攣抑制性治療。

理由：暫無證據顯示無 EEG 相關放電的肌陣攣參與了心跳停止後繼發性腦損傷。因此，對病人預後而言，抑制無相關電位變化的肌陣攣所帶來的副作用風險，可能大於其未知的效益

神經功能預後

2025（新增）：對 ROSC 後持續昏迷成人病人，如心跳停止後 72 小時內持續 EEG 背景無放電，結合其他預後檢查，視為良好神經功能結局的輔助依據可能合理。

理由：神經功能預後部分已更新，新增良好預後的預測因子。一份國際復甦聯絡委員會 (ILCOR) 2022 年的系統性回顧研究了良好預後的預測因子。

心跳停止後的復原與倖存者照護

2025（更新）：建議心跳停止倖存者及其照護者在病情穩定且出院前，對情緒困擾進行結構化評估，並尋求相應治療或轉診。

理由：約四分之一的心跳停止倖存者及其照護者經歷情緒困擾。倖存者-照護者配對及倖存者個體研究均顯示，社會心理介入措施可改善情緒困擾。

因特殊情況導致的心跳停止

某些特殊情況可能需要在標準 BLS 與 ALS 之外，採取額外的治療措施。這些建議適用於危及生命狀況（包括心跳停止）的兒童和成人處置。

重點議題與主要變更摘要

- 雖非所有機構都具備體外生命支持系統 (ECLS)，但對於潛在病因可逆的心跳停止或心跳將停止的成人與兒童病人，可採用如靜脈-動脈體外膜氧合等 ECLS 裝置進行支援。
- 胸部按壓、球囊面罩通氣、去顫、吸痰和氣管內插管等操作均可能產生氣溶膠，為復甦團隊成員造成感染風險。
- 妊娠期心跳停止管理是十分複雜的臨床場景，需要採取適應孕期生理變化的復甦策略。
- 對於因疑似鴉片類藥物過量引發的呼吸停止，應給予鴉片類受體拮抗劑（如納洛酮）。受過訓練的施救者、一般民眾施救者及公眾均可給予納洛酮。

主要新增與更新建議

危及生命的氣喘急性惡化

2025（新增）：對於標準療法無效生命垂危的氣喘成人與兒童，使用葉克膜／體外循環生命支持系統是可能合理的。

2025（新增）：對於對標準療法無效的危及生命哮喘成人和兒童，可考慮使用揮發性麻醉藥治療。

理由：哮喘下氣道阻塞可導致低氧血症、高碳酸血症和呼吸性酸中毒，伴隨胸腔內壓升高，進而引發心跳停止並降低心輸出量。對 ECLS 或揮發性麻醉藥治療的成人和兒童觀察性研究顯示，生存率在 83.5% 至 100% 之間。可根據病人具體需求，選擇靜脈-靜脈或靜脈-動脈體外膜氧合。

危及生命的高鉀血症

2025（更新）：對於因疑似高鉀血症導致心跳停止的成人和兒童，靜脈內注射鈣劑的療效尚未得到充分證實。

理由：對於因疑似高鉀血症導致心跳停止的成人和兒童，關於靜脈內注射鈣劑改善

生存率或良好神經功能結局的人體研究證據有限。在開始靜脈內注射鈣劑前，必須權衡其可能耽誤高品質 CPR、可電擊心律去顫和腎上腺素給藥等時間敏感的指引推薦復甦措施。

危及生命的低體溫

2025（新增）：對於因低體溫導致心跳停止的成人和兒童，使用預後評分來指導是否啟動 ECLS 升溫是合理的。

2025（新增）：對於嚴重環境性低體溫（核心體溫 <28 °C [84 °F]）且未發生心跳停止的成人和兒童，使用 ECLS 進行升溫可能合理。

理由：嚴重環境性低體溫（核心體溫 <30 °C [86 °F]）可導致心跳停止，並出現類似死亡的表現。代謝率與耗氧量降低可提高病人存活且神經功能完好的機率。研究顯示，與傳統 CPR 相比，低體溫所致心跳停止病人接受 ECLS 後生存率更高。對未發生心跳停止的成人和兒童採用 ECLS 升溫可更快，但同時伴有併發症風險。與其他單一預後指標相比，HOPE 概率評分和 ICE 生存評分在預測低體溫所致心跳停止後生存率方面驗證更為充分。

危及生命的體溫過高

2025（新增）：對於危及生命的體溫過高成人和兒童，優先選擇冰水浸泡（1-5 °C [33.8-41 °F]），而非其他降溫方法是合理的。

2025（新增）：對於危及生命的體溫過高成人和兒童，以至少 0.15 °C/分鐘（0.27 °F/分鐘）的速率盡快降溫是合理的。

理由：快速降溫可預防因危及生命的體溫過高（>40 °C [104 °F]）導致的心跳停止。一項針對人體臨床和觀察性研究的系統綜述顯示，與其他降溫策略相比，冰水浸泡降溫效率最高，最有可能達到至少 0.15 °C/分鐘（0.27 °F/分鐘）的最佳降溫速率。這些建議既適用於環境性體溫過高，也適用於與擬交感神經藥物及 cocaine 中毒相關的體溫過高。

左心室輔助裝置

2025（新增）：對於植入耐用型左心室輔助裝置 (LVAD) 的成人和兒童，若無反應且灌注不良，應實施胸部按壓。

2025（新增）：對於植入耐用型 LVAD 的成人和兒童，若無反應且灌注不良，考慮立即開始胸部按壓，並同步評估裝置相關的可逆原因可能合理。

理由：由於無法觸及脈搏，確認植入 LVAD 的成人和兒童是否發生心跳停止較為困難。可透過膚色、皮溫、毛細血管再回流時間、MAP 及呼氣末二氧化碳分壓評估灌流；若灌流不良，則很可能已發生心跳停止。由於研究存在偏見，該族群接受或未接受 CPR 後的心跳停止結局難以評估，但 CPR 的潛在益處超過裝置脫落的理論風險。治療應以實施 CPR 為優先；如有第二施救者，可同步嘗試恢復 LVAD 功能。LVAD 流程圖（圖 8）詳述了治療步驟。

妊辰期心跳停止

2025（更新）：對發生心跳停止的孕婦，應在確認心跳停止後即刻開始準備復甦性分娩，目標在 5 分鐘內完成。

2025（新增）：對於標準復甦無效的懷孕或周產期病人，使用 ECPR 是合理的。

2025（新增）：對於疑似危及生命的羊水栓塞的周產期病人，應採用平衡輸血策略的大量輸血方案。

理由：除團隊協作、手動子宮左側移位和常規復甦外，應在 5 分鐘內完成復甦式分娩（取代「瀕死剖腹產」一詞），以改善孕婦結局。ECPR 研究報告孕婦生存率為 55% 至 75%。周產期羊水栓塞可能導致心跳停止，表現為血流動力學不穩、呼吸窘迫和彌散性血管內凝血伴出血。平衡輸血等量紅細胞、血漿和血小板等大量輸血策略可降低死亡風險。孕婦心跳停止流程圖詳述了治療步驟。

毒理學：鴉片類藥物過量

2025（新增）：對疑似鴉片類藥物過量導致心跳停止的成人和兒童，非專業與受訓施救者給予鴉片類受體拮抗劑可能合理，前提是給予鴉片類受體拮抗劑（如納洛酮）不影響人工呼吸高品質 CPR 等標準復甦的實施。

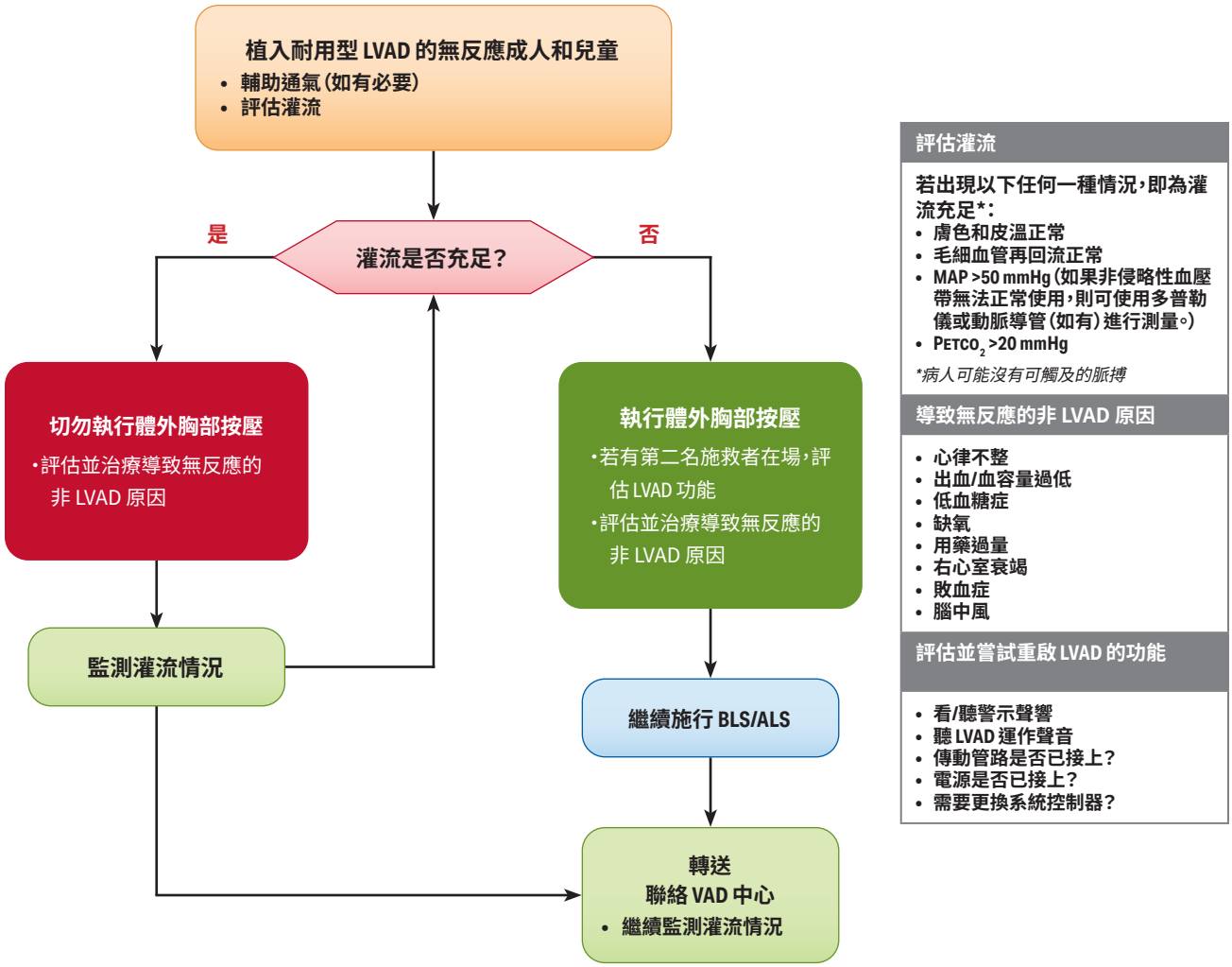
2025（新增）：鴉片類藥物過量治療後的成人和兒童，出院時應獲配鴉片類受體拮抗劑（如納洛酮）及使用說明。

理由：鴉片類受體拮抗劑可恢復成人和兒童的氣道保護反射，並逆轉鴉片類藥物過量引發的呼吸停止，因此一旦懷疑鴉片類藥物過量即應給予。尚無臨床試驗評估鴉片類受體拮抗劑對心跳停止成人或兒童的作用。在動物研究以及成人觀察性研究中，針對不明原因心跳停止或疑似鴉片類藥物過量所導致的心跳停止，使用納洛酮的療效結果存在相互矛盾的證據。然而，只要給予鴉片類受體拮抗劑不影響標準復甦，尚無證據表明對心跳停止者給予納洛酮會造成傷害。鴉片類藥物過量倖存者再次過量的風險很高。除簡短社會心理介入措施及轉診實證治療計劃外，提供「帶回家」或「備用」鴉片類受體拮抗劑並輔以使用指導，可預防未來致命過量。

教育科學

教育與訓練科學，以及支持訓練的技術持續發展，而一份全面的文獻回顧帶來了幾項影響醫護人員與非專業急救人員訓練的重要更新。最重要的更新包括：訓練中使用回饋裝置的建議、CPR 教育中的差異性、虛擬實境 (VR) 應用，以針對鴉片類藥物過

圖 8. 成人及兒童耐用型 LVAD 流程圖。



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量的非專業醫療人員訓練。

- 技術持續改變教育格局,醫療市場力量也推動了降低成本的新策略實施。
- 教育科學不斷發展,已針對不同族群(專業醫護人員和一般民眾施救者)在認知教學與操作技能訓練的技術和方法上提出差異化建議。
- 多數救命術訓練創新尚未顯示改善病人預後的證據,但這仍是訓練的最終目標。

CPR 訓練使用回饋裝置

2025(更新):建議在專業醫護人員的 CPR 訓練中使用回饋裝置。

2025(更新):針對鴉片類藥物過量的非專業醫療人員訓練。

理由:對多項面向專業醫護人員的新 RCT 統合分析顯示,CPR 回饋裝置對所有 CPR 品質指標具有中至大幅度的提升效果。三項面向非專業醫療人員施救者的 RCT 表明,回饋裝置能有效提升 CPR 各項平均品質指標。

快速循環刻意練習

2025(新增):將快速循環刻意練習納入專業醫護人員 BLS 或 ALS 訓練可能合理。

理由:快速循環刻意練習是一種基於模擬的訓練方法,融入了即時事後檢討環節。研究發現,快速循環刻意練習可提升多項 CPR 技能表現,並改善工作負荷評分。

2025 摘要

團隊合作與領導力訓練

2025（更新）：建議在專業醫護人員救命術訓練中，特別強調團隊合作能力。

理由：在審查的 14 項 RCT 中，有 12 項報告稱，在課程結束時，專門的團隊合作訓練可使學員在溝通、領導行為、非技術性技能、工作負荷管理和整體團隊合作等方面表現更佳。

遊戲化學習

2025（新增）：將遊戲化學習元素納入專業醫護人員復甦訓練可能合理。

2025（新增）：將遊戲化學習元素納入一般民眾施救者的 CPR 指導可能合理。

理由：由於關於遊戲化學習以及虛擬和擴增實境的證據不斷增加，因此將針對這些技術的建議分開，並新增了一項針對擴增實境的具體建議。遊戲化學習可提升一般民眾施救者和專業醫護人員的 CPR 知識、技能表現與自信心；但目前支持遊戲化學習應用的證據仍較薄弱。

虛擬實境與擴增實境

2025（新增）：對於一般民眾施救者和專業醫護人員的 BLS 及 ALS 訓練，使用 VR 輔助知識獲取可能合理。

2025（新增）：在一般民眾施救者和專業醫護人員的 BLS 訓練中，可考慮使用增強現實提供即時 CPR 回饋。

2025（新增）：無論對一般民眾施救者還是專業醫護人員，不應使用虛擬實境教授 CPR 技能。

理由：十三項研究探索了在專業醫護人員救命術知識訓練中使用 VR，與傳統訓練相比，其在知識獲取上的效果參差不齊。重要的是，新資料顯示 VR 在輔助知識獲取與技能訓練方面的有用性存在差異，因此對這 2 個領域提出了相反的建議。幾項研究對 CPR 技能的量化參數（如按壓深度、速率）進行評估後發現，VR 訓練在這些指標上或不及其他 CPR 訓練方式，或沒有差異。

面向一般民眾施救者的鴉片類藥物過量訓練

2025（更新）：建議一般民眾施救者接受關於辨識鴉片類藥物相關 OHCA 病人及初步治療步驟的訓練。

2025（更新）：針對一般民眾施救者識別及介入處理鴉片類藥物過量的最佳訓練方式尚未證實。

理由：三項近期系統綜述彙總了 140 多項研究，發現對一般民眾施救者的鴉片類藥物過量辨識與治療訓練可提高其知識水準、回應意願及使用納洛酮的可能性。

教育差異

2025（更新）：建議針對特定種族和族裔群體及其集中的鄰里區，定向開展並客製化一般民眾施救者的 CPR 訓練，同時加強當地宣傳。

2025（更新）：建議透過教育訓練和公眾宣傳，消除一般民眾施救者在對女性實施 CPR 時的障礙。

2025（更新）：建議將一般民眾施救者的 CPR 訓練和宣傳重點放在社會經濟地位較低的族群及其所在鄰里區。

2025（更新）：透過增加多語種 CPR 訓練教材的供應和獲取管道，幫助語言隔絕社區克服障礙是合理的。

2025（更新）：為社會經濟地位較低的族群及其環境，採用經濟高效的 CPR 訓練方法，並促進其安全獲取訓練是合理的。

理由：眾所周知，無論是院外接受 CPR 的病人，還是 CPR 訓練的可及性，都存在由社會因素造成的差異。針對特定族群開展 CPR 教育，並調整內容以消除差異，可消除 CPR 訓練及一般民眾施救者 CPR 中的不平等，有望改善這些人群的心跳停止結局。目前已針對低收入社區和語言隔絕的群體，以及如何應用符合成本效益的CPR訓練方法，提出了具體建議。

學齡兒童 CPR 訓練

2025（新增）：建議從 12 歲以下兒童開始開展 CPR 訓練，以增強其日後的施救意願和自信心。

理由：研究顯示，及早向年幼兒童介紹緊急電話呼救、心肺復甦術（CPR）及自動體外心臟去顫電擊器（AED）等概念，有助於培養他們對非專業醫療人員訓練及時施救的重要性之社會認知。

非醫療專業人員胸部按壓訓練的替代教具

2025（新增）：與使用模擬人相比，使用模擬人以外的替代教具訓練一般民眾施救者進行胸外按壓的有用性尚未得到充分證實。

理由：近期已有初步研究描述了使用常見家居物品（如枕頭、衛生紙卷、泡沫塊）進行胸外按壓訓練與練習的可行性。七項研究中，學習者使用替代物品練習胸外按壓，效果參差不齊。因此，現有證據仍不足以形成建議。

腳本化事後檢討

2025（新增）：在復甦訓練中，指導員使用腳本化事後檢討可能合理。

理由：腳本化事後檢討指制定書面計劃，在救命術訓練過程中及（或）結束後對學習者進行檢討。標準化事後檢討有助於在不同訓練中心及復甦計劃中保持事後檢討內容的一致性。六項研究顯示的結果各不相同。

使用認知輔助工具

2025（新增）：專業醫護人員在復甦過程中使用認知輔助工具可能合理。

2025（新增）：不建議一般民眾施救者在復甦過程中使用認知輔助工具。

理由：認知輔助工具是用於提示的資源，旨在幫助使用者回憶資訊並提高正確操作與行為的可能性。已發表的模擬研究表明，專業醫護人員使用認知輔助工具可能提升復甦表現。在一般民眾施救者中，使用認知輔助工具會顯著延遲 CPR 啟動，故不建議一般民眾施救者使用。

如需更多有關 American Heart Association 救命行動訓練課程的資訊，或查看購買選項，請聯絡我們:
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