INITIAL RESULTS OF TREATING THERMAL BURNS BY HYPERBARIC OXYGEN THERAPY AT THE VIETNAM NATIONAL INSTITUTE OF MARITIME MEDICINE

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ABSTRACT

Background: *Burns, especially heat-related ones, are one of the most common injuries in work and daily life. If patients are not treated properly, burns can leave a lot of sequelae which would negatively affect not only daily activities, working ability but also aesthetics and psychology of the patients. Most topical treatments have been reported that they have some adverse effects and unintentionally prolong the length of hospital stay. Therefore, topical treating method is considered as an inefficient and uneconomical therapeutic approach. Hyperbaric oxygen therapy is a new treatment. It is able to help to relieve pain quickly, accelerate wound healing process, and reduce length of hospital stay which would effectively improve the burn treatment process.* ***Objectives:****To describe the clinical characteristics right at the time thermal burn patients were admitted to hospital*

and initial results of treating them by hyperbaric oxygen therapy. ***Materials and methods:****Prospective and retrospective case series report. The study sample was the thermal burn patients who came to the Vietnam National Institute of Maritime Medicine for being treated by hyperbaric oxygen therapy in the period between 2018 and 2022.* ***Results:****of the 82 total thermal burned patients, the mean age was 48.4±19.5; the main cause of burns was boiled water which accounted for 74.4% of patients; 51.2% of them had been classified as 3rd degree burns; percentage of patients who had under 10% of total body surface area burned was 80.5%; 84.1% of patients had no pain on the 14th day; the mean length of hospital stay was 8.9±3.0 days which was significantly lower than the expected figures.* ***Conclusions:*** *Hyperbaric oxygen therapy is a new effective treatment for thermal burn patients with a variety of positive impacts on burned tissues. As a result, it should be scaled up, especially in health facilities which is specialized in burn treating.*

Keywords:*burns, thermal burns, hyperbaric oxygen therapy, length of stay.*

I. INTRODUCTION

Burns are injuries of skin or other tissues resulting from exposure to certain agents such as heat (mostly), radiation, chemicals, or electricity. Burn injuries are prevalent in daily life, accounting for 5-10% of surgical injuries. Burns have become an increasing public health problem, with more than 10 million burn injuries and more than 300,000 deaths each year. Plus, it has been the ninth leading cause of global burden of disease and injury, including long hospital stays and the possibility of a lifelong disability which leads to stigma and alienation [1]. In Vietnam, the number of burn patients is about 844,000 people per year, nearly 1% of the overall population [2]. If burns are not treated well, they can leave a variety of long-term sequelae, affecting daily activities, working ability, aesthetics and psychology of the patient. It has been recently reported that some topical treatments such as applying drugs and antiseptics have many undesirable effects, even slowing down the wound healing process. Therefore, the research and development of new methods that accelerate the healing process and prevent infection are important tasks of the current burn treatment.

Hyperbaric oxygen therapy (HBOT) is a treatment consisting of the supply of pure oxygen under augmented pressure (>1ATA). Studies around the world have confirmed that HBOT has the effect of increasing the partial pressure of oxygen in all tissues. This mechanism would be used in many applications, especially in hypoxic tissues, with antibacterial, edema-reducing, immunomodulatory, and angiogenesis-promoting effects [3]. Many clinical applications of HBOT have been approved by the US Food and Drug Administration. Among them, there is also the enhancement of burn wound healing. However, the data of applying this new therapeutic method in Vietnam are not well documented. The aim of this study was to describe the clinical characteristics and initial results of thermal burn patients treated by HBOT.

II. MATERIALS AND METHODS

2.1. Study population

Study population: Thermal burn patients who were treated with HBOT at the Underwater Medicine and Hyperbaric Oxygen Center of the Vietnam National Institute of Maritime Medicine. All 82 patients in the period from 2018 to 2022 were selected.

Inclusion criteria: Patients who were diagnosed with thermal burns, had no contraindications to HBOT and voluntarily accepted to be treated by this therapeutic method.

Exclusion criteria: Patients who requested to quit the treating process would be excluded from the study.

2.2. Study methods and content

This study was designed as a retrospective and prospective case series report. For retrospective data, we collected it by searching information on a computer system. For prospective data, patients who presented with thermal burns would take physical examination and were assessed during the treating process by HBOT. Total population sampling technique was used in this study, taking all eligible patients to participate in the study until the end of the study period.

Patients would be assessed in consideration of some epidemiological and clinical characteristics such as age, sex, the main causes of thermal burns, burn sites, percentage of total body surface area got burned and the severity of burns at the moment they were hospitalized. After that, they were monitored and assessment was done on their pain (using Visual Analog Scale), edema reducing and wound healing process on the 3rd, the 7th and the 14th day after the treatment until their wounds were basically healed. The HBOT regimens used in this study were VINIMAM 1, 2 and 3 with the supply of pure oxygen under augmented pressure (2.2-2.8ATA) for 1 hour to 3 hours. According to the depth of burns, patients with the 2nd degree burns would be treated with regimen VINIMAM 2 until their discharge and those with the 3rd degree burns would be treated with VINIMAM 3 on the first 3 days, then VINIMAM 1 until their discharge.

Data were analyzed using version 22.0 of SPSS statistical program. Continuous variables were expressed as mean±SD and categorical variables as percentages for descriptive statistics. The significance of the difference between sample mean and population mean was determined by one-sample T test. P-values < 0.05 were considered statistically significant.

2.3. Ethical clearance: The protocol of this study was approved by the medical ethics committee of the Can Tho University of Medicine and Pharmacy. All patients were clearly explained about the study. They understood and voluntarily participated in the research.

III. RESULTS

3.1. Characteristics of the participants

Table 1. Demographics of the participants

Characteristics		Number of cases	Percentage (%)
Age	< 20	9	11.0
	20-39	17	20.7
	40-59	30	36.6
	≥ 60	26	31.7
	Mean±SD (min-max)	48.4±19.5 (5-85)	
Sex	Male	35	42.7
	Female	47	57.3
Region of residence	Urban areas	59	72.0
	Rural areas	23	28.0

The mean age of the 82 total studied patients was 48.4±19.5; 57.3% of them were female; 72.0% of them were from urban areas.

Table 2. Clinical characteristics of the participants

Clinical characteristics		Number of cases	Percentage (%)
Causes	Scald	61	74.4
	Dry heat	21	25.6
Burn sites	Upper body parts	29	35.4
	Lower body parts	53	64.6
Burn depth	2nd degree	40	48.8
	3rd degree	42	51.2
Percentageoftotal body surface area burned	< 10%	66	80.5
	≥ 10%	16	19.5
	Mean±SD (min-max)	6.6±5.4% (2-30%)	

The main cause of burns was boiled water, 61 patients (74.4%); the proportion of patients having lower body part burned was 64.6%; 51.2% of patients had 3rd degree burns; percentage of patients who had < 10% of total body surface area burned was 80.5%.

3.2. Initial results of patients treated by hyperbaric oxygen therapy

Table 3. Results of patients treated by hyperbaric oxygen therapy

Symptoms		Pre-treatment		3rd day		7th day		14th day	
		n	%	n	%	n	%	n	%
Pain	No pain	0	0.0	1	1.2	17	20.7	69	84.1
	Mild	3	3.7	19	23.2	29	35.4	8	9.8
	Moderate	31	37.8	36	43.9	34	41.5	5	6.1
	Severe	48	58.5	26	31.7	2	2.4	0	0.0
Edema reducing	Yes			29	35.4	67	81.7	80	97.6
Wound healing	Good			11	13.4	50	61.0	74	90.2
	Moderate			44	53.7	28	34.1	8	9.8
	Bad			27	32.9	4	4.9	0	0.0

The number of patients having no pain reached 69 (84.1%) on the 14th day. Also the proportion of patients who got their edema reduced was 97.6% and most of them had a good wound healing status (90.2%).

Table 4. Length of hospital stay of studied patients in comparison with expected figure

Variable		Number of cases	Percentage (%)	p
Length of stay (days)	< 7 days	20	24.4	
	7-14 days	56	68.3	
	> 14 days	6	7.3	
	Mean±SD (min-max)	8.9±3.0 (5-21)		< 0.001
Expectedlength of stay (days)		13.2		

The mean length of stay was 8.9±3.0 days which was significantly lower than the expected figure ($p < 0.001$).

IV. DISCUSSION

4.1. Characteristics of the participants

In our study, the participants were mainly above 40 years old. The age range fluctuated widely, including patients in the group < 20 years old and the group of patients ≥ 60 years old. Although women predominated, the ratio of men and women was almost equal at 35/47 or 1/1.3 . When comparing Chen's study in Taiwan (2018), these figures of the two groups of patients were 37.0 ± 9.2 years old and 49.4 ± 17.4 years old, respectively, in which male accounted for 80% [4]; and Dolp's study in Canada (2018) with the mean age of the participants was 47 ± 18 years old and male accounted for 74% [5]. We can see that there are similarities in age but differences in sex distribution. This difference may be due to the location and time of sampling, as our study only chose thermal burn patients. In general, thermal burns can occur randomly in all subjects with no particular etiological factors related to age and sex.

4.2. Initial results of patients treated by hyperbaric oxygen therapy

Exposure to any causative factors of burn would damage the skin and subcutaneous tissues as well as cause embolism and skin necrosis. This leads to a local inflammatory response, or worse, a systemic inflammatory response syndrome. Numerous articles mentioned that HBOT has certain effects on substances in the inflammatory response especially interleukin and TNF-α [6]. HBOT will also increase mitochondrial function and ameliorate neurotransmitter abnormalities and at the same time, reduce the production of prostaglandin E2, thereby alleviating symptoms of inflammation, pain and edema. The anti-inflammatory potential of this therapeutic method is also related to inhibiting IFNγ release and attenuating hypoxia by regulation of HIF1A [6]. Efrati demonstrated that HBOT regulates pain onset by decreasing blood flow to the posterior brain regions and increasing blood flow levels to the prefrontal cortex [7]. At the molecular level, HBOT maintains IκBα levels in an oxygen-enriched environment, thereby inhibiting nuclear factor kappa B (NF-κB), which is a transcription factor for proinflammatory genes that contribute to a decreased response inflammation [6]. In our research, the pain symptoms of participants changed significantly in a positive way. On the 14th day, 69 (84.1%) patients had no pain and no severe pain was recorded (Table 3). This is similar to the study of Chen et al (2018). They showed that HBOT significantly reduced pain in burn patients and improved satisfaction with treatment compared with control group ($p = 0.004$) [4].

In addition, HBOT has been studied to reduce edema and preserve microcirculation in burn patients by enhancing oxygen delivery to damaged tissues, directing osmotic effects, and inactivating leukocyte adhesion. In 2005, in a randomized controlled trial evaluating the effects of HBOT on the healing of burn wounds in rats conducted by Bilic et al., the results showed that the effect of reducing edema was very effective ($p = 0.022$) [8]. And in our study, the rate of edema reduction progressed positively at each time of evaluation. Finally, 97.6% of patients had their edema symptoms alleviated on the 14th day. This is also consistent with Lambrinos' study (2017) that HBOT had the effect of reducing exudation and edema of the wound [9].

Tissue damage from thermal burns occurs since the surrounding tissues are unable to provide oxygen and nutrients for nearby damaged cells. Impeded circulation in the tissues below the wound results in the wound becoming less moist, mainly by disrupting fluid

passage through the capillaries, causing thrombosis and leukocyte congestion which slows down the natural wound healing process [10]. With the supply of oxygen under high pressure, HBOT will stimulate collagen synthesis and proliferation of fibroblasts, combined with promoting angiogenesis, will accelerate the recovery and healing of damaged tissues [3]. These reports are also similar to the study of Robinson (2000). He monitored a piece of muscle skin with adequate circulation and oxygen compared with another random piece of muscle skin under severe hypoxia and malnutrition. As a result, the amount of circulating blood and the amount of oxygen was inversely proportional to the invasion, multiplication of bacteria and also the ability to cause visible damage. On the one hand, the piece of muscle that was well nourished, was as resistant to infection as normal skin. On the other hand, the distal part of the piece of muscle skin which was in a condition of undernutrition (partial pressure of oxygen < 30mmHg) was necrotic due to infection. Necrosis was most severe in regions with the least amount of nutrients and oxygen [11]. In 2009, Flegg also suggested that oxygen is related to the synthesis of collagen fibers. The wound healing process will be slowed down when the tissue is deprived of oxygen. Ischemic lesions have been reported to be clinically markedly improved after hyperoxygenation [12]. A double-blind trial of four groups of patients stratified by the percentage of TBSA burned also showed that HBOT has the effect of reducing wound recovery time ($p < 0.005$) [13]. In 2011, Sahin reported on how to estimate length of stay based on percentage of total body surface area burned. In this way, every 1% of total body surface area corresponds to 2 days of hospital stay [14]. And in the study of factors affecting length of hospital stay of burn patients, Dolp (2018) also chose this estimation method [5]. With the results from Table 4, the actual mean length of stay of the participants was 8.9±3.0 days, significantly lower than the estimated figure ($p < 0.001$). In which, most of the patients were hospitalized for 7-14 days, accounting for 68.3%. There is a noticeable difference when compared with the study results of Doan Chi Thanh (2020) taking place in Le Huu Trac National Burn Hospital. The mean length of stay of the patients treated by conventional treatments was 12.56±18.85 days and over 50% of patients hospitalized for > 15 days [15].

The limitation of our study was the lack of controlled groups to demonstrate and compare how much effective HBOT is to accelerate wound healing process.

V. CONCLUSIONS

Given the significantly fewer days of hospital stay than estimated, along with a positive course of symptom alleviation, the combination of HBOT for the treatment of thermal burn patients should be widely recommended with a variety of beneficial effects in terms of relieving pain , reducing edema quickly and promoting wound healing. These will definitely increase satisfaction in treatment and reduce hospital costs for patients.

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