CASE IN POINT

HYPERBARIC OXYGEN FOR A U.S. SOLDIER WITH ORAL TRAUMA

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For certain ischemic injuries, hyperbaric oxygen therapy may speed healing and reduce failure rates.

Failed flaps and grafts are associated with significant patient morbidity and can be costly to treat.[1] Hyperbaric oxygen (HBO_2) therapy, in which the patient is entirely enclosed in a pressure chamber breathing 100% oxygen at greater than one atmosphere of pressure, has been shown to be extremely useful in salvaging flaps or grafts compromised by ischemia or hypoxia. In fact, many studies show HBO_2 reduces flap or graft failure rates by 50% and, in some cases, is associated with a fourfold to fivefold improvement over controls.[1] As a result, the Undersea and Hyperbaric Medical Society, which is charged with the rigorous examination of indications for and studies involving HBO_2 therapy, has recognized the usefulness of HBO_2 therapy as an adjunctive treatment for compromised skin grafts and flaps—in addition to the 12 other indications for which it has been approved.[2]

In this article, we present the case of a 27-year-old, male U.S. Army soldier who required bone grafting and mucosal flap surgery after having sustained multiple shrapnel wounds to the face, left shoulder, left leg, and back—as well as a partial avulsion of his left maxilla—during a mortar attack in Iraq. Upon indication of graft and flap failure, he was referred to our facility, the U.S. Air Force School of Aerospace Medicine's Davis Hyperbaric Medicine Laboratory, Brooks City-Base, TX, for HBO_2 treatments. This case provides further evidence that HBO_2 therapy can have extremely beneficial effects in achieving a successful outcome following ischemic crush injury and a failing mucosal flap.

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PATIENT HISTORY

Following the attack, two chest tubes were inserted into the patient. Days later, he was medically evacuated to Germany where primary surgery was performed on his facial injuries. Four days later, the patient was repatriated to the National Naval Medical Center in Bethesda, MD, where he underwent further soft tissue reconstruction for his facial wounds. At the time he presented to our hyperbaric facility, he had undergone five surgical procedures for injuries resulting from this attack.

The fifth surgery, which was performed one day prior to his visit, had included the extraction of one fractured tooth, the grafting of bone harvested from the right anterior iliac crest to the left anterior maxilla, and the creation of a mucosal flap. Scarring of the surgical bed from previous surgeries had made it difficult to obtain primary closure of the reconstructed max-

illa. A tension-free closure was achieved without the need for soft tissue grafting.

On the first postoperative day, the patient's oral and maxillofacial surgeon noted that the palatal portion of the flap had a dusky appearance, indicative of poor perfusion. Concern for the viability of the flap and the bone graft prompted the referral to our facility.

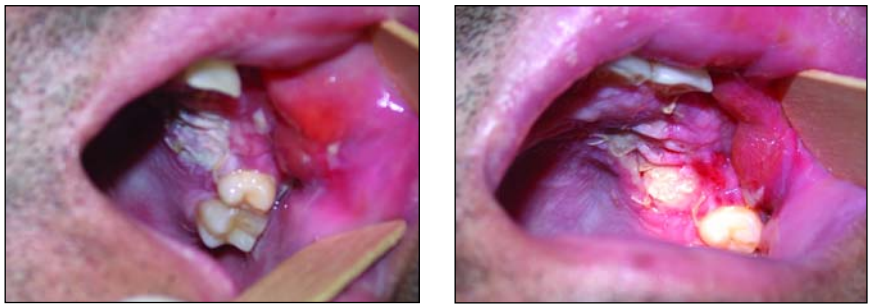

Figure 1. The patient's left maxilla before hyperbaric oxygen therapy, lateral (left) and front (right) views.

INITIAL EXAM

Physical examination revealed mild edema and scarring at his left midface. Shrapnel wound scars were noted on his face, left leg, and back. Examination of his oropharynx revealed a recent dental extraction with an edematous and tender left superior alveolar mucosal flap with palatal eschar and slight friability—but no exudates or discharge. The patient's remaining dentition was intact, nontender, and in good repair (Figure 1). His buccal vestibules were clear with no fluctuance or trismus. His right hip was tender from the bone graft.

The patient's medical history was unremarkable, with no contraindications to HBO_2 therapy. (These include current or past use of medications associated with poor outcomes—doxorubicin, bleomycin, disulfiram, cisplatin, or sulfamylon—as well as untreated pneumothorax, known malignancies, pregnancy, or an implanted pacemaker.[3]) Before initiating HBO_2 therapy, we obtained a chest X-ray to rule out pneumothorax and surgical scarring (possible consequences of traumatic injury and chest tube insertion)—which can produce air trapping lesions.

TREATMENT COURSE

We treated the patient for a failing oral flap and bone graft with HBO_2 therapy twice a day for three days, followed by once-daily treatments. We employed our standard wound care diving protocol, which uses a modified version of the U.S. Air Force Treatment Table 9 at 2.46 atmospheres absolute (45 ft of sea water) for each 90-minute treatment session, or "dive." On the second treatment day, swelling and discomfort were increased substantially at the patient's left buccal mucosa. Oral amoxicillin was prescribed in response.

After the second dive, facial swelling was reduced, color was improved, and the hard palate eschar was less friable. The patient continued to improve daily. Four days into treatment, his facial and intraoral swelling and discomfort were reduced considerably. Intraoral induration had diminished and granulation tissue was forming over the hard palate. Furthermore, his left hip had improved to the point that he no longer needed a cane for ambulation.

The patient was discharged 10 days after initiating HBO_2 treatment, having undergone a total of 12 dives. The incision was intact and well healed (Figure 2). The patient reported minimal tenderness at the suture line, there appeared to be no friability at the palate, and his facial edema had nearly resolved. He continued to improve after discharge from our facility. Several weeks later, his appearance had returned to normal.

UNDERSTANDING THE THERAPY

To be of maximum benefit, HBO_2 therapy should be started as soon as signs of flap compromise appear. Flap or graft viability can be assessed clinically and through the use of a variety of noninvasive and invasive techniques, including transcutaneous oximetry and laser Doppler studies. The pressure at which HBO_2 treatments for acute injuries are given ranges from 2 to 2.5 atmospheres absolute, depending on the type of chamber used, and the sessions can last from 90 to 120 minutes. Typically, initial treatments are performed twice daily. Once the graft or flap appears to be viable and stable, single daily treatments are sufficient.[1]

HBO_2 is neither necessary nor recommended for the support of normal, uncompromised skin or mucosal grafts or flaps. When tissue is compromised by hypoxia or ischemia, however, HBO_2 has been shown to enhance flap or graft viability by reducing the hypoxic insult, trauma-related edema, and related consequences.[1]

The immediate effect of HBO_2 is to hyperoxygenate ischemic tissues

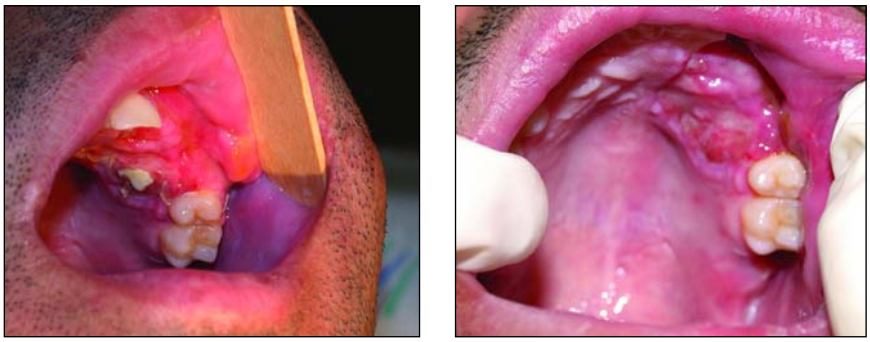

Figure 2. The patient's left maxilla after hyperbaric oxygen therapy, lateral (left) and front (right) views.

by increasing the oxygen-dissolved plasma, which varies directly with the partial pressure of inhaled oxygen.[4] Hyperoxia can be beneficial in improving oxygen delivery and thus preserving ischemic tissue,[5,6] reducing local edema through vasoconstriction while sustaining oxygenation,[7,8] preventing the ischemia-reperfusion injury syndrome,[9,10] enhancing the patient's response to local infections,[11,12] and speeding the wound healing process by stimulating angiogenesis and tissue growth.[13]

Injuries associated with trauma arise from ischemia, venous outflow obstruction, tissue hypoxia, and external compression. Under circumstances such as these, injury may be self-perpetuated through the reperfusion injury cascade, which is characterized by neutrophil activation and adhesion to endothelial surfaces, progressive free radical production, and increased tissue damage.

HBO_2 is an effective intervention against the endothelial adhesion of neutrophils and the progressive ischemic arteriolar vasoconstriction.[9] Studies show that the use of HBO_2 is associated with statistically significant reductions in the following: loss of muscle function, metabolites associated with muscle injury, edema, and muscle necrosis.[14] In addition, HBO_2 promotes flap survival by: enhancing fibroblastic activity and collagen synthesis; stimulating angiogenesis;[15,16] improving microcirculation;[9] and, possibly, closing arteriovenous shunts.[17,18]

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