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THE USE OF HYPERBARIC OXYGEN IN THE SUCCESSFUL REANASTOMOSIS OF THE SEVERED EAR: THREE CASES

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ABSTRACT

The reconstruction of a severed ear is a difficult procedure. The standard surgical approach is to remove the skin of the severed ear and bury the cartilage in a retro-auricular pocket. Staged reconstructive procedures can then be undertaken at a later date. However, even when successful, the results are cosmetically poor and several surgical procedures are needed over an extended period. Three male patients with severed, or near severed, ear have been treated with immediate reanastomosis and adjunctive hyperbaric oxygen. The completely severed ear of a 22 year old patient was replaced, sutured and then treated with 3 sessions of hyperbaric oxygen at 2 ATA, followed by 16 sessions at 2.5 ATA over eight days, all of 90 minutes, with a good result. In a 28 year old patient, the ear was only retained by a small strip of skin. After surgery, a total of 31 sessions of hyperbaric oxygen were used at 2.2 ATA for 90 minutes, three times a day. The third patient was 37 years old and the injured ear was retained by a 3 mm. strip of skin. The ear was sutured and hyperbaric oxygen sessions used at 2 ATA for 90 minutes twice a day for ten days. The use of hyperbaric oxygen was based on the reduction of edema and its ability to promote neovascularization. For new vessel growth and preservation of tissue there must be sufficient oxygen available. The results of immediate reanastomosis and adjuvant hyperbaric oxygen in three patients have been excellent and cosmetically effective. It is suggested that this may be a valid approach to this difficult problem.

INTRODUCTION

Even with the most skillful repair, near or complete ear amputations represent serious ischemic events. The standard recommended procedure is to dermabrade the avulsed portion of the ear and bury it in a subcutaneous postauricular pocket. Hopefully, it would be oxygenated by the surrounding tissues and be eventually revascularized. At a later date, with one or more surgical stages, it could again be brought out and reconstructed. There are a number of variations on this theme, but the concept is the same and this would represent a routine treatment of ear avulsion where survival of the appendage was in question. Unfortunately, however, several operations are often required with considerable time and expense being involved. Yet, the final cosmetic result is often less then optimum.

The use of hyperbaric oxygen therapy (HBOT) as a wound healing adjunct for preparation and preservation of compromised skin grafts and flaps is well established in the literature. (Ref. 1,2,3) The investigational uses of HBOT for problem wounds is evolving rapidly (Ref. 4) In regard to the ear, hyperbaric oxygen specifically addresses the ischemic, hypoxic, edematous features by way of a pressure phenomena which includes hyperoxygenation of the plasma phase of the blood, allowing what flow is available to be maximally effective while reducing edema. This may well provide the metabolic requirements for the tissue and aerobic support.

This paper deals with three cases of primary reanastomosis of the ear performed and treated at separate institutions. Adjunctive hyperbaric oxygen was used immediately post-operatively to facilitate a successful repair of amputation or near amputation of the adult ear.

MATERIALS AND METHODS

Three brief patient summaries will be presented. All are white males between the ages of 22 and 37 with complete or near complete amputation of the ear who received hyperbaric oxygen therapy within approximately one hour of the primary suturing. They were treated in monoplace hyperbaric oxygen chambers using 100% oxygen, thus assuring paO_2 measurements equivalent to the pressures used (Ref. 5). Treatments were begun immediately after surgical repair. Patients were compressed for periods of 60-120 minutes at pressures of 2.0-2.5 atmospheres absolute. In the initial stages the treatments were given every 6-8 hours around the clock. The average number of treatments given was 23.3. Since the chambers were monoplace acrylic, visual monitoring was adequate. The color of the ear was well visualized and recorded while in the chamber. Very gross positive changes were clearly visible to the naked eye while under pressure with a regression of the same when out of the chamber. A joint effort between the attending surgeon and the hyperbaric physician was effective in all cases. Two of the cases received anticoagulants. All of the cases received intravenous antibiotics. After the initial series of treatments, there was no further hyperbaric necessary, since all three cases showed 100% take.

CASE REPORTS

Case #1. A 37 year old white male involved in an auto accident suffered a near amputation of the left ear from shattering glass. At surgery he was found to have a 3 mm strip of tissue connecting an external ear fragment (6.3 by 3.7 centimeters) to the skull 'Fig. 1'. Extensive lacerations to the mastoid area and the ear itself made burial of the helix in the postauricular region inappropriate. No microvascular reattachment was possible because of the extent of the injury. The surgeon consulted the hyperbaricist with the following treatment plan. The ear was primarily reapproximated. Pre-HBOT 'Fig. 2' the flap was dusky with poor capillary filling. The patient was then treated in a monoplace hyperbaric chamber at 2.0 ATA for 90 minutes twice a day with the first treatment starting immediately after he left the recovery room. The ear continued to improve, displaying minimal swelling and the patient was discharged after 10 days of hyperbaric oxygen therapy 'Fig. 3. At follow up at one month post-discharge the ear was completely healed with a most acceptable cosmetic result.

Case #2. A 28 year old white male suffered an avulsive injury of 90% of the external ear when he stumbled into a badminton net while running at full speed. The ear was deeply cyanotic and connected to the skull only by a severely contused 7 mm. skin bridge at the posterior height of the helical rim. The ear was promptly reattached in the emergency room with several interrupted sutures 'Fig. 4'. The patient was rapidly transported to a hyperbaric facility and was treated at 2.2 to 2.5 ATA for five days (outpatient) at approximately 8 hour intervals. Intravenous heparin and cephalosporin were also given. HBOT was continued for a total of 31 treatments. The ear was left undressed and observed while in the chamber. During the treatments the ear rapidly became pink but blued when pressure was discontinued. However, it "pinked up" after each subsequent treatment 'Fig.5' (post 25 txs.). Only minimal edema was noted. Follow up at one month revealed total survival of the avulsed ear except for two small superficial eschars which left two very small depressions 'Fig. 6'. The cosmetic result was very satisfactory.

Case #3. A 22 year old white male was involved in a rollover car accident and suffered a complete amputation of the upper 25% (3.2 by 1.2 cm segment) of his left ear. He also sustained extensive soft tissue abrasions and lacerations in the postauricular region. The amputated segment was primarily reattached six hours after the injury using judicious debridement and meticulous surgical repair to achieve maximal surface contact at the anastomosis site 'Fig.7'. The patient was hospitalized for 24 hours and received HBOT beginning immediately post surgery at 2 ATA for 90 minutes b.i.d. He was also given 10 grains of aspirin daily and an oral cephalosporin. He subsequently received outpatient HBOT in a monoplace chamber for a total of 19 treatments at 2.0 to 2.5 ATA for 90 to 120 minutes (initially b.i.d., later once daily) 'Fig. 8'. During the chamber treatments the amputated segment was noted to "pink up" and between treatments it would get very cyanotic. Follow up revealed complete survival of the amputated segment 'Fig. 9'.

DISCUSSION

Initial repair is a very tempting option for the surgeon dealing with amputated ear segments. It is technically easy, relatively inexpensive and gives the best cosmetic results with the least morbidity; if the segments take. Brown (Ref. 6), in 1898, reported a successful reattachment of a large ear segment that was bitten off by a vicious horse and sutured with common thread. He even included a postoperative photo. Brown and McDowell suggest that a composite graft should be no further than 1.0 cm from the nearest blood supply (Ref. 7). Spira and Musgrave have warned that all but the smallest of composite grafts are "doomed" to failure (Ref. 8).

The ear is composed mainly of skin and cartilage and has a low tissue metabolic rate. During the interim, after a composite graft has been placed, it receives its nutrition mainly from inosculation with its surrounding recipient tissues much as a skin graft would. Accordingly, a larger area of vascular surface contact seems logical to increase graft survival. There are several reports of surgical technics which utilize this principle. Baudet (Refs. 9,10), denudes the posterior aspect of the severed ear down to cartilage, makes several holes in the cartilage and raises a flap over the mastoid for increased surface contact. Mladick dermabrades the ear fragment and buries it in a subcutaneous pocket (Refs. 8,11). Ariyan describes replantation of a totally severed ear using a platysma sandwich flap (Ref. 12). All of these technics involve several procedures (although the follow-up surgery can be simple) and require an acceptable recipient site. The cosmetic results are fair to good. There are several reports advocating denuding the severed ear of all but the cartilage and then burying this in the abdomen for later reconstruction (Ref. 8). This method involves long delays, multiple surgeries, and produces generally poor cosmetic results.

One of the cardinal technical difficulties in any replantation relates to venous drainage. With inadequate venous drainage, or even simply the edematous response of traumatized tissue, a diffusion gradient forms due to increased distance for diffusion from vessel to tissue. Another way to conceptualize this idea is that there is a given density of blood vessels, a doubling of the mean distance between them through edema results in each vessel providing for four times as much tissue, dramatically reducing tissue oxygenation, assuming a cylindrical shell model. Through its constriction of the pre-capillary arteriolar sphincter, HBO causes a net decrease in infusion volume. As well demonstrated in case #1, the use of hyperbaric oxygen can virtually prevent the occurrence of post-operative edema.

Due to the low oxygen requirement of cartilage and the extremely large surface area to volume ratio of the ear, direct oxygen diffusion is possible. Though one generally does not consider the penetration of oxygen through the skin even at 2.O ATA is only some 6O microns (Ref.13), case #2 illustrates how this effect occurs. Neither the 7 mm pedicle of case #2 or the 3 mm remaining tissue bridge in case #1 are sufficient to conduct the systemic hyperoxygenation throughout the ear.

For the amputated or nearly amputated ear to survive, a new vascular supply must be established. For neovascularization to occur, there must be both an oxygen concentration gradient and sufficient oxygen delivery to the distal tissue to support the energy requirements of that growth. By increasing the systemic pO_2 by as much as a factor of 2O, to some 2,OOO torr, and the target area to 4O-1OO torr, the gradient is increased, inducing vascular proliferation (Ref. 13). Once the tissue oxygen is increased to at least the 3O-4O torr required for vascular growth (Ref. 14), the stage is set for the establishment of a vascular tree to sustain the ear in a normoxic environment.

A criticism of the use of hyperbaric oxygen for tissue sustenance, specifically that a patient "can't stay in the chamber forever" is effectively countered by these examples. Through the neovascular induction potentiated by HBO and the aerobic support provided for hypoxic tissues during healing, the short-term goal of maintaining viable tissue is achieved. As demonstrated in all of the cases shown here, a vascular regrowth occurs, making further treatments unnecessary from that point on.

When considering an intervention the physician should contemplate if that intervention, if unsuccessful, will cause the patient greater mortality or morbidity than the absence of that intervention. Once the choice is made to deflesh the pinnae and bury it in either the mastoid or abdominal areas, options considered in all three cases, there is no going back. The patient will require multiple operations in the future to obtain results that will always be inferior to his original ear.

In conclusion, the well established and documented features of hyperbaric oxygen have been observed in these three cases, that is, a more rapid neovascularization, the reduction of stasis edema, the increase in fibroblasts. The absence of infection primarily achieved by the antibiotics is certainly also potentiated by hyperbaric oxygen and the effects on its macrophage and leukocyte killing ability and also its probability of cartilaginous stimulation. (Ref. 15)

Certainly, preparation for extensive surgery can always be done at a later date. It is a simple, safe, inexpensive procedure to establish the possible effects of hyperbaric oxygen with several trials. "Pinking up" of the ear while the patient is in the chamber is an optimistic sign and warrants further HBOT prior to any other procedure.

From the economic viewpoint, HBO was extremely cost-effective. Similar cases with multiple hospitalizations and surgical procedures would normally incur an expense in the range of about $22,OOO. The approximate cost to these patients including surgery and HBOT was approximately $8,OOO.

It is recommended that this type of therapy should be considered in the avulsed ear.

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FIG. 1

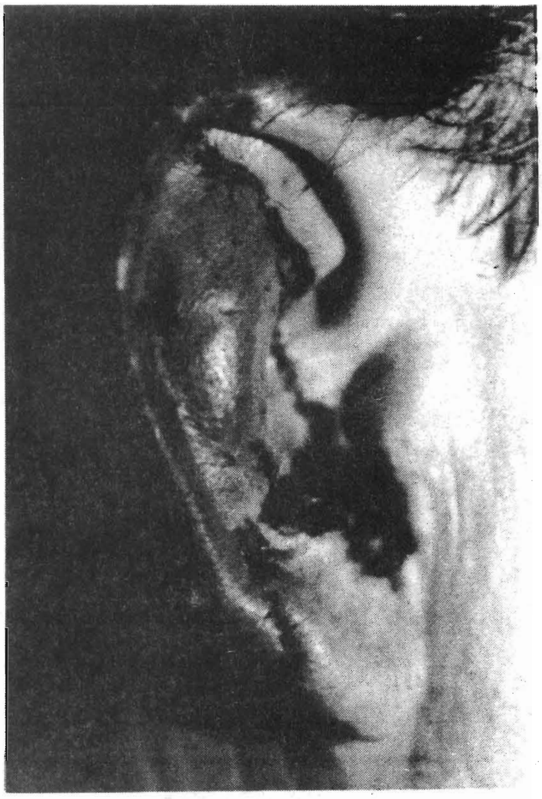

FIG. 2

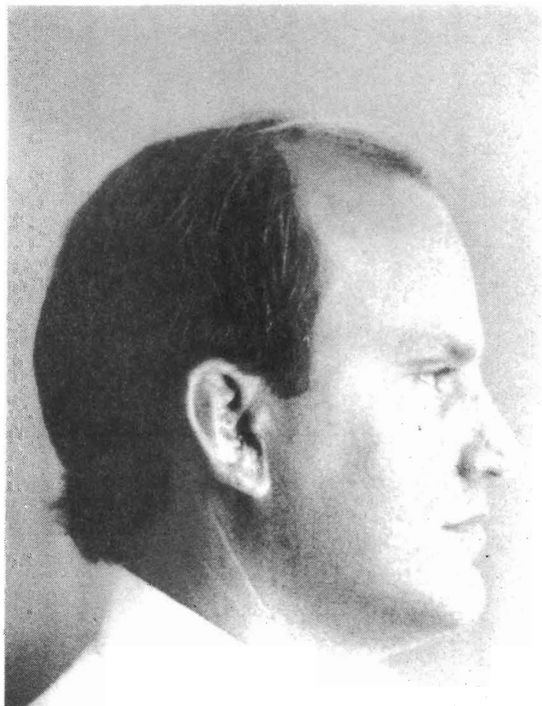

FIG. 3

FIG. 4

FIG. 5

FIG. 6

FIG. 7

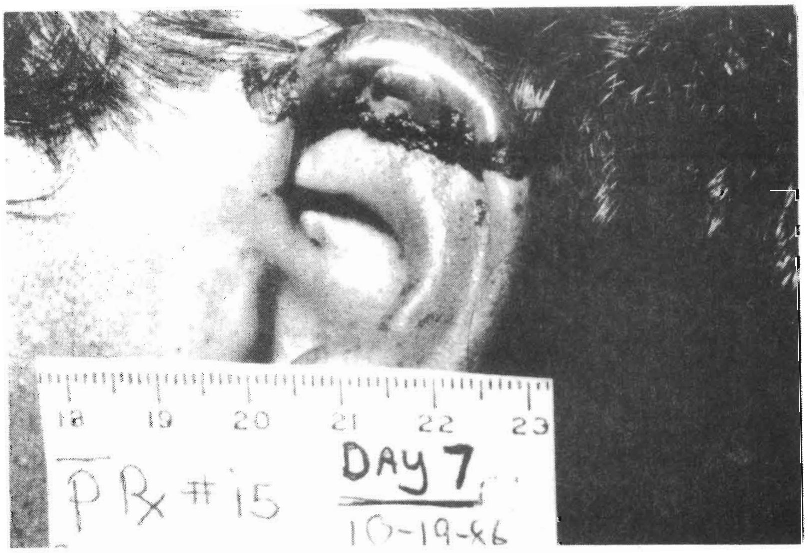

FIG. 8

FIG. 9