Thermal Injury Presentation
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Topics
• Hypothermia
• Frostbite
• Hyperthermia

Resources
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Multi media
http://www.youtube.com/watch?v=x6Mq0jFTPJI&feature=fvsr
http://www.youtube.com/watch?v=tRB1p89k7_I
Hypothermia

Epidemiology

- In the U.S. >700 people die from hypothermia each year.
- Recovery has been documented with core temp of 14.2°C and with cardiac arrest for 6.5 hours.

- At Risk Populations:
  - Elderly (loss of ability to sense cold),
  - Neonates (high surface area-to-volume ratio),
  - those with altered sensorium (lack ability to respond to behavioral response),
  - EtOH intoxication (altered and vasodilation)

Pathophysiology

- Heat is lost through
  - Conduction- transfer of heat by direct contact down a temperature gradient
  - Convection- transfer of heat by the actual movement of heated material (ie. wind)
  - Radiation- transfer of heat through the release of electromagnetic waves primarily in the infrared region.
  - Evaporation

- Head and neck can account for 80% of body heat loss

- Heat conservation is controlled by the hypothalamus-

- Heat is conserved by:
  - peripheral vasoconstriction, behavioral responses (ie. putting more clothes on).
- Heat is gained by: Shivering, rise in metabolic rate from thyroid and adrenal gland-rise in heart rate, BP and cardiac output
Hypothermia Risk Factors

- Cold exposure - accidental immersion or non-immersion hypothermia,
- Depressed metabolic rate - hypoendocrine states (hypo-thyroid, adrenalism, pituitarism), CNS dysfunction,
- Sepsis - alters the hypothalamic temperature set point,
- Severe dermal injury/disease - impairment of skin thermoregulatory functions,
- EtOH and drug use - Vasodilation and improper behavioral response.

Mild Hypothermia

- 32°C to 35°C
- Excitation stage - rise in metabolic function to compensate
- Shivering, tachycardia and elevated blood pressure

Moderate

- 28°C to 32°C
- Slowing (adynamic) stage - progressive metabolic slow down.
- Shivering ceases, heart rate and BP fall, mentation slows, loss of cough and gag.
- Impaired kidney concentration ability causing "cold diuresis" and subsequent dehydration.
- Dysrhythmias may occur at 30°C.

Severe

- <28°C
- Further altered LOC and coma, immobility causes Rhabdo and further renal impairment,
- Intravascular thrombosis and DIC.
- Impaired platelet function and inhibits the coagulation cascade -
- Leftward shift of the oxyhemoglobin dissociation curve
- ECG may show PR, QRS and QT interval prolongations and Osborn J waves.
- Dysrhythmias - tachycardia to bradycardia to A. Fib with slow Ventricular rate to V. Fib and finally asystole
Frostbite
- occurs when hypothermia or local cold exposure causes increased blood viscosity, extracellular ice crystal formation, intracellular dehydration and lysis

Trench foot
- direct injury to soft tissue from prolonged cooling, accelerated by wet conditions.
  Rarely in civilians.

Chilblains
- inflammatory lesions of skin of bared body parts caused by intermittent exposure to damp, non freezing ambient temperature.
  Mainly in UK.

1st Degree
- **1st degree** (superficial partial thickness)- erythema, edema, no blisters, painful and sensate

2nd Degree
- **2nd degree** (deep partial thickness)- similar to 1st but with blistering

3rd/4th Degree
- **3rd degree** (full thickness skin)- hemorrhagic blisters, skin necrosis, blue-grey discoloration, insensate but may develop pain.
- **4th degree** (full thickness involving muscle, tendon and bone)- initially mottled, eventually black and mummified.

Management:
- Warm with water at 42°C for 10-30 min
- Give analgesics
- Bandage with polysporin and aloe vera.
- Drain non hemorrhagic blisters- Debriding of hemorrhagic blisters may lead to tissue desiccation.
- Only discharge if able to return to a warm environment
- Admit if full thickness, unable to walk or homeless.
**General Management of Hypothermia**

- **Pre-hospital**: careful handling as manipulation can trigger V. Fib., wait 30-60 sec to check for pulse.
- **Hospital**: Monitored bed, ABCs
- Look for alternative causes and begin treatment- infection/sepsis, Thyroid dysfunction, Adrenal insufficiency, drug intoxication
- Continuous core temp (rectal or esophageal) with low reading thermometer.
- ABG- warms the blood to 37°C, thus increasing the PCO2, PaO2, and lower pH. (there are correction calculations but the optimal values in hypothermia are not known)
- Cold V. Fib is usually refractory to defibrillation until temp is > 30°C- may attempt 1 shock with 1 round of Epinephrine (ACLS - suggests 1 shock and no meds until >30°C)
- Drug therapy-
  - Thiamine if suspected EtOH Hx
  - D50W if BG unknown
  - Empirical Antibiotics is appropriate when a non infectious source is not found.
  - Hydrocortisone (100 mg) to adrenal suppression/insufficiency patients.
- Rewarming to goal temperature of >30°C

**Passive rewarming**

- mild hypothermia
- patient will warm self with shivering
  - removal from cold environment and provide insulation

**Active external rewarming**

- moderate or severe hypothermia with no cardiovascular instability.
- Beware of warming extremities- vasodilation and venous pooling may cause hypotension and hypovolemia with core temperature afterdrop.
- Warm water immersion (not likely)
- Heating blankets at 40°C
- Radiant heat
- Bear Hugger

**Active core rewarming**

- Hypothermia with cardiovascular instability. Use fluids warmed to 42°C
- Inhalation rewarming- need insulation on tubing
- Heated IV fluids
- Gastric lavage
- Bladder lavage
- Peritoneal lavage (ROR 4-8°C/hr)
- Pleural lavage with double Chest tubes on Left side (ROR 4-8°C/hr)
- Extracorporeal rewarming- method of choice for cardiac arrest
- Mediastinal lavage with thoracotomy

**Ominous Predictors of survival**: temp <10-12°C, pH < 6.5, Potassium >10, Asphyxia
Heat Illness
Epidemiology

Heat-related illnesses cause ~400 deaths/year in U.S.

- Number of non fatal heat injury cases is unknown- estimated at 60,000 visits per year in U.S.

Risk factors:
- extremes of age (<4 y.o. and > 75 y.o.)-
  - 1 per million ages 5-45 yrs to 5 per million >85 yrs
- predisposing medical conditions- heart failure, psychiatric illness, alcohol abuse, dehydration, poverty, social isolation
- on medications that interfere with thermoregulatory response- anticholinergics, BB, CaCB
- poor physical conditioning
- poorly acclimatized to hot weather

Normal physiology

Body heat is thermodynamically dissipated through:

- Radiation- primary mechanism of heat loss when environment temperature is lower than body temperature. Infrared radiation flowing from body to cooler environment may account for 60% of body cooling. But if environment is warmer then body temp acts in reverse.

- Convection- wind. Above 32°C and 35% humidity convection does not remove heat well.

- Evaporation- primary mechanism for heat dissipation accounting for 25% of heat loss in cooler settings and 100% in hotter temperatures. Impaired with higher levels of humidity.

- Conduction- When combined with convection they may account for 15% of heat loss.

- Upon exposure to heat stress the sympathetic outflow from post hypothalamus is inhibited leading to:
  - cardiac output is augmented (increase of 3L/min for each 1°C elevation in core temperature)
  - core blood circulation is shifted to the peripheral circulation
  - vasodilation occurs, causing heart rate to increase to compensate for decreased stroke volume.
  - sweating is enhanced by enhanced cholinergic stimulation
  - Several inflammatory cytokines and heat shock proteins are released to improve tissue repair and protect against tissue injury and protein denaturation
The path to heat injury
1. Increased heat production- exercise increases basal heat production by 20x
2. Increased external heat gain-
3. Decreased heat loss- obesity, meds, medical conditions involved.

Clinical Features

Heat Syncope
• Variant of postural hypotension
• Results from volume depletion, peripheral vasodilation and decreased vasomotor tone
• Commonly in elderly or poorly acclimatized
• Rule out other causes of syncope

Heat Exhaustion
• Reflects significant volume depletion +/- electrolyte disturbance
• Malaise, fatigue, weakness, dizziness, headache, nausea, tachypnea/cardia
• Core temp often elevated but may be normal
• Normal Neuro exam and sensorium

Classic Heat Stroke
• Classic definition: temp >40°C, CNS dysfunction and anhidrosis.
• Anhidrosis may not be present- not considered an absolute diagnostic criteria
• Therefore anyone with Hyperthermia (40-47°C) and CNS dysfunction- (ataxia, confusion, agitation, seizures, Altered LOC) should be treated as Heat Stroke.
• End result of heat stroke is endothelial injury, coagulation disorder, microcirculatory failure and ultimately multiorgan failure.
• Often distinguished from heat exhaustion by elevated Liver enzymes.
• Renal and hepatic dysfunction often recover completely.

• Primary factor contributing to morbidity and mortality is underlying or cormorbid medical conditions and not the absolute height of core temp.
• Mortality rates for heat stroke vary from 10-70%.

Exertional Heat Stroke
• Typically young, healthy participating in activities in which heat production adn heat gain from environment exceed the capacity of heat removal.
• Risk factors include: obesity, dehydration, similar medical conditions as above.
• Respiratory alkalosis and metabolic acidosis (lactate)
• Often have rhabdo, hyperkalemia, hyperphosphatemia, hypocalcemia
Differential Diagnosis of Hyperthermia

- Infection/sepsis,
- toxins (serotonin syndrome, anticholinergics, salicylate, PCP, sympathomimetics, EtOH withdrawal),
- Thyrotoxicosis,
- DKA,
- neuroleptic malignant syndrome and malignant hyperthermia

Management

General Management

- Cardiac monitor, IV, O2
- Continuous core temp (bladder, rectal, esophageal)
- Fluids and measure output
- Expect patient to be hypotensive because of vasodilation- be careful not to overshoot the fluid resuscitation.

- Labs- CBC, LFTS, lytes, Creat, CK, myoglobin.
- Rule out +/- treat Rhabdo, hyperkalemia (especially in exertional heat stroke)

- **Evaporative Cooling**- for goal temp of <40°C -
  - fans and spray with tepid water (Avoid cold water which may trigger shivering- if shivering may need to sedate with benzos)

- **Other Cooling Methods**
  - cool water immersion
  - cold water gastric, bladder, thoracostomy lavage
  - Cardiopulmonary bypass (most rapid)

Disposition

- Discharge heat exhaustion after treatment, temp < 40°C and period of observation.

- Most heat stroke patients will require ICU