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The Planica Protocol for Frostbite Management - 3 Case Reports

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Abstract

Frostbite is a consequence of tissue freezing. Deep frostbite injury without proper treatment results in tissue loss. The damage is mainly a consequence of irreversibly damaged vascular endothelium and vascular occlusion and partly a direct effect of cold on peripheral body areas. Amputations in hands have a strong impact on functional impairment and leave behind permanently disabled patients. Different diagnostic and therapeutic protocols for frostbite management have been developed and are implemented nowadays. The Planica protocol for frostbite management has evolved from our own research in years of clinical practice. It emphasizes frostbite as emergency condition. Three cases of alpinists are presented, who suffered frostbite on different mountains and altitudes. After hospital admission, all three alpinists were treated according to the Planica diagnostic and therapeutic algorithm for frostbite management (medication with iloprost, pentoxifylline, enoxaparin, ibuprofen, pantoprazole, amoxicillin/clavulanic acid). Additionally, management with Hyperbaric Oxygen therapy (HBO) was administered. In all patients, the preserved length of injured digits was larger, as it had been estimated at the admission and at the bone scans. Additionally, to the proper first aid and prompt emergency medical assistance, the Planica protocol for frostbite management consists of standardized hospital treatment, which is the key for a favorable outcome (without tissue loss).

Keywords: Frostbite; Freezing cold injury; Amputations; Hyperbaric oxygen treatment

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Introduction

Frostbite occurs as a consequence of tissue freezing. It mostly affects peripheral body areas (toes, fingers, ears, nose) [1]. We differentiate superficial and deep (severe) frostbite. Frostbite most commonly occurs in the feet, where deep frostbite injuries with toe amputations do not cause considerable inability [2]. In the hands, severe frostbite can cause considerable physical impairment [3]. Compared to burns, which have a similar pathophysiological mechanism, frostbite is 35-times less probable [4-7]. This might be one of the main reasons for inadequate or at least not standardized frostbite management in many first responders and hospitals, once these injuries occur [4,5].

Frostbite is linked to groups of people and activities with significant exposure to cold (alpinists, skiers, biathletes, soldiers, hikers) [6,8]. Many different frostbite protocols have been proposed for frostbite treatment [2,9-11]. In Slovenia, we treat between 5 and 10 patients a year, mostly alpinists who have suffered frostbite in mountains abroad [2,12]. In the past few years, we implemented a diagnostic and therapeutic algorithm for treating frostbite – the Planica protocol [2,12], named after Planica Olympic and Research Centre in Sports Resort in Planica, Slovenia. In all our patients we confirmed that frostbite is an emergency condition where early first aid, prompt emergency medical assistance and standardized hospital treatment are keys for a favorable outcome (without amputations) [2,12].

Materials and Methods

Case I: Matterhorn (4478 m), north wall

A 24 years old alpinist climbed the Matterhorn north face (Schmid route) in late autumn. The

Table 1: Medication dosages of Planica protocol.

Medication type	Dosage/manner	Duration of treatment
Ibuprofen	2-3 x 400 mg p.os	4 weeks
Pantoprazole	1 x 40 mg p.os	4 weeks
Pentoxifylline	3 x 400 mg p.os	4 weeks
Enoxaparin	40 mg s.c.	4 weeks
Amoxicillin/clav. acid	1,2 g/8h and 1000mg 2x1	1 week i.v, 3 weeks p.os
Iloprost	1-2ng/kgBW/min i.v. (6h/day)	3 weeks
Hyperbaric oxygenation	1x to 2x 90 min/day at 2,5 absolute atmospheric pressure	4 weeks
tPA (tissue Plasminogen-Activator)*	If<24h after Frostbite occurrence: 0.15 mg/kg over 15 minutes, followed by a continuous IV infusion of 0.15 mg/kg per hour for six hours.	1 day

rope team started 3 h before sunrise at Hoernli Hut (3260 m) but made very slow progress due to bad snow and ice conditions. The estimated temperature at 3,260 m was -10°C. At 4,000 m they were trapped by darkness and decided to bivouac after a few unsuccessful attempts to find the right couloir. They spent a night without sleeping bags on a narrow shelf in the north wall. Due to lack of sensation of one climber's toes they continued to climb at night. They summited 5 h after sunrise and descended via normal route to the Hoernli hut and later with cable car to Zermatt. The frostbitten climber did not rewarm his toes during or after descent. His toes were whitish and not sensitive to touch or pain. After arriving home (after 10 h driving), he was admitted to the Ljubljana Medical Centre (36 h to 40 h after the occurrence of frostbite). The clinical examination revealed deep frostbite of 8 of 10 toes with concomitant loss of tactile and pain sensation.

Case II: Frostbite during a winter ascent in the Alps, north wall

A 22 years old alpinist and his teammate bivouacked in sleeping bags at an altitude of 2,000 meters during a winter ascent of a north wall route in the eastern Alps. On the day 2 of the climb, one alpinist lost his climbing mittens and continued climbing with wet and thin gloves. After leading a difficult pitch, he stopped feeling any sensation in all of his fingers and could no longer warm them up. The estimated temperature at that altitude (2500 m) was -15°C. They climbed out of the wall at 10 pm and tried to warm up the fingers in warm water. They descended to 2,300 meters of altitude and called for help. They were airlifted by a rescue helicopter in the early morning hours and the frostbitten alpinist was transferred to a local hospital, where deep frostbite of all fingers was suspected. According to this diagnosis, the patient was transferred to a medical center about additional 24 h later, where the management started.

Case III: Frostbite during summit push on Pik Lenin (7134 m), northeast ridge

An 18 years old alpinist set off towards Pik Lenin from camp III (6000 m) in bad weather. After summiting, the storm worsened and he and his party (2 more alpinists) were forced to bivouac in the same camp III for several nights. The injured alpinist wore single layered footwear, while his teammates had double mountaineering boots. Apart from exhaustion and dehydration, he did not feel his fingers and toes after coming to the tent anymore and could not rewarm them in the sleeping bag. After spending three more days captured in bad weather in the high-altitude tent, the three alpinists were rescued by a local rescue team, which accompanied them in fog and bad weather to the base camp (3600 m). After rescue descent, many of the alpinist's fingers and some toes remained unsensible and manifested color change. After 3 more days and 6 days after frostbite onset, he contacted a doctor. He started to take acetylsalicylic acid in preventive dosage and antibiotics. Complete frostbite management started ten days after frostbite onset and after arrival home.

All three alpinists were treated according to the Planica diagnostic and therapeutic algorithm of treating frostbite in the hospitals (Figure 1) [2]. Only alpinist 2 rewarmed his fingers in warm water. Alpinist 3 took acetylsalicylic acid as part of first aid (onset 5 days after initial injury). During hospital treatment all patients received the following medication: Iloprost, pentoxifylline, enoxaparin, ibuprofen, pantoprazole, amoxicillin/clavulanic acid and Hyperbaric Oxygenation (HBO). All medications (except tPA) are of grade C according to the Oxford Centre for Evidence-Based Medicine Grades of Recommendation [2]. The dosages are evident from Table 1.

During hospital treatment, with the exception of alpinist 3, a Triphasic Bone Scintigraphy (TS) was performed. The ideal TS-timing is on admission (diagnosis of deep frostbite) and on day 10 (treatment evaluation and prognosis), which is an established diagnostic examination in case of suspicion of deep frostbite and a reliable prognostic method for predicting future outcomes [12-14].

In all three patients the blisters were aseptically excised immediately after hospital admittance and the wound dressings were changed every second day [2,12].

All patients were treated with HBO at 2,5 ATA once or twice daily for 90 min at intermittent 100% oxygen and air respiration every 10 min (30 days in patient 1, 20 days in patient 2 and 20 days in patient 3) [15-17].

Results

Amputations were performed on day 45 after admittance in patient 1 and on day 30 in patient 2 after clear demarcation of dry necrosis from vital tissues. In patient 3 the amputations were performed on day 60 after admittance.

Figures 2, 3 and 4 show improving of the tissue demarcation line and satisfactory final outcome comparing to incipient clinical status.

Discussion

In many cases, deep frostbite ends with amputations. According to data from the literature, the likelihood of amputations despite appropriate first aid and medical treatment depends on various factors and encompasses between 1% (if frostbite occurs in the distal joint) and up to 67% if deep frostbite occurs on the proximal

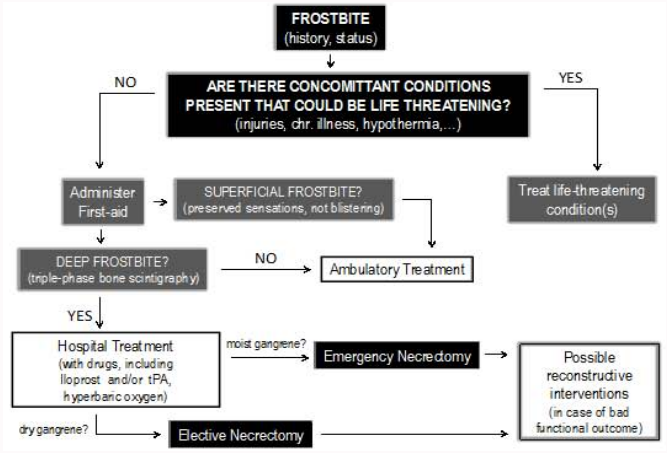

Figure 1: Planica protocol for frostbite management.

Figure 2: Toes of case I at week 1, week 4 after frostbite onset and after amputations, respectively. Note remarkable tissue preservation despite bad prospects at the start of therapy.

Figure 3: Fingers of case II at week 1, week 3 after frostbite onset and after amputations, respectively. Note successful preservation of left index finger and most of right index finger and other digit's length in all fingers despite incipient demarcation line at the proximal phalanges of all digits.

digits' phalanx [18]. The average probability of amputations in deep frostbite is 41% according to foreign reports [10] and 45% according to our own data [2]. If deep frostbite is left untreated, the probability of amputations is 100% [10].

In first two cases, the crucial positive circumstance was the short time that elapsed since the occurrence of frostbite ant management onset (36-40 hours in Case I and 32 h in Case II). Bad outcomes in deep frostbite are directly related to time, that elapses from the injury. Most frostbite cases, especially from remote areas (like Himalayas) occur several days or even weeks prior to the implementation of treatment [2,19].

Despite clear and simple first aid instructions in case of frostbite, its practical implementation still presents a problem in the field. The first aid encompasses rapid rewarming in warm water (37-40°C), wound management and immobilization of injured body parts as soon as the damaged (frostbitten) body parts are no longer exposed to further freezing or mechanical strains (walking, climbing) [2,5]. Beneficial effects of proper first aid in frostbite can be improved through constant alpinists´ and mountaineers' education [5,20].

In case I, rapid rewarming immediately after the occurrence of frostbite was not realistically possible. The only option of rescue (evacuation) in bad weather was continuing the climb in the north wall over the summit of the mountain and descending along the Hoernli ridge (normal route) back to the valley (a total of 10-12 h walking/climbing with injured toes). Rewarming would have been possible and reasonable after arrival to the valley; however, this alpinist did not think of it. It is also known that placing strain on frostbitten body parts leads to vascular microtrauma that reduces the probability of good outcome [2,11,20]. However, active rewarming after passive thawing is disadvised as it might lead to reperfusion injury [5]. Despite these facts, the final outcome in case I was surprisingly good and can be contributed to the multimodal management according to the Planica Protocol, including HBO, despite its late onset [21,22].

Figure 4: Fingers and toes of case III at week 2, week 3 after frostbite onset and after amputations, respectively. Despite management, no major differences were seen between the level of initial demarcation and later at the level of amputations.

The alpinist in case II did rewarm the fingers, once he did not use them for climbing any more - a fact, that probably improved his final outcome [2,11]. After arrival in the valley, immediate admission to a medical center would be beneficial for him (availability of TS and HBO) [2,23,24].

The alpinist in case III did not show any improvement in the preservation of tissue after treatment. This may be contributed to long term exposure (>72 h) to hypoxic conditions at high altitude after frostbite occurrence and long-time that passed before frostbite management was started (10 days).

In our three case reports, the management was started >24 h after frostbite onset and the standard protocol was used (Table 1). In case of even earlier hospital admittance (<24 h after onset of frostbite) the use of tissue Plasminogen Activator (tPA) would be an additional option, according to literature (grade C recommendation) [18,25,26].

Triphasic Scintigraphy (TS) is a powerful tool in the diagnosis of deep frostbite and should be a standard procedure to diagnose deep frostbite, evaluate treatment response and make more reliable prognosis. The initial TS scan should be started as soon as possible after admittance to the hospital. Control TS is recommended 8 days later [12,13].

The use of medication after occurrence of deep frostbite is of great importance. All of them help support microcirculation, and the preservation of tissue. As each of the drugs has its own mode of action, the combination of their use seems reasonable in the treatment of frostbite [2,25,26]. However, the use of antiaggregating, anti-inflammatory, thromboprophylactic, vasodilative and antibacterial drugs is only empyrical, lacking wide evidence-based consensus [2,11].

The role of HBO can play the key bridging role in oxygenating sub-vital peripheral tissues in frostbite [16,17]. It should be started as soon as possible in deep frostbite and performed uninterruptedly for 2 to 3 weeks after admittance [2,15]. Even late HBO with up to 2 weeks delay seems to be effective, as described recently, and should not be ruled out in alpinists who are admitted to the hospital with such delays [21,22,27].

Many frostbite-management protocols have been proposed in the past by different authors [2,9-11]. They all have in common, that frostbite is an emergency situation that requires prompt treatment in order to save as much tissue as possible [25,26]. Standardized diagnostics and treatment is essential. We propose Planica management protocol as an universal protocol, that can improve the final outcome in deep frostbite. It can also suit hospitals with low frostbite incidence, once they fulfil the protocol conditions [2].

Conclusion

Deep frostbite is an emergency that requires prompt hospital admittance in order to avoid tissue loss. Key factors for a good outcome are the time elapsed since the frostbite onset, adequate first aid, standardized management with a combination of drugs and HBO. The Planica protocol for frostbite facilitates diagnostic and treatment procedures, especially in areas or countries, where frostbite is not a frequent pathology.

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