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CONCEPTS

A New Proposal for Management of Severe Frostbite in the Austere Environment

Emmanuel Cauchy, MD; Christopher B. Davis, MD; Mathieu Pasquier, MD; Eric F. Meyer, MD; Peter H. Hackett, MD

From the IFREMMONT: Institut de Recherche et de Formation en Medecine de Montagne, Hôpital de Chamonix, Chamonix, France (Dr Cauchy); the Hôpitaux des Pays du Mont-Blanc, Sallanches, France (Dr Cauchy); the University of Colorado Denver School of Medicine, Department of Emergency Medicine, Aurora, CO (Drs Davis and Hackett); the Emergency Service, Lausanne University Hospital, Lausanne, Switzerland (Dr Pasquier); the Air-Glaciers SA and GRIMM, Sion, Switzerland (Dr Pasquier); the Rural Partners in Medicine, LLC, Steamboat Springs, (Dr Meyer); and the Institute for Altitude Medicine, Telluride, CO (Dr Hackett).

Despite advances in outdoor clothing and medical management of frostbite, individuals still experience catastrophic amputations. This is a particular risk for those in austere environments, due to resource limitations and delayed definitive treatment. The emerging best therapies for severe frostbite are thrombolytics and iloprost. However, they must be started within 24 hours after rewarming for recombinant tissue plasminogen activator (rt-PA) and within 48 hours for iloprost. Evacuation of individuals experiencing frostbite from remote environments within 24 to 48 hours is often impossible. To date, use of these agents has been confined to hospitals, thus depriving most individuals in the austere environment of the best treatment. We propose that thrombolytics and iloprost be considered for field treatment to maximize chances for recovery and reduce amputations. Given the small but potentially serious risk of complications, rt-PA should only be used for grade 4 frostbite where amputation is inevitable, and within 24 hours of rewarming. Prostacyclin has less risk and can be used for grades 2 to 4 frostbite within 48 hours of rewarming. Until more field experience is reported with these agents, their use should probably be restricted to experienced physicians. Other modalities, such as local nerve blocks and improving oxygenation at high altitude may also be considered. We submit that it remains possible to improve frostbite outcomes despite delayed evacuation using resource-limited treatment strategies. We present 2 cases of frostbite treated with rt-PA at K2 basecamp to illustrate feasibility and important considerations.

Key words: frostbite, prostacyclin, thrombolytics, field treatment

Introduction

Even with today's advances in improved outdoor clothing, preventive efforts, and medical management, severe frostbite still occurs, often resulting in catastrophic amputations. The risk of amputation is particularly high when injuries occur in the austere environment, where resources are limited. Groups at increased risk include winter recreationists such as alpinists, skiers, snowmobilers, and polar travelers, as well as those working or assigned to cold-weather operations, including the military. The main reason for poor outcome in this environment is usually delay in definitive care, which is often unavoidable. The emerging use of thrombolytics and iloprost offers the first major advances in the treatment of frostbite in decades and has reduced the rate of amputation. However, these therapies have been confined to hospital use. Given the remote locations in which many of these injuries occur, and the urgency of timely treatment, serious consideration should be given to employing these treatments in the prehospital setting under certain conditions. In this article, we discuss the field management of severe frostbite, and the indications, risks, and methods for use of thrombolytics or prostacyclin by a trained physician. We also suggest the possible adjunctive therapies of oxygenation at high altitude, and peripheral nerve block.

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Corresponding author: Emmanuel Cauchy, MD, IFREMMONT: Institut de Recherche et de Formation en Medecine de Montagne, Hôpital de Chamonix, 509 route des Pélerins 74400 Chamonix France (e-mail: cauchy@ifremmont.com).

Field Management of Frostbite

Field treatment of frostbite remains challenging for several reasons. First is the difficulty of assessing the

severity of injury, a crucial determination that dictates management and evacuation decisions. Second is determining the time of onset of injury, duration of freezing, and time since thawing in those who have spontaneously thawed. Other difficulties include the logistics of evacuation to an appropriate facility, and the presence of comorbid conditions such as hypothermia, trauma, or medical illness. In addition, treatment greatly depends on medical capabilities and available supplies, a factor that has not previously been adequately considered in treatment algorithms for field management of frostbite. Finally, the most promising therapies for severe frostbite have been confined to hospital use and are unavailable, impractical, or inappropriate for field use. Tragically, too many patients reach the hospital too late for successful use of medical therapy.

EVALUATION OF THE SEVERITY OF THE INJURY AND AMPUTATION RISK

In both the field and hospital, evaluation of frostbite injury is based on presence or absence of perfusion after rewarming, combined with extent of nonperfused tissue. For assessing perfusion, careful examination includes skin color and temperature, sensation, pulses, and capillary refill. Expedition basecamps or field clinics as well as hospitals may have fast-response infrared thermometers, pulse oximeters, and even Doppler devices. The newer high-frequency Doppler devices offer marked improvement for assessing perfusion, and are used to assess microcirculation intraoperatively and in various grafts and flaps.[1,2] Handheld battery-powered models are available. Level of nonperfusion or discoloration can be described with the usual hand/foot anatomy of joints: metacarpophalangeal, proximal interphalangeal, distal interphalangeal, or tuft. A number of classification systems may be used to evaluate severity.[3,4] We offer a practical classification of frostbite injuries in the Figure, with details in a previous publication.[5] Although bone amputation risk depends on lack of perfusion to the bone, which cannot be determined in the field, soft tissue ischemia and cyanosis are surrogate markers for amputation risk, although not at the same level. That is, the eventual level of bone amputation is always distal to the boundary between normal color and cyanotic discoloration of the digit. After rewarming, a digit with cyanosis that extends proximal to the proximal interphalangeal joint must be considered at high risk for amputation distal to that joint; the greater the extent of cyanosis, the greater the risk of amputation (Figure). At high altitude, the risk of poor outcome may increase due to hypoxemia (Spo_2 < 90%, c. 4000 m), less vasodilation in the cold, dehydration, etc.; thus, grade 2 injuries, based on our experience, should be considered at higher risk for amputation at high altitude compared with low altitude. In the hospital setting, grading of frostbite severity is easier than in the field, due to the comfort and safety of the environment, availability of easy rapid rewarming, and observation over time. Although some practitioners obtain nuclear bone scans on day 0, the literature suggests that scanning only on day 2 or later improves prognostication.[6]

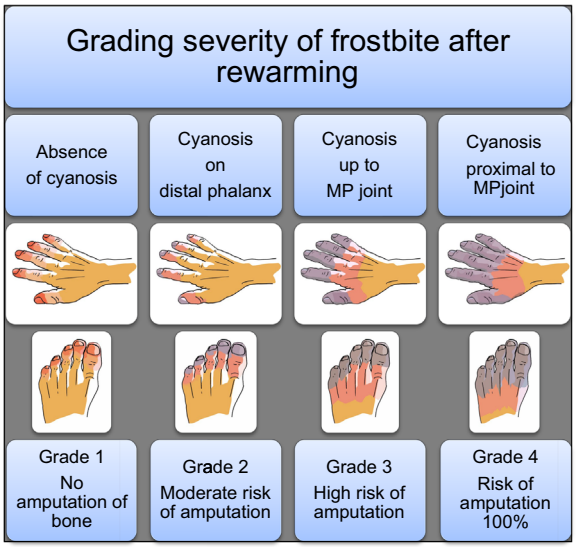

Figure. Grading severity of frostbite and bone amputation risk after rewarming.

BASIC FIELD CARE

A recent publication of frostbite management guidelines includes several important treatments for use in the field.[7] For example, the individual should rehydrate orally with warm fluids, and the injured extremity should be rewarmed by immersion in a 37 to 39°C water bath if there is low risk of refreezing. In order to treat hyperviscosity and inflammation, the guidelines recommend 12 mg/kg/day of ibuprofen, and others recommend aspirin.[8] In addition, low molecular weight dextran is a grade 2C recommendation for use when thrombolytics or iloprost are not going to be used. However, low molecular weight dextran is of questionable value and can cause anaphylaxis; we do not recommend it. If blisters appear, a dressing is suggested. Systemic antibiotics should be considered for severe frostbite (grades 3–4) in special circumstances. Others have suggested that for foot frostbite, anticoagulants should be considered to avoid the complications of thrombosis and phlebitis, especially if the individual is nonambulatory.[9]