



CRACKCast E139 (Rosen's Ch 131) – Frostbite

Key concepts:

Frostbite

- Premature termination of thawing in 37° C to 39° C (98.6° F–102.2° F) water is a common error. Reperfusion of completely frozen tissue may be painful and may require parenteral analgesia.
- The early formation of clear blebs is more favorable than delayed formation of hemorrhagic blebs, which reflect damage to the subdermal vascular plexi.
- The patient should be advised that accurate prediction of eventual tissue loss is not always possible at presentation, despite imaging.
- Thrombolytic agents may restore some flow to severely frostbitten limbs if administered within 24 hours of thawing.

Nonfreezing Cold Injuries

- Immersion injuries should be rewarmed slowly and not above 30° C (86° F).
- Cooling of nonfreezing cold injuries may be helpful to relieve pain and edema.
- Pernio can be treated by drying and gentle massage. The skin should not be warmed above 30° C (86° F).

Signposts

- 1) Describe the pathophysiology of frostbite (the freezing injury cascade).
- 2) What are the types of cold injuries?
- 3) Describe the clinical differentiation between each of the following:
 - a) Frostnip
 - b) Frostbite
 - c) Trenchfoot
 - d) Chilblains
- 4) List 10 predisposing factors for frostbite
- 5) Describe the pre-hospital and ED management of frostbite
- 6) List 8 sequelae of frostbite.
 - a) Describe the early and late complications of frostbite.

Rosen's in Perspective

Humans are “physiologically tropical” - so we need to adapt our behaviour to survive in cold.

- What is frostbite?
 - Tissue freezing with the formation of ice crystals
- NON-freezing injuries include:
 - Immersion injuries - aka trench foot = exposure to wet cold
 - Pernio - chilblains - exposure to dry cold
- We talk a lot about the dx and management of frostbite but let's quickly emphasize that the best prevention is YOU!
 - Behavioural responses - clothing and shelter are key



- Unless you are an adapted Inuit or true northern person you're not really adapted with cold-induced vasodilation

Core Questions

[1] Describe the pathophysiology of frostbite (the freezing injury cascade).

- Frostbite only occurs when the tissue gets below 0°C. (Usually more likely -4° to -10° C)
- The tissues become injured due to ice crystal formation, microvascular thrombosis and stasis.
- Here we walk about the “Freezing Injury Cascade”
 - **Pre-freeze stage:**
 - Temps below 10 deg
 - CUTANEOUS SENSATION LOST
 - Microvascular changes (see below)
 - **Freeze thaw phase**
 - Ice crystals form outside the cell
 - Then inside the cell
 - Cells die
 - Blood flow stops
 - As the tissue becomes thawed the next stage starts
 - **Vascular stasis and ischemia stage**
 - Coagulation in microcirculation
 - Damage tissue releases toxic mediators
 - Tissues become ischemic as the coagulation system is activated
 - Tissue edema for 48-72 hrs as tissue is thawed
 - Necrosis appears as the edema resolves
 - Dry gangrene appears

Advanced imaging may help delineate which tissue is viable before July rolls around.... (referencing the frostbite in January amputate in July adage)

See Box 131.1: Freezing Injury Cascade

*Extremely rapid cooling produces more initial intracellular than extracellular ice crystallization.

[2] What are the major types of cold injuries?

Freezing and NON-freezing!

These injuries can occur together, especially in climates that hover around 0 degrees.



[3] Describe the clinical differentiation between frostnip, frostbite, trenchfoot, and perino:

[1] Frostnip

- Superficial freezing injury = transient numbness and tingling that resolves after rewarming
 - NO tissue destruction

[2] Frostbite

- This is the big one for this episode! Frozen tissue!
- #1 presenting symptom = numbness = loss of pain, temperature and light touch sensation
 - Any of the commonly exposed areas
 - Also:
 - Clumsiness
 - “Block of wood” sensation
 - The initial presentation of frostbite is usually deceptively benign
 - (Assuming the person doesn’t have an obviously frozen hand)
 - Violaceous, waxy, white, pale yellow
 - Unable to move the skin over bony tissues
 - Rapid warming usually causes hyperemia - even in severe cases of frostbite
- Post rewarming:
 - Good prognosis =
 - Normal sensation, warmth and colour
 - Concerning prognosis:
 - Bleb formation
 - Residual violaceous hue
 - Hemorrhagic vesicles
 - Lack of edema formation
 - Eschar and mummification
- There are at least three different tissue classification models
 - Superficial vs deep injury (based on whether tissue is lost)
 - 1st through 4th degree (not recommended because it is inaccurate and may mislead management)
 - Grade 1–4: based on response to rapid rewarming (see below)

From uptodate:

A more useful clinical prediction tool has been developed for frostbite of the hands and feet, based on the level at which skin lesions are noted after rapid rewarming in warm water. The categories are as follow:

- **Grade 1 frostbite** is characterized by no cyanosis on the extremity. This predicts no amputation and no sequelae.
- **Grade 2** involves cyanosis isolated to the distal phalanx. This predicts only soft tissue amputation and fingernail or toenail sequelae.
- **Grade 3** frostbite is characterized by intermediate and proximal phalangeal cyanosis. This predicts bone amputation of the digit and functional sequelae.
- **Grade 4** frostbite involves cyanosis over the carpal or tarsal bones. This predicts bone amputation of the limb with functional sequelae. PMID: <https://www.ncbi.nlm.nih.gov/pubmed?term=11769921>



[3] Trenchfoot (immersion injury)

- Injury occurs due to immersion or damp conditions over days (wet socks on a long hike for days or weeks)
- Neurovascular damage, blistering and tissue loss can occur

Stages:

1. Cold exposure - numbness
 - Red to pale to white tissue
 - Lasts until out of the cold
2. Rewarming - mottling, pale blue
 - Cold and numb and progresses to pain and edema
 - Can last days
3. Hyperemia:
 - Hot, red and prolonged cap refill
 - Vasomotor paralysis
 - Severe pain, hyperalgesia
 - Edema and bullae formation
 - Can last weeks to months
4. Post-hyperemia
 - Normal appearance unless tissue lost
 - May have chronic pain

[4] Chilblains (Perino)

- Due to repetitive exposure to cold conditions or in someone with underlying disease
- Look like cold sores that appear within 24 hrs after exposure to cold
 - Face, hands, feet, tibia
- Risk groups: Young women, Raynaud's / SLE / APLAb pts.
- Symptoms: burning, pruritus, erythema, edema.
- Resolves in 1-2 weeks.
- Analgesia; consider nifedipine

[4] List 10 predisposing factors for frostbite

- a. **All you outdoor adventurers!**
- b. **Homeless or displaced persons**
- c. **Military or service people in the outdoors**
- d. **Any Canadian, Alaskan or northern American!**

See Box 131.2 in Rosen's for a Comprehensive List

Physiologic, Mechanical, Environmental, and Psychological Factors

Physiologic

1. Genetic
2. Core temperature
3. Previous cold injury
4. Acclimatization
5. Dehydration



6. Overexertion
7. Trauma—multisystem, extremity
8. Dermatologic disease
9. Physical conditioning
10. Diaphoresis, hyperhidrosis
11. Hypoxia

Mechanical

1. Constricting or wet clothing
2. Tight boots
3. Vapor barrier, Aveolite liners
4. Inadequate insulation
5. Immobility or cramped positioning

Psychological

1. Mental status
2. Fear, panic
3. Attitude
4. Peer pressure
5. Fatigue
6. Intense concentration on tasks
7. Hunger, malnutrition
8. Intoxicants

Environmental

1. Ambient temperature
2. Humidity
3. Duration of exposure
4. Wind chill factor
5. Altitude and associated conditions
6. Quantity of exposed surface area
7. Heat loss—conductive, evaporative
8. Aerosol propellants
9. Cardiovascular
10. Hypotension
11. Atherosclerosis
12. Arteritis
13. Raynaud's syndrome
14. Cold-induced vasodilation
15. Anemia
16. Sickle cell disease
17. Diabetes
18. Vasoconstrictors, vasodilators

[5] Describe the pre-hospital and ED management of frostbite

Priorities

1. Prevent re-freeze injury & thaw
2. Analgesia
3. Wound care
4. Tetanus prophylaxis
5. Consider if there is a role for thrombolytic therapy (IV or IA)
6. Post-thaw wound care and follow-up



Prehospital:

DO:

- Remove from the cold environment
- Prevent any thaw-refreeze cycles
- Remove constricting and wet clothing
- Insulate and immobilize the affected areas (unless you need to walk out on frozen feet)
- If unable to evacuate thaw in 37-39 degree water

DON'T

- Use dry heat sources
- Rub the tissue vigorously
- Use heat forced air
- Use fire

ED management (Box 131.4)

Prethaw

Assess Doppler pulses and appearance.

1. Protect part—no friction massage.
2. Stabilize core temperature.
3. Address medical and surgical conditions.
4. Administer volume replacement as indicated.

Thaw

Provide parenteral opiate analgesia as needed.

1. Administer ibuprofen 400–600 mg (or aspirin, 325 mg).
2. Immerse part in circulating water at 37° C–39° C (98.6° F–102.2° F), monitored by thermometer.
3. Encourage gentle motion, but do not massage.

Postthaw

Dry and elevate.

1. Aspirate or débride clear vesicles.
2. Débride broken vesicles and apply topical antibiotic or sterile aloe vera ointment every 6 hours.
3. Leave hemorrhagic vesicles intact.
4. Administer tetanus prophylaxis if indicated.
5. Provide streptococcal prophylaxis if high risk.
6. Consider phenoxybenzamine in severe cases.
7. Perform imaging, including angiography, if thrombolysis may be indicated.
8. Carry out thrombolysis, if indicated and available.
9. Obtain admission photographs.

A couple keys:

- Water warmer than 39 degrees causes more pain, and no significant benefit



- Thermal injury occurs if the water temperature is > 42 degrees
- Usually 30 mins of immersion is needed - if in doubt keep it in longer (until distal erythema is noted)
- Don't massage the tissue, but encourage gentle active movement
- Have IV access available and note the risk for core temperature afterdrop and VF!
- Elevate the affected extremity post thaw to prevent edema
- Consider thrombolysis
 - IV tPa or intra-arterial tPa (both with heparin)
 - Given within 24 hours of thawing (you have time!!)
- Indications for thrombolysis:
 - No contraindication to tPa
 - Risk for significant tissue loss (e.g. extending to proximal phalanx)
- Other “unproven therapies”
 - LMWH
 - Hyperbaric O2
 - Iloprost (prostacyclin)

[6] List 8 sequelae of frostbite.

Box 131.3

Categories = Neuropathic, MSK, Dermatologic, Miscellaneous

Neuropathic

1. Pain
 1. Phantom pain
 2. Complex regional pain syndrome
 3. Chronic pain
2. Sensation
 1. Hypesthesia
 2. Dysesthesia
 3. Paresthesia
 4. Anesthesia
3. Thermal sensitivity
 1. Heat
 2. Cold
4. Autonomic dysfunction
 1. Hyperhidrosis
 2. Raynaud's syndrome

Musculoskeletal

1. Atrophy
2. Compartment syndrome
3. Rhabdomyolysis
4. Tenosynovitis
5. Stricture
6. Epiphyseal fusion
7. Osteoarthritis
8. Osteolytic lesions
9. Subchondral cysts
10. Necrosis
11. Amputation



Dermatologic

1. Edema
2. Lymphedema
3. Chronic or recurrent ulcers
4. Epidermoid or squamous cell carcinoma
5. Hair or nail deformities

Miscellaneous

1. Core temperature afterdrop
 2. Acute tubular necrosis
 3. Electrolyte fluxes
 4. Psychological stress
 5. Gangrene
 6. Sepsis
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