

## Efficacy of HBOT as Adjuvant in Burn Patient

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### Abstract

**Background:** It a great challenge which requires great efforts to treat the patient with burn injury. Immediate treatment significantly improves mortality rates. Management of a burn case usually involve, appropriate fluid resuscitation, attainment of resuscitation targets using consensus formulas for initial fluid administration, topical agents to control pain, reduction of fluid loss as well to prevent bacterial growth.

**Objective:** our aim was to look for the evidence of effectiveness of HBOT and the patient's satisfaction improvement due to reduction in wound pain.

**Study Design:** Study carried out was prospective case control study.

**Place of Study:** Prana HBO Centre, located in the Northern parts of Mumbai, in India.

**Methods:** In group I in comprised of 22 patients with burn injury who got regular HBO therapy. HBO therapy was given with compressed with air at a pressure of 2.5 atmosphere absolute (ata). At this pressure the patient breathed 100% oxygen via facial mask. The HBO therapy protocol included 90 minutes oxygen breathing at 2.5 ata, twice daily over 6 days. 20 sessions were performed for each patient. In group II patients with burn injury were 21 who also received burn treatments in our setup but without HBO therapy.

**Results and Discussion:** The mean improvement in pain relief in group I was  $4.9 \pm 1.2$  in comparison

to group II which was  $3.2 \pm 0.85$ , comparatively improvement in pain score was significantly higher in group I and at par with group II. Hyperbaric Oxygen therapy can improve pain score and patient satisfaction in our study. However the possibility of cost effectiveness of the HBO therapy would need further discussion. Future, the clinical trials with large sample size and different types of burn injury shall be considered.

**Conclusion:** Findings shows the beneficial effects of HBO therapy, as well suggests that the HBO therapy has a significant improvement in the pain relieve and satisfaction improvement. Hence, HBO therapy, as an adjuvant treatment, could be helpful for pain control and satisfaction associated with burn injuries.

**Keywords:** Patients satisfaction; Pain relief; HBOT; Burn Injury.

### Introduction

Damage to skin integrity depending upon depth, subcutaneous tissues or organs resulting due to high temperature, electricity, chemicals or radiations is termed as Burns.<sup>1</sup> The classifications of burns are based on depth expressed in degrees and their related corresponding symptoms. Burn causes skin barrier, which serves as protection from various external environmental factors, which is interrupted leading to homeostasis and

physiological disruption. In superficial burns damage of epidermis causes swelling and blister formation. In deep dermal full thickness burns it leads to loss of skin barrier causing loss of water by evaporation from wound, as well loss of thermoregulatory function and decrease in number of electrolytes and proteins.<sup>2,3</sup> Later due to progressive dehydration causes disruption of process of repair, cell damage as well it inhibits the regenerative changes in wound environment. Similarly, cell membrane damage, increase in vascular permeability leads to leakage of body fluids in intracellular spaces followed by gradual onset of swelling, as water leaks through the burn wound to the environment.<sup>4,5</sup>

In burn wounds, swelling affects development of hypoxia, adjacent tissues and leads to accumulation of harmful cellular metabolites, leading to formation of inflammation and necrotic tissues which ultimately delays the process of healing. Hence Necrosectomy is usually performed after five to seven days after the injury at the latest. By the end of fifth day after injury, microorganisms begin to colonize necrotic tissue, which serves as a good medium.<sup>6</sup> Hence in order to normalize patient physiological condition and to restore hemostasis, after surgical debridement of burn wound, its protection through application of autologous skin graft or skin substitutes should be the priority.<sup>7</sup> As such Thermal burns are with maximum morbidity and mortality, they are complex and injury which involves both local and systemic consequences. It is seen if there is more than twenty percent of the total body surface area, severity increases.<sup>8</sup>

It a great challenge which requires great efforts to treat the patient with burn injury. Immediate treatment significantly improves mortality rates. Management of a burn case usually involve, appropriate fluid resuscitation, attainment of resuscitation targets using consensus formulas for initial fluid administration, topical agents to control pain, reduction of fluid loss as well to prevent bacterial growth. It is observed in past two decades that early closure of full thickness wounds had improved the outcome in extensive burn cases by preventing colonization and infection.<sup>8</sup>

To get a good outcome in cases with thermal burns, HBO therapy is used as adjuvant therapy and this and been well studied. HBOT is application of hundred percent oxygen at two or three times the atmospheric pressure at sea level, at environmental pressures between 1.4 and 3.0 atmosphere absolute (ATA), for periods between 60 and 120 min once or

more daily.<sup>9</sup> It causes most of the physiological and therapeutic effects. This therapeutic procedure has a range of positive effects for the inhaling process and it is being prescribed along with other treatment in various other clinical situations.<sup>10</sup> The Undersea and Hyperbaric Medical Society recognizes 14 valid medical indications for hyperbaric oxygen therapy, commonly ate diabetic foot ulcer, radiation tissue injury, condition with acute ischemia which includes crush injuries as well in acute poisoning by carbon monoxide, acute occlusion of central retinal artery, diving accidents, severe anemia and burns.<sup>11</sup>

For acute thermal burn injury the undersea and hyperbaric medical society (UHMS) had approved and HBO therapy is an adjuvant treatment for burn patient and it specifically reduces the length of hospital stay of the patient and cost of care is also reduced.<sup>12</sup> In this study our aim was to look for the evidence of effectiveness of HBOT and the patient's satisfaction improvement due to reduction in wound pain.

## Patients and Methods

### *Study setting*

The study was carried out at the Prana HBO Centre, which is owned by the Investigator and located in the Northern parts of Mumbai, in India. The center has one Sechrist Monoplace hyperbaric chamber and a TCOM machine with 3 electrodes. The oxygen gas supply is from oxygen cylinders of 7000 liters' capacity each. The center has all the requisite certifications and registrations as required by the local authority in Mumbai. Study was conducted over a period of 2 years and patient with Burn injury referred to the Hyperbaric Unit at Prana HBO center. Center took care in a specialized form and provided care to patients with burns and critical soft tissues conditions and was responsible for caring for all patients. Written informed consent was obtained from the patient and patient's relative.

### *Study Design*

Study carried out was prospective case control study.

### *Study Population*

In our study total 43 patients with burn injury were included which were referred to our Prana hyperbaric center Mumbai over a period of two years. Furthermore, all the patients were screened for eligibility to be included in the study and

they had no previous or current history of pain disorders and no known neurologic, rheumatologic or psychiatric clinical features in association with chronic pain.

#### *Inclusion Criteria*

Burn injury patients referred to Prana Hyperbaric center, without a history of chronic pain and any further treatment of burn received were included in the study.

#### *Exclusion criteria*

All of the following patients who died during the treatment, with excessive comorbidities, burn injury area more than 60% of the total body surface area, patient suffering with septic shock or showing unstable vital signs were excluded from the study.

#### *Ethics review*

This study was performed within the scope of international ethical guidelines and legislation. Ethics review and approval was provided by Stellenbosch University (number: U16/06/015) and the ethics committee of the Hyperbaric Society in India.

#### *Procedure*

In our study the selected patients were divided into two groups and both group received regular wound dressing and surgery as per requirements. In group I in comprised of 22 patients with burn injury who got regular HBO therapy. HBO therapy was given with compressed with air at a pressure of 2.5 atmosphere absolute (ata). At this pressure the patient breathed 100% oxygen via facial mask. The HBO therapy protocol included 90 minutes oxygen breathing at 2.5 ata. 20 sessions were performed for each patient. In group II patients with burn injury were 21 who also received burn treatments in our setup but without HBO therapy. Selection of the patients was random. In our study all patients received burn wound treatments which includes dressing, pain control, infection control and if required surgical intervention in the form of debridement and skin grafts was given. During the study all of the following parameters such as HBO sessions given to the patients of group I, age, sex, inhalation injury status, total body surface area, hospital stay duration, and location of scars with its characteristics were all documented meticulously. Vancouver Scar scale was used to evaluate the condition of scar and very well documented.

Visual analog Scale was used to score and assess pain. Patients satisfaction was documented by the principal investigator of the study, patients were asked to mark the satisfaction score about the current health status on a scale of one to ten, before and after the whole course of therapy and the differences in subjective score was graded accordingly.

#### *Statistical Analysis*

A descriptive table prepared to present the distribution of HBO and non HBO group of therapy. The graphical presentation was used to present the improvement after burn injury treatment by patient's satisfaction. The small sample t-test was used to compare the difference between mean of TBSA and score improvement. The odds ratio was used to determine the relative risk. The Chi-square test was used to test the association between age and pain relief score. The complete statistical analysis was done by MS-Excel software.

## **Results**

Total 43 patients with burn injury were enrolled in our study, of which 22 in group I and 21 in Group II were included. In our study patient's burn wound were mostly on the extremities, group I consist of 18 males were as in group II it comprised of males. The mean age of Group I is 28 and for group II is 26 with an average of 39.7 and 41.84 respectively in both group. The mean TBSA of wounds in group I was  $23.8 \pm 9.7$  in group I and  $26.3 \pm 10.9$  in group II which did not showed up significant difference. The mean improvement in pain relief in group I was  $4.9 \pm 1.2$  in comparison to group II which was  $3.2 \pm 0.85$ , comparatively improvement in pain score was significantly higher in group I and at par with group II. The mean debridement time in group I was  $1.4 \pm 0.4$  as compared to that of  $0.9 \pm 0.7$  in group II, which reflected not much significant differences. The mean skin graft times in group I was  $3.1 \pm 1.2$  and in group II  $1.9 \pm 1.4$  which also reflected that there is not much significant differences. The mean length of hospital stay of the patients in group I showed  $31.5 \pm 8.9$  days and in Group II was  $34.8 \pm 10.1$  days, it also had no significant differences. In group I significant improvement in patient's satisfaction was 90.9% in comparison to group II where it was 66.7%.

Relative risk estimation: Odds Ratio = 5 (Total no. of cases is 43)

At 95% Confidence interval is, The Lower value

**Table 1:** Descriptive analysis of baseline parameters

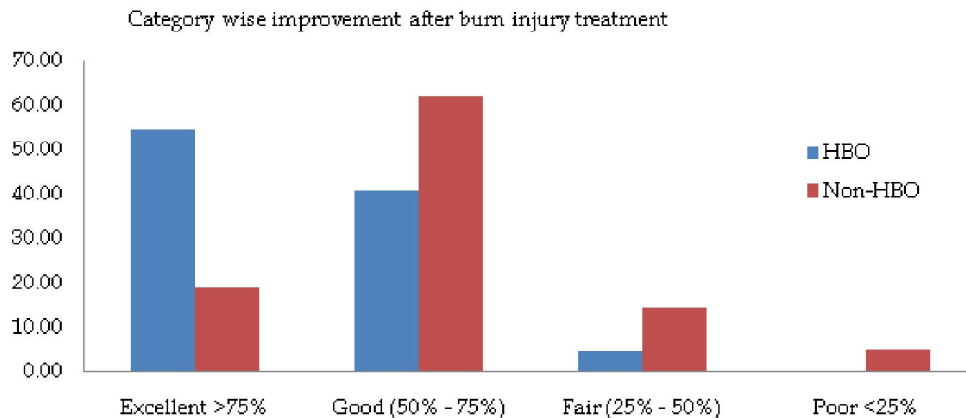
Parameters		Group - I HBO (n = 22)	Group - II Non-HBO (n = 21)	Total
Age	Min. Age	28	26	26
	Average	39.7	41.84	40.
	Max. Age	56	59	59
Sex Ratio (Male : Female)		18 : 4	16 : 5	34 : 9
TBSA		23.8 ± 9.7	26.3 ± 10.9	25.7 ± 10.4
Pain Relief		4.9 ± 1.2	3.2 ± 0.85	4.2 ± 0.96

**Table 2:** Result of different characteristics in HBO and Non HBO groups

Parameter score	HBO (n = 22)	Non- HBO (n = 21)
Debridement times	1.4 ± 0.4	0.9 ± 0.7
Skin graft times	3.1 ± 1.2	1.9 ± 1.4
Patients stay (in days)	31.5 ± 8.9	34.8 ± 10.1
Development in scar	0.8 ± 1.1	1.7 ± 1.4
Infection rate (in %)	34%	49%

**Table 3:** Satisfaction improvement between HBO and Non-HBO groups by Odds ratio

Improvement		HBO (n = 22)	Non - HBO (n = 21)	Total
Significant improvement of satisfaction	No. of Patients	20	14	35
	Percentage (%)	90.9%	66.7%	81.4%
No Significant improvement of satisfaction	No. of Patients	02	07	8
	Percentage (%)	9.1%	33.33%	18.6%
Total	No. of Patients	22	21	43
	Percentage (%)	100%	100%	100%

**Fig. 1:** Category wise Improvement after treatment

= 3.21 & The Upper value = 6.79 of odds ratio is recorded.

To compare the mean value of TBSA of wounds between HBO and Non-HBO groups by using small sample t-test, at 5% level of significance the p-value is 0.2893 which is greater than  $\alpha=0.05$ , It means there is no significant difference between them.

Similarly to compare the scar improvement between HBO & non-HBO groups.

The p-value is 0.0837 > 0.05 which showed there is no significant difference of scar score between two groups.

## Discussion

The tissue damage in burn injury is due to multiple factors which include the failure of surrounding tissue to supply borderline cells with oxygen and nutrients which are necessary to sustain

viability.<sup>13</sup> Impediment of the circulation below the injury results in desiccation of the burn wound, as fluid cannot be supplied through the thrombosed or obstructed capillaries. As such topical agents and dressings may reduce but they cannot prevent the desiccation of the burn wound and inexorable progression of deeper layers. Altered permeability is not caused by heat injury all alone; even oxidants and other mediators like prostaglandins, kinins and histamines all of them contribute to vascular permeability.<sup>14</sup> Neutrophils are a major source of oxidants and injury in the ischemia or reperfusion mechanism, they may be complex but favorably affected by several interventions. Therapy is focused on the reduction of dermal ischemia, reduction of edema and prevention of infection. During the period of early hemodynamic instability edema reduction has a markedly beneficial effect as well as modulating later wound conversion from partial to full thickness injury.<sup>15</sup>

Infection remains the leading overall cause of death in case of burn injury cases, infection susceptibility is tremendously increased due to loss of the integumentary barrier to bacterial invasion, ideal substrate in the burn wound and the compromised or obstructed microvasculature that prevents humoral and cellular elements from reaching the injured tissue, along with additionally immune system is seriously affected, which demonstrate levels of immunoglobulin's and serious perturbations of polymorph nuclear leukocyte functions<sup>16,17</sup>, that includes disorders of chemotaxis, phagocytosis and diminished killing ability. These functions greatly increase morbidity and mortality. Progressive ischemic process can be potentiated by poor tissue perfusion, experimental data significantly support the adjuvant use of hyperbaric oxygen therapy in burn patients, it is evident that this improves microcirculation of the wounded area whereas it decreases wound depth and size.

Several investigators clearly pointed out that hyperbaric oxygen therapy promotes wound healing, by direct increase in fibroblast replication, collagen synthesis as well neovascularization. Giving oxygen at the cellular level will increase leukocyte bactericidal activity and gives direct lethal effect on anaerobic organisms.<sup>18</sup>

Korn et al. presented second degree burn wounds heal faster when treated with HBO<sub>2</sub>.<sup>19</sup> Research on epithelial tissue pointed that it can survive without oxygen, but cells cannot divide or migrate.<sup>20</sup> Enough oxygen in tissue to enable epithelial cells to migrate and divide is required to wound healing.<sup>21</sup>

Epithelisation process is dependent on the total cell population which survives initial and subsequent later injury as well as mitosis and migration. HBO<sub>2</sub> surely had an affect the process by allowing minimum wound desiccation and destruction as well increasing oxygenation of hypoxic, thermally damaged cells which may not survive otherwise.<sup>22</sup> Perrins et al. reported that there is no effect of HBO<sub>2</sub> in a pig scald model.<sup>23</sup> Niccole et al. also highlighted that there is no advantage in wound healing achieved by HBO<sub>2</sub> when the modality was compared to topical antibiotics.<sup>24</sup> They pointed and made a proposal that HBO<sub>2</sub> alone acted just as a mild antiseptic.

Cianci, 2004<sup>25</sup> reported that the WBC that fight the infection in the ulcer use twenty times more oxygen when they are killing bacteria. Also it is proposed that the more oxygen the more efficiently the repair of the connective tissues. New capillaries mean that more blood gets to the site of the ulcer, which spreads healing. High oxygen levels also make RBC cells more flexible so they can get through the twists and turns of the capillaries and get to where are needed.

The Hyperbaric Oxygen therapy has a treatment modality for around a broad range of ailments, which includes chronic pain, and reduces pain in animal models. Clinical research had indicated that the HBO therapy is useful to modulate human pain. A research carried out by Katznelson et al. highlighted a reduction in pain, swelling, and allodynia and an improvement in skin color and range of motion in patients with complex regional pain syndrome after completion of three weeks of HBO therapy.<sup>26</sup>

Our research reflected that the HBO group had better pain relieve and satisfaction improvement, it may be probably only due to the gratification of receiving HBO therapy. However, we cannot exclude the possibility of few complications for HBO therapy such as barotrauma, sinus or tooth squeeze, all such conditions will affect satisfaction; further more meticulous studies with more number of patients and parameters need to be done. In our study we excluded persons with excessive comorbidities; if the patient had excess comorbidities, it may loss to followup during the course of study likely chance as well even after well explaining the risk for HBO therapy, many patients with excess comorbidities did not tolerate and refused the management. Hyperbaric Oxygen therapy can improve pain score and patient satisfaction in our study. However, the possibility of cost effectiveness of the HBO therapy would

need further discussion. Future, the clinical trials with large sample size and different types of burn injury shall be considered.

## Conclusion

In this study to conclude the impact of hyperbaric oxygen therapy in burn injury patients, outcome is favorable to Burn injury patients. Our findings shows the beneficial effects of HBO therapy, as well suggests that the HBO therapy has a significant improvement in the pain relieve and satisfaction improvement. Hence, HBO therapy, as an adjuvant treatment, could be helpful for pain control and satisfaction associated with burn injuries. Consequently, when pairing the clinical experiences and laboratory data, justification for using HBOT as an adjunct for managing Burn injuries is strong. Despite these encouraging results further research is needed to more clearly define the mechanism and potential role of HBOT following Burn injury. However, in no situation should HBOT be used as a substitute for indicated surgical and medical interventions.

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*Conflict of Interest:* The author declares no conflict of interest for this study.

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