

Use of Hyperbaric Oxygen Therapy for Preventing Amputation in Severe Crush Injury due to Earthquake in a Pediatric Patient: A Case Report

Deprem Kaynaklı Şiddetli Ezilme Yaralanmasında Ampütasyonu Önlemek için Hiperbarik Oksijen Tedavisi Kullanımı: Bir Olgu Sunumu

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Abstract

Hyperbaric oxygen therapy (HBOT) is a treatment modality whose indications expand over time. Although its use is not as widespread in children as in adults, HBOT can also be applied in pediatric patients with similar indications. This case presentation discusses the application of HBOT in a pediatric patient with an upper extremity crush injury. A 3-year-old female patient was stuck under rubble in the February 6, 2023, Türkiye earthquake. After the patient was rescued, a fasciotomy was performed, and a few days later, an amputation was indicated and he was referred to our hospital. In the evaluation made after the transfer to our hospital, amputation was postponed and HBOT was applied. The patient underwent 21 sessions of HBOT. Amputation was prevented after recovery of the extremity with HBOT. In conclusion, HBOT can be used safely and effectively in pediatric patients with extensive damage to the extremities due to crush injuries.

Keywords: Hyperbaric oxygenation, crush injuries, earthquakes, forearm injuries, fasciotomy

Öz

Hiperbarik oksijen tedavisi (HBOT), endikasyonları zamanla genişleyen bir tedavi yöntemidir. Çocuklarda kullanımı yetişkinler kadar yaygın olmasa da, HBOT benzer endikasyonlarla pediatrik hastalara da uygulanabilir. Bu olgu sunumu, üst ekstremitede ezilme yaralanması olan bir pediatrik hastada HBOT uygulanmasını tartışmaktadır. 6 Şubat 2023 tarihli Türkiye depreminde enkaz altında kalan 3 yaşında hastaya kurtarıldıktan sonra fasyotomi yapılmış ve birkaç gün sonra hastada amputasyon endikasyonu oluşmuş ve hasta hastanemize sevk edildi. Hastanemize nakil olduktan sonra yapılan değerlendirme sonucunda ampütasyon ertelendi ve HBOT uygulandı. Hastaya 21 seans HBOT uygulandı. HBOT ile ekstremitedeki iyileşme sonrasında ampütasyon önlendi. Sonuç olarak, ezilme yaralanmalarına bağlı ekstremitede hasarları olan pediatrik hastalarda HBOT güvenli ve etkili bir şekilde kullanılabilir.

Anahtar Kelimeler: Hiperbarik oksijenasyon, ezilme yaralanmaları, depremler, ön kol yaralanmaları, fasyotomi

Introduction

Hyperbaric oxygen therapy (HBOT) is a treatment method in which a hyperoxygenic environment is provided to tissues by inhaling 100% oxygen within specially designed high-pressure

chambers. At pressures higher than atmospheric pressure, the solubility of oxygen in blood and body fluids increases. Increased arterial oxygen pressure enhances the capillary oxygen gradient, leading to an elevation in tissue oxygen pressure. Oxygen suppresses nitric oxide synthesis in endothelial

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cells, causing vasoconstriction and reducing extravasation, consequently decreasing tissue edema. Studies have shown that HBOT stimulates growth factors and increases fibroblast proliferation, migration, granulation, and angiogenesis, thereby accelerating wound healing.^{1,2} Neutrophils and macrophages exhibit oxygen-dependent antibacterial effects. Additionally, oxygen directly exerts antibacterial effects through reactive oxygen species. Since its introduction, the indications for HBOT have expanded. Initially used for decompression sickness and carbon monoxide poisoning, HBOT is now involved in the treatment of conditions such as soft tissue infections, chronic wounds, gangrenous lesions, arterial emboli, compartment syndrome, and limb ischemia.^{3,4} While not as widespread as in adults, HBOT is also used in pediatric patients with several indications.⁵⁻¹³ Pediatric patients can undergo HBOT in chambers with equipment suitable for their age, accompanied by an appropriate companion. In this case report, we present a pediatric patient with a severe crush injury due to the February 6, 2023, Türkiye earthquake and discuss the effect of HBOT in preventing amputation.

Case Report

In the February 6, 2023, Türkiye earthquake, a 3-year-old female patient, foreign national, was stuck under rubble for 48 hours. After being rescued, the patient was diagnosed with crush injury, and compartment syndrome in the right upper extremity, and a fasciotomy was performed at a hospital near the earthquake zone. Because of compromised circulation in the forearm and hand, the patient was referred to our hospital for potential amputation and subsequent intensive care.

The patient arrived at our hospital 4 days after being rescued from the rubble. The patient's medical history was unremarkable for any known diseases. Upon the first examination after transfer to our hospital, intravenous fluid resuscitation and broad-spectrum antibiotic therapy were started. Upon admission, laboratory evaluation demonstrated a total creatine kinase (CK), level of 19,663 U/L and a lactate dehydrogenase (LDH), level of 1,312 U/L. It was observed that a fasciotomy had been performed on the right hand and forearm, with widespread ecchymosis and blisters. The 3rd, 4th, and 5th fingers were cyanotic (Figures 1, 2). Doppler ultrasound revealed blood flow in the radial and ulnar arteries. It was decided to postpone the amputation and apply HBOT. The patient was started on Iloprost therapy at a dose of 0.5 ng/kg/min and Heparin at a dose of 20 IU/kg/hour. At the end of the 7th day, anticoagulant therapy was continued with subcutaneous enoxaparin. Over the course of a month, the patient underwent 21 sessions of HBOT, with one session per day. Benefiting from these sessions, patients observed a reduction in cyanosis in the fingers and increased blood



Figure 1. Dorsal side view of the forearm in the first evaluation after referral to our hospital



Figure 2. Ventral side view of the forearm in the first evaluation after referral to our hospital

circulation in the forearm. One week following the initiation of treatment, total CK and LDH levels normalized within their respective reference ranges. The plan for amputation was abandoned. Throughout the course of treatment, no indication for the use of any extracorporeal treatment methods was observed in the patient. While continuing HBOT, the patient underwent 10 sessions of debridement of necrotic tissues and 8 sessions of negative pressure wound therapy. After achieving sufficient granulation, the patient's wounds were closed with a partial-thickness skin graft (Figure 3). The patient was discharged three months after admission and transferred to her hometown.

Informed consent for participating in the study was obtained from the parents of the patient.

Discussion

HBOT minimizes the effects of trauma-induced hypoxia and edema through the hyperoxygenation and vasoconstriction it provides. Hyperoxia triggers fibroblast proliferation and neovascularization. Studies have shown that hyperbaric oxygen prevents reperfusion damage and exhibits anti-infective effects by influencing the immune system cells.^{1,2}



Figure 3. Dorsal side view of the forearm after 21 sessions of HBOT. Circulation appears to be significantly improved. Split-thickness skin grafts were applied to areas with sufficient granulation

HBOT: Hyperbaric oxygen therapy

Considering these effects and the effectiveness observed in this case, it can be stated that HBOT is effective in the management of a patient with crush syndrome.³

In the literature, it is observed that in cases of crush syndrome treated with HBOT, amputation rates decrease, wound healing accelerates, and the need for additional surgical procedures decreases.³ However, studies on the use of HBOT in pediatric crush injuries are limited.¹²⁻¹⁵ This case presentation involves a pediatric patient, a victim of an earthquake, referred to our hospital, with a need for amputation. The patient was managed using HBOT without undergoing amputation. Benefiting from these therapies, including the antimicrobial effect of hyperbaric oxygen and increased granulation speed, combined with negative pressure wound therapy, the treatment was completed in a shorter time than expected.

The routine use of hyperbaric oxygen in the pediatric group with crush injuries is not a standard practice. Future clinical studies in the pediatric age group are necessary to establish the benefits of HBOT, expand its indications, assess cost-effectiveness, and integrate it into routine practice during the treatment process. This could lead to a wider adoption of HBOT in pediatric trauma management.

Based on this case report of earthquake-related severe crush injury in a pediatric patient treated successfully with HBOT, we can conclude that HBOT can be used safely and effectively in pediatric patients with extensive damage to the extremities due to crush injuries.

Ethics

Informed Consent: Informed consent for participating in the study was obtained from the parents of the patient.

Footnotes

Authorship Contributions

Surgical and Medical Practices: M.D., A.I.E., E.A., N.M.K., Concept: M.D., A.I.E., E.A., N.M.K., Design: M.D., A.I.E., Data Collection or Processing: M.D., A.I.E., Analysis or Interpretation: M.D., A.I.E., E.A., N.M.K., Literature Search: M.D., A.I.E., Writing: M.D., A.I.E.

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