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Adjunctive Hyperbaric Oxygen Reduces the Need for Surgery in 40–80% Burns

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Cianci P, Lueders H, Lee H, Shapiro R, Sexton J, Williams C, Green B. Adjunctive hyperbaric oxygen reduces the need for surgery in 40–80% burns. J Hyper Med 1988; 3(2):97–101.—The burn wound is a hypoxic injury. Adjunctive hyperbaric oxygen therapy may attack this problem directly, supplying borderline tissue with oxygen, thus preventing dermal ischemia, reducing edema, and maintaining microvascular integrity. Preservation of marginally viable tissue should result in a lessened need for surgery. We report our experience with patients burned over 40–80% of their total body surface area, showing a significant reduction ($P = < 0.041$) in the need for surgery in patients receiving this additional therapy.

adjunctive hyperbaric oxygen, burns, surgery

Introduction

The burn injury is a complex, nonuniform wound characterized by a central zone of coagulation, surrounded by a region of stasis, bordered by an area of hyperemia (1). At the time of injury, some tissues are totally coagulated; others are seriously damaged but salvagable. An intense inflammatory reaction leading to rapid edema formation, increased microvascular permeability, and sluggish blood flow results in thrombosis, progressive dermal ischemia, and advancing necrosis (2). This progressive ischemic process may increase by a factor of 10 during the first 48 h after injury (3) and is responsible for the ongoing destruction of tissue noted in thermal burns (4). Reduction of dermal ischemia, control of edema, preservation of marginally viable tissue, enhancement of host defenses, rapid wound closure, and functional rehabilitation are goals of therapy.

Infection is greatly increased due to the loss of integumentary barrier to invasion, the ideal substrate provided by the burn wound, and the compromised or obstructed microvasculature, which prevents humoral and cellular elements from reaching the burned tissue. Qualitative and quantitative deficiencies in the immune system, with decreased circulating polymorphonuclear (PMN) cells, defective PMN cell killing, and diminished levels of immunoglobulins, are additional problems with host defenses (5–7). Regeneration within the burn wound cannot take place until equilibrium is reached, an event delayed by the ongoing damage as the burn wound extends its margins due to failure of the surrounding tissue to provide oxygen and nutrients necessary to sustain viability and cell function (1). Prolongation of the healing process leads to excessive scarring (8).

Many advances in burn care in the last decade have resulted in a dramatic reduction in mortality and length of hospitalization. We report here our experience in the treatment of severely burned patients, most with inhalation injury, and our observations on the impact of adjunctive hyperbaric oxygen (HBO) therapy in reducing the need for surgery.

Methods and Materials

All patients, aged 14–42 yr with total body surface area (TBSA) burns of 40–80%, admitted to our center between January 1982 and March 1987 were included in the study. Patients were followed clinically, and their hospital records were carefully monitored. The patient's age, sex, percent TBSA burn vs. full-thickness injury, respiratory involvement, length of stay, number of surgeries, cost of hospitalization, and cost of HBO therapy were factors studied. All hospital bills were corrected for inflation to 1987 dollars. All patients were treated according to established burn center protocols. Statistical analysis of data was carried out using the two-tailed Mann-Whitney test.

Patient Population

There were 6 patients in the control group, all males, ranging in age from 14 to 42 yr, with an average age of 33.3 yr. In the HBO-treated group there were 6 patients, 4 males and 2 females, between 20 and 31 yr of age, with an average age of 25.6 yr. Patients in the control group were burned over 49.8% of their total body surface, with 23.5% estimated to be full-thickness injury. The HBO-treated patients suffered burns over 61.6% of their TBSA, with 21.2% felt to be full-thickness burn. Burn resuscitation and methods of treatment were basically the same for all patients. There was no difference in distribution of patients relative to year treated. The control group did not receive adjunctive HBO therapy due to psychological problems and/or the nonavailability of this form of therapy between June 1984 and June 1985.

Methods and Materials of Administration of Adjunctive HBO Therapy

Oxygen was administered in a monoplace chamber (Sechrist, Los Angeles, CA) pressurized to 2 atm for 90 min (plus descent and ascent time) twice daily. Patients were ventilated and monitored as appropriate when undergoing therapy. Medications and fluids were administered through the hull of the chamber as required. Fluid protocols as ordered by the burn surgeon were continued unmodified during HBO therapy. Patients received 400 U of alpha-tocopherol by mouth before each HBO treatment.

Results

The 6 patients in the control group had an average TBSA burn of 49%, with 23.5% estimated to be full-thickness injury. Four of these patients had also suffered inhalation injury. Length of stay averaged 111 d, with a range of 47 to 184 (Table 1). In the HBO-treated group the TBSA burn averaged 61.6%, with 23.6% felt to be full-thickness injury. Four of these 6 patients had suffered inhalation injury. Length of hospital stay for the HBO-treated group was 65.3 d, with a range of 42 to 95 d. The cost of care in the control patients averaged $292,000/case, or $2,630/d. For the HBO-treated group, the average hospital bill totaled $185,000, or $2,800/d. The average saving per case in the HBO-treated patients was $107,000.

Although these differences are impressive, none are statistically significant due to the wide variation in the non-HBO-treated group. The incidence of

Table 1: Comparison of Factors in HBO and Non-HBO Groups

	HBO, $n = 6$	Control, $n = 6$	
Age, Yr			
Average	25.7 ± 4.6	33.3 ± 9.8	$P = 0.064$ N.S.
Range	20–31	14–42	
Total body surface burn			
Average	61.7 ± 18.6%	49.8 ± 8.5%	$P = 0.309$ N.S.
Range	40–80%	40–60%	
Full-thickness injury			
Average	23.7 ± 21.3%	23.5 ± 15.5%	$P = 0.818$ N.S.
Range	0–50%	7–50%	
Surgeries			
Average	3.7 ± 2.6	8.0 ± 3.4	$P = 0.041$
Range	0–6	3–12	
Days hospitalized			
Average	65.3 ± 23.4	111.0 ± 57.7	$P = 0.132$ N.S.
Range	42–95	47–184	
Cost			
Average	$185,000 ± 90,500	$292,300 ± 184,300	$P = 0.309$ N.S.
Range	$110,000–318,000	$114,000–602,000	
HBO cost	$15,500 ± 10,000[a]		
Average	$4,800 – 25,900		

[a]Eight percent of the total hospital bill. N.S. = not signficiant.

surgery in the non-HBO group, however, is statistically higher than the HBO-treated patients (8.0 vs. 3.7) ($P = < 0.041$).

Professional fees were not examined, but a reduction in need for surgery would be expected to reduce this component of patient care. The cost of HBO therapy averaged $15,500, or 8% of the total hospital bill (Table 1.) This compared quite favorably with pharmacy and laboratory charges.

Discussion

Although HBO therapy is not widely used in the treatment of burns, the pathophysiology of thermal injury may well be beneficially altered by its use. A significant body of animal data supports the effectiveness of HBO in the treatment of thermal injury (9–13). Clinical experience dates back to 1965, when Wada et al. (14) noted faster healing of burned miners being treated for carbon monoxide poisoning with adjunctive HBO. Hart et al. (15), in a randomized double-blind study, observed a reduction in fluid requirements, reduced healing time, fewer complications, and increased salvage. Grossman et al. (16–18) and Wiseman and Grossman (19) have collected a large, uncontrolled clinical series and have reported a reduction in hospital stay, increased salvage, and fewer complications. Waisbren et al. (20) reported a small, retrospective series showing diminished renal function, decreased circulating neutrophils, and an increase in positive blood cultures. Neither a deleterious nor a salutory effect on mortality was observed. The amount of skin grafting, however, was markedly reduced in the HBO-treated group (1237 ± 1405 cm^2 vs. 5035 ± 1882 cm^2 in the nonhyperbaric group).

Inasmuch as the burn wound is a hypoxic injury (21), the potential benefits of HBO would seem to relate to its ability to attack the problem of the burn wound directly: preventing dermal ischemia, preventing or reducing edema, and maintaining microvascular integrity necessary to preclude the permeability changes characteristic of the burn injury (9, 11, 12). Preservation of ATP levels necessary to sustain cell viability and capillary integrity may be one of the mechanisms whereby HBO achieves this goal (22). Oxygen inhaled at pressure dissolves in plasma. At 2 atm an arterial Po_2 of nearly 1500 mmHg may be achieved. This physically dissolved oxygen may stream into areas of the compromised microvasculature sufficiently to sustain marginally viable tissue and cellular integrity. An additional benefit of HBO may be the enhancement of neutrophil killing ability later in the course of the burn injury (23).

These promising observations suggest that HBO therapy is a useful adjunct in the treatment of severe burns at our burn center.

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