Frostbite Treatment Guidelines Handout

This treatment guidelines handout is based on the Wilderness Medical Society (WMS) Clinical Practice Guidelines for the Prevention and Treatment of Frostbite. These guidelines provide evidence-based recommendations for the prevention, treatment and management of frostbite.

Prevention

The adage that “prevention is better than treatment” is especially true for frostbite, which is typically preventable and often not improved by treatment. Underlying medical problems such as peripheral vascular disease, malnutrition, Raynaud's disease, diabetes mellitus, and tobacco use may increase the risk of frostbite; prevention must address both environmental and health-related aspects.

Frostbite injury occurs when tissue heat loss exceeds the ability of local tissue perfusion to prevent freezing of soft tissues (blood flow delivers heat). One must both ensure adequate perfusion and minimize heat loss to prevent frostbite. The individual should recognize cold-induced “numbness” as a warning that frostbite injury may be imminent if protective or avoidance measures are not taken to decrease tissue cooling.

Subsequent loss of sensation does not mean the situation has improved; rather, receptors and nerves are not conducting pain/cold signals because they are nearing the freezing point.

Maintaining peripheral perfusion

Preventive measures to ensure local tissue perfusion include:

1. Maintaining adequate core temperature and body hydration;
2. Minimizing the effects of known diseases, medications, and substances that might decrease perfusion (including awareness and symptoms of alcohol and drug use);
3. Covering all skin and the scalp to insulate from the cold;
4. Minimizing blood flow restriction, such as occurs with constrictive clothing, footwear, or immobility;
5. Ensuring adequate nutrition; and
6. Using supplemental oxygen in severely hypoxic conditions (eg, >7500 m).

Recommendation: Strong recommendation, low-quality evidence.

Exercise

Exercise is a specific method to maintain peripheral perfusion. Exercise enhances the level and frequency of cold-induced peripheral vasodilation (CIVD). In one study, cold-induced peripheral vasodilation occurred in the toes of 58% of subjects who were exercising versus only 28% in those subjects not exercising.

Another study found increased skin temperature in the hands during exercise. An additional study demonstrated the CIVD response may be negatively affected by the introduction of hypoxia, whereas metabolic heat production via exercise may counteract adverse effects of hypoxia and improve CIVD responses.

However, using exercise to increase warmth can lead to exhaustion, with subsequent profound systemic heat loss should exhaustion occur. Recognizing this caveat, exercise and its associated elevation in core and peripheral temperatures may be protective in preventing frostbite.

Recommendation: Strong recommendation, moderate-quality evidence.

Protection from cold

Measures should be taken to minimize exposure of tissue to cold. These measures include the following:

1. Avoiding environmental conditions that predispose to frostbite, specifically below 0 °C (some risk 0 to −15 °C and increasing risk below −15 °C, even with low wind speeds)
2. Protecting skin from moisture, wind, and cold;
3. Avoiding perspiration or wet extremities;
4. Increasing insulation and skin protection (eg, by adding clothing layers, changing from gloves to mitts);
5. Ensuring beneficial behavioral responses to changing environmental conditions (eg, not being under the influence of illicit drugs, alcohol, or extreme hypoxemia);
6. Using chemical hand and foot warmers and electric foot warmers to maintain peripheral warmth (note: warmers should be close to body temperature before being activated and must not be placed directly against skin or constrict flow if used within a boot);
7. Regularly checking oneself and the group for extremity numbness or pain and warming the digits and/or extremities as soon as possible if there is concern that frostbite may be developing;

8. Recognizing frostnip or superficial frostbite before it becomes more serious; and
9. Minimizing duration of cold exposure. Emollients do not protect against—and might even increase—the risk of frostbite. The time that a digit or extremity can remain numb before developing frostbite is unknown; thus, digits or extremities with paresthesia should be warmed as soon as possible.

An extremity at risk for frostbite (eg, numbness, poor dexterity, pale color) should be warmed with adjacent body heat from the patient or a companion, using the axilla or abdomen.

Recommendation: Strong recommendation, low-quality evidence.

Field treatment and secondary prevention

If a body part is frozen in the field, the frozen tissue should be protected from further damage. Remove jewelry or other constrictive extraneous material from the body part. Do not rub or apply ice or snow to the affected area.

Refreezing Injury

A decision must be made on whether to thaw the tissue. If environmental conditions are such that thawed tissue could refreeze, it is safer to keep the affected part frozen until a thawed state can be maintained. Prostaglandin and thromboxane release associated with the freeze-thaw cycle causes vasoconstriction, platelet aggregation, thrombosis, and, ultimately, cellular injury.

Refreezing thawed tissue further increases release of these mediators, and significant morbidity may result. One must absolutely avoid refreezing if field thawing occurs.

Recommendation: Strong recommendation, moderate-quality evidence.

Spontaneous or passive thawing

Most frostbite thaws spontaneously and should be allowed to do so if rapid rewarming (described in the following) cannot be readily achieved. Warming with available methods, such as against warm body parts (eg, axilla), should be employed if rapid rewarming is not possible.

Do not purposefully keep tissue below freezing temperatures because this will increase the duration that the tissue is frozen and might result in more proximal freezing and greater morbidity. If environmental and situational conditions allow for spontaneous or slow thawing, tissue should be allowed to thaw.

Recommendation: Strong recommendation, low-quality evidence.

Strategies for 2 scenarios are presented:

- **Scenario 1:** The frozen part has the potential for refreezing and is not actively thawed.
- **Scenario 2:** The frozen part is thawed and kept warm without refreezing until evacuation is completed.

Therapeutic options for both scenarios

- **Treatment of hypothermia**

No studies examine concurrent hypothermia and frostbite. Hypothermia frequently accompanies frostbite and causes peripheral vasoconstriction that impairs blood flow to the extremities. Mild hypothermia may be treated concurrently with frostbite injury. Moderate and severe hypothermia should be treated effectively before treating frostbite injury following recommendations in the WMS Hypothermia Clinical Practice Guidelines.

Recommendation: Strong recommendation, low-quality evidence.

- **Hydration**

Vascular stasis can result from frostbite injury. No studies have specifically examined the effect of hydration status on frostbite outcomes, but appropriate hydration and avoidance of hypovolemia are important for frostbite prevention and recovery. Oral fluids may be given if the patient is alert, capable of purposeful swallowing, and not vomiting.

If the patient is nauseated or vomiting or has an altered mental status, IV fluids should be given to maintain normal urine output. Intravenous fluids should optimally be warmed (minimally to 37 °C but preferably to 40 °C to 42 °C with a method that has been proven to be effective in the present environmental conditions) before infusion and be infused in small (eg, 250 mL), rapid boluses because slow infusion will result in fluid cooling and even freezing as it passes through the tubing. Fluid administration should be optimized to prevent clinical dehydration.

Recommendation: Strong recommendation, low-quality evidence.

- **Low molecular weight dextran**

Intravenous low molecular weight dextran (LMWD) decreases blood viscosity by preventing red blood cell aggregation and formation of microthrombi and can be given in the field once it has been warmed.

In some animal studies, the extent of tissue necrosis was found to be significantly less than in control subjects when LMWD was used and was more beneficial if given early. In one animal trial, tissue in the LMWD group thawed slightly more rapidly, but overall tissue loss was no different from that of control animals. A test dose before administration is recommended because of the low risk of anaphylaxis. This low risk of anaphylaxis should not deter administration. The slight risk of bleeding is minimal, and benefits seem to outweigh this risk; however, availability is limited in the United States and the United Kingdom.

The use of LMWD has not been evaluated in combination with other treatments, such as thrombolytics or iloprost. If systemic treatment such as thrombolytic or iloprost therapy is not available or considered, LMWD should be administered if locally available.

Recommendation: Weak recommendation, low-quality evidence.

- **Ibuprofen**

Nonsteroidal anti-inflammatory drugs (NSAIDs) block the arachidonic acid pathway and decrease production of prostaglandins and thromboxanes. These mediators can lead to vasoconstriction, dermal ischemia, and further tissue damage. No studies have demonstrated that any particular anti-inflammatory agent or dosing is clearly related to outcome. Aspirin has been proposed as an option and is used in many parts of the world for anti-inflammatory and inhibition of platelet aggregation.

One rabbit ear model study showed 23% tissue survival with aspirin versus 0% in the control group. However, aspirin theoretically blocks the production of certain prostaglandins that are beneficial to wound healing, and the authors of the rabbit ear model study recommend ibuprofen in their treatment algorithm. No studies specifically compare aspirin with ibuprofen in frostbite. Ibuprofen should be started in the field at a dose of 12 mg/kg per day divided twice daily (minimum dose to inhibit harmful prostaglandins) to a maximum of 2400 mg/d divided 4 times daily.

Recommendation: Weak recommendation, low-quality evidence.

Specific recommendations—scenario 1

Therapeutic options for frostbite in scenario 1 (no active thawing) are as follows.

- **Dressings**

No evidence supports applying a dressing to a frostbitten part intended to remain frozen until rewarming can safely be achieved. If this is considered, it should only be done if practical and will not interfere with mobility. Bulky, clean, and dry gauze or sterile cotton dressings should be applied to the frozen part and between the toes and fingers.

Recommendation: Weak recommendation, very low-quality evidence.

- **Ambulation and protection**

If at all possible, a frozen extremity should not be used for walking, climbing, or other maneuvers until definitive care is reached. If use of the frozen extremity for mobility is considered, a risk-benefit analysis must consider the potential for further trauma and possible poorer outcome. Although it is reasonable to walk on a foot with frostbitten toes for evacuation purposes, it is inadvisable to walk on an entirely frostbitten foot because of the potential for resulting morbidity. This risk is theoretical and based on the panel's opinion.

Mills described frostbite patients who ambulated on frozen extremities for days and sustained no or limited amputation. If using a frozen extremity for locomotion or evacuation is unavoidable, the extremity should be padded, splinted, and kept as immobile as possible to minimize additional trauma.

Recommendation: Weak recommendation, low-quality evidence.

Specific recommendations—scenario 2

Therapeutic options for frostbite in scenario 2 (thawing and continued warming) are as follows.

- **Rapid field rewarming of frostbite**

Field rewarming should only be undertaken if the frozen part can be kept thawed and warm until the victim arrives at definitive care. Field rewarming by warm water bath immersion can and should be performed if the proper resources are available and definitive care is more than 2 h distant. Other heat sources (eg, fire, space heater, oven, heated rocks) should be avoided because of the risk of thermal burn injury. Rapid rewarming by water bath has been found to result in better outcomes than slow rewarming.

Water should be heated to 37 °C to 39 °C (98.6 to 102.2°F) using a thermometer to maintain this range. If a thermometer is not available, a safe water temperature can be determined by placing a caregiver's uninjured hand in the water for at least 30 s to confirm that the water temperature is tolerable and will not cause burn injury. Circulation of water around the frozen tissue will help maintain correct temperature.

Because the water will cool once the frostbitten tissue is immersed, the water should be regularly rewarmed and replaced while taking care not to burn the immersed skin. For example, immersion could alternate between two containers: one for thawing while the other is being reheated to the target temperature. If a thermometer is not available to measure water temperature, a healthy hand should be able to be fully immersed long enough to experience a very warm but tolerable sensation. Thawing tissue in a container that is actively being heated increases the risk of burn injury. If this is the only option available, immersed tissue should not touch the container itself.

The water should be stirred, and its temperature must be continually monitored with a thermometer or healthy hand. Rewarming is complete when the involved part takes on a red or purple appearance and becomes soft and pliable to the touch. This is usually accomplished in approximately 30 min, but the time is variable depending on the extent and depth of injury. The affected tissues should be allowed to air dry or be gently dried with a blotting technique (not rubbing) to minimize further damage. Under appropriate circumstances, this method of field rewarming is the first definitive step in frostbite treatment.

Recommendation: Strong recommendation, moderate-quality evidence.

- **Antiseptic solution**

Most injuries do not become infected, but adding an antiseptic solution (eg, povidone-iodine, chlorhexidine) to the rewarming water has theoretical benefits of reducing skin bacteria. Evidence for this practice does not exist for frostbite care, however. Adding an antiseptic solution to the water while rewarming is unlikely to be harmful and might reduce the risk of cellulitis if severe edema is present in the affected extremity.

Recommendation: Weak recommendation, very low-quality evidence.

- **Pain control**

During rewarming, pain medication (eg, NSAIDs or an opiate analgesic) should be given to control symptoms as dictated by individual patient situation

Recommendation: Strong recommendation, low-quality evidence.

- **Spontaneous or passive thawing**

According to the foregoing guidelines, rapid rewarming is strongly recommended. If field rewarming is not possible, spontaneous or slow thawing should be allowed. Slow rewarming is accomplished by moving to a warmer location (eg, tent or hut) and warming with adjacent body heat from the patient (eg, frozen hands/fingers in the axillae) or a caregiver, as previously described. The expert panel agrees that slow thawing is a reasonable course of action to initiate the rewarming process if it is the only means available.

Recommendation: Strong recommendation, very low-quality evidence.

- **Debridement of blisters**

Debridement of blisters should not be routinely performed in the field. If a clear, fluid-filled blister is tense and at high risk for rupture during evacuation, blister aspiration and application of a dry gauze dressing should be performed in the field to minimize infection risk. Hemorrhagic bullae should not be aspirated nor debrided in the field. These recommendations are common practice but lack evidence beyond case series.

Recommendation: Weak recommendation, low-quality evidence.

- **Topical aloe vera**

Aloe vera ointment has been shown in an observational study and an animal model to improve frostbite outcome by reducing prostaglandin and thromboxane formation. Topical agents do not penetrate far into tissues, however, so aloe vera is theoretically only beneficial for superficially injured areas. The study supporting the benefit of aloe vera examined its application on unroofed blebs where it would be able to penetrate underlying tissue. Topical aloe vera should be applied to thawed tissue before application of dressings.

Recommendation: Weak recommendation, low-quality evidence.

- **Dressings**

Bulky, dry gauze dressings should be applied to the thawed parts for protection and wound care. Substantial edema should be anticipated, so circumferential dressings should be wrapped loosely to allow for swelling without placing pressure on the underlying tissue.

Recommendation: Strong recommendation, low-quality evidence.

- **Ambulation and protection**

A risk-benefit analysis must consider the potential for further trauma and, ultimately, potentially higher morbidity if a thawed part is used for ambulation. For example, it might be reasonable to walk on a foot with thawed toes for evacuation purposes, but it is inadvisable to walk on a recently thawed frostbitten foot because of the potential resulting morbidity. Very little evidence is available to guide recommendations.

- **Ambulation and protection**

In one study, mobilization within 72 hours after thawing did not affect tissue loss, complications, or hospital length of stay.

After the rewarming process, swelling should be anticipated. If passive thawing has occurred, boots (or inner boots) may need to be worn continuously to compress swelling. Boots that were removed for active rewarming may not be able to be redonned if tissue swelling has occurred during the warming process. The panel's clinical experience supports the concept that a recently thawed extremity should ideally not be used for walking, climbing, or other maneuvers and should be protected to prevent further trauma.

Recommendation: Weak recommendation, low-quality evidence.

- **Elevation of extremity**

If possible, the thawed extremity should be elevated above the level of the heart, which might decrease the formation of dependent edema.

Recommendation: Strong recommendation, low-quality evidence.

- **Oxygen**

Recovery of thawed tissue partly depends on the level of tissue oxygenation in the postfreezing period. One small study that measured hand temperature at normobaric hypoxia found decreased skin temperatures with decreasing FIO2. However, hyperoxia has been found to cause vasoconstriction in the extremities and may increase mortality in patients with accidental hypothermia.

While the exact effects of hypoxia and hyperoxia are not completely described, oxygen should not be applied routinely to patients who are not hypoxic. Although evidence is lacking to support use of supplemental oxygen for frostbite, oxygen may be delivered by face mask or nasal cannula if the patient is hypoxic (oxygen saturation <88%) or at high altitude above 4000 m.

Recommendation: Weak recommendation, low-quality evidence.

Reference

McIntosh, S. E., Freer, L., Grissom, C. K., Rodway, G. W., Giesbrecht, G. G., McDevitt, M., Imray, C. H., Johnson, E. L., Pandey, P., Dow, J., & Hackett, P. H. (2024). Wilderness medical society clinical practice guidelines for the prevention and treatment of frostbite: 2024 update. *Wilderness & Environmental Medicine*. https://doi.org/10.1177/10806032231222359