

# Frostnip, Chilblain, and Frostbite

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# Ice, Ice, Baby

- ▶ Frostnip, pernio/chilblain, and frostbite are part of a spectrum injuries caused by exposure to cold or freezing temperatures
- ▶ Immersion foot (also known as trench foot) is a similar injury but does not require freezing temperature
- ▶ Though all three are a bit different, they are all the result tissue damage, whether permanent or transient, caused by cold-induced tissue inflammation and/or ischemia
- ▶ Mostly a concern when temperatures reach 32F, but wind chill and being wet can allow these injuries to occur even at warmer temps. Other risk factors will be discussed later
  - ▶ The recorded low on the day before and day of admission for our patient was 33F.
- ▶ Most commonly affected parts of the body are ears, nose, cheeks, chin, fingers, and toes, though this is also highly dependent on clothing.
  - ▶ Can even get frostbite of the cornea!



# The How and Why

- ▶ What's the mechanism?
  - ▶ When skin, muscle, and nerve cells freeze, so does the water in the cells.
  - ▶ When water freezes slowly (as in, when not dropped into liquid nitrogen), it forms crystals which can damage and lyse cells.
  - ▶ Cell lysis releases electrolytes, proteases, etc. which causes further lysis
  - ▶ All this lysis triggers inflammation via thromboxane 2, prostaglandin F2-a, and histamine, which causes MORE inflammation, ischemia, and necrosis
  - ▶ Rapid warming (and thus, reperfusion), causes vascular dilation and a flood of inflammatory proteins, worsening the damage, especially if refreezing occurs (vasospasm)
  - ▶ This is the reason we rapid-freeze bacterial and mammalian cell cultures in liquid nitrogen! Fewer crystals, more viable cells when you thaw them.

# Frostnip

- ▶ Every kid that grew up in a northern (or cold) state was taught to recognize this and how to treat it to avoid frostbite
- ▶ Also considered “first degree frostbite” (total of four degrees)
- ▶ Frostnip, by definition, does not cause permanent damage. The effects (paresthesia, pain) will eventually resolve with rewarming.
- ▶ Tissue damage is superficial, with a blanched appearance (central pallor surrounded by edema), with the pallid area being the site of paresthesia.
- ▶ Earliest sign is a loss of sensation of cold in the affected part of the body. This is when you should GO INSIDE!
  - ▶ If limbs are affected, can develop clumsiness or, similar to diabetics, cause injuries to numb digits/limbs because you can't feel what you're doing.



# Pernio or Chilblain

- ▶ This is second degree frostbite, involves tissues a bit deeper than first degree (frostnip).
- ▶ Skin progresses from blanched and numb to serous or hemorrhagic blisters
  - ▶ These blisters can also develop (and thus, the injury progresses from first to second degree) during rewarming, especially if rewarmed too quickly. This is part of that inflammatory flood I mentioned earlier.
- ▶ Blisters can continue to develop and expand over the first 24 hours post-injury.
- ▶ Though an eschar may form and slough off, the tissue underneath is healthy (granulation tissue), so no deeper tissue is lost.
- ▶ Sensory changes are often still transient, though it is possible to develop permanent insensitivities to temperature at the site of the blisters (not a total paresthesia)
  - ▶ You can have areas of frostnip surrounding areas of chilblain. Only blistering, chilblain regions are at risk for developing the permanent temperature insensitivity.





# Frostbite

- ▶ Third and fourth degree frostbite
  - ▶ Third degree → deeper tissue injury, smaller and more proximal hemorrhagic blisters
  - ▶ Fourth degree → extension into muscle and bone, complete tissue necrosis, mummification (deshication) in 4-10 days
- ▶ Damage to this extent is permanent. Lots of possible short and long-term complications at this level:
  - ▶ Gangrene and infection in the short term
  - ▶ Auto-amputation (up to weeks post-injury)
  - ▶ Throbbing pain in first few days post-rewarming, can continue for weeks
  - ▶ Paresthesia (ischemic neuritis), neuropathic pain, hyperhidrosis (risk for future frostbite)
  - ▶ Scarring, tissue atrophy, bony abnormalities
  - ▶ Pediatrics → epiphyseal necrosis causing growth abnormalities





# Diagnostic Considerations

- ▶ Mainstay of diagnosis is a thorough history combined with a good clinical exam
  - ▶ Even if the temperature outside isn't 32F or below, you have to be sure the patient wasn't wet, poorly clothed, or that wind chill didn't push the temperature below ambient recorded temps.
- ▶ Work-up is similar to hypothermia:
  - ▶ EKG (hypothermia → arrhythmogenic)
  - ▶ Electrolytes, to include calcium and potassium
  - ▶ Lactate
  - ▶ CPK
  - ▶ ABG (gas tensions change as temp drops, may need more oxygenation)
  - ▶ Blood glucose (insulin ineffective below 30C)
  - ▶ CBC (Hct increases 2% per 1C drop in temp)
- ▶ Imaging can help determine extent of tissue damage, but isn't diagnostic in itself:
  - ▶ Plain films → soft tissue swelling, coincidental trauma or fractures (paresthesia + broken toe/foot/hand), bone destruction
    - ▶ Thumbs often spared due to clenched fists
  - ▶ MRI → limited data, but might be useful for demarcating ischemic and nonischemic tissue (viability study)
  - ▶ Tc-99 scintigraphy (bone scan) → viability study, guides early debridement and amputation in an attempt to retain living tissue





# Acute Treatment



## ▶ Frostnip

- ▶ Get into a warm environment. Remove wet clothes, sit by a warmer (NOT a fire, you can get burns while sensation returns). If using water, it needs to be lukewarm, NOT hot, as this increases tissue damage (rapid reperfusion). Alternatively, put your hands in your armpits.

## ▶ Chilblain and Frostbite

- ▶ GET TO A HOSPITAL!
- ▶ While enroute, use above treatments
- ▶ Best way to rewarm a patient is water immersion (temp 37-39C). Dry heat is hard to regulate.
  - ▶ Pain control! Rewarming hurts!
- ▶ Current recommendations include tPA for patients facing life-altering amputations that have no tPA contraindications within first 24 hours of injury. Data is limited to small studies.
  - ▶ Absolute contraindications → previous ICH, known structural cerebral vascular lesion, malignant intracranial neoplasm, ischemic stroke within 3 months, aortic dissection, active bleeding, significant facial or closed head trauma in last three months
  - ▶ Relative contraindications → systolic BP > 180, intracranial pathology including dementia, major surgery within last 3 weeks, traumatic/prolonged CPR, internal bleeding in last 2-4 weeks, non-compressible vascular puncture, pregnancy, active peptic ulcer, current use of anticoagulants.

# Further Treatment

- ▶ Early surgical consultation for debridements, delayed amputations, escharotomy, fasciotomy, etc.
- ▶ Tetanus vaccine if not recently vaccinated
- ▶ Wound care:
  - ▶ Avoid walking on frost-bitten feet in the short term (increases injury) and use splints-padding while healing
  - ▶ Allow wound drying before dressing
  - ▶ Topical aloe, NSAIDS → reduce inflammation
- ▶ No role for prophylactic antibiotics, but have a low threshold for treating as these wounds, especially in third and fourth degree frostbite, can easily develop deep infections with staphylococcus, streptococcus, and pseudomonas
  - ▶ Abx should be parenteral, not topical (increases moisture → maceration)
- ▶ Experimental therapies
  - ▶ Pentoxifylline → claudication medication, some animal studies with positive results in early frostbite
  - ▶ Distal forearm lidocaine → chemic sympathectomy causing vasodilation, limited data in animal studies, similar drugs in the past didn't work well
  - ▶ Hyperbaric oxygen → unproven, questionable effect on microcirculation

# Risks and Prevention

## ▶ Risks

- ▶ Convective heat loss → wind
- ▶ Conductive heat loss → water (sweating), metal
- ▶ Conditions that impair or impede your sense or response to cold → alcohol, DM, PVD, mental illness, exhaustion, dehydration, malnutrition
- ▶ Smoking, prior cold injury (temperature insensitivity)
- ▶ Poor choice of clothing or coverage

## ▶ Prevention

- ▶ WEAR. THE RIGHT. CLOTHES. This can't be stressed enough. If you're going out for even a planned short trip (because those can often turn into long trips in winter), you need to cover vulnerable areas like ears, hands, feet, nose, cheeks, etc.
  - ▶ Always, always, always keep extra dry winter clothes and/or blankets in your trunk
- ▶ Avoid alcohol consumption and smoking, avoid water and metallic surfaces
- ▶ Don't believe the topical frostbite prevention balms. They don't work and might even increase your risk.



# References

- ▶ UpToDate
- ▶ CDC