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ORIGINAL PAPERS

THE ROLE OF HYPERBARIC OXYGEN IN THE TREATMENT OF THERMAL BURN INJURIES: A BRIEF REVIEW OF THE LITERATURE AND THE RESULTS OF A PILOT STUDY.

Des Gorman and Ian Leitch

Introduction

Thermal burn injuries are common, and have a substantial morbidity and mortality. Both the treatment in specialised Burns Units, and the rehabilitation of the patient back into the community are expensive[1]. Despite this background, the evaluation of different treatments for burnt patients has been poor. Often studies have inadequate control data and there are difficulties in accurately assessing burn wound depth[2].

Hyperbaric oxygen (HBO) therapy administered systematically may be an effective adjuvant to the conventional care of thermal burn wounds, since it can reduce tissue ischaemia, attenuate interstitial fluid oedema and compartment pressure, improve the micro-circulation, and stimulate both revascularisation and re-epitheliasation of hypoxic wounds[3].

Since the original observation of accelerated burn wound healing in rabbits treated with HBO was reported in 1969[4], data have been collected in a variety of other animal-models to demonstrate at least three ways in which HBO acts directly to promote healing of thermal burn wounds.

The first is a reduction in the eventual depth of the burn wounds (ie. the progression of partial-thickness burns to full thickness is retarded)[5]. This reduction is associated with less extravasation of fluid[6,7], an increase in the ATP concentrations in the burn wounds (even when HBO administration is delayed)[8], and a reduction in overall animal mortality[6]. The second direct action is an increased healing rate of burn wounds in animals treated with HBO[4,5], and the third is an anti-septic effect[4,6]. This anti-sepsis is mediated probably both by enhanced host responses and by direct anti-bacterial action[3].

The beneficial effects of HBO may be enhanced by the concurrent administration of antioxidants, but their use is controversial. For example, while a free oxygen-radical scavenger enhanced the protective effect of HBO on a rabbit lung smoke inhalation injury[9], similar benefit could not be demonstrated in ischaemic skin flaps in rats[10]; and elevated oxygen tensions have been shown to actually antagonise, not potentiate, lipid peroxidation in-vitro[11].

In addition to these direct effects on burn wounds, HBO has also been shown to improve outcome in animals who have inhaled cooled smoke[9], by reducing the fluid extravasation into the lung interstitium. Lung injury from smoke inhalation is common after thermal burn injuries, and is a significant cause of mortality[12]. Carbon monoxide (CO) intoxication has been claimed to be the commonest cause of death of victims dying at the scene of a fire[13,] and HBO has been shown to be the definitive treatment of CO intoxication in a controlled prospective study[14].

In contrast to these controlled animal studies, reports of HBO use in humans with thermal burns are, with perhaps a single exception, poorly controlled. Also, these human studies have used unreliable methods of assessing burn-wound depth[2]. These retrospectively, semi, or uncontrolled studies have reported that HBO: reduces the mortality in severely burnt patients[15]; reduces either the number of areas, or the surface area requiring grafting[1,15,16]; reduces fluid requirements[13,15,17]; reduces hospital-stay time and overall treatment costs[1,13,16]; reduces burn wound sepsis[17]; and increases skin graft survival in patients who have had burn wounds grafted[13,15]. However there has been only one prospective controlled, but not randomised, study of 875 patients with thermal burns, which showed HBO to significantly reduce the mortality of severely burnt patients[18]. There are no human data and only a single report of an inhalational injury in rabbits being improved by the administration of normobaric oxygen (NBO)[19].

There are no reports of adverse effects on burns with systemic HBO, and a solitary report of topical HBO increasing scar thickness[20].

There are then substantial animal and human data to support a role for HBO in the treatment of thermal burns. However, there is an urgent need for randomised prospective and controlled human studies to examine both HBO and NBO.

Pilot Study

We conducted a pilot study from July 1986 to June 1988 at the Royal Adelaide Hospital (RAH), South Australia, to determine the feasibility of administering HBO to burn patients at the RAH, and to determine if HBO produced deleterious effects.

A control group of 113 patients was generated retrospectively by considering all admissions to the RAH Burns Unit from January 1983 to June 1986, when HBO treatment was introduced. We excluded patients with less than 10% total body surface area (TBSA) burns, as the mortality is negligible, and those with more than 75% TBSA burns as many were given analgesia only. The data for age, area burnt, and mortality for this control group are shown in TABLE ONE. All these patients received conventional surgical care only.

From July 1986 to June 1988 inclusive, 67 patients with more than 10% TBSA burns and less than 75% TBSA burns were given HBO as an adjuvant to their conventional surgical care. Their results are also summarised in Table One. The HBO patients did not differ significantly from the retrospective non-HBO control group for age (34.2 + 14.9 (SD) years .v. 38.6 + 17.2 (SD) years; $p > 0.05$) or mean area burnt (28.9 + 20.6% .v. 25.5 + 15.5%; $p > 0.1$). However, the mortality of the HBO patients was significantly lower (4.4% .v. 21.3%; Fisher's exact probability, $p = 0.002$).

Clearly, other factors such as improved nursing could have contributed to the fall in mortality, and it is not possible to attribute this reduction to HBO alone. We could conclude, however, that it was feasible to conduct a prospective randomised controlled study to evaluate the relative roles of HBO and NBO in the treatment of thermal burns injury at the RAH, and further that there was no evidence that HBO adversely affected the outcome of these patients. A prospective study is now being implemented.

Summary

In addition to its beneficial effects on CO intoxication in burnt patients, HBO therapy may also have a positive direct effect on the thermal burn wound. In animal burn injuries, HBO not only speeds the healing of the burn, but also reduces the mortality and reduces the area of partial-thickness burns that proceed to full-thickness. The data from burnt patients is consistent with these findings, but with a single exception, are generally inadequately controlled and

TABLE 1

	Control Group (Non-HBO) 1983-1986	**HBO Group 1986-1988**
Number:	113	67
Mean age (+ SD):	38.6 + 17.2 yrs	34.2 + 14.9 yrs
Mean TBSA burnt (+ SD):	25.5 + 15.5%	28.9 + 20.6%
Mortality:	21.3%	4.4% *

*** p = 0.002 (Fisher's Exact)**

Characteristics of patients admitted to the RAH Burns Unit with TBSA burns > 10% and < 75% in the period from January 1983 to June 1988 inclusive; and treated with conventional surgery alone (Control Group, January 1983 to June 1986), or with conventional surgery and HBO (HBO Group, July 1986 to June 1988).

are gathered using inaccurate methods of assessing burn wound depth.

A pilot study conducted at the Royal Adelaide Hospital has shown a significant decrease in mortality in severely burnt patients treated with HBO when compared to a retrospective control group. On the basis of these findings, and the positive animal and human literature published already, it is clear that a prospective randomised controlled study of the role of HBO in the treatment of thermal burns injury is long overdue.

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