Edward A. Wilson (1872-1912):
Sledge Hauling on the Great Barrier 1903 (on Scott’s Expedition to Antarctica 1901-1904)
Jack London: To Build a Fire. In Lost Face: MacMillan, 1910
Edward A. Wilson (1872-1912):
Sledge Hauling on the Great Barrier 1903 (on Scott's Expedition to Antarctica 1901-1904)
Out in the Cold: Medical Aspects of Cold Exposure

Keith Conover, M.D., FACEP
Department of Emergency Medicine, Mercy Hospital of Pittsburgh
Traditional Cold Injury Topics

- **Local**
  - Chilblain
  - Trench Foot = Immersion Foot
  - Frostbite
    - Superficial Frostbite = Frostnips
    - Deep Frostbite
- **Generalized**
  - Hypothermia
Non-Freezing Cold Injury

Chilblain

Immersion Foot = Trench Foot
Non-Freezing Cold Injury

- **Chilblain**
- **“Trench Foot” and “Immersion Foot”**
  - rough synonyms (but trench/immersion include damp and maceration)
  - chronic conditions
Non-Freezing Cold Injury

- **Prolonged exposure to cold**
- **Risks:**
  - Sub-Saharan African Ancestry
  - Smoking
  - Tight shoes
  - ? SLE (lupus)
Chilblain

chil·blain (chilˈblān), n. Usually, chilblains. Pathol.
an inflammation of the hands and feet caused by exposure to cold and moisture.
Also called pernio.
[1540–50; CHILL + BLAIN]
—chilˈblained, adj.
Chilblain

perni-o (pûr’ ne ô’), n. Pathol.
chilblain.
[1670–80; < L pernîč chilblain on the foot, deriv. of pern(ā) haunch of the leg; see -ION]
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<td>Cribier</td>
<td>2001</td>
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<td>Lavigne</td>
<td>2000</td>
<td>Lethal pancytopenia associated with chilblain lupus erythematosus</td>
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<td>Chilblain lupus erythematosus Hutchinson: successful treatment with mycophenolate...</td>
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<td>1999</td>
<td>Chilblain lupus erythematosus is associated with antibodies to SSA/Ro</td>
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<td>[A case of male who was taken systemic lupus erythematosus with chilblain lupus]</td>
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<td>1996</td>
<td>Violaceous rash of dorsal fingers in a woman. Diagnosis: chilblain lupus erythema...</td>
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<td>Chilblain lupus erythematosus of Hutchinson responding to surgical treatment: a report...</td>
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<td>Su</td>
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<td>Chilblain lupus erythematosus (lupus pernio): clinical review of the Mayo Clinic experience...</td>
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<td>Chilblain lupus erythematosus and lupus pernio--the same entity?</td>
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<td>[Evaluation of the past history of chilblain in cases of systemic lupus erythematosus (...</td>
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<td>[Sequelea of chronic chilblain in agricultural workers]</td>
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<td>Chilblain lupus erythematosus (Hutchinson). A clinical and laboratory study of 17 pat...</td>
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<td>[Chilblain-lupus, its relation to lupus erythematosus and its characteristics]</td>
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<td>1959</td>
<td>[Comments on vasculo-cutaneous diseases of the extremities. Chilblain]</td>
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<td>[Lupus erythematosus of the nose &amp; extremities (chilblain lupus) associated with hilar...</td>
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<td>Kellerman</td>
<td>1955</td>
<td>Observation on the critical temperature for necrotic reaction in the fingers of chilblain...</td>
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</table>
Chilblain: ‘Lupus Pernio’

lupus pernio

Sarcoid lesions, clinically resembling frostbite and microscopically resembling lupus vulgaris, involving ears, cheeks, nose, hands, and fingers.
Non-Freezing Cold Injury

chilblain lupus erythematosis

Skin lesions seen in patients with lupus erythematosis, resembling the small, hardened nodular areas of a cold injury called chilblains. Syn: chilblain lupus(1).
Non-Freezing Cold Injury

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<td>Parlette</td>
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<td>Erythrocyanotic discoloration of the toes</td>
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<td>Duffill</td>
<td>1993</td>
<td>Milkers' chilblains</td>
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<td>Goette</td>
<td>1990</td>
<td>Chilblains (perniosis)</td>
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<td>Rustin</td>
<td>1989</td>
<td>The treatment of chilblains with nifedipine: the results of a</td>
</tr>
<tr>
<td>Dowd</td>
<td>1986</td>
<td>Nifedipine in the treatment of chilblains</td>
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Rustin, 1989

Abstract:
A pilot study, a double-blind placebo-controlled randomised study and a long term open trial have indicated that nifedipine is effective in the treatment of perniosis. At a dose of 20 mg to 60 mg daily, nifedipine significantly reduced the time to clearance of existing lesions and prevented the development of new chilblains. Nifedipine also reduced the pain, soreness and irritation of the lesions. A comparison of the pre- and post-treatment skin biopsies showed resolution of the dermal oedema and diminution of the perivascular infiltrate. An increase in cutaneous blood flow following administration of nifedipine suggests that the vasodilator action of this drug may be important in its action.
Non-Freezing Cold Injury
Non-Freezing Cold Injury

Cold Injury: Diagnosis and Management of Long Term Sequelae

Independent Study Course
1998, Revised May 1999
Reviewed October 2000
Revised March 2002
Non-Freezing Cold Injury

• Sequelae ... [include] ... cold sensitization, pain, and hyperhidrosis.

• Remarkable similarities with conditions including “deprivation hands and feet,” which appears to NFCI in infants, and “reflex sympathetic dystrophy,” ... involving chronic pain and vascular instability following diffuse trauma.
Non-Freezing Cold Injury

• *In cases where an adequate history can be obtained, the key diagnostic criterion is of a sensory neurological disturbance during the period of exposure. This usually amounts to local anaesthesia, and is distinct from sensations of prolonged or extreme cold.*
Non-Freezing Cold Injury

- **Stage One: Ischaemia**
  - “Wearing someone else’s feet.”

- **Stage Two: Early reperfusion**
  - Pain
  - Lasts minutes to hours

- **Stage Three: Hyperaemia**
  - Red, more painful, dysesthesias, swollen, increased pulses but decreased capillary refill
  - Lasts days to weeks
Non-Freezing Cold Injury

• Stage Four: Sequelae
  – Most recover 3 months-12 years
  – Continued cold sensitivity
  – Vasomotor changes (constriction), hyperhydrosis
    (‘secondary Raynaud’s)
  – Continued pain, may get allodynia:
    • light touch transmutes to pain
    • considered pathognomonic for Reflex Sympathetic
      Dystrophy (RSD) AKA Complex Regional Pain Syndrome II
Non-Freezing Cold Injury

• VAMC Treatment Recommendations
  – *Slow rewarming*
  – *Stage 4: sustained release nifedipine*
  – *Avoid sympathectomy*

• Keith’s take: Chilblain is either Lupus or chronic phase of Non-Freezing Cold Injury
“Feet is Froze”: Frostbite

Freezing
Local Cold Injury
1812: The March to Moscow
Barron Larrey’s Treatment

• Rub with Snow
• (Better than warming over a fire!)
Frostbite

- **Freezing Cold Injury 1. Frostnip**
  - Superficial Frostbite = ‘Frostnip’ (? Initial insult of chilblain)
  - Skin turns pale and waxy as superficial tissues freeze and blood flow stops (no pictures)
  - Skin still *soft*
  - Treated by immediate rewarming (hand over nose, finger in armpit or mouth)
Frostbite

- After rewarming:
  - Turns mottled and blue (reperfusion)
  - Turns red and throbs (painful)
- Good prognosis
Frostbite

83 A magnified view of the arterial wall, with total unorganized thrombus and extensive necrosis.

84 This pattern is typical of a freeze–thaw–refreeze injury. Demonstrated are occluded small vessels, and devitalized structures, including nerve necrosis. Loss of intimal lining, subintimal necrosis and fracture of normal elastic fibers are present.
Frostbite
Hypoxia, a high-altitude environment injury with tissue dehydration, severe freezing of the tissues with the imprint of a neoprene sock with zipper. This is a freeze–thaw–refreeze injury of great severity which, despite fasciotomy and other care, resulted in demarcation across the proximal tarsi. The injury was sustained between 5,200 and 5,800 m, on Mt. McKinley, where the patient was without food or water for at least three days. Irrevocable changes were apparent from the moment of thawing.
Frostbite
Frostbite
Frostbite
Frostbite
Frostbite
Deep Frostbite Treatment

• Rapid rewarming
  – 104 degrees F (40 degrees C)
  – Water bath

• “You can walk on frozen feet, but you can’t walk on thawed feet”
  (and danger of re-freezing)

• Analgesia
Deep Frostbite Treatment

• Meticulous wound care
• Elevation
• NO amputation unless grossly infected
• Watch for compartment syndrome

• Medications:
  – ASA daily (though ? benefit only if started prior to frostbite)
  – ibuprofen (Motrin) 12 mg/kg/day divided BID
  – Dextran-40 @ 25cc/hr
  – Aloe (topical effects only, unlikely to harm)
  – Consider tPA, iloprostin
Deep Frostbite Treatment

• Technetium 99m scan or MRA or angiogram
• Hydration, oxygen, protect injured tissue
• Update tetanus immunization
• No antibiotics unless infected
• No unroofing blisters unless infected
Frostbite Prevention

• Properly-fitting shoes (avoid “Two-Sock Frostbite”)
• Warm-when-wet clothing (including wool socks)
• Cover face and hands when wind chill equivalent temperature low.
Wind Chill Temperature

- By U.S. Army Antarctic explorers in late 1940s.
- Experimented with how fast water freezes in certain wind speeds and temperatures.
- Compared to rate bare skin loses heat.
Wind Chill Temperature
# FAHRENHEIT WIND CHILL EQUIVALENT TEMPERATURE

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<td>48  37  33  27  21  16  12  6  1  -5  -11  -15  -20  -26  -31  -36  -41  -47  -52  -57  -65  -70</td>
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**FIGURE 3A  "WIND CHILL CHART - FAHRENHEIT"**

**NOTE 1.** The above chart has been based upon the Siple Equation and reflects Wind Chill Equivalent temperatures in Fahrenheit.

**NOTE 2.** At low wind speeds, relative humidity and radiant heat are more important than wind speed in determining equivalent temperature comfort.

**NOTE 3.** Most charts indicate that at wind speeds over 40 mph there is little additional wind chill effect. This is a reflection of an error in the basic equation at these higher wind speeds and is not correct. Heat loss IS magnified by these higher wind speeds, but the chart is an accurate indicator of equivalent temperature at speeds lower than 40 mph.
Old vs. New

Wind Chill Temperature Comparison (Old vs. New)

Air Temperature of 5°F

Wind Speed (mph)

Old Wind Chill Formula

New Wind Chill Formula
### New NWS Wind Chill Chart

Furnished by National Weather Service Gray Maine

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<td>-74</td>
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**Frostbite occurs in 15 minutes or less**

Wind Chill (°F) = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})

Where,  
T = Air Temperature (°F)  
V = Wind Speed (mph)
Wind Chill on Face Now Known to be Less

Fig. 2. Wind chill equivalent temperatures calculated at an air temperature of 14°F (−10°C).
“Hug a Tree and Survive”
Short-Term Survival

• Food?
• Water?
• Shelter?
• Air?
• Will to Live?
Short-Term Survival
Short-Term Survival
Short-Term Survival

Hypothermia: Killer of the Unprepared
Hypothermia: Killer of the Unprepared

January, 1999
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Departments of Emergency Medicine
Mercy Hospital and University of Pittsburgh;
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Appalachian Search and Rescue Conference
This document available at www.conovers.org

※ Hypothermia = low (hypo-) temperature (-therm-) condition (-ia)
※ Hypothermia is when the body gets chilled -- not just the skin and muscles, but deep inside

※ Heat Balance:
※ The body produces heat continuously; this production of heat must be balanced by an equal heat loss to keep the body temperature from going up or down.
※ The body temperature must be kept within a narrow range for vital chemical processes to work.
※ Use clothing and knowledge to keep your body core near 99°F, even in hypothermia weather.
※ Heat is lost from the body several ways...
Short-Term Survival

- 99°
- 94°
- 85°
- 75°
- 90°
- 70°
- 70°
- 50°
- 50°
Short-Term Survival
Leaf-Bag
Survival Shelter

• Most critical survival “kit”
• Cheap
• Light
• Can carry spares for others
OK, MEN, YOU HAVE YOUR MISSION.

NOW REMEMBER:
DON'T GET SEPARATED FROM YOUR PACK...
DON'T GET SEPARATED FROM YOUR PACK...
DON'T GET SEPARATED FROM YOUR PACK!!!
The First Rule of Mtn. Rescue
Short-Term Survival
Thermal Regulation

How the human body’s thermostats, furnaces and A/C work
Thermal Regulation

- *Thermostat, nervous system:*
  - Hypothalamus
  - (and peripheral sensors)
Thermal Regulation

- **Thermostat: Endocrine**
  - Thyroid gland
  - Adrenal glands
    
    (adrenaline = epinephrine)
Furnace

- **Glycogen “Animal Starch”**
  - In muscles
  - In liver
- **Fat**
- **Protein breakdown**
Heat Balance

Heat Production:
- Basal Metabolism
  1. Carbohydrate
  2. Fat
  3. Protein

Heat Loss:
- Basal Heat Loss
  1. Radiation
  2. Convection
  3. Conduction
  4. Respiration
  5. Evaporation

Heat Balance:
- Normal
- Hotter
  - Deliberate Muscular activity
  - Shivering
- Colder
  - Windchill
  - Waterchill

Temperature Ranges:
- Hypothermia: 96° 97° 98° 99°
- Heat Exhaustion: 100° 101° 102°

Body Core Temperature
Lose a little, gain a little
Countercurrent Heat Exchange
Core vs. Shell

- Warmer core
- Colder shell
- Hypothermia
Thermostat Questions

• Why:

• *Does someone with a fever get shaking chills just like someone out in the cold?*

• *If you give someone with a fever a Tylenol, do they throw off the covers and start sweating?*
Hypothermia: Medical Aspects

“They’re not dead until they’re warm and dead.”
“Afterdrop”

- ? Rewarming
  Shock

- Cooled blood to core
- Blood through cold shell
- Rewarming
- After drop
Susceptibility of the heart to ventricular fibrillation seems to be a simple function of how cold the heart is, and how long it stays that cold. The risk may be proportional to the shaded area. Rapid core rewarming may decrease this risk.
“Afterdrop”

- Rewarming Shock
- Tilting = death
Where to rewarm

• Areas of high heat exchange with core
Cold, or Cold and Dead?

- *How long to check for pulse?*
- *Any downside to CPR?*
If Your Mind Isn’t Full Already . . . Questions?