High Altitude Illness: Prevention & Treatment

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A High Altitude Scenario

- You have agreed to serve as medical support for a trek to summit Mount Kilimanjaro.
- Mount Kilimanjaro is located in Tanzania
- The Summit is 5895 m
- The group you are traveling with plans to take the Marangu route
- How will you prepare and what supplies will you take?
The Seven Summits

Tanzania
Climbing Routes

Introduction
- Definitions
- Epidemiology
- Acclimatization
- Pathophysiology
- Acute Mountain Sickness
- High Altitude Pulmonary Edema
- High Altitude Cerebral Edema
- Other Altitude Related Disorders
- Prevention
Definitions

- High Altitude
- High Altitude: 1500-3500 m
- Very High Altitude: 3500-5500 m
- Extreme Altitude: > 5500 m
- High Altitude Illness
- Acute Mountain Sickness
- High Altitude Pulmonary Edema
- High Altitude Cerebral Edema
- Acclimatization
History
- Mild forms of the illness are common
- Severe forms are rare
- Most people experience some symptoms over 10,000 feet

Risk Factors/Categories
- Genetic factors
- Youth
- Seizures
- Pulmonary Hypertension
- Sickle cell trait
- Sleep apnea
- COPD
- CHF
- CAD

Previous HAS
- Rapid Assent
- Poor conditioning
- Dehydration
- Use of drugs/ETOH
### Risk Categories for High Altitude Illness

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Description</th>
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</thead>
</table>
| **Low**       | - No history & ascending to < 2800 m  
|               | - Taking > 2 days to arrive at 2500 m with subsequent increase of sleeping elevation of < 500 m/d  |
| **Moderate**  | - Prior history of AMS and ascending to 2500 m in one day  
|               | - No history of AMS and ascending to > 2800 m in 1 day  
|               | - Ascending > 500 m/d above 3000 m  |
| **High**      | - History of AMS and ascending to > 2800 m in one day  
|               | - Prior History of HAPE or HACE  
|               | - Ascending to > 3500 m in one day & ascending > 500 m/d above 3500 m  
|               | - Very rapid ascents  |
Acclimatization

- Increased Sympathetic Activity
- Increased Cardiac Output
- Tachycardia
- Hyperventilation
- Diuresis
- Increased erythropoietin levels
- Increased 2,3 DPG production

Acclimatization: Altitude versus oxygenation

<table>
<thead>
<tr>
<th>Altitude</th>
<th>Atm Press</th>
<th>$P_aO_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea Level</td>
<td>760</td>
<td>90-95</td>
</tr>
<tr>
<td>2800 m</td>
<td>543</td>
<td>60</td>
</tr>
<tr>
<td>6100 m</td>
<td>356</td>
<td>35</td>
</tr>
</tbody>
</table>
**Acclimatization: Oxygen Dissociation Curve**

![Graph showing the oxygen dissociation curve with labels for decrease and increase in DPG.]

**Pathophysiology**

- Hypoxia
- Failure to Acclimatize
- Complex neurohumoral & hemodynamic responses
- Overperfusion of microvascular beds
- Elevated capillary pressure
- Capillary leakage
- Edema
Scenario One

You are on day two of your trip when a member of your party approaches you complaining of a severe, throbbing headache and nausea.
Acute Mountain Sickness

- Incidence
- Symptoms
- Signs
- Differential diagnosis
- Prevention
- Treatment

AMS: Incidence

- 1991 Study in Summit County, CO:
  - 22% at 1850-2750 m
  - 42% above 3000 m
- United States mountaineering data:
  - 50% of people ascending Mt. McKinley
  - 70% of people ascending Mt. Rainer
AMS: Signs and Symptoms

- Headache and at least one of following symptoms:
  - anorexia, nausea, vomiting
  - fatigue or weakness
  - dizziness or lightheadedness
  - difficulty sleeping

AMS: Differential Diagnosis

- Dehydration
- Carbon monoxide poisoning
- Exhaustion
- Hangover
- Diabetic ketoacidosis
- Hypoglycemia
- Hyponatremia
- Migraines
- Infection
AMS: Prevention

- Gradual Ascent: Always and all that is needed in low risk situations
- Acetazolamide: In moderate to high risk situations
- Dexamethasone: Can’t tolerate acetazolamide?
- ? Ibuprofen

AMS: Treatment

- Stop, rest, acclimatize
- Symptomatic treatment
- Acetazolamide
- Dexamethasone
- Other options
- If symptoms persist/worsen -> descent
One the third night, a frantic hiker calls you to her tent because her husband is short of breath and coughing up pink, frothy sputum.
High Altitude Pulmonary Edema

- Incidence
- Signs
- Symptoms
- Differential Diagnosis
- Prophylaxis
- Treatment

HAPE: Incidence

- 0.5-15% depending on location
- Occurs 1-3 days after ascent
- Half will previously have had AMS
- Frequently occurs at night
- Accounts for most deaths due to high altitude
HAPE: Symptoms and Signs

- Symptoms (at least two):
  - dyspnea at rest
  - cough
  - weakness/decreased exercise performance
  - chest tightness/congestion

- Signs (at least two):
  - crackles or wheezes
  - central cyanosis
  - tachypnea
  - tachycardia

HAPE: Differential Diagnosis

- Asthma
- Bronchitis
- Heart failure
- Hyperventilation syndrome
- Myocardial infarction
- Pneumonia
- Pulmonary embolus
HAPE: Prophylaxis

- Gradual Ascent
- With prior history of HAPE consider:
  - Nifedipine
  - Acetazolamide
  - Others?

HAPE: Treatment

- Descend if possible
- Oxygen
- Hyperbaric chamber
- Nifedipine
- ?? Beta agonists
- ?? Phosphodiesterase inhibitors
Scenario Three

It is the day before your final ascent and you awake to find a member of your party wandering confused through camp in only his underwear.
High Altitude Cerebral Edema

- Incidence
- Signs
- Symptoms
- Differential Diagnosis
- Prevention
- Treatment

HACE: Incidence

- Incidence of 0.1 to 1%
  - Usually progression of AMS
- Can progress rapidly to death
HACE: Signs and Symptoms

- Change in mental status
- Change in behavior
- Confusion
- Lethargy
- Seizure
- Coma
- Ataxia

HACE: Differential Diagnosis

- Psychosis
- AV malformation
- Brain tumor
- Carbon monoxide poisoning
- Hypoglycemia
- Hyponatremia
- Stroke
- TIA
- Intoxication
HACE: Prevention and Treatment

- For prevention, refer to AMS
- Immediate descent/evacuation
- Oxygen
- Hyperbaric chamber
- Dexamethasone
- Acetazolamide
Other Altitude Related Disorders

- Retinopathy
- Peripheral edema
- Venous stasis and thrombotic complications
- Pharyngitis and bronchitis
- UV keratitis
- HAPE

Prevention

- Physical fitness
- Hydration
- Adequate sleep
- Gradual ascent
- Hike high, sleep low
- Avoid ETOH and drugs
- Prophylactic treatment
## Recommended Drug Dosages

<table>
<thead>
<tr>
<th>Medication</th>
<th>Indication</th>
<th>Route</th>
<th>Dosage</th>
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<tbody>
<tr>
<td>Acetazolamide</td>
<td>AMS, HACE prevention</td>
<td>Oral</td>
<td>125 mg BID</td>
</tr>
<tr>
<td></td>
<td>AMS TX</td>
<td>Oral</td>
<td>2.5 mg/kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>250 mg BID</td>
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<tr>
<td>Dexamethasone</td>
<td>AMS, HACE prevention</td>
<td>Oral</td>
<td>2 mg q 6/ 4 mg</td>
</tr>
<tr>
<td></td>
<td>AMS, HACE prevention</td>
<td>Oral, IM, IV</td>
<td>q12</td>
</tr>
<tr>
<td></td>
<td>HAPE TX</td>
<td></td>
<td>4-8 mg q 6</td>
</tr>
<tr>
<td>Nifedipine</td>
<td>HAPE prevention</td>
<td>Oral</td>
<td>30 mg SR q 12</td>
</tr>
<tr>
<td></td>
<td>HAPE TX</td>
<td>Oral</td>
<td>30 mg SR q 12</td>
</tr>
<tr>
<td>B2 Agonist</td>
<td>HAPE TX/Prevention</td>
<td>Inhaled</td>
<td>2-4 puffs BID</td>
</tr>
<tr>
<td>Ibuprofen</td>
<td>AMS prevention</td>
<td>Oral</td>
<td>600 mg TID</td>
</tr>
</tbody>
</table>

**Questions?**
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>
</tr>
</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>
</tr>
</tbody>
</table>

**CONDUCTION**
Convection

Evaporation
Radiation

$E_2$

$E_1$

$\text{ACTIVITY}$
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: INCREASED HEAT LOSS

AT RISK: DECREASED HEAT PRODUCTION
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
LITERATURE
- Jack London: To Build a Fire, 1908
- Peter Stark: As Freezing Persons Recollect the Snow, Outside Magazine, January 1997

HISTORY
- 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
EXPOSURE TOLERANCE

- Records for neurological recovery
  - 55.4 °F (13C)
    - 7yo near-drowning (Sweden Dec 2010)
  - 56.6°F (13.7C) Dr. Anna Bagenholm
    - 29yo 80 min under ice (Norway 1999)
  - 57°F (19.9C) Karlee Kosolofski
    - 2½yo found on doorstep -7.6°F (-22C)
- No precise temperature causing death
  - Nazis calculated death at 77°F (25C)
Four Inns Walk

2/13/2014

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?”

**HYPOTHERMIA**

- 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/BLT 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

STOP!
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)
EXTREMITIES 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

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**

- 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

*Figure 15-3. Improvised sunglasses.*
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
I. Avalanche Basics (Not included in the Lecture)
   A. V-Shaped or Loose Snow Avalanches
      1. More common in Steep Snow
      2. May be dangerous in warm / wet snow
   B. Slab Avalanches
      1. Occur in Dry or Wet Snow
      2. Characterized by Propagating Fracture lines at the start point
      3. Caused by a cohesive snow layer sliding on a weak layer
      3. Account for 95% of fatal avalanche accidents in the US
   C. Inclination
      1. Most Slabs fracture on slopes 30-45° (Start Zone)
      2. Rarely, Wet Snow Slabs may start 15-30° (Track and Runnout Zone)
      3. Frequent Sluffs or Loose Snow Avalanches at 50-85°
   D. Slope Aspect (Predominance of Sun Exposure)
      1. Northern Hemisphere: (Most Common) N, NE, and E Facing Slopes
      2. Southern Hemisphere: S, SE and E Facing Slopes
      3. Prevailing W to E winds in mid-latitudes lead to leeward snow deposits on Eastward-facing slopes.
   E. Weather Influences
      1. 80% Avalanches run during or just after a storm
      2. Depth >1 foot and Rate of snowfall >1"/hr. for >10hrs. are red flags
      3. Presence of strong winds create drifting and areas of uneven depth
   F. Temperature Influences
      1. Rapid temperature rise to above freezing is a red flag
      2. Persistent very cold temperatures destabilize existing snowpack
      3. Very cold, warm or windy weather destabilizes the snowpack
   G. Continentality
      1. Maritime – Mild Climate, dense and heavy snowfall; Rain
      2. Continental – Cold, Light snowfall, Low density; Wind
      3. Transitional “Intermountain” – Mix of above (Wasatch, Tetons)
   H. Stability and Slope Testing (Snow Pit)
      1. Allow visual inspection for location / composition of weak layers
      2. Allow assessment of fracture propagation
      3. Allow controlled assessment of skier/ rider’s impact

II. Personal Protection and Rescue Equipment
   A. Prediction Bulletins
      1. Regional Avalanche Danger Scale: Likelihood, Size, Distribution
         - Scales Standardized for NA or Europe
      2. Local Avalanche Recommendations: Specific route or trail conditions
B. Personal Safety Devices
1. Avalanche beacon – Switched to “transmit” while touring
2. RECCO – Reflector integrated into clothing/ gear (Not a beacon replacement)
3. “Avalung” – Device for redirecting exhaled air away from face
4. Airbag (ABS) – Rapidly inflated to keep victim visible and close to the surface based on “reverse segregation” principle.

C. Rescue Equipment
1. Avalanche beacon – Switched to Receive to locate buried victims
2. Shovel and Probe
3. RECCO Detector – Transmits radio signal which is amplified by reflector; useable from the air; Carried by many patrol and rescue groups
4. Rescue Dogs – Body retrieval; used in conjunction with above

D. Evidence of Benefit
1. Airbag – Significant mortality reduction from 18.9% to 2.9% with airbag; although 20% failure of airbag inflation and 20% still completely buried despite inflation (Brugger 2007).
2. Avalanche Beacon – Significant reduction in burial duration from 125 min to 25 min with beacon (Brugger 2007). Reduction 120 min to 20 min without mortality benefit (Hohlrieder 2005).
3. RECCO – No Medline/ Pubmed Data
4. Artificial Air Pocket “Avalung” – Time to hypoxia increased from <14 min to as high as 60 min; 8 Subj, 7 Control (Grissom 2000).
5. Probe Grid vs Dogs – No significant Difference in duration to rescue

E. Discussion of optimal Search and Retrieval techniques will not be included

III. Epidemiology and Survivor Considerations
A. 150 People killed yearly in North America and Europe; Far more in developing nations (Etter 2010).

B. Degree of Burial is the Strongest Predictor of Survival (Brugger 2001).
1. Overall 77% survival, although sig variation by Country
2. Complete Burial (head and chest buried) 47.6%
3. Partial burial: 95.8%

C. Death from burial occurs in 3 distinct stages based on duration: Trauma, Asphyxia, and Hypothermia
1. Most Immediate deaths are due to Trauma
2a. Swiss Study with 80% Survival at 18min (Boyd 2009)
2b. Canadian Study 77% survival at 10min (Haegeli 2011)
3. Linear survival decrease due to asphyxia until 35min plateau (35% Boyd, 7% Haegeli)
4. Further decline at 90min due to Hypoxia, Hypercapnea, Hypothermia (Triple-H)

IV. Resuscitation Guidelines and Recommendations
A. CPR (Brugger 2012)
1. Do not start CPR if injuries are obviously lethal or body is frozen
2. Standard CPR; Compression-only is inappropriate for avalanche victims
3. Consider applying mechanical compression device, as prolonged CPR may be indicated.
4. <35 min burial, presume asphyxia, start CPR regardless of airway patency
5. >35 min with obstructed airway very unlikely to benefit from attempted resuscitation.

B. Cooling Rate and Hypothermia
1. Core temperature measurement with epitympanic device (not infrared), rectal at 15cm or esophageal (intubated).
2. Maximum cooling rate 9°C/hr (Oberhammer 2008); likely much slower
3. Any victim with a pulse and core temp <32°C should be presumed to have had a patent airway, as it takes more than 35 min to drop to <32°C (Boyd 2010).
4. Initiate CPR for core temp <32°C with patent or unknown airway (Brugger 2012).
5. Withhold CPR for core temp <32°C with obstructed airway and asystole

C. Arrhythmia Management
1. 32°C accepted risk threshold for spontaneous V Fib.
2. Transport with ECG monitoring, Minimize irritation and movement, Horizontal extrication
3. May attempt Defibrillation for shockable rhythm. Hold after 3 attempts until temp >30°C (Brugger 2012)

D. Out of Hospital Rewarming
1. Cover with a vapor barrier provides the same warming as removal of wet clothing; only remove wet clothing if further insulation is available (Henriksson 2012)
2. Warmed IVF (40°C), affect hypothetical rise of 0.3°C/L (Paal 2006)
3. Chemical heat packs applied to chest affect comfort but not rate of rewarming (Lundgren 2011); may aid cold stress response.

E. ALS Measures
1. Advanced airway should be considered for experienced providers
2. Epinephrine may be considered with the caveat that it may induce arrhythmia, increase risk for frostbite and is likely less efficacious at low temperature.

F. Transport Decisions for Hypothermic Patients
1. Consider bypassing closest hospital for ECMO or CPB (Cardiopulmonary Bypass) Capable facility for:
   a. Patent or unknown airway with temp <28°C;
   b. Temp <30°C with cardiac arrest OR instability
2. Closest Hospital for temp >28°C, no hemodynamic instability or ventricular dysrhythmias

G. Prognosis
1. Potassium >12mmol/L indicates cardiac arrest prior to onset of hypothermia, therefore demonstrating prolonged asphyxia and futile resuscitation (Mair 1994, Brugger 2012)
2. 13.7°C = Lowest Core Temp with subsequent ROSC (non-avalanche)
3. 6.5 hours = Longest continuous CPR with survival to hospital discharge
4. Victims have survived after burials of almost 5 hours (300 minutes)

H. Terminating Resuscitation
1. Consider prehospital termination of CPR for patients with unwitnessed arrest, core temp >32°C; No shock advised, no ROSC after 20min CPR.
2. Consider termination rules for >35min burial and obstructed airway on retrieval, regardless of core temperature.
3. Consider termination rules for temp <32°C, obstructed airway and asystolic arrest, regardless of burial time.

Proposed Resuscitation Algorithm based on core temperature with unknown burial duration.

If unable to measure core temperature on scene, may substitute “Burial >35 minutes” for “Cooled <32°C”. It will take at least 35 minutes (and likely much longer) for a patient to cool to a temperature from which they will derive protection for pre-arrest hypothermia. A patient who has suffered cardiac arrest in <35 minutes should be treated with standard ACLS resuscitation, even if there is presence of an air-pocket on retrieval.
Overview of Today's Talk

- General Approach to Venom
- Rattlesnakes
- Insects and Marine Creatures
- Cobra Wrestling Demo / Q and A

The Venom Menagerie

Terrestrial Creatures
- Snakes
- Gila Lizards
- Spiders and Scorpions
- Insects

Marine Creatures
- Jellyfish and Cone Snails
- Scorpionfish
- Stingrays

Background

- Venom Injuries occur worldwide

- A Neglected Tropical Disease:
  - Approximately 2.5 million cases/year of snakebites
  - Approx 35 K – 50 K deaths/year (up to 95K)
  - In AMERICA: 8-15 K cases of snakebite with 5 deaths
  - BEESTINGS KILL ABOUT 25/YEAR IN THE US

- Venoms are still poorly understood in many species
- Venom-specific therapies lacking for most species
- We still have A LOT to learn about venomous creatures

- Let's focus clinically by discussing venom effects

Venom: "Nature's Polypharmacy"

Venom = digestive and defensive MIXTURE
- Small molecules and monoamines
- Digestive Enzymes and Proteases
- Vasoactive/Neuroactive/ Allergenic peptides
- Venom components are HIGHLY variable
• Different responses in different patients
• Envenoming apparatus → Mechanical Injury
  – Fangs, hairs, stingers and barbs: “*Nature’s jailhouse shivs*”

6 **Mechanical Injuries**
• Fangs: Specialized venom-channels
  – Curved vs Straight – can be hard to track venom injection
  – Dead snakes may still injure and ENVENOMATE
  – Rattlesnake fangs do not penetrate into deep muscles

• Teeth
  – Most spiders cannot penetrate human skin
  – Gila Monsters are notoriously destructive
• Impalers: Sea Urchins, Stingrays
• Jellyfish nematocysts

• Stingers: Bees, Wasps, Ants
• Telsons: Venom bulbs on Scorpions
• Hairs/Setae: Caterpillars and Tarantulae
  – Uveitis and dermal irritation
  – Oral injury/irritation if swallowed

7 **Neurotoxins**

**Major Effects:**
• Rapid Paralysis
  – Alpha and Beta Bungarotoxins
  – Cobras, Kraits, Aust. Snakes
• Fasciculations (myokymia)
• Muscle contractions
  – Black widow spider venom
• Rhabdo (multifactorial)

**Minor Effects:**
• Tingling/ Paresthesias
• Vomiting/ Metallic taste (snakes)
• Facial edema (spiders)
• Oculogyric Crisis/ Ataxia (scorpions)

8 **Venom: Tissue Toxins**

• Enzymes
  – Metalloproteinases
  – Hyaluronidases
  – Phospholipase A2
• Locally destructive: blebs, necrosis
• Tourniquets worsen ischemia and injury
• Spitting cobras: corneal injuries
2. Found in:
   - Viper Snakes
   - Some elapids (mamba, cobras)
   - Gila Monsters
   - Massive beestings
   - Scorpionfish

9. **Hematotoxins**
   
   1. Laboratory Effects
      - Fibrinogen depletion
      - Low Platelets
      - INR increases

   • Clinical Effects
      - Spontaneous hemorrhage
      - DIC-like syndrome
      - Rarely thrombosis

   2. Pit Vipers & Viperids
      - Asian Vipers: Pituitary Hemorrhage and Apoplexy
      - South American Vipers: Hematuria, nailbed/ hair root bleeding, ICH, ARDS

   • Lonomia species caterpillars (Brazil)

11. **Complications of Snakebites**
    
    Generally manifest over 24 hrs
    - Hemorrhage
    - Consumptive Coagulopathy
    - Renal Failure
    - Respiratory Paralysis
    - Infections/Tetanus
    - ARDS/ MI/ Stroke
    - Allergic Reactions

12. **Venomous Medicines**
    
    • *Bothrops jararaca (South Am)*: Hypotension
      - Bradykinin Potentiating Factor (BPF)
        - research led scientists to discover ACE-inhibitors
    
    • Gila Monster Saliva: glucagon-like peptides
      - Gila-derived antidiabetic medication (exenatide) recently FDA-approved for DM type 2
    
    • Cone Snails: Potent non-opioid analgesic
      - Ziconatide, (Prialt) N- CCB

13. **Snakes: The Global Challenge**
    
    • Viper snakes:
      - Rattlesnakes/ Copperheads
      - Bushmasters, Bothrops (South America)
- Ecchis, Bitis, Cerastes (Africa, Asia, Middle East),
- Habu, Mang Mountain, and Russell's Vipers (Asian vipers)
- Taipans and Puff Adders

\[ \text{•} \]

- Neurotoxic snakes:
  - Coral Snakes in the USA
  - Naja species: cobra, king cobra, and spitting cobras
  - Kraits
  - Mamba
  - Brown/tiger snakes (Australia)
  - Sea Snakes and Kraits

\[ \text{•} \]

**North American Snakes**
- Pit Vipers of North America
  - Pits are sensitive, infrared heat sensors
  - Rattlesnakes, cottonmouths/copperheads
  - Very complex venoms and fang apparatus

\[ \text{•} \]

- Coral snakes (elapids) are neurotoxic, mainly in Southern and Southeastern USA

\[ \text{•} \]

**First Aid Measures**
- **DOs:**
  - Determine the genus of animal
  - Reassure the patient, remove rings, etc.
  - Not necessary to bring in the animal
  - In USA, not necessary to identify the species
  - Pressure Wrap bitten extremity if long txport

- **DO NOTs:**
  - Shock, freeze, heat, suck, or cut the wound!
  - Tourniquets are harmful with tissue-toxic venom (rattlesnakes, vipers, adders)
- **DONUTs:**
  - Mmmm, donuts.

**Snakebite Physical Exam**
- Neurotoxic Snakes:
  - Assess for peripheral and respiratory weakness
  - Cobras and mambas CAN cause tissue damage; mambas can cause MI!
  - Ptosis can be initial symptom
- Viperid Snakes
  - 5-25% Rattlesnake bites are “dry” → d/c in 4 hrs
- Local tissue necrosis causes most morbidity
- Fasciculations>> paralysis in rattlesnakes
- Hemorrhagic complications (South AM, Asia)
- Superinfection (South Am, Asia/Africa)

**Snakebite Treatment Initial Steps**
- Pain meds and IVFs
- MEASURE and MARK SWELLING of limbs
- Lab abnormalities indicate venom effects
  - Platelets, CBC, fibrinogen, coag panel
  - Renal function, lytes, CK
  - Can occur prior to significant swelling
  - Can help track inpatient progress and treatment responses
- Fasciotomy: JUST SAY NO!! Give Antivenom
  - VERY RARE to get a compartment syndrome in RSB
  - Number of reported cases of ischemic contractures= 0!
  - Local debridement of digits may be done in 3-5 days

**Antivenoms**
- Made by “milking” snake venom(s)
- Inoculate into horse/sheep--> Antivenom
- Antivenom is purified, sometimes fragmented
- FAB= fragmented antibody AV (less allergy)

**CroFab (Crotaline polyvalent immune ovine fab)**
- Sheep-derived F-ab fragments
- Approved for moderate crotalid envenomations
- 4-6 vials initial dose then 2 vials q 6 hrs x3
- Less antigenic than whole IgG AV
  - 17% allergic reactions, mostly mild
- Can use machines to gently mix solution
- Rewash vials with extra saline to get all the foamy residues and improve product yield
- No upper limit despite package insert (“18 vials”)

**Case: Fussy, Target lesion, Belly Pain**
- 2 yo child with irritability and abdominal tenderness, was playing outdoors
- VS bp 140/85, hr 160’s, temp 100 f
- Macular eruption on the face, periorbital edema, and dime-sized red lesion without central
pallor on the right buttock
  • No oral erythema, no tremors, no rigidity

What was the toxin?

• 30,000 spider species worldwide...and all are venomous!!!
• Good news: envenomation apparatus is usually insufficient to penetrate human skin
• Some venoms are specific to insect receptors/ tissues.
• So the vast majority of spiders are not harmful from a venom standpoint.
• Widows, Aus funnelwebs, recluses,

Black Widow Spider Envenomation
Effects of Excess Ach and NE release:
• HTN, tachycardia, cramps
• diaphoresis (can localized to bite site)
• SEVERE PAIN: “acute” abdomen, back, legs
• Target lesion at the bite site-red/pale/red.
• Nausea, vomiting, pulm edema, weakness.
• Facial edema, conjunctivitis, trismus (facies latrodectesma).
• Rare- priapism, MI can result.

Black Widow Bite Therapy
Great analgesia + Muscle relaxation
• Morphine and ativan→may require high doses for relief.
• 70-90% pts will require only these meds.
• Avoid calcium... no benefit, potential worsening of symptoms
• IgG Antivenom: only for severe symptoms, young and older pts

Scorpions
• Centruroides genus in US, many others globally
• 12000 stings in US, mainly Arizona
• Venom causes increased sodium ion-channel activity in the nerves
  – Local Pain, hypersalivation, tachycardia, HTN Crisis
  – NEUROMOTOR Toxicity is Unique
    • Ocular gyric crisis, ataxia
    • Dysphonia and dysarthria
    • Choreiform and ballismus activity
• Treatment: Symptomatic
  – Benzodiazepines, analgesics
  – Antivenoms used rarely in Mexico and AZ

Hymenoptera
• Bees, wasps, ants, yellowjackets
• Most allergenic of all know venoms
• Thousands of deaths/year from anaphylaxis
• Localized hives, sterile pustules
• Secondary infection
• Massive envenomations (20stings/kg) from bees can cause critical illnesses (rhabdo)

Gila Monster/ Mexican Beaded Lizard
• Heloderma horridum and H. suspectum
• Jaws can grip very tightly
• Venom Effects
  – Severe hypotension
  – hypoglycemia??
  – arrythmias may manifest
  – Severe tissue swelling and loss
• No antivenoms available
• Treat as complex animal bite and involve plastic surgeon for delayed repairs

CATERPILLARS
• Setae (hairs) allow venom into SC tissues
• PAIN with Megalopyge (puss caterpillar)
• others usually produce pruritus
• Grids/ lines of urticaria/ hemorrhage;
• Dermal edema and lymphangitis

Opthalmia Nodosa
• Tarantula/caterpillar hairs
• Inflammatory eye reaction
• Mechanical/ chemical injury to the eye tissues
• Effects may be seen for months, and recur if setae are left in ocular tissue
• Steroids and (Surgical) removal of foreign body may be indicated

Venomous Marine Life
• Fish (scorpion, puffer)
• Coelenterates
• Corals/Urchins
• Rays

Wilderness First Aid
• Preparation/Prevention
  – Clothing, boots and walking sticks
• Treatment and Stabilization
  – Wrap/Litter Transport (treat like a fracture)
  – Allergy/Pain/ Itching treatment (insects)
  – Hot water/ foreign body tx (marine venoms)
• Evacuation
  – Transport all venomous snakebites
  – Evac. sickest spider/scorpion/marine attacks

Summary
• Venoms are complex molecular mixtures
• Simple clinical observations can identify most envenoming syndromes and severity
• Most injuries are not lethal
• Antivenom: most useful for snakes
• Anaphylaxis risk from AV is real– know how to TX!
• Know your “local critters”

**Venom Resources**

• UCSD SnakeBite Protocols → *updates coming soon*
  - Txs for snakes from all over the world
  - See me if you would like to help update!
  - [http://drdavidson.ucsd.edu/Portals/0/snake/proinde.htm](http://drdavidson.ucsd.edu/Portals/0/snake/proinde.htm)

• AZA Antivenom Index ([www.aza.org](http://www.aza.org))
  - Needs a poison center password for access

• [www.Toxinology.org](http://www.Toxinology.org)
  - (Australian, some free info, good first aid and basic antivenom info)
• Miami Fire-Rescue (Venom-1) Webpage
HEAT RELATED ILLNESS

Lori Weichenthal, MD, FACEP
Associate Professor of Clinical Emergency Medicine
UCSF Fresno
INTRODUCTION

• Thermoregulation
• Acclimatization
• Field Management of Heat Illness
• Solar Injury
• Questions and Conclusion

THERMOREGULATION

• The body regulates temperature like a furnace
• The hypothalamus is the thermostat
• It responds to various receptors
• Adjust to keep core temperature between 36.5 and 37.5 degrees Celsius
THERMOREGULATION

- Reactions at a cellular level are mainly exothermic
- At rest, a human generates about 100 kcal/hr.
- Moderate activity adds an additional 300-600 kcal/hr.
- Solar radiation adds 150 kcal/hr.

THERMOREGULATION

- Heat can be lost and gained from the body by:
  - Evaporation
  - Radiation
  - Conduction
  - Convection
EVAPORATION

- Most efficient cooling mechanism
- Respiratory loss and sweat
- Accounts for 30% of heat dissipation at average external temperatures
- Major cooling mechanism at temperatures greater than 35 degrees Celsius
RADIATION

• Transfer of heat between the body and the environment via electromagnetic waves
• Over 50% of cooling when ambient temperature is less than body temperature
• Why it is important to cover up when it is cold

CONDUCTION

• Transfer of heat between two objects that are in direct contact
• Heat loss is minimal except with:
  ▪ Water immersion
  ▪ Lying on cold ground
CONVECTION

- Heat transfer between the body and a moving gas or liquid
- Rate of heat transfer is dependent on:
  - Speed of air or water
  - Temperature of each substance
- In still air, 25% of heat loss is via convection
- As wind speeds up, becomes greater

### NWS Windchill Chart

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<th>5</th>
<th>10</th>
<th>15</th>
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<td>5</td>
<td>7</td>
<td>9</td>
<td>11</td>
</tr>
</tbody>
</table>

Wind Chill (°F) = 35.7 + 0.6215T + 35.75V^{0.16} + 0.4275V^{0.16}

Where: T = Air Temperature (°F), V = Wind Speed (mph)

Effective 1/1/87

Frostbite Times

- 30 minutes
- 10 minutes
- 5 minutes

2/13/2014
HEAT ACCLIMATIZATION

• Requires up to 14 days
• Early
  • Reduced heart rate
  • Expanded plasma volume
  • Autonomic nervous system habituation
• Late
  • Increased sweat rate/production
  • Conservation of sodium

HEAT ILLNESS

• Physiologic Response
• Pathophysiology
• Presentation
• Management
• Prevention
PHYSIOLOGIC RESPONSE TO HEAT

- Hypothalamus attempts to maintain ideal body temperature
- Shunts blood
  - Vasodilation, especially of skin
  - Splanchnic vasoconstriction
- Increases cardiac output
- Increased catecholamines activate sweat glands
- Adaptive responses

PATHOPHYSIOLOGY OF HEAT ILLNESS

- Physiologic response deteriorates as cardiac output and vasodilatation reach their limits
- Electrolyte losses and dehydration contribute to progression
- Serious heat illness occurs when normal body temperature cannot be maintained
- Is a spectrum
RISK FACTORS FOR HEAT ILLNESS

- Elderly
- Neonates
- Obesity
- Alcoholism
- Dehydration
- Hyperthyroidism
- Medications
- Drugs of abuse
- Socioeconomic
- Confinement
- Extreme activities

TYPES OF HEAT ILLNESS

- Heat edema
- Heat rash
- Heat cramps
- Heat syncope
- Heat exhaustion
- Heat stroke

Mild to severe
CASE SCENARIO

You are serving as a medical volunteer for the Badwater Ultra marathon at an aid station at Stovepipe Wells, at the 42 mile point for the race, when a bystander approaches you concerned that she has increased lower extremity edema since arriving to Death Valley from Ontario, Canada.
HEAT EDEMA-PRESENTATION

- Swelling of extremities associated with high temperatures
- Occurs during heat waves or when a person from a cool climate travels to a warm one
- Body retains water and has trouble excreting salt
- Due to an increase in aldosterone

HEAT EDEMA-TREATMENT

- Move to a cool space
- Provide cool fluids
- Elevate swollen extremities
- Allow time for acclimatization
CASE SCENARIO

Still at your post at Stovepipe Wells, a staff member for the race approaches you with the complaint of a red itchy rash. She is extremely uncomfortable and is asking you what to do.

HEAT RASH-PRESENTATION

• Also know as prickly heat or miliaria
• Develops when sweat ducts become blocked
• Presentation ranges from superficial blisters to deep, red bumps
• Usually in folds of skin or where clothing causes friction with skin
• Symptoms range from asymptomatic rash to severe itchy/prickly rash
HEAT RASH-MANAGEMENT

• Usually goes away on its own
• Keeping skin cool and preventing sweat is helpful
  ▪ Dress in loose, lightweight clothing
  ▪ Stay in air conditioning
  ▪ After bathing, let your skin air dry
  ▪ Use calamine lotion or cool compresses
• In severe cases, steroids may be required

CASE SCENARIO

As the runners start to reach your aid station, a 45 year old male participant presents with severe right calf cramping that makes him unable to walk or run.
HEAT CRAMPS-PRESENTATION

• Painful muscle spasms due to sustained skeletal muscle contractions
• Often unilateral and involving calf muscles
• Caused by relative hyponatremia due to replacement of water losses with hypotonic solutions

HEAT CRAMPS-MANAGEMENT

• Rest and cool down
• Oral salt rehydration with electrolyte containing sport drink or salt solution
• Gentle range of motion and massage
• Avoid strenuous activity for several hours
• In severe cases, IV hydration may be required
• May be able to return to event
CASE SCENARIO

A 25 year old female participant stops at your aid station for water and promptly passes out. One of the water attendants catches her and lowers her to the ground. She promptly regains consciousness and wants to return to the race.

HEAT SYNCOPE-PRESENTATION

- Syncope due to orthostatic hypotension
- Often not profoundly dehydrated or hyperthermic
- Usually in the poorly acclimatized or elderly
- Often occurs when person is standing/stationary
HEAT SYNCOPE-TREATMENT

• Place patient in supine position
• Elevate the feet
• Remove from direct sunlight
• Oral rehydration
• Should not return to the event
• Need further medical evaluation

CASE SCENARIO

A 63 year old male runner approaches your aid station but collapses prior to reaching it. When he is carried into your tent he is sweating profusely, vomiting, and complaining of headache. He is awake and alert. When you measure his temperature it is 39.4 C (103 F).
HEAT EXHAUSTION-PRESENTATION

- Symptoms include:
  - Nausea, vomiting
  - Fatigue, weakness, dizziness
  - Headache, muscle cramps
- Patients are usually sweating
- Temperature is typically < 40 C (104 F)
- Mental status is normal

HEAT EXHAUSTION-MANAGEMENT

- Move to cool, shaded area
- Remove constrictive clothing
- Oral rehydration or IV fluids
- Apply active cooling measures
- If patient stabilizes, transfer for medical attention
- If no improvement, evacuate immediately
CASE SCENARIO

A 42 year old woman is transported to your aid station after having a witnessed seizure. She is obtunded, tachycardic, hot and dry to touch. Her temperature is 40.5 C (105 F).

HEAT STROKE-PRESENTATION

- Symptoms similar to heat exhaustion
- Patients frequently lose the ability to sweat
- Temperature is > 40 C (104 F)
- Patients do not have a normal mental status
- Organ system failure occurs
HEAT STROKE-MANAGEMENT

• Address the ABCs
• Plan for immediate evacuation
• Remove as much clothing as possible
• Perform active cooling measures
HEAT ILLNESS-PREVENTION

• Allow for acclimatization
  ▪ 7-10 days for adults
  ▪ 10-14 days for children and the elderly
• Monitor weather conditions
• Good hydration
  ▪ Goal of clear urine
• Wear light weight, light colored clothing

SOLAR INJURY

• Prolonged sun exposure can cause skin and eye damage
• People with light skin, hair and eyes are more at risk
• Certain medications increase risk
• Remember the five S’s
## MEDICATIONS ASSOCIATED WITH SUN SENSITIVITY

<table>
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<tr>
<th>Category</th>
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<td>NSAIDs</td>
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<td>Hypoglycemics</td>
<td>sulfonyleureas (glipizide, glyburide)</td>
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<td>Diuretics</td>
<td>furosemide, hydrochlorothiazide</td>
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<td>Sunscreens</td>
<td>para-aminobenzoic acid (PABA), cinnamates, benzophenones, salicylates</td>
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<tr>
<td>Fragrances</td>
<td>musk ambrette, 6-methylcoumarin, sandalwood</td>
</tr>
</tbody>
</table>

## THE FIVE S’S
- Slip on protective clothing
- Slop on sunscreen
- Slap on a broad-brimmed hat
- Seek shade
- Slide on sunglasses
QUESTIONS AND CONCLUSION
Don’t Forget Your Safety Pin – 30 Ways it Can Save Your Life

Desiree H. Crane, DO
UCSF-F Wilderness Medicine Fellow
High Sierra Wilderness Medicine Conference
February 2014

Disclosure

I have no disclosures
Objectives

- Become familiar with the 10 "systems" of a survival kit
- Become familiar with the history of the safety pin
- Understand the factors that make for an adequate emergency shelter
- Become familiar with the different methods of building a fire
- Become familiar with the different tick-borne diseases in the United States
- Understand the factors that influence wound irrigation
- Become familiar with different methods for water disinfection
- Become familiar with different ways to use a safety pin in survival, wilderness, and backcountry settings

Survival Kits
Survival Kits

Duct Tape
1. Duct Tape, 2" x 26'
Instrument
1. Scissors
4. Safety Pins #3, 2"
Sewing
1. Heavy Duty Sewing Needle
1. Heavy Duty Nylon Thread (50 ft.)
Survival Instructions
1. Waterproof Survival Instructions
Survival Tools
1. Aluminum Foil, Heavy Duty, 3 Sq. Ft.
1. Compass, Button, Liquid Filled
4. Fish Hook, #10
1. Fresnel Lens Magnifier (2" x 3")
1. Nylon Cord, #18, Braided, (50 ft. 150 lb test)
1. Pocket Survival Pak Contents List
1. Safety Wire, Stainless Steel, (6 ft of 0.020")
1. Scalpel Blade #22
1. Signal Mirror, Rescue Flash™
1. Snap Swivel, Size 12
1. Spark-U-Lite™ Firestarter
2. Sinks, Tin
4. "Tinder Quik™
2. Waterproof Paper
1. Whistle, Rescue Howler™
Survival Kits

Homemade Survival Kits
Homemade Survival Kits

http://survivalpacksupplies.blogspot.com

Safety Pin

Two Sub-Mycenaean/early Proto-Giorgian bronze Sbdes of the 15th-14th century B.C. and a Proto-Giorgian bronze Sbde of the 13th-12th century B.C. All are from Vachiari, Crete. Lengths: 9 cm, 7.2 cm, 5.4 cm.

Northern two-piece Sbdes from Denmark. Length, 7.3 cm. An example of the earliest Mycenaean one-piece Sbde from Mycenae. Length: 7.4 cm. Lower, a single-piece Sbde from Northern Italy, this comes from Paestum.
Safety Pin

Safety Pin

[Diagram of a safety pin]

[Image of a group of people]
Safety Pin

- No. 00 3/4"
- No. 0 15/16"
- No. 1 1/16"
- No. 2 1 1/4"
- No. 3 1 1/2"
- No. 4 1 3/4"
- No. 5 2 3/4"

Survival Kits
10 “Systems” for Creating a Survival Kit

- Shelter
- Fire
- Medical
- Hydration
- Communication
- Navigation
- Nutrition
- Insulation
- Sun Protection
- Tools

10 “Systems” for Creating a Survival Kit

- Shelter – Tent, bivvy, garbage bag, emergency shelter
- Fire
- Medical
- Hydration
- Communication
- Navigation
- Nutrition
- Insulation
- Sun Protection
- Tools
10 “Systems” for Creating a Survival Kit

- Shelter – Tent, bivvy, garbage bag, emergency shelter
- Fire – Flint, matches, lighter
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- Communication – Mirror, whistle, pen/pencil, paper
- Navigation – Map and compass
- Nutrition – Fishing line, hook, prepackaged food
- Insulation – Extra clothing
- Sun Protection – Sunglasses, sunblock, hat, lip block
- Tools – Knife, axe, flashlight, paracord

Shelter

- Building or finding shelter should be the FIRST step in a survival situation.

- Shelters should:
  - Allow adequate ventilation
  - Permit easy and rapid construction with simple tools
  - Provide good protection from adverse environmental elements (wind, rain, snowfall, sun)
Shelter

- **General guidelines and considerations:**
  - Avoid exposed windy ridges
  - Avoid areas at risk for flooding
  - Avoid low-lying areas (tend to collect colder night air)
  - Timbered areas protect from foul weather but block sun
  - Site should be near access to water
  - Entrance should be 90 degrees to the prevailing winds
  - Snow is a good insulator as it traps warmed air, but avoid direct contact with snow
    - Insulation barriers can be created with equipment, grass, leaf piles, or tree boughs.

- **Examples of survival shelters**
  - Tarpaulins
  - Plastic Bag Shelters
  - Space Blankets
  - Tube Tents
  - Tents
  - Bivvy
  - Snow Trenches
  - Snow Caves
  - Igloos
Shelter and Safety Pins

- Connect blankets, plastic bags, or other available materials to create improvised shelters
- Repair tents and tarps
- Safety pin tent zipper closed for added security
Fire

- Heat source + tinder + kindling and fuel

- Fire provides
  - Warmth
  - Protection
  - Light
  - Communication
  - Method of cooking food
  - Source for creating potable water

Fire

- Devices should be easy to use when hands are cold and have lost their dexterity, or when only one hand can be used.

- Devices must function every time
  - Temperature
  - Altitude
  - Wind
  - Precipitation
Types of Heat Sources

Matches
- Safety Matches
- Waterproof Matches (not recommended for survival situations)
- Windproof Matches
- Strike-anywhere Matches
- Storm Matches

Lighters
- Bic-style
- Zippo
- Colibri Quantum

Metal Matches
- Two-handed
- One-handed

Bow and Drill
Fire and Safety Pins

- Attach a safety pin over the terminals of a battery to start a fire
Medical

- Medical Kit Design Considerations
  - Trip Duration
  - Maximum Interval to Medical Care
    - Self-rescue v. Evacuation
  - Location
    - Remote or Heavily Traveled
  - Recreational and Environmental Hazards
    - Altitude
    - Temperature Extremes
    - Climbing, Boating, etc.
  - Number in your party (and their overall health)
  - Base camp or mobile

Medical and Safety Pins

- Wounds/Fractures
  - Skin Hooks and Retractors
  - Remove foreign bodies/splinters/ticks, etc
  - Subungual Hematomas
  - Blister
  - Thrombosed hemorrhoids
  - Wound irrigation
  - Wound closure
  - Finger Splint
  - Improvised Sling

- Airway
  - Pin tongue to lip in unconscious patients
  - Improvised nasopharyngeal airway (NPA)
  - Tracheal hook(s)
  - Secure ET tube in a surgical airway
Wounds and Fractures

Skin Hooks and Retractors
Foreign Body, Tick & Splint Removal

- Ticks are the most common arthropod vectors of disease in the United States and second worldwide (behind mosquitoes)
- Ticks are attracted by heat, carbon dioxide, and butyric acid (found in butter, sweat, feces, urine)
- Of the 840 known tick species, 100 species transmit infections to humans
- Ticks feed from 2 hours – several days
- Barbed-shaped jaw (hypostome) embeds into skin

Major Tick-Borne Diseases in the United States

<table>
<thead>
<tr>
<th>Disease</th>
<th>Organism</th>
<th>Major Vector</th>
<th>Geographic Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyme Disease</td>
<td>Borrelia burgdorferi</td>
<td>Ixodes scapularis, I. pacificus</td>
<td>Coastal mid-Atlantic states, northern West Coast, Wisconsin, Minnesota</td>
</tr>
<tr>
<td>Rocky Mountain spotted fever</td>
<td>Rickettsia rickettsii</td>
<td>Dermacentor andersoni, D. variabilis</td>
<td>South-central states, coastal southern states</td>
</tr>
<tr>
<td>Relapsing fever</td>
<td>Borrelia hermsi, Borelia turicatae, Borelia parkeri</td>
<td>Ornithodoros hermsi, turicata, parkeri</td>
<td>Worldwide; most often rural and wilderness areas of western states</td>
</tr>
<tr>
<td>Colorado tick fever</td>
<td>Orbivirus</td>
<td>Dermacentor andersoni</td>
<td>Rocky Mountain states, California, Oregon</td>
</tr>
<tr>
<td>Erlichiosis</td>
<td>Erlichia chaffeensis</td>
<td>Ixodes scapularis</td>
<td>Coastal mid-Atlantic states, northern West Coast, Wisconsin, Minnesota South-central states, coastal southern states</td>
</tr>
<tr>
<td>Babesiosis</td>
<td>Babesia microti</td>
<td>Ixodes scapularis</td>
<td>Coastal southern New England and mid-Atlantic states</td>
</tr>
<tr>
<td>Tularemia</td>
<td>Francisella tularense</td>
<td>A. americanum</td>
<td>South-central states, Montana, South Dakota</td>
</tr>
</tbody>
</table>
Foreign Body, Tick, Splint Removal

Subungual Hematomas
Blisters & Thrombosed Hemorrhoids
Wound Management

Primary determinants of infection:
- Bacterial counts
- Amounts of devitalized tissue remaining in the wound

Irrigating wounds with a forceful stream is the most effective method of reducing bacterial counts and removing debris and contaminants.

Wound Irrigation
Wound Irrigation

- Water for irrigation should be clean, but does not need to be sterile
- Disinfect water with iodine tablets, iodine solution, or by boiling/cooling it
  
  If you can drink it, you can irrigate with it

Wound Irrigation
Backcountry Tips

Create your own 0.9% saline solution for wound or eye irrigation

1 L disinfected water + 9 grams (roughly 2 teaspoons) of salt
Wound Irrigation

- Safe and effective irrigating pressures are 4-15 psi
  - 18- or 19-gauge catheter to a 35-mL syringe (7-8 psi)
  - 22-gauge catheter to a 12-mL syringe (13 psi)
- Amount of irrigation varies with size and contamination
  - Average volume should be no less than 250 mL

“The solution to pollution is dilution”

Wound Irrigation Technique

- Fill container (sandwich bag, garbage bag) with irrigation fluid
- Puncture the bottom of the bag with the safety pin
- Squeeze the top of the bag forcefully while holding it at a perpendicular angle, 1-2 inches above the wound.
Wound Irrigation Technique

Wound Closure
Wound Closure

- Options for closing low risk wounds in the backcountry include:
  - Taping
  - Safety Pinning
  - Suturing
  - Stapling
  - Gluing
  - Hair-tying

Wound Taping
Wound Closure

Finger Splint
Improvised Sling

Medical

- **Wounds/Fractures**
  - Skin Hooks and Retractors
  - Remove foreign bodies/splinters/ticks, etc
  - Subungual Hematomas
  - Blister
  - Thrombosed hemorrhoids
  - Wound irrigation
  - Wound closure
  - Finger Splint
  - Improvised Sling

- **Airway**
  - Pin tongue to lip in unconscious patients
  - Improvised nasopharyngeal airway (NPA)
  - Tracheal hook(s)
  - Secure ET tube in a surgical airway
  - Pleural decompression?
Airway

Airway
Airway

Tracheal Hook

THE IMPROVISED TRACHEAL HOOK
Secure Airway

Secure an ET tube or surgical airway

Hydration

- A minimum daily intake of 1200 mL of water is necessary to avoid dehydration (based on a temperate climate at sea level)
- Hot, dry climates, high altitude, or exertion/sweating, increase insensible losses, so intake should be increased
Water Treatment

- Of the 1700 million square miles of water on Earth, less than 0.5% is potable.
- Contamination:
  - Organic or inorganic material
  - Land erosion
  - Dissolution of minerals
  - Decay of organic vegetation
  - Biologic organisms
  - Chemical pollutants
  - Microorganisms from animal or human biologic waste
- Appearance, odor, and taste are not reliable indicators of safety

Waterborne Enteric Pathogens

<table>
<thead>
<tr>
<th>Category</th>
<th>Pathogen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacterial</strong></td>
<td>Escherichia coli</td>
</tr>
<tr>
<td></td>
<td>Shigella</td>
</tr>
<tr>
<td></td>
<td>Campylobacter</td>
</tr>
<tr>
<td></td>
<td>Vibrio cholerae</td>
</tr>
<tr>
<td><strong>Viral</strong></td>
<td>Hepatitis A</td>
</tr>
<tr>
<td></td>
<td>Hepatitis B</td>
</tr>
<tr>
<td></td>
<td>Nonvirus</td>
</tr>
<tr>
<td><strong>Protozoal</strong></td>
<td>Giardia lamblia</td>
</tr>
<tr>
<td></td>
<td>Entamoeba histolytica</td>
</tr>
<tr>
<td></td>
<td>Cryptosporidium</td>
</tr>
<tr>
<td></td>
<td>Blastocystis hominis</td>
</tr>
<tr>
<td><strong>Parasitic</strong></td>
<td>Ascaris lumbricoides</td>
</tr>
<tr>
<td></td>
<td>Ancylostoma duodenale (hookworm)</td>
</tr>
<tr>
<td></td>
<td>Taenia spp. (tapeworm)</td>
</tr>
<tr>
<td></td>
<td>Fasciola hepatica (sheep liver fluke)</td>
</tr>
<tr>
<td></td>
<td>Dracunculus medinensis</td>
</tr>
<tr>
<td></td>
<td>Strongyloides stercoralis (pinworm)</td>
</tr>
</tbody>
</table>
Water Disinfection

- **Disinfection**: A process that kills or destroys nearly all disease-producing microorganisms, with the exception of bacterial spores.

- **Heat**

- **Physical Removal**
  - Sedimentation
  - Coagulation-flocculation
  - Granular activated carbon

- **Filtration**

- **Chemical Disinfectants**
  - Halogens (chlorine and iodine)

Disinfection Methods

- **Heat**
  - Oldest means of water disinfection
  - Limited by fuel availability
    - 1 kg wood needed to boil 1 L water
  - Microorganisms have varying sensitivity to heat
    - Bacterial spores are the most resistant
  - Boiling time
    - Old recommendation:
      - Boil x 10 minutes + 1 minute for each 1000 feet in elevation
    - New recommendation:
      - Bring to a boil (WHO)
      - Bring to boil + 1 minute (CDC and EPA)
      - Bring to a boil + 3 minutes at high altitude (wide margin of safety)
Boiling Temperatures at Various Altitudes

<table>
<thead>
<tr>
<th>Altitude (ft)</th>
<th>Altitude (m)</th>
<th>Boiling Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>5000</td>
<td>1524</td>
<td>95°C (203°F)</td>
</tr>
<tr>
<td>10,000</td>
<td>3048</td>
<td>90°C (194°F)</td>
</tr>
<tr>
<td>14,000</td>
<td>4267</td>
<td>86°C (186.8°F)</td>
</tr>
<tr>
<td>19,000</td>
<td>5791</td>
<td>81°C (177.8°F)</td>
</tr>
</tbody>
</table>

Water Disinfection

- **Filtration**
  - Water treatment products are the 3rd largest purchase of outdoor equipment (behind backpacks and tents)
  - **Size** of the organism is the **primary determinant** of its susceptibility to filtration
  - **Pros:** Simple, require no holding time
  - **Cons:** Filters clog
Filtration and Microorganism Size

Hydration and Safety Pins
- Improvised water filter
  - 2 L plastic bottle with cap, glass bottle, clay pot, sheet of tree bark rolled into a cone, bamboo
  - Fresh charcoal
  - Grass or fabric
  - Sand
  - Safety pin
Hydration and Safety Pins

Communication

- Self-rescue
- Evacuation
Communication and Safety Pins
Crystal Radio or Fox Hole Radio

- Earphone
- Diode Detector (picks up audio frequencies)

Navigation

- Backcountry travelers should always carry a compass and map, even if travelling in familiar territory
- Become experienced with map reading and compass use prior to traveling
Navigation

- Compass
- Map
- Altimeter
- GPS
- Celestial Navigation
- Improvised compass

Navigation and Safety Pins

- Improvised compass
Nutrition

- A person can survive for weeks without food, even in cold weather
- Success is more likely on river and stream banks, lake shores and margins of forests and natural clearings
- Often, the amount of food will not provide enough calories to replenish the energy expended searching for it
  - Important to always carry extra food, even for short hikes.

Nutrition and Safety Pins

- Improvised fishing hook
- Can opener
Improvised Fishing Hooks

Improvised Can Opener
Insulation

Sun Protection

- Ultraviolet Photokeratitis (Snow Blindness)
  - Intense exposure to UV light can cause a corneal burn in 1 hour
  - Symptoms may not become apparent for 6-12 hours

- Signs and Symptoms
  - Pain, gritty sensation in eyes
  - Photophobia, tearing
  - Conjunctival erythema and chemosis
Sun Protection

- **Treatment**
  - Spontaneous healing in 24 hours
  - Topical anesthetics
  - Topical NSAIDS
  - Antibiotics
  - Patch eye

- **Prevention**
  - Wear sunglasses that block > 99% UV-B light

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Improvised Sunglasses

![Improvised Sunglasses](image)
Repair Sunglasses

[Image of broken sunglasses]

Repair Glasses

[Image of glasses with a clip holding them together]
Tools

- Defense
- Zipper pulls
- Unclog camp stove jet
- Sewing needle
- Spring for mechanical devices
Tools

Uses for a Safety Pin

- Shelter
  - Connect blankets, bags, tarps
  - Repair tents, tarps
  - Safety pin tent zipper for added security
- Fire
  - Connect safety pin to terminal of battery
- Medical Kit
  - Skin hooks, retractors
  - Remove foreign bodies, splinters, ticks
  - Subungual hematomas, blisters, thrombosed hematomas
  - Wound irrigates
  - Wound closures
  - Finger splint
  - Improved splint
  - Pin tongue to lip
  - Improved NFA
  - Teaches hooks
  - Secure ET tube to surgical aspirator
- Hydration
  - Improved water filter
- Communication
- Navigation
  - Improvised compass
- Nutrition
  - Fish hook
  - Improvised can opener
- Insulation
- Sun Protection
  - Improvised sunglasses
  - Fix broken sunglasses lens
  - Replace lost screw in glasses
- Tools
  - Defense
  - Zipper pull
  - Unplug camp stove jets
  - Sewing needle
  - Spring for mechanical devices
References

- Special thanks to www.tacmedsolutions.com for videos.