Case Report: Successful use of hyperbaric oxygen therapy for a complete scalp degloving injury.

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INTRODUCTION

Hyperbaric oxygen (HBO₂) therapy is approved by the Undersea and Hyperbaric Medical Society (UHMS) as the primary or adjunctive therapy for thirteen conditions, including compromised flaps and grafts(1). Through multiple mechanisms including improved oxygen delivery, vasoconstriction, down regulation of inflammatory mediators, reduction in reperfusion injury and stimulation of angiogenesis, HBO₂ reduces necrosis and promotes survival in poorly perfused tissue. Here we present a dramatic case of a farm-related scalp degloving injury that was successfully treated with HBO₂.
CASE REPORT

The patient was a 43-year-old Caucasian female who presented with a complete scalp degloving injury, the result of a tractor power take-off (PTO) catching her hair. A PTO is a spindled drive shaft designed to transfer power from the tractor motor to a secondary device such as a mower. The drive shaft is often unprotected and spins at speeds in excess of five hundred revolutions per minute. The avulsed tissue included her scalp, forehead, eyebrows, upper cheeks, right and left ears and nape of the neck with a total laceration length extending more than 100 cm. The avulsed scalp was intact and in one piece with a small laceration to the left parietal region. She had no prior medical problems and was not on any medications at the time of her injury. Her only previous surgery was a tubal ligation. She was a 1 pack-per-day smoker with a 28 pack-year history. Her height and weight were 160 cm and 57 kg respectively.

She presented to a community hospital approximately 25 minutes after the initial injury. She was transferred to our tertiary care hospital as a trauma via aeromedical transport and arrived at 1.5 hours post injury. Her scalp, which was retrieved by a family member, was transported with her in a plastic bag placed in an ice bath. She presented to our facility alert and oriented, with cervical spine precautions (Figure 1).

The CT of her head and spine were negative. After initial evaluation and stabilization, the Department of Otolaryngology - Head and Neck Surgery was consulted. Owing to the rare nature of this type of injury, multiple surgeons evaluated the patient and an operative intervention was planned. She was taken to the operating room by the Head and Neck surgeons for microvascular reanastomosis and replantation of her scalp. Time to initial incision was 4 hours post injury.

During surgery, the avulsed tissue was bathed repeatedly in sterile saline prior to reattachment. The eyelids and ears were repaired followed by the right external auditory canal, which was packed with petroleum jelly-impregnated gauze to prevent stenosis. The left external auditory canal had remained intact. The cheek and neck tissue were then approximated with skin staples. Surgeons were able to anastomose both superficial temporal arteries, the left in an end to end fashion and the right with an interposition venous graft using the superficial temporal vein. No nerve ends were visible for repair. Finally, two #10 French drains were placed anteriorly and posteriorly and secured. Bacitracin ointment was applied along with sterile, non-adherent dressings following the repair. The total time of the procedure was 3 hours and 50 minutes. She received 1 unit of packed RBCs and the total OR estimated blood loss was 25 ml. She did not receive any vasoactive medications. Her hemoglobin prior to surgery was 12.1 g/dL and immediately after surgery it was 11.4 g/dL.

Postoperative management included low molecular weight heparin for VTE prophylaxis, 81 mg of aspirin daily until discharge, and leech therapy four times daily for ten days to provide venous outflow while neovascularization developed. Wound care was provided by the inpatient wound service including the application of 4% chlorhexidine gluconate, 1% silver sulfadiazine cream, beta

Fig 1. Initial presentation to our facility.
glucan, and topical 5% mafenide solution. Due to the extensive contamination of the avulsed flap, prophylactic antibiotic therapy was initiated and consisted of an eight day course of clindamycin and ciprofloxacin, followed by vancomycin, doxycycline and cefepime for an additional four days. No tissue blood flow monitoring was used post-operatively.

The blood flow restored to the flap was tenuous following reattachment. The flap had a predominantly dusky appearance with areas of pink being isolated to the center of the forehead (Figure 2). The most prominent area of compromise was the right lateral aspect. Given the noted ischemic appearance of the scalp as well as the mechanism of injury, HBO2 therapy was instituted immediately after surgery.

The initial HBO2 treatment was at 2.5 ATA for 90 minutes. Further treatments were administered at 2.5 ATA for 90 minutes twice daily for seven days and then once daily for 30 days.

Clinically, the patient did well. She never developed any signs of infection. She had signs of anxiety with her initial HBO2 treatments requiring the use of anxiolytics, but the severity of her anxiety diminished with repeated exposure to HBO2 treatments. She was discharged 40 days following presentation to our facility, having received a total of 45 HBO2 treatments. The patient’s right auricle was completely lost as was most of the left auricle, however the rest of her scalp was salvaged (Figure 3). She did not require any further surgery and was discharged with petrolatum and Neosporin dressings. At a 3 month follow-up visit the patient was noted to have reepithelialization of her scalp except for a moderately large area of exposed granulation tissue in the occipitoparietal area measuring approximately 79 cm². Despite having no regular wound care and continued smoking, the patient demonstrated improvement at a 1 year follow up visit. The area of exposed granulation tissue in the occipitoparietal area measured 20 cm². At both visits, there was no detectable hair growth or nerve function.

**DISCUSSION**

Replantation is the best surgical option following a total scalp amputation(2). The extensive collateral circulation of the scalp enables tissue survival with a single arterial anastomosis(3). However, total scalp replantation is still a rare procedure, with the
largest published case series consisting of only 20 patients(4). Several case studies report successful surgical replantation with both arterial and venous repair without HBO2(2, 4-9). Due to extent of the injury in our patient, venous anastomosis was not possible thus resulting in severe arteriovenous congestion. The venous outflow problem was treated with the use of leech therapy. HBO2 in combination with leeching has been found to dramatically increase tissue survival when compared to leeching alone in the setting of venous occlusion(10). Without successful reattachment and subsequent tissue survival post-operatively, the patient’s options become more complicated and likely involve a high probability of staged reconstruction consisting of skin expansion, grafts and/or pedicled or free flaps(3). In the case presented here, given the absence of any venous anastomosis, we believe that HBO2 exerted a therapeutic effect and improved her chances at flap survival via several postulated mechanisms discussed below.

The increase in blood oxygen content can promote oxygen delivery to poorly vascularized tissue(11, 12). Hyperbaric oxygen also causes a stimulation of fibroblasts, promotion of collagen synthesis, formation of granulation tissue, and angiogenesis(13-15). Additionally, a decrease in post-ischemic edema is also seen(11, 12, 16-19) resulting from vasoconstriction and from down-regulation of inflammatory mediators(20, 21). Finally, hyperbaric oxygen reduces reperfusion injury by down-regulating the expression of ICAM-1 and hindering β2 integrin-mediated leukocyte adhesion(22, 23).

Friedman et al.(24) recently conducted an extensive review of the research pertaining to the treatment of flaps and grafts with HBO2 and combinations of HBO2 with adjunctive therapies. They concluded that the majority of animal studies demonstrate varying degrees of benefit including increased area of flap survival by 18 to 30% depending on location and size, reduction in tissue necrosis, inhibition of reperfusion injury and an improved tolerance to secondary ischemic events. Other studies not included in Friedman’s review also demonstrate benefit with HBO2, specifically increased tissue granulation (25) and increased tissue survival(26, 27). While animal studies have tended to be positive with regard to the use of HBO2, there is unfortunately a gross lack of clinical data, which is currently comprised of several small, historical and non-randomized studies. These studies, however, have also generally reported a positive effect with hyperbaric therapy(24).

Although the success rates without HBO2 are varied, we believe that the poor prognosis of a failed surgery warrants the use of HBO2 therapy as adjunctive treatment in compromised scalp avulsion injuries. Even though the clinical research into HBO2 for compromised flaps and grafts may not be substantial, case reports such as the one presented here, as well as animal data and other clinical studies, strongly support its continued application in these conditions. This argument is further strengthened by the fact that there is no proven detriment in the use of HBO2 in compromised flaps and that there are few serious side effects associated with HBO2 therapy(28-30). In this report, the treatments provided resulted in almost complete survival of the scalp flap without further surgeries. Although at a recent 1 year follow up appointment she still did not have complete reepithelialization, the area of granulation tissue was improved and continues to improve with local wound management. The Otolaryngology team involved in the case does not believe that she will need any further reconstructive surgery.

REFERENCES

1. Zamboni WA, Shah HR. (Undersea and Hyperbaric Medical Society). Skin grafts and flaps
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