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Case Report

Hyperbaric oxygen therapy for a pediatric electrical burn: A case report

Laura Marín, Graciela Fioravanti, Elisabet Cristaldo, Carlos Emilio Sereday, Oscar Merbilhaá, Mercedes Portas *

Burns Hospital of Buenos Aires, Argentina

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ABSTRACT

Contact electrical burns are more severe than others forms of contact burn injury. We present a 2- year-old case of electric injury admitted 48 h after injury treated with Hyperbaric Oxygen Therapy (HBOT) at 1.45 ATA ≈ 100%O_2 like adjuvant therapy. She had thumb necrosis of right hand with 0.2% burn (0.1% type AB and 0.1% type B). After 6 sessions of HBOT, the amputation was limited to necrotic distal phalanx. This is a report of a successful limitation of amputation using escharotomy, skin flap and HBOT as therapeutic approach in a low voltage pediatric electrical burn.

1. Introduction

Contact electrical burns are more severe than other forms of contact burn injury. Low voltage (<1000 V) injuries are commonly seen in children less than six years of age, whereas high voltage (>1000 V) injuries occur in older children and adolescents [1]. Soft injuries are devastating and surgically demanding and autologous skin grafts and flap coverage were common strategies of wound management in electrical burns [1].

The surgical treatments practiced are escharotomy or fasciotomy was traditionally, excisional debridement and limb amputation. Early fasciotomy was traditionally employed to treat compartment syndrome, caused by deep muscle necrosis and tissue edema. Despite early fasciotomy or escharotomy as a limb saving measure, there are still cases of limb amputation being reported [2]. When presented with a fixed neurological deficit, irreversible nerve damage should be considered, as fasciotomy may not improve the outcome of restoring limb function [2]. In a serial of 595 electrical burns, amputation was performed in 107 cases (18.0%) and concentrated on the hands (43.9%) [1].

Electrical injuries were 16% of total burns in pediatric population in Argentina due to domestic accidents (data provided by the statistical division of Burns Hospital of Buenos Aires, Argentina, a major Burns Reference Center) in the period of 2014–2018.

Hyperbaric oxygen therapy (HBOT) is a treatment in which a patient breathes high level oxygen inside a treatment chamber at a pressure higher than sea level pressure, usually greater than 1.4 ATA [3]. It is used extensively to resolve certain recalcitrant, expensive, or otherwise hopeless medical problems. While the European Committee of Hyperbaric Medicine recommended treatment at >2 ATA for wounds and burns [4], the required physiological effects for tissue healing, like angiogenesis [5] and collagen synthesis [6], are achieved at <2 ATA (medium pressure of treatment). Moreover, the neurological response to oxygen in rehabilitation is better at lower pressures of treatment, so it is probable that the optimal axonal regeneration necessary in electrical burns with neurological deficit occurs at that safer medium pressure HBOT [7].

Although HBOT is widely used for thermal burns [4,8], as far as we are aware, there is only an electrical injury case report treated with 20 sessions of HBOT at 2.4 ATA. There were 2nd and 3rd degree burns over 35% of his body which led to amputation of the limb and in this case HBOT was started on the 5th day of the injury. The authors suggest that adjunctive HBOT could be instituted as soon as possible to promote healing of electrical injuries [9].

We present a case of electric injury admitted in Burns Hospital of Buenos Aires, Argentina, treated with HBOT at 1.45 ATA as adjuvant therapy

2. Case report

A 2-year-old child who entered the emergency room with a low voltage electrical injury was examined in our hospital on the sec-

* Corresponding author at: Burns Hospital of Buenos Aires, Pedro Goyena 369, CABA, CP1424. Hospital de Quemados, Argentina.
E-mail address: mportas84@gmail.com (M. Portas).

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ond day of injury. The injury was caused 48 h before she was admitted, by a domestic accident due to the explosion of a cell phone charger. There was thumb necrosis of right hand with 0.2% of burn (0.1% type AB and 0.1% type B) Group II, with a marked necrosis in the first phalanx without a compartmental syndrome. The finger was cold, sensations to touch and pressure were decreased, and active movement was limited. The patient had indication of thumb amputation and was referred to the Plastic Surgery Medical Unit.

Before starting of HBOT, escharotomy was performed after 24 h of being admitted to hospital and after that, she was treated with papaine and carbopol prepared in hospital (commonly used in our hospital in 3rd degree burns) and propolis (an ingredient commonly present in small quantities in honey).

Three total debridement procedures were carried out and HBOT was applied for 60 min twice daily for three days in a hyperbaric chamber at 1.45 ATA ≈ 100%O_2 (Revitalair 430).

Laboratory parameters were normalized during the 39 days of admittance and all the time the patient was hemodynamically stable.

Wound became well granulated and free of infection without antimicrobials after 6 sessions of HBOT and surgical procedures (Fig. 1). However, necrotic distal phalanx was amputated. As a therapeutical measure, tissue coverage with an autologous skin flap from abdominal tissue split was performed, in combination with autologous platelet concentrate and mupirocine topical. After 10 days due to uncontrolled movement of the child, the flap failed and a dehiscent and distal necrosis was presented in the palmar flap. A second skin flap was successfully used and it was epithelized and released after a 4-week-stay at the hospital, with only one surgical toilette intervention. Treatment at discharge was fusidic acid and betamethasone topical. The patient was subsequently transferred to a rehabilitation unit to continue rigorous physiotherapy of the hand for future reconstructive surgery, necessary to achieve clamp movement. The patient carried out only 6 sessions of HBOT before amputation which was limited to the first phalanx instead of the total finger and 3 sessions after the second skin autologous flap (Fig. 1).

3. Discussion

Early fasciotomy or escharotomy is required as a priority step that reduces intra-compartmental pressure and restores perfusion to viable tissues. Selective fasciotomy performed by most surgeons, based primarily on clinical findings of compartment syndrome, such as neurovascular compromise and increased compartment pressure, is generally accepted [1,2]. However, the objective of early fasciotomy or escharotomy is to avoid the amputation of distal part of human body through preservative blood vessels of viable surrounding tissues [2].

The primary rationale for using HBOT is that it increases tissue oxygen tension in hypoxic tissue to higher levels, which makes it is possible for the host responses to work. With HBOT at 1.45 ATA,

Fig. 1. Electrical injury of a child treated with Hyperbaric Oxygen Therapy (HBOT) at 1.45 ATA near 98–100% O_2.

arterial blood oxygen contenst is increased; plasma and tissue oxygen tension increase 10-fold [10].

HBOT could be effective in fighting against necrosis, infection and tissue loss in thermal burns [8]. So, it could be expected to be effective in electrical burns. In thermal burns, there are studies, however, that have shown little to no benefit with HBO therapy [11,12].

A Cochrane review was published in 2004 [13] that looked at a total of two small randomized trials of HBOT in thermal burns. The main effect is the success of grafts with additional HBOT. It was reported in a low-quality randomized study with a risk ratio of 1.75 [0.53, 5.76] for HBOT [13].

HBOT has demonstrated utility in the salvaging compromised grafts/flaps [14], and animal models suggest the benefits of hyperbaric oxygen as a preconditioning stimulus in setting Ischemic/Reperfusion, including flap preparation to improve survival, by attenuating the inflammatory response and increasing flap perfusion [15].

Although insufficient evidence is available to support the routine use of HBOT in patients with thermal burns, it is a widely used adjunct therapy and recommended by experts [4]. European Consensus Conference on Hyperbaric Medicine (ECCHM) consensually considered burns (2nd degree > 20% TBSA) as an indication type C, and the US Food and Drug Administration approved burns and thermal injury as indication for HBOT [4,11]. Its use would be limited in each particular medical center, because of cost effectiveness evaluation. The hyperbaric chamber used in this case is property of the hospital and it is used routinely to improve multidisciplinary surgical approach of complex burns and wounds.

Emphasizing, the hyperbaric oxygenation of the tissues could contribute to restore the perfusion of viable tissues, and repair damaged nervous tissue, contributing to decrease limb necrosis [9].

This is a report of treatment at 1.45 ATA HBOT in a pediatric electrical burn. Minimal effective dosages of the active ingredients in HBOT (pressure and oxygen concentration) are still unknown, and future studies are needed to test the benefit of using HBOT in electrical burns. Moreover, the main issue is the future evaluating of the optimal case-specific dose–response curves [7]. It is conceivable that HBOT above two atmospheres can be less effective than below 2 ATA in angiogenesis [5].

Hyperbaric oxygen does have the potential to increase skin grafts success in burns, but more studies must be conducted to adopt this therapeutic tool into routine practice, especially in electrical burns. The benefits could have been much greater if HBOT would have started earlier, preferably within the first 24 h following injury [12] and as post- surgical conditioning of amputation and flap coverage.

This is a report of having successfully limited amputation, using escharotomy, skin flap and HBOT as therapeutic approach in a low voltage electrical pediatric burn. More studies are required to suggest that adjunctive HBOT could promote healing of electrical injuries. Because of its low frequency, it would be optimal to have more observational multicenter trials to evaluate the efficacy of HBOT for limiting amputation and increasing the skin success in electrical burns.

4. Consent for publication

Consent for publication was obtained from the patient.

5. Disclosure of funding

None.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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