Practice Guidelines

Frostbite: Recommendations for Prevention and Treatment from the Wilderness Medical Society

Key Points for Practice

- To prevent worsening tissue damage, a frostbitten extremity should be rewarmed only if there is no risk of refreezing.
- Rapid rewarming via water bath immersion and intravenous low-molecular-weight dextran leads to improved outcomes in frostbite.
- To limit tissue loss, oral ibuprofen should be started as soon as available and continued until surgery or complete healing.
- Tissue plasminogen activator improves outcomes for deep frostbite extending to proximal interphalangeal joints if given within 24 hours.

From the *AFP* Editors

Frostbite is divided into four overlapping phases: prefreeze, freeze-thaw, vascular stasis, and late ischemic. The prefreeze phase consists of tissue cooling, which leads to vasoconstriction and ischemia without ice crystal formation. In the freeze-thaw phase, ice crystals form intracellularly during rapid-onset freezing or extracellularly during a slower freeze. Thawing leads to ischemia, reperfusion injury, and an inflammatory response. In the vascular stasis phase, vessels fluctuate between dilation and constriction. The late ischemic phase involves progressive tissue ischemia and infarction from a cascade of events: inflammation, intermittent vasoconstriction, reperfusion injury, emboli in microvessels, and thrombus formation in larger vessels.

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This series is coordinated by Sumi Sexton, MD, editor-in-chief.

A collection of Practice Guidelines published in *AFP* is available at https://www.aafp.org/afp/practguide.

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First-degree frostbite causes numbness, erythema, and often edema. White or yellow, slightly raised plaque develops over injured areas. Second-degree frostbite causes erythema, edema, and superficial skin blisters. Third-degree frostbite causes deeper hemorrhagic blisters, indicating that the injury has extended into the reticular dermis and beneath the dermal vascular plexus. Fourth-degree frostbite extends completely through the dermis and involves comparatively avascular subcutaneous tissues, with necrosis extending into muscle and bone.

Frostnip is a superficial nonfreezing cold injury associated with intense vasoconstriction in exposed skin, usually the cheeks, ears, or nose. Ice crystals can form on skin surfaces, but not within the tissue. Numbness and pallor resolve quickly after warming, and no long-term damage occurs.

Prevention

The following measures can minimize the risk of frostbite:

- Protecting skin from moisture, wind, and exposure to cold
- Avoiding perspiration or wet extremities
- Increasing insulation and skin protection (e.g., adding layers of clothing, wearing mitts instead of gloves)
- Using supplemental oxygen in extremely hypoxic conditions (above 25,000 ft [7,500 m])
- Avoiding alcohol, illicit drugs, or medications that reduce perfusion
- Avoiding cold weather exposure during illness
- Using chemical or electric hand and foot warmers
- Avoiding the use of skin emollients, which do not protect against frostbite and may actually increase risk
- Maintaining adequate hydration and nutrition
- Minimizing blood flow constriction caused by tight clothing or footwear
- Minimizing duration of exposure to cold

- Frequently assessing for extremity numbness or pain and warming extremities as soon as possible if there is concern that frostbite is developing
- Recognizing frostnip or superficial frostbite before it becomes more serious

If early frostbite is recognized, exercise can be protective by enhancing cold-induced peripheral vasodilation and elevating core and peripheral temperatures. However, if exercise leads to exhaustion, systemic heat loss can increase the risk of frostbite and hypothermia.

Field Treatment and Secondary Prevention

If a body part is frozen in the field, it should be protected from further damage. Jewelry and other constrictive objects should be removed. If environmental conditions make it possible for thawed tissue to refreeze, it is safer to keep the area frozen until a thawed state can be maintained.

Mild hypothermia can be treated concurrently with frostbite. Moderate to severe hypothermia should be treated before initiating frostbite treatment.

The effect of hydration on frostbite outcomes has not been studied, but appropriate hydration is important for recovery. Oral fluids can be given to alert patients; otherwise, intravenous saline (ideally warmed to 104 to 107.6°F [40 to 42°C]) should be administered to maintain urine output.

Intravenous low-molecular-weight dextran decreases blood viscosity by preventing red blood cell aggregation and microthrombi formation. Its availability is limited in the United States, but it can be administered in the field if available once it has been warmed. Because of the low risk of anaphylaxis, a test dose should be given first.

Ibuprofen should be given in the field at standard dosages (up to 600 mg four times daily) to decrease vasoconstriction and further tissue damage.

If possible, a frozen extremity should not be used for walking, climbing, or other activity until care has been obtained.

FIELD REWARMING

Although outcomes are better with rapid rewarming, frostbite should be allowed to thaw spontaneously if rapid rewarming is not possible. Rapid rewarming in the field should be performed only if definitive care is more than two hours away and refreezing can be prevented.

Water should be heated to 98.6 to 102.2°F (37 to 39°C), with a thermometer used to maintain this range. If a thermometer is unavailable, an uninjured extremity should be placed in the water for 30 seconds to confirm that the temperature is tolerable. Although there is no evidence that adding antiseptic solution produces better outcomes, it is not likely to be harmful and may reduce infection risk.

Rewarming is complete when the injured extremity appears red or purple and becomes soft and pliable, typically within 30 minutes depending on the extent and depth of frostbite. To minimize further tissue damage, skin should air dry or be gently blotted dry (not rubbed).

Bulky gauze dressings, with or without aloe vera cream, should be applied to thawed areas for protection and wound care. Substantial edema should be anticipated. If possible, thawed extremities should be elevated above the heart to decrease edema.

Oxygen supplementation via face mask or nasal cannula should be considered for patients who are hypoxic or at high altitude (above 13,000 ft [4,000 m]). Hyperoxemia will lead to peripheral vasoconstriction that can slow healing.

Immediate Treatment (Hospital Setting)

Once the patient reaches a hospital or high-level field clinic, frozen tissue should be assessed to determine whether spontaneous thawing has occurred. Further rewarming is not beneficial if tissue has completely thawed. It is common practice to drain clear blisters and leave hemorrhagic blisters intact, but there is insufficient evidence to recommend this practice.

IMAGING AND MEDICAL THERAPY

Frostbite is not an inherently infection-prone injury, so antibiotic prophylaxis is unnecessary. However, tetanus prophylaxis should be administered. If nonsteroidal anti-inflammatory drugs have not been given in the field, ibuprofen should be administered at a standard dosage until the frostbite wound is healed or surgery occurs.

Noninvasive imaging with technetium-99m pyrophosphate scintigraphy or magnetic resonance angiography can predict the level of tissue viability in patients presenting to a hospital four to 24 hours after tissue thawing. For patients who have frostbite injury extending at least to the proximal interphalangeal joints, intravenous or

intra-arterial administration of tissue plasminogen activator (tPA) may help salvage tissue if given within 24 hours of thawing. Each hour that tPA therapy is delayed decreases the salvage rate by 28%. Risks of thrombolysis include systemic and catheter site bleeding, compartment syndrome, and failure to salvage tissue. Long-term functional outcomes of tPA use to salvage digits are not known. Thrombolytic therapy is typically administered as a 3-mg bolus of tPA (30 mL of 0.1-mg-per-mL solution) and 500 units of heparin per hour until a vascular surgeon, burn specialist, or radiologist recommends discontinuation.

The prostacyclin analog iloprost (Ventavis) inhibits platelet aggregation, dilates blood vessels, downregulates lymphocyte adhesion to endothelial cells, and may have fibrinolytic activity. It has consistently shown favorable effects when given up to 72 hours after freezing injury. Although intravenous iloprost is not yet approved by the U.S. Food and Drug Administration, it is considered first-line therapy for grades 3 and 4 frostbite when given up to 72 hours after injury in patients for whom tPA therapy is contraindicated. Unfractionated or low-molecular-weight heparin is commonly used with tPA, and case reports document use with iloprost, but there is no evidence for the use of heparin as monotherapy.

OTHER POST-THAW THERAPIES AND SURGICAL MANAGEMENT

Physicians should monitor for compartment syndrome after frozen tissue has thawed. This surgical emergency can be caused by reperfusion of ischemic tissue.

Daily or twice-daily hydrotherapy at 98.6 to 102.2°F has been recommended in the post-thaw period. Evidence on outcomes is lacking, but hydrotherapy has few negative sequelae and may benefit recovery. Although hyperbaric oxygen therapy has resulted in faster and more complete healing for many types of nonfrostbite wounds, it is not recommended in frostbite because of the risk of vasoconstriction from hyperoxemia.

Chemical or surgical sympathectomy is not recommended because it has not been shown to reduce tissue loss in immediate postexposure phases.

Complete demarcation of tissue necrosis after frostbite may take up to three months. Until demarcation is complete, amputation should be performed only if signs of sepsis are present.

Editor's Note: An article on hypothermia and cold weather injuries was published in the December 1, 2019, issue of *American Family Physician* (https://www.aafp.org/afp/2019/1201/p680.html). In addition to frostbite, the article includes discussions of hypothermia and nonfreezing injuries such as frostnip, pernio, and immersion foot, which are not discussed in this guideline. The article references the current version of this guideline. –Michael Arnold, MD, Editorial Fellow

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