Objectives

• Thermoregulation basics
• Management of human-sickles
• Understanding cold toes and how to say no to the surgeons
The Misguided Mountaineer

- 29 year old climber found at 4500m after falling in a glacial lake,
- He crawls out and is lost in an ensuing snowstorm
- Core T 26C, P 40, BP 80/50, RR 8
- PE: Difficult to arouse, clear lungs
- EKG: Sinus bradycardia
Thermoregulation 101

• **Heat Production**
  - Basal Metabolic Rate (100 kcal/hr)
  - Shivering (500 kcal/hr)
  - Physical activity (200-? kcal/hr)
Thermoregulation 101

• Heat Loss
  – Radiation (60% of all heat loss)
  – Evaporation (sweat/ lungs)
  – Conduction (5-25X greater when wet)
  – Convection (wind)
Thermoregulation Limitations

- Fuel availability
- Oxygen
- Hydration
- VO₂ max
- Fatigue
- Alcohol
- Medications/Drugs
Hypothermia: Kids

• Young children more prone to hypothermia due to:
  – Higher surface area/ body weight ratio
  – Diminished shivering
  – Tendency to play naked in snow and not care
Hypothermia: Clinical Presentation

**Mild**
- Temperature: 33-35C
- Symptoms: Shivering

**Moderate**
- Temperature: 28-32C
- Symptoms: Lethargy, unsteady gait, confusion

**Severe**
- Temperature: <28C
- Symptoms: Respiratory depression, cardiac arrhythmias, stupor/coma
How Cold Do You Feel?

• Your skin is your thermostat
• Lowest recorded temperature in survivor: 13.7 C (56F!)
• Cold people aren’t dead until they are warm (>35C) and dead
Hypothermia: Field Management

**Stop heat loss:**
- Shelter against cold and wind
- Remove wet clothing
- Insulate

**Increase Heat Production**
- Blanket/sleeping bag
- Warm water bottles at groin/neck/axilla or warm human
- Warm oral fluids if able
- Fuel/food
- Oxygen if at altitude
Evacuation

• Gently
ED Management

• Passive External Re-warming for all (remove heat sinks):
  – Dry clothes
  – Blanket
  – Allow patient to raise his own body temperature
ED Management

• **Active External Re-warming: (< 33C)**
  - Convective heating blanket ("Bair Hugger")
  - Radiant warmer (babies)
ED Management

- **Active Internal Re-warming:**
  - *Minimally invasive:* (≤33°C)
    - Warm IV fluids (42°C)
    - Warm humidified air (42°C)
  - *Invasive:* (significant cardiac arrhythmias)
    - Chest tube lavage
    - Peritoneal lavage
    - AV Bypass
# Rates of Re-warming by Technique

<table>
<thead>
<tr>
<th>Technique</th>
<th>Max Re-warming Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humidified Air (42°C)</td>
<td>Mask: 1 C/hr, ETT: 2 C/hr</td>
</tr>
<tr>
<td>Warmed IVF (42°C)</td>
<td>1 liter: 0.33 C/hr</td>
</tr>
<tr>
<td>Chest Tube Lavage</td>
<td>3-4 C/hr</td>
</tr>
<tr>
<td>Peritoneal Lavage</td>
<td>3-4 C/hr</td>
</tr>
<tr>
<td>AV Bypass</td>
<td>Up to 9 C/hr</td>
</tr>
</tbody>
</table>
Complications of Hypothermia

- **Rewarming shock**: due to decreased systemic vascular resistance
- **Pulmonary Edema**: capillary leakage
- **Renal Failure**
- **DIC**: bleeding/clotting
- **Infection**
Dress for the Weather

- Conserve energy
- Minimize sweating
- Layering:
  - Wicking layer
  - Insulating layer
  - Protective layer
Check out those tootsies

- 25 year old backcountry skier lost for 2 days
- New boots, wet snow
- Feet “numb”
- In ED, T 35°C, other VS nl
- PE: mottled, white “woody” feet
Differential Diagnosis

- Frostnip
- Superficial frostbite
- Deep frostbite
Frostbite

- **Pathophysiology**: tissue ischemia from low blood flow
- **Contributing factors**:
  - Poor insulation
  - Moisture
  - Constriction
  - Dehydration
Clinical Presentation

- **Frozen**: white, hard, numb
- **Thawed < 24hr**: variably soft, +/- blisters
- **Thawed > 24-48hrs**:
  - **Superficial**: edema, clear blisters, pain, warmer, light purple
  - **Deep**: little edema, no blisters, painless, dark, cold
Frostbite: Field Management

- Aggressive re-warming: 38-42C bath
- Ibuprofen
- Hydration
- Do NOT allow refreezing
Frostbite: ED Management

- Field protocol
- Irrigation
- Bulky dressing
- Medications:
  - Ibuprofen
  - Aloe Vera
  - Vasodilators:
    - Nifedipine (calcium channel blocker)
    - Phenoxybenzamine (alpha 1 blocker)
Frostbite Prognosis

Better if:
- Early edema
- Early formation of clear blisters
- Pain!

Role of surgery: NONE early
• Hard to get cold humans warm: be aggressive
• Mantra of altitude illness: DESCEND
• Aggressively re-warm frostbite but do not allow refreezing