JURNAL
REKONSTRUKSI DAN ESTETIK

CLINICAL PROFILES OF FROSTBITE IN DR. SOETOMO GENERAL ACADEMIC HOSPITAL: A CASE SERIES

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ARTICLE INFO

Keywords: Frostbite, good health and well-being, cold-related injuries, hand surgery

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History:
Received: February 2, 2019
Revised: February 16, 2019
Accepted: May 12, 2019
Published: June 1, 2019

JRE : Jurnal Rekonstruksi dan Estetik
e-ISSN:2774-6062; p-ISSN: 2301-7937
DOI: 10.20473/jre.v4i1. 24348

Available at:
https://e-journal.unair.ac.id/JRE/

How to cite: Nugroha, T.E,S,W, & Nata'atmadja, B. S. CLINICAL PROFILES OF FROSTBITE IN DR. SOETOMO GENERAL ACADEMIC HOSPITAL: A CASE SERIES . Jurnal Rekonstruksi Dan Estetik, 2019.4(1):6–13.

ABSTRACT

Introduction: Frostbite is a common cold-related injury, especially among mountaineers in high-altitude settings. These injuries can occur both in freezing and above-freezing temperatures. The main goal of this study is to understand the clinical aspects of frostbite cases treated at Dr. Soetomo General Academic Hospital in Surabaya.
Case Illustration: We present three cases of frostbite in adults who were part of a Mount Denali expedition, reaching an altitude of 6192 meters. Initial treatment included rewarming and pain relief. They were admitted to our facility 11st days after the injury, with one patient undergoing finger amputation on the 71st day. All received standard antibiotics and three days of hospital care. No initial surgeries were performed; instead, wound checks and rehabilitation were done as outpatients. On the 71st day, one patient had the third and fourth fingers amputated. The study found changes in platelet counts during the acute frostbite phase but no significant changes during the subacute phase following cold exposure.
Discussion: The cases showed substantial improvements in wound healing, reduced swelling, increased mobility, and overall better health. Clear demarcation of damaged tissue occurred during observation. While frostbite is rare in tropical areas, it can impact individuals in cold-weather activities like mountain climbing and winter sports. Effective prevention and management are vital for good outcomes. Initially, conservative treatment is suggested, but surgery may be needed when the extent of tissue damage is apparent.
Conclusions: Long-term follow-up management is necessary to achieve a good functional outcome. Preservation and if necessary reconstruction of the finger should become a priority in the patient management.

Highlights:

1. This study presents three cases of frostbite in adults who participated in a Mount Denali expedition, highlighting the treatment process and outcomes.
2. The importance of long-term follow-up management and prioritizing finger preservation and potential reconstruction in patient care.

INTRODUCTION

Frostbite is the most common cold injury in mountaineering and is frequently seen in high-altitude climbers[1]. Frostbite is a thermal injury and the clinical features of frostbite relate to the initial freezing and the subsequent thawing of tissue, and the severity is dependent upon the temperature and duration of exposure[2]. Injury due to cold may be general or local. Local cold injury may occur at temperatures above freezing (wet-cold conditions), as in immersion or trench foot. At temperatures below freezing (dry-cold conditions), frost bite occurs; the tissues freeze and ice crystals form in between the cells[3]. Local cold injury may or may not be associated with hypothermia. Although frost bite is the most common cold injury[4], in

civilian life, frost bite is uncommon despite populations of about 100 million at risk in areas where sub-zero temperatures occur at some period of the year3. Among mountaineers at high altitude this cases still occur regularly[4].

Frostbite is a thermal injury and the clinical features of frostbite related to the initial freezing and the subsequent thawing of tissue, and the severity is dependent upon the temperature and duration of exposure. The wide spectrum of injuries observed range from minimal tissue loss and mild long-term sequelae, to extensive necrosis and subsequent amputation. Such severe injuries can have devastating consequences in young, otherwise fit individuals[2].

CASE ILLUSTRATION

Symptoms

Patients initially describe a cold numbness with accompanying sensory loss[2]. The extremity feels cold to touch and it feels clumsy, "like a block of wood". Thawing and reperfusion is often intensely painful and pain may persist for weeks or months, even after tissue demarcation. Residual tingling sensation starting after one week has been described and may be due to an ischaemic neuritis[7]. Symptoms are exacerbated by warm environments. Other sensory deficits include spontaneous burning and electric current-like sensations and may persist for years after the initial injury[2].

Signs

Initial appearances are often deceptively benign. However with thawing, frozen tissue may appear mottled blue, yellowish-white or waxy. Following rapid rewarming, there is an initial hyperemia even in severe cases, often with a purplish discoloration[2].

Classification

Frostbite injury has been classified as either mild/superficial (no tissue loss) or severe/deep (with loss of tissue)[2], and this classification is based upon final outcome (Table 1). Cauchy et al[8] proposed a predictive classification system that is based on the topography of the lesion(s) and early 99 technetium bone scanning. Using these techniques it is now possible accurately to predict the likely outcome as early as two days (Table 2).

Table 1. Classification of Cold Injury According to Severity[2]

Initial lesion	Radiotraceruptake on bone scan	Skin blisters	Grade
None	Not indicated	None	1
Distal phalanx	Hypofixation of radiotracer	Clear fluid	2
Middle phalanx	Absence of uptake on digits	Haemorrhagicon digits	3
Carpal or tarsal	Absence of uptake on carpal/tarsal	Haemorrhagicon carpal/tarsal	4

Table 2. Cauchy Predictive Classification of Frostbite[8]

Grade	Outcome
1	No amputation, no long term sequelae
2	Soft tissue amputation with fingernailsequelae
3	Bone amputation on digit. Functionalsequelae
4	More extensive amputation, may develop thrombosis or sepsis. Functional sequelae

Table 3. Classification of Frostbite Degree

Superficial Frostbite
1st degree – Partial skin freezing – Erythema, edema, and hyperemia – No blisters or necrosis – Occasional skin desquamation (5-10 day later)
Full-thickness skin freezing
2nd degree – Erythema, substantial edema – Vesicles with clear fluid – Blisters, desquamation and black eschar (gangrene) formed – Deep frostbite 3rd Degree –Full-thickness skin & subcutaneous freezing –Violaceous/haemorrhagic blisters –Skin necrosis –Blue-grey discoloration 4th Degree –Full-thickness skin, subcutaneous tissue, muscle, tendon and bone freezing –Little edema –Initially mottled, deep red or cyanotic –Eventually dry, black and mummified

Frostnip

Skin becomes white and loses sensation. On rewarming becomes hyperemic and paraesthetic. Recovers completely. paraesthesia persists for some weeks. Cauchy et al proposed a new classification of frostbite lesions involving the extremities and is based upon findings after initial rewarming and on day 2 after admission. Parameters a) initial lesion on day 0 after rapid rewarming, b) radiotracer uptake in bone scan on day 2, c)skin blisters on day [2].

Maintenance of the central core temperature is essential to life and this may be carried out at the expense of the peripheral expendable structures such as the toes and fingers[3]. Cold damages tissues through cellular injury and vascular impairment. Cellular injury may be due to intracellular water crystallization, temperature-induced protein changes and membrane damage[5]. Vasoconstriction, endothelial injury, and thromboembolism contribute to vascular insufficiency and ischemia. Overtime, necrosis and gangrene becomes apparent[1]. Mummification and autoamputation may occur[6].

We report 3 adults who suffered frostbite of the hand and face following Mount Denali Expedition (6192 meters above sea level) in early June 2017. At the summit (6192 m) 2 patient felt extremely cold. When they took off his gloves to take pictures, they felt even colder and had severe pain in all of their fingers. They was shivering and had numbness and tingling in his extremities. They also felt fatigued with loss of appetite and they drank very little fluid. By the time they descended to base camp, they had swelling of the fingers with darkening of the skin of some of his fingers. They also got reddish on his nose and cheek Gradually, the swelling in the fingers turned into blisters, some of which ruptured spontaneously. / ne patient stays in the basecamp Çot his nose sliÇhtly swollen and turn darËer with painful on touch‼ (e Çot no blister nor swollen finÇer‼

When the two climber reached base camp, their hands and feet had already thawed spontaneously. The patients get rewarming as first treatment. Povidone-iodine dressing was applied and sent to local clinics by helicopter. On the local clinic the patients is given Silver sulfadiazine dressing on is fingers and tetanus toxoid injection was given. Blistered areas were not debrided. they was given analgesics and the patient go back to Indonesia.

Figure 1. Case 1 Pre- and Post Treatment

Figure 2. Case 2 Pre- and Post Treatment

Figure 3. Case 3 Pre- and Post Treatment

On day 11th after injury the patient arrived at our hospital, the first patients finger was turning to black on the distal

phalanx and have some blister on his right hand. his nose got dark colored but his does not feel pain, the sensation is a little decreased.

The second patient got blister both of his hand and dark colored nose with decreasedsensation on his nose. The finger is painful to touch. The third patient (who doesn't go to the summit) got blacked nose with decreasedsensation.

After 3 days of intravenous antibiotics administration, the patient treated as outpatient and have routine follow up for regular wound evaluation and rehabilitation. The first patient got his 3rd and 4th finger getting darked and mumificated. On day 71st after injury,the patient performed amputation. The dark coloured nose is fadedand barely seen, and the sensation turned tonormal.

The second patient got his finger turned to normal, the necrotic skin debrided and we found there already epithelialization underneath it. Although the still feel tingling sensation on touch. The nose is getting normal,with improved sensations.

Maintenance of the central core temperature is essential to life and this may be carried out at the expense of the peripheral expendable structures such as the toes and fingers[3]. Cold damages tissues through cellular injury and vascular impairment. Cellular injury may be due to intracellular water crystallization, temperature-induced protein changes and membrane damage[5]. Vasoconstriction, endothelial injury, and thromboembolism contribute to vascular insufficiency and ischemia. Overtime, necrosis and gangrene becomes apparent[1]. Mummification and autoamputation may occur[6].

The third patient blacked nose is turned to normal, the necrotic skin was debrided and the epithelialization was formed underneath it. The sensation was turn to normal.

DISCUSSION

Frost bite is the most common cold injury[4]. Extremities are most commonly affected[9]. One of the major groups at risk of frostbite is mountaineers, who are mostly affected in cold seasons and at high altitudes. Frostbite occurs when unprotected tissue is exposed to temperatures well below freezing even for relatively short periods[10]. The tissues in the affected areas freeze. Ice crystals form intracellulary (if freezing is very rapid) or in the intracellular space. This results in water being drawn out of the cell, causing cell damage. Concurrently, there is slowing of blood flow in the affected area, eventually leading to thrombosis and to tissue ischemia[7].

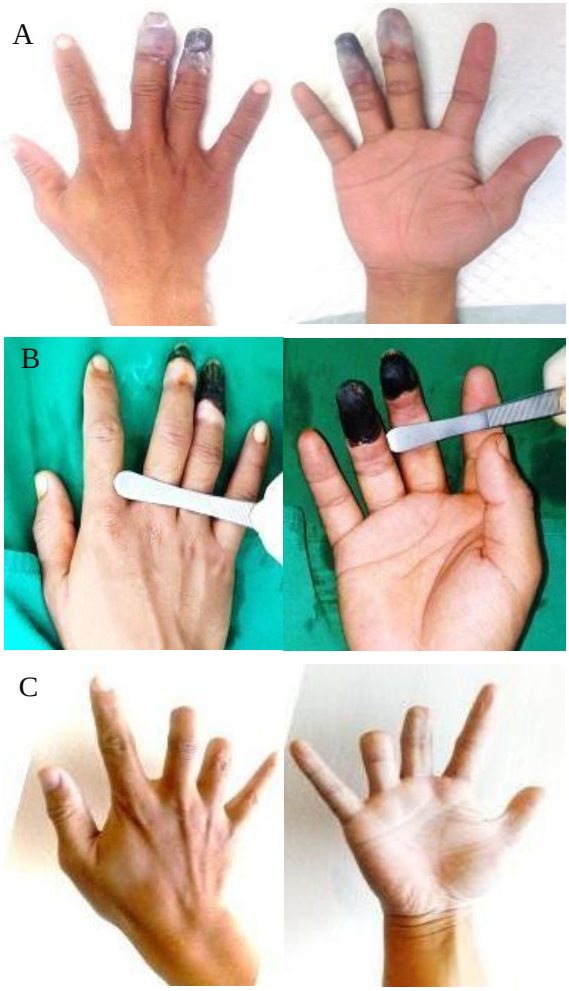

Figure 4. Case 1. Finger Follow-Up after Treatment. (A) Pre- Treatment, (B) Follow-Up Day-54, (C) Follow-Up 6 Month

From the clinical view point it is classified into four degrees of progressive injury identified by physical signs and the following sequelae[11,12]. First degree injury is characterized by epidermal involvement, which causes erythma, mild edema, and sequelae over the next few weeks such as desquamation and cold sensitivity. Second degree injury is full thickness skin freezing with substantial edema and formation of clear blisters, which contract and dry within two to three weeks, forming a dark eschar. Third degree injury is characterized by formation of hemorrhagic blisters, blue-greydiscolouration of the skin, deep burning pain or rewarming, thick gangrene eschar formation. In fourth degree injury, muscle, bone and tendons are involved. Our patient had probably sustained a fourth degree frost bite injury which had sequentially led to autoamputation of distal portion of her feetover time[13].

Factors that contribute to frostbite include hypothermia, inadequate clothing, wet clothes, wind chill, and dehydration from increased metabolic activity associated with climbing[1,10].

In addition, fluid loss, inadequate intake of water, hypoxia due to high altitude, and poor circulation from any cause, such as tight boots, increase the risk of frostbite. Certain medications, smoking, alcohol use, or any systemic or local disease affecting blood vessels may also predispose to frostbite[7,10]. Initial treatment of frostbite is rapid rewarming of the frozen tissue by submersion in warm water at 37°C to 39°C (just above body temperature) until return of circulation, usually about 15 to 30 minutes. High temperature thawing may be deleterious. Thawing and subsequent refreezing can cause devastating tissue injuries[14,15].

Two main reactions take place when tissues come into contact with a very cold object. Firstly, a vascular reaction occurs under the frozen superficial tissues consisting of damage to the wall of the blood vessels, leakage of plasma into the tissues (forming blisters), and an increased viscosity of the remaining intravascular blood, with local hemoconcentration or "sludging." The small vessels may thus become blocked. If the blood flow is then stopped by the action of the precapillary sphincters, the arteriovenous shunts will open up and blood bypasses the frozen area, which becomes avascular: in other words, the diseased part is sacrificed for survival of the whole organism[13].

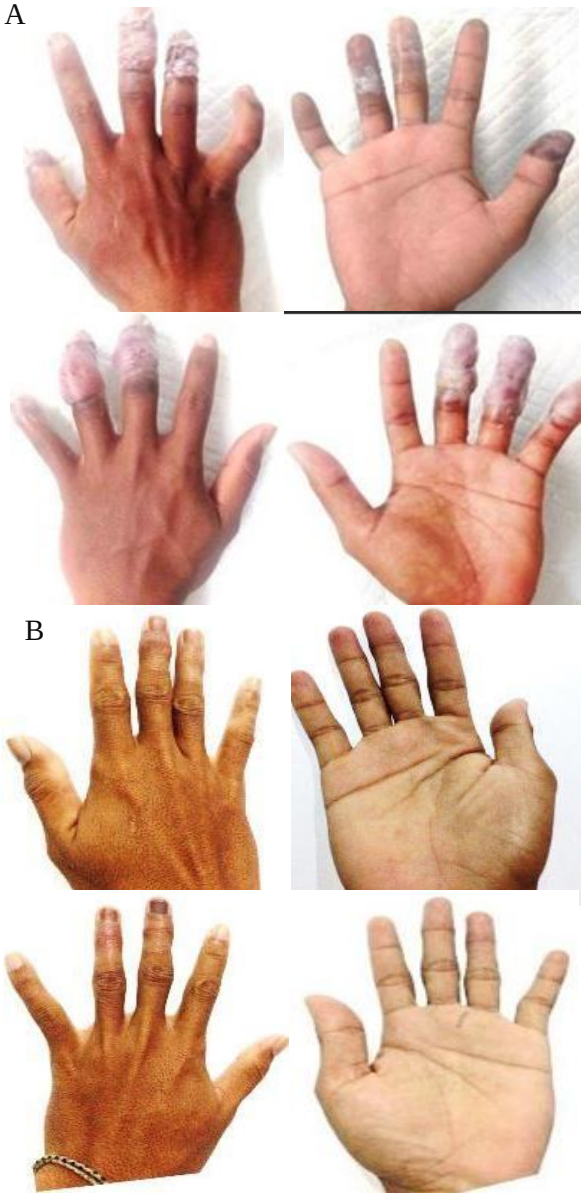

Figure 5. Case 2. Finger Follow-Up after Treatment. (A) Pre- Treatment (B) Follow-Up 6 Month

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The second reaction is the formation of intercellular ice crystals. The intracellular osmotic pressure rises and enzyme mechanisms are disturbed with subsequent cell death[3]. A layering system, which creates a microclimate around the body protecting against cold and wind, is highly efficient in preventing frost bite and hypothermia[4]. Management of such cases demands attention to hypothermia and local cold-induced injury as well as to coexisting trauma, infection and intoxication if any. In the prehospital care of frost bite, nonadherent wet clothing should be removed. Local rewarming started. In hospital, rapid rewarming of a frost bitten extremity in a bath of water between 40°C and 42°C for 15 to 30 minutes may minimize tissue loss[16]. Splinting and elevation of affected part reduce edema and improve perfusion. Hospital stay for patients with deep frost biteis often prolonged. Surgical amputation may be required many weeks after the injury[4]. *Aloe vera* dressing, wrapping, and elevation of the frostbitten extremities are often recommended. *Aloe* vera may aid healing of frostbite[17]. Tetanus prophylaxis and analgesics are routinely recommended[7,15]. Antibiotics are not routinely prescribed for all cases of frostbite. However, we decided to use antibiotics, since we suspected localized infection. Use of thrombolytic therapy, either locally or systematically, shows promise. It may improve tissue perfusion and reduce amputations[14,15]. There are claims that hyperbaric oxygen may improve blood flow in frostbitten areas more than 2 weeks after the injury[7,10].

Debridement of necrotic tissues is generally delayed until there is a clear demarcation from viable tissues, a process that may take up to 3 months. Surgical intervention is reserved mainly for late treatment of frostbite or when guided by advanced imaging such as triple-phase bone scanning or magnetic resonance imaging[7,14,15]. Even brief exposure to cold, as in our case where the climbers took off their gloves at the summit, can cause frostbite. Those who recognize these problems and take preventive measures like drinking adequate fluids, wearing warm protective clothing, and using supplemental oxygen for mountain climbing are less likely to suffer from frostbite[7,10].

Simple steps to prevent hypothermia, hypoxia, and dehydration can benefit any climber at high altitude. Fortunately, our patient did not suffer any major sequelae of frostbite[18].

The study discusses a specific and relatively uncommon medical issue - frostbite resulting from a Mount Denali Expedition. This uniqueness can attract the interest of readers and researchers in the field of cold-related injuries. The article provides valuable clinical observations and outcomes of three cases of frostbite. The improvements in wound epithelialization, resolution of edema, range of motion, and general condition are noteworthy, as they contribute to the understanding of frostbite management. The study highlights the importance of timing in surgical intervention, specifically in the case of amputation. The decision to perform amputation on day 71 after injury is discussed, which can serve as a reference point for medical practitioners facing similar cases.

The novelty of this study lies in the geographical context of the frostbite cases. Frostbite is indeed rare in tropical countries, making this report unique in its focus on individuals who engage in extreme cold activities like mountain climbing.The article delves into the decision-making process between conservative and surgical management based on the demarcation of the wound. This aspect of frostbite management, especially in the context of the specific cases presented, adds a novel dimension to the discussion.

The fact that these frostbite cases occurred during a Mount Denali Expedition distinguishes them from typical frostbite cases, which often happen in different circumstances. The expedition's extreme conditions and challenges set these cases apart. The cases presenting to the institution on day 11 following the injury highlight a unique aspect. This delay in seeking medical attention and its impact on frostbite management and outcomes could be of interest to the medical community. The emphasis on long-term follow-up management for achieving a good functional outcome sets this article apart. It underscores the importance of continued care and rehabilitation in frostbite cases, which may not be commonly discussed in the literature.

CONCLUSION

While frostbite occurrences are infrequent in tropical regions, they can still affect individuals engaged in activities involving extreme cold, such as mountain climbing and winter sports. Effective prevention and proper treatment are essential to achieve favorable outcomes. Following appropriate conservative treatments initially, surgical intervention should be considered by surgeons when the extent of tissue damage is well-defined. Maintaining long-term follow-up care is crucial to ensure a positive functional outcome. The preservation of affected digits should be a primary focus in patient management, with reconstruction being considered when necessary.

ACKNOWLEDGMENT

The authors would thanks to Department of Plastic Reconstructive and Aesthetic Surgery, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in this study.

FUNDING DISCLOSURE

The authors declare there is no financial interest in this study.

AUTHORS CONTRIBUTION

All authors contributed to make this study.

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