HYPOTHERMIA

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OBJECTIVES

- Review hypothermia physiology
- Introduce historical-cultural context
- Discuss field management
- Define freezing and non-freezing injuries
- Share survival pearls
Mechanisms of heat loss

- Radiation: Majority of heat loss
- Conduction: Increases 25x wet
- Convection: Wind Chill, rewarming
- Evaporation: hot environments
- Respiration: small but obligate
### Heat Loss: Rest and Prolonged Exercise (70% of VO₂MAX)

<table>
<thead>
<tr>
<th>Mechanism of heat loss</th>
<th>Rest (% total)</th>
<th>Exercise (% total)</th>
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</thead>
<tbody>
<tr>
<td>Convection and Conduction</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Radiation</td>
<td>60</td>
<td>5</td>
</tr>
<tr>
<td>Evaporation</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
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### Conduction
Convection

Evaporation
Radiation

$E_2$

$E_1$

$h\nu$
Skin disorders

- Increased blood flow to periphery
  - Ethanol
    - Cutaneous vasodilator
    - Impaired central regulation
  - Unacclimatized
    - Cold and altitude
  - Elderly
    - Less adept at increasing heat production
  - Neonates: surface area-to-mass ratio
    - Relatively deficient subcutaneous layer
    - Inefficient shivering mechanism

Metabolic

- Hypoglycemia, malnutrition, exertion,
- Hypothyroidism, DKA/AKA
AT RISK: DYSREGULATION OF TEMPERATURES

“The cold remains a mystery, more prone to fell men than women, more lethal to the thin and well-muscled than to those with avoirdupois, and least forgiving to the arrogant and unaware.”

Peter Stark
Jack London: To Build a Fire, 1908
Peter Stark: As Freezing Persons Recollect the Snow, Outside Magazine, January 1997

Hannibal: 218 BC
- ½ of the army perished from exposure

Napoleon: 1812
- Nearly 480,000 soldiers perished

Hitler: 1941
- 100,000 soldiers (10%) suffered cold injuries with 15,000 amputations
- Nuremberg Trials, 300 victims of forced freezing experimentation
CURRENT STATISTICS

- 700 people / year die from hypothermia
  - Half older than 65
  - 66% men
- Highest incidents?
  - Florida, California
- Highest death rates?
  - Alaska, New Mexico, North Dakota, Montana
Record for neurological recovery:
- 55.4 °F (13°C)
  - 7yo near-drowning (Sweden Dec 2010)
- 56.6°F (13.7°C) Dr. Anna Bagenholm
  - 29yo 80 min under ice (Norway 1999)
- 57°F (19.9°C) Karlee Kosolofski
  - 2½yo found on doorstep -7.6°F (-22°C)

No precise temperature causing death:
- Nazis calculated death at 77°F (25°C)
Four Inns Walk

240 hikers walk 45 miles, usually 2/3 finish

1964: 45 °F (7.2°C)

Only 22 finished the walk

3 Rover Scouts died, ages 19, 21, and 24

4 were rescued in critical condition

Definition: Core temp < 35°C (95°F)
- mild 32-35°C (90-95°F)
- moderate, 28-32°C (82-90°F)
- severe, 20-28°C (68-82°F)
- profound at less than 20°C (68°F)*

32-35°C: shivering thermogenesis

<32°C (89.6°F) slowed metabolism
- ↓O₂ utilization, ↑CO₂ production
- Therapeutic Hypothermia range*

Below 28°C (86°F) poikilothermia
Hypothermia Video

Hypothermia: Pathophysiology

- CNS: AMS, incoordination, confusion, lethargy, coma
- Pulmonary: increased aspiration risk
- Renal: cold diuresis with volume loss
- Vascular: hyperviscosity, thrombosis, DIC
- Cards: Bradycardia and slow AFIB
  - Myocardial irritability
HYPOTHERMIA: PATHOPHYSIOLOGY

- Hunter's response (CIVD)
  - Cold induced vasodilation
  - Paradoxical undressing
  - Paradoxical Core Afterdrop (PCA)
    - Cold lactate rich blood returns to core
    - Core pH and temp drop initially despite warming efforts

- Thermogenesis: shivering lost at 28 °C
- Cold Pancreatitis
- Oxyhemoglobin curve to left
  (Hangs onto O2)
HYPOTHERMIA: ASSESSMENT

- ABC’s (two minutes)
- Vital signs
- Mental status
- History
- Meds
- Temperature
- Assess: coexisting illness or injury
HYPOTHERMIA: TREATMENT

- **Remove from cold source**
  - Shelter/insulate from ground/snow
  - Remove wet clothes IMMEDIATELY
- **Avoid shaking/jostling** patient
- **Dry, Dress, insulate** patient
  - Cover head and trunk first
  - Reflect body heat: Space blanket
**HYPOTHERMIA: TREATMENT**

- Active external core re-warming
- Beware: Do **not** let pt apply heat
- Plan evacuation

**HYPOTHERMIA: TREATMENT**

- **Volume resuscitation - Cold Diuresis**
  - Keep water bottles under jacket
  - Warm sugary drinks from camp stove
    - If pt is protecting airway
    - Glucose:
      - High if diabetic or CVA
      - Low if metabolized to keep warm
“For crying out loud, I was hibernating... Don’t you guys ever take a pulse?”

The patient is not dead unless warm and dead (core temp >30) is false.....

The State of Alaska Cold Injuries Guidelines
- Only pre-hospital guidelines for hypothermia treatment
HYPOTHERMIC ARREST

- Hypothermic arrest: core < 30°C,
- PEA vs VFib or VT
  - Single shock patterns better
  - Only re-shock when core rises 1-2°C
  - Epi, Atropine, Dopamine ineffective

WHEN TO HOLD ACLS/BL S TREATMENT?

- Core temp< 10°C/ 50°F
- Victim submersed in water > 1 hour
- Obvious lethal injury (decapitation)
- Chest wall too stiff (compressions impossible)
- Pt is frozen (ice formation in the airway)
- Definitive care is available within 3 hours
- Rescuers are exhausted or in danger
NO CARDIAC MONITOR?

- Definitive care is available in 3 hours:
  - Ventilate (intubate if possible)
  - Protect from further cooling
  - Do Not start chest compressions
  - Wait for rescue crew
- Definitive care is not available:
  - Ventilate
  - Compressions for 30 minutes, rewarm
  - If unsuccessful (no ROSC), Pronounce dead
- Do NOT attempt CPR while litter bearing (ineffective)

THE HAZARDS OF CAPILLARY REFILL IN SUB-ZERO TEMPERATURES
**Extremity Injuries**

- **Local Trauma in cold environments**
  - “Make limbs look like limbs”
  - Prevent additional injuries
  - Splints should not be constrictive

- **Cold Injuries**
  - Frost nip, Chilblains, Trench foot
  - Frost bite

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**Frostbite: Predisposing Factors**

- Contact with good thermal conductors (eg. metal)
- Direct exposure to cold wind (wind chill factor)
- Constrictive clothing and immobility (reduce heat delivery)
- Vasoconstrictive medications
- Dehydration
NONFREEZING COLD INJURIES

- **Chilblains**
  - redness, itching, blisters, inflammation

- **Frost nip**
  - Numbness/tingling, no tissue injury

- **Trench foot**
  - “fat foot,” swelling, erythema or cyanosis
  - untreated gangrene
**Frostbite - Freezing Injury**

- **Pathophysiology**
  - Ice crystals
  - Earlobes, cheeks, nose, hands and feet
- **Superficial:** Cold to touch, pale, gray and bloodless but tissue is pliable
- **Deep:** Tissue is woody and stony
- **Treatment**
  - Re-warming
  - Local wound care
  - Delayed surgery
FROSTBITE TIDBITS

- Refreezing is VERY BAD
  - Causes more damage than waiting for evacuation and definitive treatment
- Early clear blebs = GOOD
- Early hemorrhagic blebs = BAD
- “Frostbite in January, amputate in July”

SURVIVAL TIPS

- Survival planning is nothing more than realizing something could happen that would put you in a survival situation and, with that in mind, taking steps to increase your chances of survival. Thus, survival planning means preparation.
**Survival Tips**

- Shelter
- Heat
- Water
- Help

**Tree-Pit Snow Shelter**

- Dig out the snow around tree
- Pack the snow around the top and inside of hole to provide support
- Cut evergreen boughs
- Place them over top of the pit & in bottom of pit for insulation
Figure 15-6. Fallen tree as shelter.
Never sleep directly on the ground
Never go to sleep without turning out your stove or lamp (carbon monoxide)
Use eye protection to prevent snow blindness
Water is better than ice
- Don’t waste fuel

Ice is better than snow
- Ice yields more water
- Ice takes less time to melt

Melt ice or snow in a crane
Knowledge is the best preparation

Hypothermia:
- Recognize predisposing risks early
- Remove victim from cold source(s)
- Assess for co-morbid conditions
- Find Shelter and Plan Evacuation

Cold injuries are prevented, not treated, in the field
QUESTIONS?