ORIGINAL RESEARCH PAPER
Volume - 12 | Issue - 09 | September - 2023 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

# HYPERBARIC OXYGEN THERAPY IN FROSTBITE: A BOON

Plastic Surgery

**Dr. Anand Agrawal*** MBBS, MS, Senior Resident, Department of Burns and Plastic Surgery, All India Institute of Medical Sciences, Rishikesh *Corresponding Author

**Dr. Vishal Mago** MBBS, MS, MCH, Professor and Head of Department, Department of Burns and Plastic Surgery, All India Institute of Medical Sciences, Rishikesh

**Dr. Neeraj Rao** MBBS, MS, MCH, Assistant Professor, Department of Burns and Plastic Surgery, All India Institute of Medical Sciences, Rishikesh

## ABSTRACT

Frostbite remains one of the major health hazards in the troops posted in the Himalayan region of India and mountaineers. We present a case series of three Indian soldiers of Indo-Tibetan Border Police presented to the Burn and Plastic Surgery Department, AIIMS, Rishikesh, with the history of frostbite while manning the India China border. The purpose of this case series is to throw light on new Hyperbaric Oxygen therapy for frostbite, and to review the literature of hyperbaric oxygen cases in the world. All three patients received multiple sessions of Hyperbaric Oxygen Therapy due to inadequate response to primary treatment of frostbite. Starting from the sixth session onward, objective evaluation and clinical observation indicated notable improvement in both wound healing and pain for all three patients. There were no instances of tissue loss, and the affected toes regained their sensitivity. Considering the extensive involvement of the Indian Armed Forces in high-altitude mountain warfare, which includes operations on glaciers, soldiers are inevitably exposed to environmental factors that pose significant risks. Therefore, it is strongly advised from an Indian standpoint to establish guidelines for Hyperbaric Oxygen Therapy (HBOT) to potentially benefit such patients.

## KEYWORDS

Frostbite; Hyperbaric Oxygen Therapy.

## INTRODUCTION:

According to descriptions found in pre-Columbian mummies, records of frostbite injuries date as far back as 5000 years.[1] Due to the deployment of soldiers in harsh weather, a medical condition known as frostbite is frequently seen in military medicine. For instance, Indian army jawans are posted at locations between 12,000 and 22,000 feet above sea level, such as the Siachen glacier or the border of the Uttarakhand region's Garhwal mountain range. Soldiers stationed in these regions, as well as mountaineers, continue to face a serious health hazards from frostbite. Frostbite can induce tissue sloughing, gangrene, or severe necrosis of the distal limbs, which may need amputation of the affected area. Extremes of age, smoking, prior history of cold injury, high altitude, duration of being exposed, wet tissues, and peripheral vascular disease are risk factors for frostbite.[2]

An adjuvant therapy called hyperbaric oxygen therapy (HBOT) is very well-liked for treating a variety of illnesses, from diabetic foot to decompression sickness. HBOT is not recommended as a therapeutic option for frostbite by the UHMS guidelines or the guidelines of the European Society of Hyperbaric and Underwater Medicine.[3,4] The literature is scarce on modalities helping to treat frostbite cases.

Several soldiers have tragically lost their lives or limbs as a result of the harsh weather conditions they encounter while stationed at strategic heights along the borders of North India. These incidents serve as a stark reminder of the immense risks soldiers face when operating in inhospitable terrains at altitudes reaching 21,000 feet, amidst extreme weather conditions on the world's highest battlefield. It is worth noting that there is currently no standardized data available in India specifically focusing on reported cases of frostbite. The purpose of this case series is to shed light on the application of Hyperbaric Oxygen Therapy (HBOT) as a new treatment approach for frostbite, as well as to review existing literature on HBOT cases worldwide.

## Case Series:

We present a case series of three Indian soldiers of age 28years, 34years and 54years of Indo-Tibetan Border Police(ITBP) presented to the Burn and Plastic Surgery Department, AIIMS, Rishikesh, with the history of frostbite while manning the India China border at 17,000 feet, at -10 degree Celsius temperature near the Nilapani, ITBP Check Post Unit in the Himalayan ranges, Uttarakhand. The patients did not have any notable medical history and denied having thyroid or other metabolic disorders. There was no history of smoking or alcoholism. Additionally, the patients had substantial experience and training in mountaineering. They were in excellent physical condition, regularly engaging in climbing activities and maintaining a consistent exercise routine.

There was snowfall for three continuous day during this period. There was sunlight next day which melted the snow and formed cold water. The cold water drenched the shoes of all the three patients and caused frostbite of feet of these patients. Initially, patients had numbness and loss of sensation of bilateral feet. When they removed the shoes, there was bluish discoloration of the involved toes of feet. Rewarming was done by hot water and first aid was given by other team members. But due to snowfall and bad weather forecast there shifting got delayed to ITBP hospital unit at Uttarkashi, Uttarakhand. Patients reached the ITBP hospital next day after 24 hours.

At the ITBP hospital, rewarming and initial primary treatment was given. Dressing with aloe gel and paraffin gauze was done of the affected parts in all the three patients. These patients were treated at the ITBP hospital with dressing, antibiotics, pain killers and warming of the affected part. During this period, all three patients had severe neuropathic pain at the affected parts. Due to inadequate response, all three patients were shifted to AIIMS, Rishikesh for further management.

All three patients presented to Burn and Plastic Surgery Department, AIIMS, Rishikesh and on arrival, these patients were evaluated and managed by Reconstructive and Plastic surgery team. The patients were assessed on basis of duration of first exposure, time interval of onset of disease, and initiation of treatment . First patient who was 54 years old male had second degree frostbite injury of great & 2nd toe of both the feet which was associated with blackening and severe pain. Second patient who was 28 years old had second degree frostbite injury of 4th & 5th toe of right foot and 3rd & 5th toe of left foot associated with severe pain of the affected parts. There was blackening of left foot 5th little toe. Third patient who was 34 year old male had first degree frostbite injury of great & 2nd toe of left foot. It was associated with severe neuropathic pain. (figure 1 to figure 4)

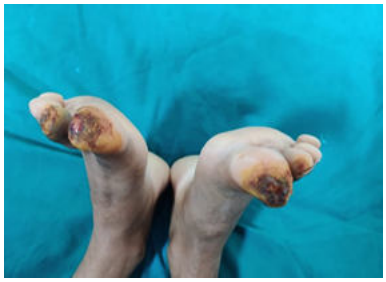

**Figure 1. 54 years old male with 2nd degree frostbite injury of great toe & 2nd toe of bilateral feet.**

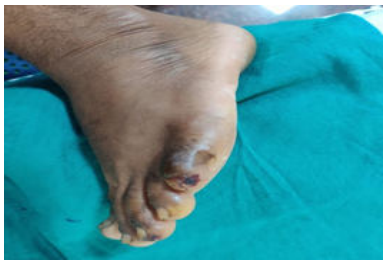

**Figure 2: 28 years old male with blackening of 5th toe left foot & 2nd degree frost bite of 4th toe**

**Figure 3. 28 years old male with 2nd degree frostbite injury of Left Foot 3rd & 5th toe..**

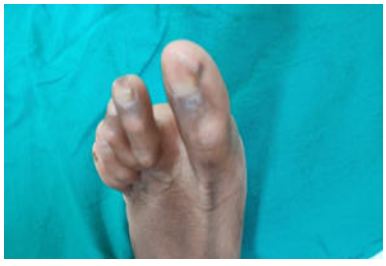

**Figure 4: 34 years old male with 1st degree frost bite injury of great and 2nd toe left foot**

Due to inadequate treatment response, patients were recommended to undergo HBOT. With adequate precautions and mandatory pre anaesthetic evaluations, HBOT was planned for all the three patients. HBOT was administered every day with 2.5 ATA pressure for 90 min (six days a week).

Two of the three patients underwent 16 sessions of HBOT uneventfully and were closely monitored before, during and after each session. Third patient underwent 10 sessions of HBOT following which he had left ear ache. He was managed by otolaryngologist at AIIMS, Rishikesh and had developed acute otitis media (AOM). Due to this HBOT was not recommended for this patient and treatment was given as advised by otolaryngologist.

From the sixth session onwards objective assessment and clinical profile suggested significant improvement both of wound and pain in all the three patients. By the end of 16 sessions of HBOT, both patients became asymptomatic. There was no tissue loss and all the affected toes regained their sensitivity. There was small wound remained at bilateral great toes of 54 year old male patient.(figure 5 to figure 7)

Regular follow up was complementary to their asymptomatic clinical status. Third patient who developed AOM had received 10 sessions of HBOT. He also became asymptomatic following HBOT therapy. His AOM also got resolved after 15 days of treatment.

**Figure : 28 years old male with left foot 5th little toe blackening dramatically improved after 16 sessions of HBOT.**

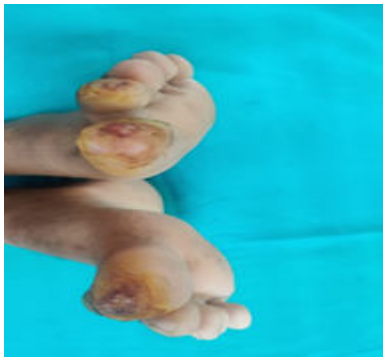

**Figure 6: 54 years old male with bilateral great and 2nd toe frost bite. After 16 sessions of HBOT.**

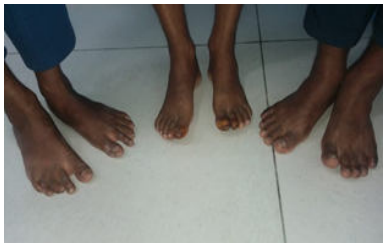

**Figure 7: All three patients after completion of HBOT**

**DISCUSSION:**

The high-altitude mountain presents a danger from intruders or civilian uprisings, which puts the Indian Military Jawan at constant risk of exposure to extreme cold, leading to serious health issues and even death. Frostbite commonly affects certain areas of the body: 19% in the upper extremities, 47% in the lower extremities, and 31% in both upper and lower extremities combined.[5] Additionally, vulnerable areas include the ears, nose, cheeks, and genitals.

Various studies have shown that adults between the ages of 30 and 49 are the most affected by frostbite, compared to the elderly and adolescents. This could be attributed to the higher participation of this age group in mountaineering activities, which ultimately exposes them to freezing environments.

The initial treatment for frostbite involves applying warm water (at a temperature of 40-42 degrees Celsius) with an antiseptic solution to the affected area for 15-30 minutes.[6] It is important to elevate and immobilize the affected limb immediately to minimize swelling and enhance blood flow to the tissues.[7] Patients are administered pain-relieving medications and should be moved away from cold environments. Nowadays, thrombolytic therapy, alpha blockers, and t-PA (tissue plasminogen activator) are utilized in the treatment of frostbite cases.[6]

Following acute pathology, frostbite long-term sequelae are associated with vasomotor dysfunction—in particular, vasospasm leading to circulatory disturbances, resulting in chronic pain and cold hypersensitivity. Also, cold-induced nerve damage is linked to neuropathic pain and ischemic neuritis. Furthermore, cold-induced arthritis is an important chronic condition that occurs in patients with a history of cold injury, which often only appears months or years later.[7]

In frostbite, the condition of acidosis results in elevated levels of lactate in the body. This is caused by a combination of factors, including reduced oxygen supply due to damage to blood vessels and clot formation, increased metabolic demand due to heightened cellular response (resulting in anaerobic glycolysis), and aerobic glycolysis by inflammatory cells.[8]

Research studies have indicated that hyperbaric oxygen therapy has several effects on the body. It influences the elasticity of red blood cells, enhances the bactericidal activity of leukocytes, reduces the risk of infection by promoting the growth of new capillaries, and stimulates collagen synthesis by significantly increasing tissue oxygen pressure levels by 10-15 times the normal level.[9,10] Additionally, hyperbaric oxygen therapy leads to vasoconstriction, which helps reduce the formation of oedema.[10]

Hyperbaric oxygen therapy (HBOT) plays a crucial role in rapidly reversing hypoxia and meeting the metabolic needs of wound tissue. It also helps minimize endothelial inflammation and reduces the suppression of reperfusion injury by lowering leukocyte adhesion. Although there have been no randomized control trials conducted to assess this concept, numerous case series have been published, examining the use of HBOT at different intervals after rewarming.[11]

These studies suggest that varying degrees of tissue recovery have been observed, although no direct comparisons to control groups have been made.[11] It has been observed that patients who receive HBOT earlier tend to have better outcomes, likely due to reducing damage to the penumbral area. Some studies have reported efficacy when combining HBOT with vasodilators, anticoagulants, or drugs such as pentoxifylline.[12]

There is paucity of literature on the use of HBOT in human frostbite instances. Despite the dearth of randomised control trials in this area of treatment, all existing studies and reported cases point to favourable outcome. According to this case series of three patients, HBOT helped speed the creation of line of demarcation, helped in virtually complete wound healing in two cases, and neurological symptoms subsided after 16 sessions of HBOT. Following HBOT, one patient who developed AOM became asymptomatic. After 15 days of medication, his AOM was likewise resolved. Following improvement in this three patients, these individuals have remained asymptomatic for the past three months without the need of any medicine.

## CONCLUSION:

The use of hyperbaric oxygen therapy (HBOT) can be advantageous in the treatment of frostbite, particularly for reversibly injured cells. HBOT enhances the viability of cells that have suffered reversible damage. In later stages of frostbite, HBOT can help shorten the duration of hospitalization and reduce the likelihood of secondary infections by promoting faster wound healing.

Considering the significant involvement of the Indian Armed Forces in high-altitude mountain warfare, including operations in glacier regions, soldiers are inevitably exposed to high-risk environmental conditions. From an Indian perspective, it is highly recommended to establish HBOT guidelines for the potential benefit of such patients. The timely and appropriate utilization of HBOT, regardless of the severity of frostbite injuries, is crucial for salvaging reversibly injured viable tissues.

## REFERENCES:


1. Handford C, Thomas O, Imray CH. Frostbite. Emerg Med Clin North Am 2017;35:281-99.
2. Kober A, Scheck T, Fulesdi B, Lieba F, Vlach W, Friedman A. Effectiveness of resistive compared to passive warming in treating hypothermia associated with minor trauma: A randomized controlled trial. Mayo Clin Proc 2001; 76: 369-375.
3. http://www.uhms.org/resources/hbo-indications. html. Accessed on 05 Jul 16.
4. Kamil Buda et al. The guidelines of the European Society of Hyperbaric Medicine, the Society of Underwater and Hyperbaric Medicine and the National Health Fund Polish Republic on a hyperbaric oxygen therapy (HBOT) in 2013. Journal of Heath Sciences 2013; 3(9): 125-134
5. Efrati S, Bergan J, Fishlev G, Tishler M, Golik A, Gall N. Hyperbaric oxygen therapy for nonhealing vasculitic ulcers. Clin Exp Dermatol. 2007; 32 (1):12-17.
6. ValnicekSM, ChasmirLR, ClapsonJB. Frostbite in the prairies: A 12-year review. Plast Reconstr Surg 1993; 92: 633-641.
7. Biem J, Koehncke N, Classen D, Dosman J. Out of the cold: Management of hypothermia and frostbite. CMAJ 2003; 168: 305-311.
8. Hopf HW, Kelly M, Shapshak D. Oxygen and the basic mechanism of wound healing. In: Tom SN, Stephen R. Thom, editors. Physiology and medicine of hyperbaric oxygen therapy. 1st ed. 2008: 205-211.
9. Dwivedi DA, Alasinga S, Singhal S, Malhotra VK, Kotwal A. Successful treatment of frostbite with hyperbaric oxygen treatment. Indian J Occup Environ Med. 2015 May Aug;19(2):121-2.
10. TandaraAA, MustoeTA. Oxygen in wound healing- more than a nutrient. World J Surg 2004; 28:294-300.
11. Robins M, Hendriksen S, Cooper JS. Hyperbaric Management Of Frostbite. 2021 Aug 30. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan–. PMID: 28846273.
12. Haik J, Brown S, Liran A, Weissman O, Yaffe B, Rivkind A, Efrati S, Winkler E, Epstein Y. Deep Frostbite: the Question of Adjuvant Treatment. Isr Med Assoc J. 2016 Jan;18(1):56-7.