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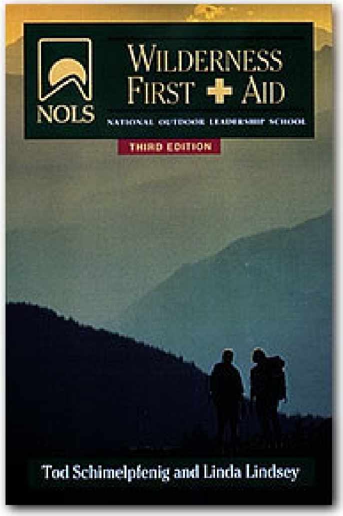
Cold Injuries

An excerpt from NOLS Wilderness First Aid

Chapter 9



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Introduction

On a snowy subzero morning in early November, after two days of searching, a lost hunter was found in the Wind River Mountains south of Lander, Wyoming. His nose, hands, feet and stomach were severely frostbitten and he showed limited signs of life. After several hours of evacuation by snow litter and four-wheel drive, rescuers delivered him to the emergency room with a rectal temperature of 74°F.

His ordeal was not over yet. The hypothermia caused his heart to stop, and only after three hours of rewarming and CPR did he begin to recover. His story was presented by the media as one of "miraculous" survival. He was lucky, and he knows it. Today, this man is a strong advocate of prevention.

Knowledge of causes, assessment and treatment of cold injuries is an essential component of wilderness medicine. Hypothermia is usually associated with cold climates, but hypothermia can set in even in warm climates, as it has on NOLS sea kayaking courses in Mexico. If you spend enough time outdoors, you will almost certainly gain firsthand experience with cold injuries such as hypothermia, frostbite and immersion foot.

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The Physiology of Temperature Regulation

Humans are warm-blooded animals who maintain a relatively constant internal temperature regardless of the environmental temperature. We do this by producing heat internally by metabolizing food and by adjusting the amount of heat we lose to the environment.

Human cells, tissues and organs operate efficiently only within narrow temperature limits. If our temperature rises 2°F above the normal of 98.6°F, we become ill. If it rises 7°F, we become critically ill. If our temperature decreases 2°F, we feel cold. A 7°F decrease puts our life in jeopardy.

Human beings are designed to live in tropical climates, so our heat loss mechanisms are highly developed. Our insulation mechanisms, however, are less efficient. To adapt structurally to cold, our bodies would have to grow thick insulating hair all over and develop greater reserves of fat. Rather than remaining angular and cylindrical, which promotes heat loss, our body shape would become rounder and shorter to prevent heat loss. This would especially affect our ability to tolerate lower body temperatures and near-freezing temperatures in our fingers and toes.

Physiological adaptations to cold might also include the ability to dramatically increase heat production through fat metabolism and changes in metabolic rate, as well as to develop chemicals that could act like antifreeze in our cells.

As it is, human beings can live in the cold because our intellectual responses enable us to deal effectively with environmental stress. Much of what students learn on NOLS courses is how to live comfortably in extreme environmental conditions by employing skill, disciplined habits and quality equipment. We compensate for our physical deficiencies with behavioral responses such as eating and drinking and creating microclimates through the use of clothing, fire and shelter. The diminished intellectual response evident in early stages of hypothermia, as well as altitude sickness, heat illness and dehydration, dangerously impairs our ability to react to the environment.

Mechanisms of Heat Production

The three main physiological means for producing heat are our metabolic rate, exercise and shivering.

Mechanisms of Heat Production

- Resting Metabolism
- Exercise
- Shivering

Resting Metabolism

The biochemical reactions keeping us alive produce heat as a by-product. Our basal metabolic rate is a constant internal furnace. The rate increases slightly when we are exposed to cold for long periods of time but not enough to satisfy our body's entire heat requirements in winter conditions.

Exercise

Exercise is an important method of heat production. Muscles, which make up 50 percent of our body weight, produce 73 percent of our heat during work. Short bursts of hard physical effort can generate tremendous amounts of heat, while moderate levels of exercise can be sustained for long periods. This valuable source of heat does have its limitations. Physical conditioning, strength, stamina and fuel in the form of food and water are necessary to sustain activity.

An important heat source for infants and hibernating mammals is the oxidation of brown fat from deposits on their abdomen, in their armpits and behind their shoulders. Oxidizing or burning brown fat produces considerable heat--of particular significance for infants, who because their small size have a large surface area for heat loss. Brown fat cells are almost completely absent in adult humans.

Shivering

Shivering-a random, inefficient quivering of our muscles- produces heat at a rate five times greater than our basal metabolic rate. It is our first defense against cold. Shivering occurs when temperature receptors in the skin and brain sense a decrease in body temperature and trigger the shivering response.

As with all forms of work, the price of shivering is fuel. How long and how effectively we shiver is limited by the amount of carbohydrates stored in muscles and by the amount of water and oxygen available. In order to shiver, we have to pump blood into our muscles. Warm blood flowing close to the sur-face reduces our natural insulation and increases heat loss.

Shivering also hinders our ability to perform the behavioral tasks necessary to reduce heat loss and increase heat production. It is difficult to zip up your parka, start your stove or ski to camp during violent shivering. On the other hand, vigorous physical activity can override the shivering response, causing a person to cool past the point of shivering without experiencing the response.

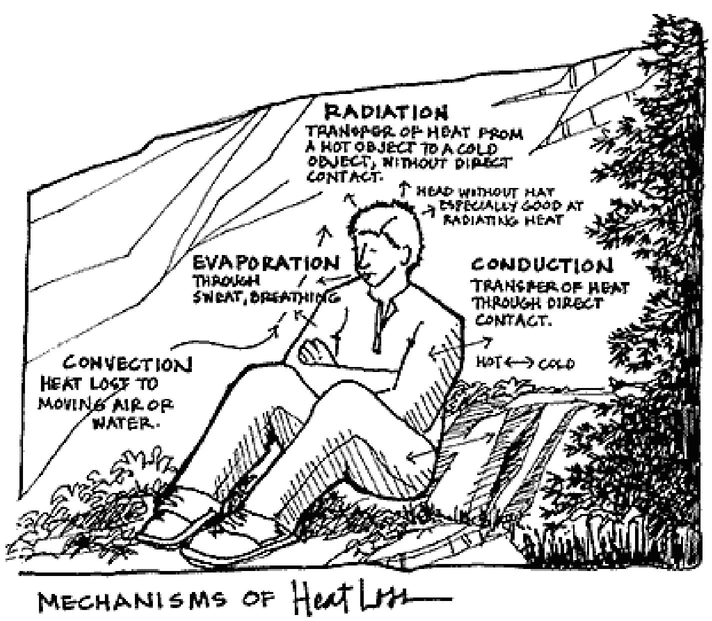
Mechanisms of Heat Loss

The core of the body contains the organs necessary for survival: the heart, brain, lungs, liver and kidneys. The shell consists of the muscles, skin and superficial tissues. The ebb and flow of blood from core to superficial tissues is a constant process. As our temperature rises, blood volume shifts and carries heat to the outer layers of the skin. As we cool, less blood flows to the periphery, preserving heat for the vital organs.

Our mechanisms for heat loss are so well developed that we lose heat in all but the hottest and most humid conditions. If on a warm day we do not lose most of the heat our bodies produce, our temperature rises. The primary means of heat loss is through the skin. Warm, flushed skin can dispose of the heat through radiation, convection, conduction or evaporation.

Mechanisms of Heat Loss

- Conduction
- Convection
- Radiation
- Evaporation



Our circulatory system controls heat by regulating the volume of blood flowing to the skin and superficial muscles. When we are resting comfortably, only a small percentage of blood flows directly to the skin. During heat stress, however, the blood vessels open up and blood flow to the skin may increase a hundred-fold.

During cold stress, blood is shunted from the periphery to the core, reducing the heat lost to the environment. Constricted blood vessels can reduce blood flow to the skin by 99 percent.

Conduction

Conduction is transfer of heat through direct contact between a hot and a cold object. Heat moves from the warmer to the colder object. We lose heat when we lie on the cold, wet ground. We gain heat when we lie on a hot beach or rock. The rate of heat transfer is determined by the temperature difference between the two objects, the surface area exposed to the cold surface and the effectiveness of the insulation between the body and the cold surface. The more efficient the insulation, the less heat is transferred. Warm, still air is an effective insulator. Water is a good conductor. Immersion in cold water is a profound threat to temperature balance.

Convection

Convective heat transfer occurs when the medium of transfer moves. Whether through moving air or water, heat escapes from the surface of the body by convection. Moving air (wind chill), besides cooling us directly, strips us of the microclimate of air heated by the body. The loss of this insulating layer next to the body further accelerates heat loss.

Moving water carries heat directly from the surface of the body. To discover the cooling power of moving water, place your fingers in a bowl of cold water. Slowly swirl your fingers. The increase in heat loss is immediately perceptible.

Heat is transferred convectively through the body by the blood. As we cool and the body shunts blood away from the skin, the superficial tissues-especially in our fingers and toes-no longer gain heat from the blood, which increases the likelihood of frostbite.

Radiation

Radiation is the transfer of infrared, or heat radiation, from a hot object to a cold object. In winter, with a normal body temperature of 98°F, we lose heat to the environment through radiation. We can receive radiative heat input from fires, from the sun or from reflection off snow, water or light-colored rocks.

Clear winter nights tend to be colder than cloudy ones. Cloud cover reflects much of the earth's radiative heat back to the ground, reducing the severity of the nighttime temperature drop. Reflected, radiated heat waves bouncing off the walls and snowfields of a cirque during bright sunshine increase warmth--and the possibility of sunburn.

When exposed to the environment, the skin acts as a radiator. Unlike in the rest of the body, the blood vessels in the head do not constrict and reduce the blood supply flowing to the scalp. The head is therefore an excellent radiator of heat, eliminating from 35 to 50 percent of our total heat production. The effectiveness of garments designed to reflect and conserve radiative heat is not agreed upon universally, but the effectiveness of dry insulation, especially on the head, is undeniable.

Evaporation

Heat is necessary to the evaporation of perspiration from the skin's surface. Evaporative heat loss accounts for 20 percent of the body's normal total heat loss. When we become overheated, though, evaporation becomes our major mechanism for heat loss. Evaporation can liberate as much as 1,000 kilocalories an hour.

Sweating accounts for roughly two thirds of our evaporative heat loss. The remaining one third is lost through breathing. Inhalation humidifies air and warms it to body temperature. During exhalation, evaporation of moisture from the surface of the lungs and airways uses heat and cools the body. The rate and depth of breathing and humidity of the air determine the amount of heat and moisture lost. The colder and dryer the air and the faster the breathing rate, the greater the heat loss. To reduce heat loss through evaporation, avoid hard breathing and sweating. Sweating in cold environments is a bad habit. It wets insulation and cools the body.

A constant balance of heat gain and loss is required to maintain a stable body temperature. The adjustments the body makes are designed to keep our vital organs-heart, brain, lungs, kidneys and liver-within a temperature range in which they operate effectively. If core temperature rises above normal, potentially life-threatening conditions-heat stroke or high fever-develop. When core temperature drops below normal, hypothermia may be the result.

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Hypothermia

Hypothermia occurs when body temperature drops to 95°F or lower, a condition that is not exclusive to the winter environment. Hypothermia can develop whenever heat loss exceeds heat gain and is as common during the wind, rain and hail of summer as it is during winter. Immersion in cold water can cause hypothermia. If body temperature drops as low as 80 degrees F, death is likely.

Signs and Symptoms

The signs and symptoms of hypothermia change as body temperature falls. Mental functions tend to go first, and the patient loses his ability to respond appropriately to the environment. Muscular functions deteriorate until he is too clumsy to walk or stand. Biochemical processes become slow and deficient as the body cools.

Signs and Symptoms of Hypothermia

- Mental
  - Deterioration in decision making ability
  - Slow and improper response to cold
  - Apathy, lethargy
  - Increased complaints, decreased group cooperation
  - Slurred speech, disorientation progressing to incoherence and irrationality and possible unconsciousness
- Muscular
  - Shivering
  - Loss of fine motor ability progressing to stumbling, clumsiness and falling
  - Muscle stiffness and inability to move (in severe cases)

Hypothermia in which body temperatures remain above 90°F is classified as mild to moderate. Hypothermia below 90°F is severe. A healthy adult with a body temperature of 93°F is dangerously cold, but chances are good that rewarming will be successful. If the same person has a temperature of 90°F or less, rewarming in the backcountry can be difficult, and the patient's life may be in grave danger.

Early signs and symptoms of hypothermia can be difficult to recognize and may easily go undiagnosed. The patient does not feel well. You may assume he is tired, not hypothermic. Yet this is the stage in which successful rewarming in the wilderness is possible if our awareness is such that we catch the problem.

On the other hand, hypothermia in its later stages may be more

obvious. The patient collapses, slurs his words, is semi-conscious, grossly uncoordinated or unconscious and unresponsive. This stage of hypothermia is easier to recognize, yet much harder to treat in the wilderness.

Mild Hypothermia

In the early stages of hypothermia the patient feels chilled. The skin may be numb with goose bumps. Minor impairment of muscular performance is evident in stiff and clumsy fingers. Shivering begins. Mental deterioration occurs at the same time. Responses are slow and/or improper, such as not changing into dry clothes or failing to wear a rain jacket, wind garments or hat.

Shivering is the first response to cold. It reaches its maximum when body temperature has fallen to 95° to 93°F. Shivering stops when the temperature falls to 92° to 90°F. During the fast cooling phase, the pulse rate increases to as high as 150 per minute. Later, as the body becomes cooler, pulse rate and blood pressure falls. Respirations slow and may finally cease around 78°F.

Moderate Hypothermia

As body temperature drops into the mid-nineties, muscular coordination deteriorates. The patient may stumble, walk slowly, lack energy and become apathetic, and lethargic. He talks less and may become uncooperative and complaining. Responses to questions may be inappropriate; the patient may exhibit slurred speech and confusion about time or place.

As body temperature approaches the low nineties, gross muscular incoordination becomes obvious: stumbling, falling, and inability to use hands. The patient may become cantankerous or forgetful and display inappropriate behavior.

Severe Hypothermia

When body temperature drops below ninety, shivering stops. Energy reserves are depleted and obvious mental deterioration is present, along with incoherence, disorientation and irrationality likely. Exposed skin is very cold and may be blue.

In the mid-to-low eighties, severe muscular rigidity may occur. The patient may become unconscious and exhibit dilated pupils. His pulse may be undetectable and he may appear to have stopped breathing or to have already died.

Recognizing Hypothermia (Assessment)

Hypothermia is easily overlooked and in the wilderness and has been mistaken for fatigue, irritability, dehydration and mountain sickness. It may be associated with illnesses such as diabetes, stroke and drug overdose.

The most important diagnostic tools in the backcountry are the first-aider's awareness of and suspicion concerning the condition and his attention to the patient's mental state. Oral or axillary temperatures may not reflect the status of the core organs; a rectal temperature is the most accurate temperature available in the field. However, obtaining a rectal temperature reading on a cold and confused patient can be awkward. Also, exposing the patient in order to obtain a rectal reading may cause further cooling. Whether you can obtain a rectal temperature or not, if you suspect hypothermia, treat it immediately and aggressively.

Conventional thermometers read only to 94°F. Low-reading thermometers should be included in the first aid kits of cold weather rescue units or of any outdoor group traveling in a potentially cold environment.

Anyone in a cool or cold environment is at risk for hypothermia. Persons with altered mental status (confused, slurred speech, disoriented) in the outdoors may be hypothermic. Any ill or injured person may have difficulty maintaining proper body temperature.

Assessment of Hypothermia

- Above 90°F (Mild and Moderate
    - Conscious
    - Shivering
    - Able to walk
    - Alert
- Below 90°F (Severe)
    - Abnormal level of consciousness
    - No shivering
    - Unable to walk
    - Decreased mental awareness

Treatment for Hypothermia

Prevention of hypothermia is simple. Treatment is not. Rewarming can be a long and complex process taking hours, and it may be impossible in the backcountry.

Mild to Moderate Hypothermia

A mildly hypothermic patient may be rewarmed in the field. In the absence of a serious underlying medical condition, the chances for successful rewarming are good. The patient in early hypothermia may respond well to removal of the cold stress. While we cannot change the air temperature, we can replace wet clothing with dry, protect the patient from the wind, add layers of insulation and apply heat.

Severe Hypothermia

A severely hypothermic patient produces little or no heat and in the absence of external heat sources, may cool further. A cold heart is susceptible to abnormal rhythms such as ventricular fibrillation, a random quivering of the heart that fails to pump blood. Jarring or bouncing, almost inevitable in transport from the backcountry, can trigger this rhythm.

There may be complications from an underlying medical condition or trauma and complex disturbances in the body's biochemical balance. For these reasons a patient with severe hypothermia must be rewarmed in a hospital.

Evacuation of the severely hypothermic patient must occur simultaneously with attempts to prevent further cooling. If you do not apply heat to the patient during transport, further cooling is almost certain. Monitor ABCs and vitals and carry the patient as gently as possible.

Treatment for Hypothermia

- Above 90°F (Mild and Moderate)
    - Prevent further heat loss

        - Remove from cold
        - Dry
        - Insulate
    - Actively rewarm
        - Sleeping bags
        - Heat sources
        - Hydrate, hot drinks
- Below 90°F (Severe)
    - Evacuate to rewarm
        - Dry, insulate
        - Prevent further heat loss (apply heat)
        - ABCs
        - Handle gently

Backcountry Rewarming Techniques

Most rewarmings are simple. We dry the patient, dress him in warm clothes, give him a hot drink and everything works out fine. If the patient is more seriously cold, we usually place him in a sleeping bag with warmers inside, build a fire and take other aggressive actions as necessary.

Backcountry Rewarming Techniques*

- Simple Rewarming (Prevent Further Heat Loss)
    - Remove from the cold environment
    - Dry the patient, dress in dry clothing
    - Insulate the head and neck
- Complex Rewarming
    - Feed and hydrate the patient, if conscious and alert
    - Place patient in sleeping bag(s) with other person(s)
    - Place hot water bottles on torso
    - Use fires as heat sources
    - Feed, hydrate and rotate the warmers
    - Be persistent; rewarming takes time
    - Monitor ABCs
    - Handle the patient gently

**These are options for rewarming hypothermic patients in the backcountry. "Simple" and "complex" do not necessarily correspond with "mild or moderate" (above 90deg.) and "severe" (below 90°).*

Prevent Further Heat Loss

Remove the patient from the cold environment and make sure he is dry. Dress him in dry clothing, especially a hat to reduce heat loss from the head and neck. For mild hypothermia, this and a hot drink are often all the treatment that's needed.

Feed and Hydrate the Patient, if Conscious and Alert

Hot drinks are a good source of heat, fluid and sugar. Again, be careful of burning the patient. The patient must be conscious and alert to drink. Hydrate and feed with hot drinks and simple foods, such as candy bars, followed by a good meal after he is rewarmed. A rewarmed patient should not return to the cold until his energy and fluid reserves have been replenished. A fatigued or dehydrated patient is a strong candidate for another episode of hypothermia.

Place the Patient in Sleeping Bag with Other Person(s)

A sleeping bag is the backcountry's most tried and true rewarming tool. Place the patient in one or more bags with at least one other person as a heat source. If the patient is left alone in the bag, he will only be insulated at his current body temperature, since the hypothermic patient has lost the ability to produce heat himself. In fact, further cooling may occur.

Clothing placed over the opening of zipped-together sleeping bags helps reduce heat loss. Several sleeping bags placed over the patient and the warmers will also help. The more humid environment inside the sleeping bag reduces respiratory heat loss as does loosely wrapping a scarf or other article of clothing across the patient's mouth and nose.

In our experience, it's best to keep the rewarmed patient in the sleeping bag for a good night's sleep and to give him a good hot meal and several liters of water.

Place Hot Water Bottles on Torso

Hot water bottles applied to the chest, abdomen, neck and groin--areas close to the core and containing large blood vessels--are an excellent source of heat. Be careful not to burn the patient. Apply the hot water bottles to yourself before applying them to your patient. Wrap them in socks to insulate them from direct contact with the patient.

Use Fires as Heat Sources

Fires are an excellent source of heat. Position the patient in the sleeping bag next to or between two fires. Use a space blanket as a reflector. If you are without a sleeping bag, dress the patient in dry clothes for insulation. One or more individuals huddling around or hugging the patient will provide insulation and heat. A windproof outer layer will reduce the patient's convective and evaporative heat loss.

Feed, Hydrate and Rotate the Warmers

Warmers expend energy to rewarm the patient and in the process themselves become potential hypothermia victims. Watch the warmers, they need to be fed and hydrated or they may become hypothermic.

Be Persistent; Rewarming Takes Time

Individuals such as the hunter described in the Introduction have recovered from prolonged, profound hypothermia. Newspaper headlines occasionally describe "frozen and dead" people who were successfully rewarmed. The adage to remember about hypothermia treatment is that "the victim is never dead until he is warm and dead."

Monitor ABCs

It may be difficult to find the pulse or respiration rate of a cold patient. A severely cold patient may have a heart rate of 20 to 30 beats per minute and be breathing only three to four times a minute. Cold reduces metabolic demands; a patient can sustain life with these abnormally low rates. Take your time during assessment.

The Wilderness Medical Society advises not to start CPR on a hypothermia victim if the chest wall is frozen. Prognosis is poor for patients with a core temperature below 82°F, patients who have been under water for more than 40 minutes, have life-threatening injuries or if transport time to a hospital is more than four hours. If you do start CPR on a hypothermic patient, you are committed to continuing it until the patient is rewarmed.

Because of the cold patient's reduced physiological processes, some experts advise delaying CPR until the patient's core temperature reaches at least the high eighties and reducing the rate of compressions and ventilations to half of normal. Check with your local physician to see if protocols for CPR and hypothermia have been established in your area.

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Frostbite

Frostbite acts locally on areas such as fingers, toes and ears. It is not life-threatening, but tissue damage from frostbite can result in loss of function or, in serious cases, gangrene and amputation.

Frostbite occurs when tissue is frozen. As blood flow declines, cooling can progress to freezing. The fluid between cells freezes. The formation of ice crystals draws water out of the cells, dehydrating them. Mechanical cell damage also occurs as the crystals rub together. Blood clots in small vessels and circulation stops, further damaging cells.

A second phase of injury occurs during rewarming. Damaged cells release substances that promote constriction and clotting in small blood vessels, impairing blood flow to the tissues.

Causes of Frostbite

- Cold stress
- Low temperatures
- Wind chill
- Moisture
- Poor insulation
- Contact with supercooled metal or gasoline
- Interference with circulation of blood
- Cramped position
- Tight clothing (gaiters, wristwatches, etc.)
- Local pressure
- Tight fitting or laced boots
- Dehydration

Low temperatures, contact with moisture and wind chill accelerate heat loss and increase the likelihood of frostbite. Metal and petroleum products can cool well below the point of freezing. Skin contact with metal or supercooled gasoline will cause immediate freezing. Constriction of an extremity, as caused by tight boots, gaiters or watchbands, or confinement in a cramped position may reduce blood flow and increase the likelihood of frostbite.

Remember: blood brings oxygen and nutrients to the tissue, as well as heat. Dehydration and hypothermia impair circulation to the extremities by reducing the available fluid and by promoting constriction of blood vessels to preserve heat in the core.

Frostnip

Simple classification of frostbite includes frostnip, superficial frostbite and deep frostbite. Many experts classify frostbite only after it has thawed and the extent of the damage is apparent.

With frostnip only the outer layer of skin is frozen. It appears white and waxy or possibly gray or mottled. Frostnip may occur from contact with a cold metal or a supercooled liquid or from exposure to severe windchill. High winds together with cold temperatures create conditions for frostnip on exposed areas of the face, nose, ears and cheeks.

Frostnip is similar in physiology to a first degree burn and is sometimes called first degree frostbite. After the nipped area is rewarmed, the layer of frozen skin becomes red. Over a period of several days the dead skin will peel. As it heals, the appearance of the injury is similar to that of sunburn, a first degree burn.

Warm frostnip immediately. Placing a warm hand on a cheek, placing cold fingers into an armpit or warm (101° to 108°F) water will rewarm the frozen area. Covering up from the wind and cold, thereby reducing the exposure, should prevent further injury.

Superficial Frostbite

Superficial frostbite injures a partial thickness of the skin, similar to a second degree burn. This injury has progressed from frostnip into the underlying tissues. Externally it appears as a white, mottled or gray area. It feels hard on the surface, soft and resilient below. Blisters usually appear within 24 hours after rewarming.

Treatment for second degree or superficial frostbite is rapid rewarming by immersion in warm (101° to 108°F) water. This injury extends into the underlying tissues and is more extensive than frostnip. Unlike frostnip, the injury should not be rewarmed by simple application of heat. Proper rewarming is crucial to healing.

Deep Frostbite

The most serious form of frostbite is deep or third degree frostbite. The injury extends from the skin into the underlying tissues and muscles. The external appearance is the same as frostnip and superficial frostbite, but the frozen area feels hard. After thawing the area may not blister or may blister only where deep frostbite borders on more superficial damage.

Differentiating superficial from deep frostbite before thawing is difficult. Blisters containing clear fluid, extending to the tips of the digits and forming within 48 hours of rewarming suggest superficial frostbite. Blood-filled blisters that don't reach the tips of the digits, delayed blisters or the lack of blisters indicates deep frostbite. Like superficial frostbite, deep frostbite is rewarmed by immersion in warm water.

Treatment for Frostbite

Dangerous folk remedies for frostbite include rubbing the frozen part with snow, flogging the area to restore circulation and exposing it to an open flame. The treatment of choice is rapid rewarming in warm water.

Treatment for Frostbite

- Delay rewarming until it can be done once and done well
- Rapidly rewarm in warm water

  - The water should be between 100° to 108°F
  - Completely immerse the frozen tissue
  - Use a large basin
  - Thaw completely
- Post-thaw care
  - Protect the thawed tissue from trauma
  - Elevate to reduce swelling
  - Place pads between toes and fingers
  - Do not constrict the extremity
  - Prevent refreezing

Delay Rewarming

Try to keep the injury frozen until rewarming can be carried out correctly. Many people, including this author, have traveled long distances with frozen feet in order to reach a place where rewarming could be done once and done well. How long the area can be kept frozen without increasing the damage is a matter of controversy. Tissue damage does seem related to the length of time the tissue stays frozen.

There are several problems with keeping a frostbitten extremity frozen while evacuation takes place. If the injury occurred from exposure to extreme cold, lack of proper clothing or in conjunction with hypothermia, the frostbitten area may rewarm as the problem that caused it is corrected. The activity of traveling may generate enough heat to begin thawing, thus increasing the possibility of further injury from refreezing or bruising. Unintentional slow rewarming is common.

If the injury is confined to a small area of the body, tips of toes or fingers, slow thawing is likely, and field rewarming should be started. If the injury is extensive, thawing will be difficult. Try to keep the area frozen. Adjustments in clothing and work rate will be necessary.

Rapidly Rewarm In Warm Water

Treatment for frostbite, best done in a hospital, is rapid rewarming in water between 100° to 108°F. Use a thermometer to ensure that the water is the proper temperature. For a rough estimate, 105°F is hot tap water. Water colder than 100°F will not thaw frostbite rapidly. Water hotter than 108°F may burn the patient.

Water temperature should remain constant throughout the procedure. This requires a source of hot water and several containers large enough to contain the entire frozen part. Do not pour hot water over the frozen tissue. Rather, immerse the frozen area, being careful not to let it touch the sides or bottom of the container. When the water cools, remove the frostbitten part, quickly rewarm the water and re-immerse the part.

Thawing frozen fingers generally takes 45 minutes. There is no danger of overthawing, but underthawing can leave tissue permanently damaged. A flush of pink indicates blood returning to the affected site. Rewarming frostbite is generally very painful. Aspirin or ibuprofen are appropriate for pain relief. If hypothermia is present, it takes priority in treatment.

Post-Thaw Care

Air dry the extremity carefully; don't rub. Swelling will occur, along with blister formation. Inserting gauze between the fingers or toes will keep these areas dry as swelling occurs. Blisters may be drained with a sterile syringe and then dressed with aloe vera ointment. Once the tissue is thawed, it is extremely delicate and seemingly minor trauma can damage it.

Prevent refreezing after thawing. The freeze-thaw-freeze sequence will produce permanent tissue damage. The seriousness of frostbite injury is increased if freeze-thaw-freeze has occurred or if it is accompanied by fracture or soft tissue injury.

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Immersion Foot

Immersion foot is a local, non-freezing cold injury that occurs in cold, wet conditions, usually in temperatures of 30° to 40°F. At least 12 hours' exposure to cold, wet conditions is necessary to produce the injury. People have contracted immersion foot in hip waders and vapor barrier boots. Dry socks and feet provide total protection.

Immersion foot occurs when cold, wet conditions constrict blood vessels. Reduced blood flow to the extremity deprives cells of needed oxygen and nutrients. Permanent muscle and nerve damage may result.

Signs and Symptoms of Immersion Foot

The extremity appears cold, swollen and mottled. Cyanosis is usually present. Tactile sensitivity is reduced, as is capillary refill time. The foot may look shiny. The patient may describe the foot as feeling wooden.

When the extremity rewarms, the skin becomes warm, dry and red. The pulse is bounding. The injury is painful. The injured area may itch, tingle and exhibit increased sensitivity to cold, possibly permanently. The recovery period can last weeks. Nerve damage may be permanent. The development of blisters, ulcers and gangrene is possible. Loss of a foot or lower leg is also possible.

Signs and Symptoms of Immersion Foot

- Cold, mottled extremity
- Foot feels "wooden, numb, pins and needles"
- When rewarmed, the foot becomes red, dry and painful with bounding pulses
- Prevention
    - Rotate socks as needed to keep feet dry
    - Check feet daily
    - Sleep with feet warm and dry

Treatment for Immersion Foot

Warm an immersion foot slowly at room temperature. In serious cases swelling, pain and blister formation will prevent walking. In most cases the extremity will be sore. Avoid walking on injured feet, and elevate the feet to reduce the swelling. Bed rest, along with avoiding trauma, is necessary until the injury heals.

Treatment for Immersion Foot

- Remove the feet from the cold, wet environment
- Air dry
- Do not constrict the extremity
- Protect the feet from trauma
- Elevate the feet to reduce the swelling

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Final Thoughts: Prevention

The possibility of cold injury is our constant companion on wilderness trips. You can successfully treat hypothermia, frostbite and immersion foot 24 hours a day by practicing prevention.

Summary: Cold Injuries

Hypothermia is a lowering of the core body temperature occurring when heat loss exceeds heat production. It is a dangerous disturbance of body function. Mild hypothermia (above 93°F-patient conscious, shivering, able to walk) is treatable in the field. Severe hypothermia (below 93° F -- patient unconscious, not shivering, unable to walk) requires rewarming in a hospital.

Signs and Symptoms of Hypothermia

- Mental
  - Deterioration in decision making ability
  - Slow and improper response to cold
  - Apathy, lethargy
  - Increased complaints, decreased group cooperation
  - Slurred speech, disorientation progressing to incoherence and irrationality
  - and possible unconsciousness
- Muscular
  - Shivering
  - Loss of fine motor ability progressing to stumbling, clumsiness and falling
  - Muscle stiffness and inability to move (in severe cases)

Treatment for Hypothermia

- Mild Hypothermia
  - Prevent Further Heat Loss
    - Dry
    - Remove from cold
    - Insulate
  - Actively Rewarm
    - Hydrate, Hot Drinks
    - Food
    - Sleeping Bags
- Severe Hypothermia
  - Evac to Rewarm
    - Dry, insulate
    - Prevent further heat loss, (apply heat)
    - ABCs
    - Handle gently

Frostbite is a local freezing injury classified as frostnip, superficial or deep. Frostbitten tissue is cold, gray, white or mottled. Frostnip only affects the skin and is easily treated with immediate rewarming. Superficial and deep frostbite progress into underlying tissue layers and should be rewarmed rapidly in warm water.

Treatment for Frostbite

- Delay rewarming until it can be done once and done well
- Rapidly rewarm in warm water
  - The water should be between 100° and 108°F
  - Completely immerse the frozen tissue
  - Use a large basin
  - Thaw completely
- Post-thaw care
  - Protect the thawed tissue from trauma
  - Elevate to reduce swelling
  - Place pads between toes and fingers
  - Do not constrict the extremity
  - Prevent refreezing

Immersion foot is a local, non-freezing injury. Signs and symptoms are swollen, cyanotic and mottled feet with slow capillary refill.

Treatment for Immersion Foot

- Remove the feet from the cold, wet environment
- Air dry
- Do not constrict the extremity
- Protect the feet from trauma
- Elevate the feet to reduce the swelling

Order a copy of NOLS Wilderness First Aid by calling (888) 332-3636.

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