Heat- and Cold-Related Illnesses

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January 2014
Heat-Related Illnesses

- Heat edema
- Heat tetany
- Prickly heat (miliaria rubra, heat rash)
- Heat syncope
- Heat cramps
- Heat exhaustion
Miliaria Rubra
Heat Stroke

- Core temp > 40°C with CNS dysfunction in setting of environmental heat load
  - Life-threatening: mortality rate 30-80%
- Neurologic abnormalities include:
  - Ataxia, irritability, confusion, combativeness, hallucinations, posturing, hemiplegia, seizures, coma
- Prognosis depends on early recognition, treatment
  - Duration/degree of temperature elevation, number of organ systems involved correlate with outcome
Types of Heat Stroke

- **Classic**
  People physiologically unable to cope with heat burden
  - Elderly, small children, chronically ill/addicted, obese

- **Exertional**
  Healthy people exposed to severe heat during exertion
  - Athletes, religious pilgrims, workers in impermeable clothing/other occupations, military recruits
  - Exertional heat stroke can occur in cool conditions (marathon runners)
France heat wave death toll set at 14,802 PARIS (AP) — The death toll in France from August's blistering heat wave has reached nearly 15,000, according to a government-commissioned report released Thursday, surpassing a prior tally by more than 3,000 — The bulk of the victims — many of them elderly — died during the height of the heat wave, which brought suffocating temperatures of up to 104 degrees in a country where air conditioning is rare.
Classic Heat Stroke


• Temperature rise measured continuously over a 60-minutes in a dark sedan on 16 different clear sunny days with ambient temperatures ranging from 72 to 96 degrees F.
  – On 2 of days, additional measurements made with windows opened 1.5 inches.

• Regardless of the outside ambient temperature, rate of temperature rise inside vehicle was not significantly different.

• The final temperature of vehicle depended on starting ambient temperature, but even at the coolest ambient temperature, internal temperatures reached 117 degrees F. Cracking windows open did not decrease the rate of temperature rise in the vehicle.
Exertional Heat Stroke
Other Causes of Heat Stroke

• Fatal heat stroke from falling asleep under electric blanket, prolonged submersion in bathtub or hot tub

• Drugs
  – Cocaine, ecstasy ("Molly")
  – Diphenhydramine
    • Anticholinergics in general
  – Phenothiazines (other dopamine blockers)
  – Ethanol
  – Diuretics
Pathophysiology of Heat Illnesses

• Body temperature maintained by balancing heat load/generation and heat loss

• Lose heat by:
  – Behavioral modification
  – Evaporation
  – Conduction
  – Convection
  – Radiation
Pathophysiology of Heat Illnesses

- Thermoregulation controlled by hypothalamus
- As core temp ↑, hypothalamus signals ANS to:
  - Induce sweating
  - Vasodilate skin blood vessels
    - Cardiac output increases in order to maintain BP
    - If heart unable to maintain ↑CO, blood vessels vasoconstrict to maintain BP

\[ BP = CO \times TPR \]
Pathophysiology of Heat Illnesses

• Above 42°C, organ systems fail
  – Vascular endothelium, hepatocytes, neural tissue most sensitive
  – Major complications:
    ✓ DIC
    ✓ Noncardiogenic pulmonary edema
    ✓ Rhabdomyolysis
    ✓ Renal failure
    ✓ Liver failure
    ✓ Seizures
Heat Stroke: Physical Exam

- **VS:** P/RR↑, BP nml/low, T > 40°C (core)
- **Skin:** Warm and dry, or diaphoretic
  - *Anhydrosis not diagnostic criterion*
- **CV:** Hyperdynamic, with vasodilatation
- **Lungs:** Rales (pulmonary edema)
- **Neuro:** ↓MS, seizures, delirium, posturing, focal deficits
Heat Stroke: Diagnostic Tests

- **CBC**: $\uparrow$ wbc (20-30K), $\downarrow$ plt
- **PT/PTT**: Baseline (pt at risk for DIC)
- **SMA-7**: $\uparrow$ glu, $\downarrow$ glu, $\uparrow$ K, $\downarrow$ K, $\uparrow$ AG due to lactic acidosis
- **UA**: Dip + blood, none on micro suggest myoglobinuria
- **LFTs**: $\uparrow$ in almost all cases. AST $> 1000$ U/L $\rightarrow$ poor prognosis.
  - Elevated LDH also associated with worse prognosis.
Heat Stroke: Diagnostic Tests

- **CXR** Pulmonary edema, etc.
- **Head CT** Hemorrhage/mass
- **LP** If etiology unclear
- **ECG** QT (most common) and ST prolongation, RBBB, sinus tach, a fib, SVT, apparent MI
Heat Stroke: Diagnostic Tests

• A case of severe heat stroke with abnormal cardiac findings. *Int Heart J.* 2005 May;46(3):543-50.
  – 22-year-old comatose male with heat
  – ECG showed diffuse ST elevation
  – Serum levels of myocardial markers were high
  – ECHO showed diffuse hypokinesis
  – Patient recovered, moved out of ICU after 14 days
  – Cardiac abnormalities had normalized without any myocardial damage; no Q waves on ECG
Heat Stroke: Treatment

- Airway
- Breathing
- Circulation: Are these patients dehydrated?
- Disability: In setting of ΔMS, check blood glucose, pulse-ox
- Exposure: Remove cloths to begin cooling
Heat Stroke: Treatment

• During Hajj in Saudi Arabia 34 patients with heat stroke had central lines placed to measure CVP
• 12 had zero or below zero C.V.P.
• 22 patients had normal or above normal C.V.P.
  – 6 had CVP > 10, could have developed CHF/pulmonary edema if aggressively fluid resuscitated.
• An average of 1 liter of NS or LR was sufficient to normalize C.V.P. without predisposing to CHF/and pulmonary edema
Cooling Techniques

• Ice packs to axillae/groin/back of neck
• Evaporative and immersion techniques
• Cardiopulmonary bypass
• Endovascular cooling
• Cold hemodialysis
• Iced peritoneal lavage/gastric lavage/enemas?
• Cooling blankets
Cooling Techniques

• Other cooling devices:
  – Ice cooling jacket
  – Cooling vest
  – Neck cooling devices
  – Head cooling devices
  – Carotid artery-cooling cuff
  – Carotid artery-cooling patch
Cooling Techniques

- Use a fan to lower temperature
- Elevate feet
- Apply cold compresses
- Give fluids
- Have the person lie down
Heat Stroke: Prevention

- Air conditioning/fans
- Avoid the heat and direct sunlight
- Wear light, loose clothing that is vapor-permeable
- Decrease activity level
- Increase fluid intake - avoid ethanol, caffeine
- Take frequent showers
- Follow heat index (hazardous > 90°F)
- Check on the elderly, disabled, or homebound
- Never leave children/pets alone in cars
Cold-Related Illnesses

• Frostnip
• Pernio
  – Chilblains, kibe (ulcerated chilblains on heel)
• Trench foot (Immersion foot)
• Surfer’s ear
• Frostbite
Cold-Related Illnesses
Frostbite

• Characterized by freezing of tissue
• More likely in extreme cold, high wind
• Seen in soldiers, homeless, outdoor jobs/recreation
  – Risk factors: smoking, prolonged hand/arm vibration, chronic diseases affecting vasculature
• Cold exposure leads to:
  – Ice crystal formation
  – Vasoconstriction
  – Tissue ischemia
  – Reperfusion injury
  – Endothelial damage
  – Cascade of inflammatory responses
Frostbite

• Affects head, ears, nose, cheeks, hands, feet
• Area appears waxy, hard, insensate
  – Blisters containing blood or clear fluid
• Prehospital treatment
  – Protect affected part and transport
  – Avoid further heat loss
  – Don’t let frostbitten tissue thaw and refreeze
  – Don’t rub the affected area with hands or snow
Frostbite
Frostbite

• Clinical diagnosis supplemented with angiography, MR-angio, technetium-99 scanning

• ED treatment:
  – Prompt rewarming
  – Analgesia
  – NSAIDS
  – Topical aloe vera
  – Leave blood-filled blisters alone; consider draining clear blisters (contain thromboxane)
  – Tetanus prophylaxis
  – Delay debridement/amputation
  – Intravenous or intra-arterial tPA
Hypothermia

• Defined as core temp. < 35°C (95°F)
  – Mild (T 32-35°C [89.6-95°F])
  – Moderate (T 28-32°C [82.4-89.6°F])
  – Severe (T < 28°C [< 82.4°F])
Hypothermia

• Lowest recorded core temperature in surviving adult: 13.7°C (56.7°F)
  – In child: 13.0°C (55.4°F)
• A 5-year-old boy recovered without neurologic sequelae after 40 minutes of submersion in ice-cold water
• More commonly associated with regions of country with severe winters, but....
1985 Boston marathon, when the ambient temperature was 76°F, there were 75 cases of hypothermia among the runners.
Pathophysiology

• Heat loss by evaporation, radiation, convection, conduction
• Conduction enhanced by immersion in water
  – Thermal conductivity 25x that of air
• Illustration: RMS Titanic
RMS Titanic

- On April 14, 1912, at 2340 h, the ship struck an iceberg and sank off the Newfoundland. The temperature of the water was -2·2°C (28°F). There were 2201 people aboard, and all 1489 people who fell into the water were recorded as having drowned. There were 3560 lifebelts aboard the ship, so presumably all those who died were wearing lifebelts; 712 people were able to leave the ship in lifeboats. The rescue ship Carpathia arrived at the site in 1 h 50 min. The crew were able to rescue everyone on board the lifeboats, but all the others were left for dead, even though they were presumably floating with their heads above water.
- The Titanic passengers were only exposed to hypothermia and not to cold-water inhalation into the lungs. Therefore, the primary cause of death was immersion hypothermia...not drowning as recorded in the official report. Many of the presumed dead were probably alive...

Pathophysiology

• In response to cold, hypothalamus directs body to increase heat production through:
  – Shivering
  – Increased metabolic activity
    • ↑thyroid hormones, catecholamines
  – Vasoconstriction
  – Behavioral response
    • Putting on more clothing, seeking shelter
Signs/Symptoms

• Mild hypothermia
  – Excitatory state characterized by:
    • Shivering and ↑P, RR, BP, cardiac output
  – Ataxia, hyperreflexia, dysarthria
  – Impaired judgment
  – Cold diuresis
  – Bronchorrhea, bronchospasm
  – Decreased GI motility
Signs/Symptoms

• Moderate hypothermia
  – Shivering stops
  – See ↓P, RR, CO
  – CNS depression, decreased reflexes
  – Paradoxical undressing
  – Cardiac dysrhythmias develop
    • Sinus bradycardia, a. fib. with slow ventricular response
  – Myocardium becomes sensitive to movement
    • Jostling patient may precipitate ventricular fibrillation
  – Osborn J wave
Osborn J Wave

Osborne Waves or “J-Waves”

Here we see the Osborn waves of severe hypothermia (blue arrows).

The rhythm is atrial fibrillation.

Bradycardia is present.

The QT/QTc is prolonged.

The patient’s core temperature was measured at 76°F (24°C).
Signs/Symptoms

• Severe hypothermia
  – Pulmonary edema
  – Oliguria
  – Loss of reflexes (patellar last to go)
  – Acidosis
  – Hypotension
  – Coma
  – Ventricular fibrillation, asystole
Risk Factors

• Environmental exposure
• Decreased metabolic activity
• Underlying infection/sepsis
• Hypothalamic/other CNS pathology
• Skin disorder
• Chronic debilitating illnesses
• Ethanol, other drugs
• Malnutrition
• Extremes of age
• Iatrogenic
ED Evaluation

• Lab tests
  – Electrolytes
  – CBC
  – PT/PTT
  – Creatine kinase
  – ABG
  – UA
• CXR
• ECG
• *Et cetera*
  – Was hypothermia the cause or a consequence?
Prehospital Management

- ABCs
- Goal is to minimize further heat loss
- Get the victim to shelter
- Remove wet clothing and replace with dry, insulated clothing
  - Insulate patient with blankets, tarps, plastic bags, sleeping bag
    - Place above, below victim to minimize heat loss to air or ground
- Lay person flat to avoid aggravating hypotension
- Build a fire
  - Boil water and have patient inhale the steam
- Give the victim warm food and sugar-containing drinks
- Consider possibility of trauma
- *Handle the hypothermic patient gently*
- Warm packs?
Prehospital Management

Hypothermia Wrap

Apply heat

![Image of hypothermia wrap being applied]

![Image of person wrapped in hypothermia wrap]

![Image of person lying down with hypothermia wrap and a bag nearby]

![Image of a fire]

ED Management

• ABCs
  – Endotracheal intubation, fluid resuscitation, pressors
• Monitor $T_{\text{core}}$ with low-reading thermometer
• Consider trauma or other precipitant
• Initiate rewarming while treating complications
• Watch for hyperkalemia and treat as indicated
  – Calcium chloride
  – D50/insulin
  – Sodium bicarbonate
  – Albuterol
  – Kayexalate
Rewarming

- Faster better than slower, within reason
- Passive external rewarming
  - Method of choice for mild hypothermia
  - Removing wet garments, apply blankets, allow pt to shiver
- Active external rewarming
  - Heat applied externally
    - Warm blankets
    - Heating pads
    - Radiant heat lamps
    - Warm baths
Rewarming

- Active internal rewarming
  - Most aggressive, invasive approach
  - Cardiopulmonary bypass
  - ECMO
  - Pleural and peritoneal irrigation with fluid at 42°C
  - Continuous arteriovenous rewarming
    - Requires a pulse to drive the blood through the circuit.
  - Esophageal rewarming tubes
    - Popular in Europe, not in U.S.
- Endovascular rewarming
Rewarming

• Of minimal benefit:
  – Warm, humidified oxygen
  – Warm IV fluids
  – Bladder/GI irrigation
Dysrhythmias/Cardiac Arrest

• Atrial dysrhythmias often resolve with rewarming

• Cardiac arrest management:
  – Usually refractory until patient rewarmed (~32-34°C)
  – In prehospital setting, prevent further head loss
    • Remove wet clothes, replace with warm/dry cover
  – Theoretical reasons to modify CPR/ACLS but little evidence
  – Standard intervention with ongoing warming
Dysrhythmias/Cardiac Arrest

• No one is dead until warm and dead, i.e. core temperature of 32-35°C
• EXCEPTION: chest too frozen to do chest compressions; nose/mouth blocked with ice
QUESTIONS?