The Hot, The Cold, The Wet & The Poisoned

50 minutes to a better C.E.N.

Andrew Bartkus, RN, MSN, JD, CEN, CCRN, CFRN, NREMT-P, FP-C

No nursing presentation is complete without objectives:

- Discuss body systems and mechanisms responsible for thermal homeostasis
- Briefly skim over heat-related illness, hypothermia, near-drowning
- Convey random thoughts about decontamination, antidotes and enhanced elimination of toxins
- Ramble on about various toxicological emergencies

Disclaimers

- Not intentionally endorsing or promoting any products or services
- Not a formal CEN review-I took some liberties with the content/depth
- No intentional plagiarism, it is tough to paraphrase a symptom list without adding confusion
- Most references from Up To Date (www.uptodate.com) or Emedicine (emedicine.medscape.com)
  - Peer reviewed
  - <12 months old
  - Nothing written that didn't come from a reliable source…
Thermoregulation: Elementary School Science

- **Endotherms** ("warm blooded")
  - Birds and mammals
  - Maintain normal body temperature 35-40 deg. C.
  - Internal and behavioral temperature regulation

- **Ectotherms** ("cold blooded")
  - All other animals
  - Behavioral temperature regulation only

Human thermoregulation

- Thermoreceptors in hypothalamus monitor core temperature
- Thermoreceptors in skin monitor external temperature
- Information from both sets of thermoreceptors processed by thermoregulatory center in hypothalamus, which then triggers a variety of body mechanisms

Thermoregulation for dummies:

- Heat produced by the body and absorbed by the environment must equal heat lost
Transfer of Heat

- Conduction: direct transfer from one object to another
- Convection: transfer of heat through movement of air currents
- Evaporation: change from liquid to gas state, cools during process
- Radiation: Emission of infrared energy

Heat Exchange

<table>
<thead>
<tr>
<th>Heat Gains</th>
<th>Heat Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metabolism</td>
<td>Conduction, convection, radiation to the environment</td>
</tr>
<tr>
<td>Conduction, convection, radiation from environment</td>
<td>Evaporation (sweating)</td>
</tr>
<tr>
<td>Artificial (hot beverages, iatrogenic)</td>
<td>Artificial (cold beverages, iatrogenic)</td>
</tr>
</tbody>
</table>

Increase core temperature= Increased oxygen consumption

Temperature Homeostasis

<table>
<thead>
<tr>
<th>Effector System</th>
<th>Response to low temperature</th>
<th>Response to high temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral</td>
<td>Finding shelter, turning up thermostat, building, more clothes</td>
<td>Swimming, cool beverage, seeking A/C, taking off warm clothes</td>
</tr>
<tr>
<td>Smooth muscles in arteriosides</td>
<td>vasoconstriction</td>
<td>vasodilation</td>
</tr>
<tr>
<td>Sweat glands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skeletal muscles</td>
<td>Shivering</td>
<td></td>
</tr>
<tr>
<td>Adrenal glands</td>
<td>Secretion adrenaline and thyroxine</td>
<td></td>
</tr>
<tr>
<td>Effector pili muscles in skin</td>
<td>Raise skin hairs (not very effective in humans)</td>
<td>Lower skin hairs (table copied from source)</td>
</tr>
</tbody>
</table>
Caveats to temperature homeostasis

- Sweating loses effectiveness at >75% humidity
- Other heat compensatory mechanisms lose effectiveness at >35 deg. C/95 deg. F
- Fever - pyrogens, released by WBC's raise set point of thermoregulatory center by 2-3 deg. C., helps inhibit certain microorganisms
- Hibernation- hormones lower temperature set point to approx. 5 deg. C.
- Various endocrine conditions, medications, CNS abnormalities will interfere with temperature homeostasis
- Age extremes have decreased ability to compensate for altered temperatures
Heat Illness

**Mild manifestations:**
- Miliaria (heat rash)
  - Variety of appearances (rubra, crystallina, punctulosa, profunda)
  - Trapped sweat beneath skin; supportive care/topicals
- Heat Edema
  - Vasodilation; pooling of interstitial fluid in lower extremities
  - Elevation of extremities, compression stockings, AVOID DIURETICS
- Heat Syncope
  - Vasodilation, dizziness, orthostatic hypotension and syncope; Normal core temperature, fluid distribution problem
  - Rehydrate, keep patient supine until improved

**Severe Manifestations:**
- Heat Tetany
  - Hyperventilation related to heat stress
  - May have normal or elevated core temperature (<40 deg. C.)
  - Respiratory alkalosis
    - Chvostek sign (masseter/jaw muscle spasm/twitch after being tapped)
    - Trousseau sign (spasm of arm/hand muscle)
  - EKG may show atrioventricular block or premature atrial contractions
  - Consider other causes
    - Cooling measures, partial rebreather, +/- benzodiazepines
- Heat Exhaustion
- Heat Stroke

Heat Exhaustion

- Known heat exposure; elevated core temp (typically <40 deg. C.), with additional symptoms:
  - Tachycardia
  - Sweating
  - Nausea/vomiting
  - Headache
  - Dizziness
  - Brief syncope
  - Increased thirst
  - Brief episode of altered mental status
Heat Exhaustion

- Treatment:
  - Stop activity
  - Move to cooler environment
  - Cool electrolyte beverages

- If Severe:
  - Intravenous fluids
  - Electrolyte monitoring/replacement
  - Supportive treatment/Differential diagnosis

Heat Stroke

- Heat exposure, elevated core temperature, CNS dysfunction
  - >40 deg. C. likely not febrile illness
  - Consider NMS, malignant hyperthermia, febrile illness

- May be exertional or non-exertional
  - Exertional: athletes, military, firefighters, etc.
  - Non-exertional (Classic): elderly, kids in hot cars, disabled/incapacitated, drugs/alcohol, underlying medical conditions

- High mortality 21-63% (max temp, duration, delays in cooling, anuria)

Heat Stroke

- Management:
  - Maintain airway/support ventilation

- Rapid aggressive cooling
  - Evaporative methods most common (fan/water mist or wet sheets)
  - Avoid shivering (benzos if needed)
  - Cool aggressively to 36.5-37 deg. C, then gradual cooling to avoid hypothermia
  - Fluid-volume resuscitation

- Supportive treatment
- Core temperature monitoring with appropriate thermometer
Heat Stroke

- Pediatric considerations:
  - Higher baseline metabolic rate
  - High surface area/mass ratio (greater heat absorption)
  - Lower blood volume (decreased heat dissipation)
  - Decreased sweating ability
  - May not be acclimatized
  - Young children can’t act to protect themselves (can’t, locks)
- CYFD
- Education: children & parents

The Cold

-The Cold

(Accidental) Hypothermia

- Core body temperature below 35 deg. C./ 95 deg. F.
  - Mild: 32-35 deg. C.
  - Moderate 28-32 deg. C.
  - Severe <28 deg. C.

Consider differential/concurrent diagnosis of sepsis (especially in elderly), endocrine dysfunction (adrenal or thyroid), hypoglycemia, neuromuscular disease, toxic exposure, trauma, etc.
Hypothermia

Convective loss through air and conductive loss through water are most common mechanisms.

Occurs as body compensatory are inhibited or become overwhelmed.

Behavioral compensation is critical; limited physiological compensation.

Risk factors:
- Alcohol/drug use
- Homelessness
- Psychiatric disease
- Extremes of age

Clinical presentation:
- Initial:
  - Shivering-increases metabolism and heat production, CO, ventilation,
  - Mild neurological changes even with temp >35 deg. C.
  - Cold diuresis
- Moderate:
  - Bradycardia, hypoventilation, loss of shivering, CNS depression, hyporeflexia
- Severe:
  - Pulmonary edema, arrhythmia, asystole, hypotension
Hypothermia

Assessment Pearls:
- Use appropriate thermometer to assess monitor core temp
- Temp. often lag behind actual core temperature
- May actually indicate opposite of core trend
- Esophageal probe most accurate during rewarming, must be in distal inferior esophagus
- Rectal probe may measure cold stool rather than core temp
- Full body assessment for concomitant trauma, frostbite, etc.
- HCT increases 2% for every 1 deg. C. drop in temp.
- Use uncorrected ABG values (coordinate with lab/RT) to guide therapy
- Clotting studies may be falsely normal because of lab technique, monitor for signs/symptoms of bleeding
- Tachycardia in hypothermia should make you very suspicious of another problem!!!!

EKG Findings in Hypothermia

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 78 F (26°C).

Hypothermia

- Treatment:
  - "Misdiagnosis of a non-perfusing rhythm is a hazard"
  - Careful pulse check for 1 minute in severe situations
  - Consider doppler or ultrasound/echocardiogram
  - Some sources suggest withholding compressions when PEA "appears" to be present
“Warm and Dead”

- Continue resuscitation until core temp is at least 32-35 deg. C. (may take hours)
- Resuscitation efforts are not indicated on frozen bodies!
- Obscene hyperkalemia (10-12 mEq/L) = OK to stop (NH3, Fibrinogen also)

Hypothermia

- Treatment:
  - Significant resuscitation with warmed (40-42 deg. C.) isotonic crystalloid
  - Patients have profound fluid shifts and may require repeat boluses.
  - Consider early specialty consultation, invasive monitoring, frequent lab reassessment

Hypothermia-Rewarming

- Passive External Rewarming:
  - Preferred method in mild hypothermia; adjunct in moderate/severe situations
  - Remove wet clothing
  - Warm room
  - Blankets
Hypothermia Rewarming

- Active External Rewarming
  - Warm blankets
  - Heating pads
  - Radiant Heat
  - Forced warm air
  
  Rewarm trunk before extremities (prevents “afterdrop”)

- Avoid localized burns/injury from overzealous heating

Hypothermia-Afterdrop

- Cold, acidemic blood has pooled in extremities. As extremities are warmed:
  - Blood moves from extremities into core, re-cooling core
  - Vasodilation during warming produces hypotension
  - Acidosis, hypotension and re-cooling may precipitate arrhythmias/cardiac arrest during rewarming process

- Re-warm core while slowly, gradually warming extremities

Hypothermia-Internal rewarming

- Minimal benefit from bladder or gastric lavage
- Warm air/oxygen provides limited benefit but may be helpful
- Level-One, Hot Line, etc.- (monitor for rate-related cooling)
- Consider risk/benefit/salvage-ability for:
  - Warm pleural lavage (avoid left-sided chest tubes)
  - Warm peritoneal lavage
  - Endovascular warming devices
  - ECMO/cardiac bypass (expertise, heparin, transport, etc.)
Hypothermia-Arrhythmias

- Rough handling may precipitate arrhythmias; Do not defer lifesaving interventions due to fear of arrhythmias.
- Bradycardia is OK, unlikely need/benefit of cardiac pacing in hypothermia
- A-fib/A-flutter are usually benign, transient
- Consider single defib if patient <30 deg. C.
- Normal ACLS if patient >30-35 deg. C.
- Poor evidence +/- other ACLS meds in severe hypothermia; Vaspressors may be more effective than antiarrhythmic medications.

Frostbite

- "Severe, localized, cold-induced injury"
  - Local cell death
  - Surrounding area of inflammation
  - Summertime causes of frostbite???
  - Thawing then re-freezing dramatically worsens prognosis for affected area.
  
Frostbite

- Classified similar to burns:
  - 1st degree: superficial, with pallor or redness and edema
  - 2nd degree: Blisters
  - 3rd degree: Deep, may have hemorrhage, dead tissue
  - 4th degree: Extension and dead tissue in muscle or bone
Frostbite

- Treatment:
  - Remove from cold, remove any cold or constricting clothing (only after assured no risk of refreezing)
  - Avoid pressure or walking on affected area
  - DO NOT RUB AREA!!!
  - Avoid high intensity direct heat
  - Ideal=gradual rewarming by submersion in warm water
  - Evaluate for need of local thrombolysis and/or heparin

The Wet

- Quick Trivia:
  - Approx 4000 deaths annually in U.S.
  - Peak incidents among <6 y/o’s and 15-25 y/o’s
  - Increased incidence:
    - Florida, California, Arizona
    - Males
    - Lower socioeconomic status
    - Southern states
    - More common in the summer (duh)
    - Alcohol/drugs
    - Freak medical events MI/arrhythmia/seizure/truma/stroke
    - Inability to swim (duh)

Near-Drowning
Near-drowning

- Gruesome way to go:
  - Panic
  - Air hunger/altered breathing patterns
  - Struggle to stay above water
  - Hypoxia
  - Laryngospasm
  - Loss of consciousness

Wet versus Dry & Saltwater versus Freshwater

- Who Cares:
  - Fresh and Saltwater both wash out pulmonary surfactant leading to pulmonary edema
  - Nonfatal drowning victims typically aspirate <4ml/kg water,
    - Fluid shifts at 1 ml/kg; electrolyte changes at 22ml/kg
  - Deaths are primarily related to hypoxia and end-organ damage
  - Duration of submersion, water temperature, pollution, rescue/bystander CPR major indicators of prognosis, along with initial presentation

Near-Drowning

- Treatment:
  - Prompt rescue/CPR, start CPR even before removal from water if possible ???
  - Treat for SCI only if suggestive mechanism or clinical finding
  - Thorough pulse check
  - Atrial fibrillation per ACLS protocols
  - Treat hypothermia
  - Airway/ventilation support as appropriate,
    - no special nuances
  - May need PEEP, CPAP, BiPAP
  - Supportive treatment related to organ system dysfunction
  - No benefit to therapeutic hypothermia/Specialty Consultation
The Poisoned

Principles of Toxicological Emergency Management

- Provider/Responder Safety!!!!
- Support Airway, Breathing and Circulation
  - Only a couple of antidotes will help an immediate ABC problem
- Decontamination
- Antidote (if available/appropriate) or Ideal treatment medication
- Enhanced Elimination
- Supportive Treatment
- Specialty Consultation-Disposition

Provider/Responder Safety

- What you don’t know can kill you
- Be alert for Toxidromes/Toxic Syndromes
- Multiple patients with same symptoms/complaint
- Blue canary’s
- Can your PPE protect against this???
Toxidromes

<table>
<thead>
<tr>
<th>Toxidrome</th>
<th>Signs / Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticholinergic (Benadryl,</td>
<td>Tachycardia, hyperthermia, dilated pupils,delirium,</td>
</tr>
<tr>
<td>Cogentin, Atropine)</td>
<td>seizures, psychosis</td>
</tr>
<tr>
<td>Cholinergic-Nicotinic Toxicity</td>
<td>Tachycardia, hypertension, weakness,</td>
</tr>
<tr>
<td></td>
<td>dilated pupils, fasciculations, hyperglycemia</td>
</tr>
<tr>
<td>Cholinergic-Muscarinic Toxicity</td>
<td>Salivation, lacrimation, urination, diarrhea,</td>
</tr>
<tr>
<td></td>
<td>emesis, bradycardia, sweating,</td>
</tr>
<tr>
<td>Opioid Toxicity</td>
<td>Lethargy and sedation, hypoventilation or apnea,</td>
</tr>
<tr>
<td></td>
<td>constricted pupils, pulmonary edema</td>
</tr>
<tr>
<td>Sympathomimetic</td>
<td>Tachycardia, agitation, hypertension, seizures,</td>
</tr>
<tr>
<td></td>
<td>hyperthermia, diaphoresis, dilated pupils</td>
</tr>
</tbody>
</table>

Support ABC’s

- Endotracheal intubation for anybody at risk of airway compromise or respiratory failure
- Rescue airways (LMA, King, etc.) if unable to intubate
  - Avoid if high airway pressures, laryngospasm, caustic ingestion
- BiPAP or CPAP inappropriate if nausea, vomiting, severe CNS depression, or if activated charcoal is used
- Ventilator as appropriate
  - Must be able to match minute ventilation in patients with a profound metabolic acidosis (TCA, salicylate, etc.)

- Cardiac Monitoring
- ACLS per ACLS
- Adequate IV access
  - At least two Large-bore IV’s
  - Consider IO
  - Central access if vasopressors or dialysis anticipated
Decontamination

- “Dilation is the solution to pollution” (credit unknown)
- Fresh air
- Copious irrigation for most dermal exposures
- Eye irrigation like you really mean it... (anesthetic, actually in the eye) STAT
- Maintain adequate IV/PO hydration to promote hepatic/renal function

GI Decontamination

- Syrup of Ipecac: Don’t use it
- Activated Charcoal (AC)
  - 1g/kg up to 50g
  - Major aspiration hazard; Secure airway is essential
  - Limited benefit >2 hours post ingestion
  - Many substances not absorbed by AC or get absorbed by stomach too quickly
  - Some substances benefit from MDAC, even after GI system is empty
  - May administer with cathartic (Mg Citrate or Sorbitol)
- Gastric Lavage: helpful in some situations; requires prompt decision and initiation

Enhanced Elimination

- Dialysis
- Multidose Activated Charcoal (MDAC)
- Hyperbaric Oxygen
- Urinary Alkalinization
- Charcoal hemoperfusion
Noteworthy Toxicological Emergencies

- Acetaminophen
- Amphetamine/Methamphetamine
- Benzodiazepine
- Carbon Monoxide
- Tricyclic antidepressant (TCA)'s
- Ethylene Glycol and Methanol
- Salicylate

Acetaminophen (APAP)

- Assessment
  - Often asymptomatic
  - Vomiting and abd pain are very concerning for severe toxicity
  - 4-7g in 24 hours or 150mg/kg single dose begins toxicity; 250-350mg/kg is highly toxic
- Diagnosis
  - >150mcg/ml on Rumack-Matthew Nomogram at 4 hours
  - Evidence of hepatic injury after significant APAP exposure
- Treatment
  - N-acetylcysteine (NAC; mucomyst)
  - 72 hour oral or 21 hour IV

Acetaminophen Nomogram
### Amphetamines / Methamphetamines

- Dose-toxicity paradox: patients require increasing doses due to tolerance, but a small increase from “normal” dose can cause toxicity
- Washout syndrome: profound sleep, fatigue, lethargy and depression with ability to return to normal mental status
- Sxs: hypertension, agitation, seizures, tachycardia, cardiac ischemia, hyperthermia
- Treatment:
  - Benzodiazepines—often massive doses
  - Hydration, supportive care

### Benzodiazepine

- Valium, Ativan, Serax, Klonopin
- Cardiac arrest from pure Benzo overdose is rare; Toxicity often occurs when mixed with opioids or alcohol
- Sxs: CNS and respiratory depression, hyperthermia, slurred speech, ataxia
- Treatment:
  - Supportive care, rarely need intubation
  - Avoid flumazenil/Romazicon except in very particular circumstances

### Carbon Monoxide (CO)

- May see intentional exposure for suicide attempts (rare); most common is accidental from fires, misuse of heaters or generators
- Displaces oxygen on RBC’s, causes cellular hypoxia
- Often misdiagnosed as viral syndrome
- Sxs: Headache, lethargy, N/V, seizures, coma; Classic “cherry red” skin is rare; other signs of end-organ damage/dysfunction
- Dx: Handheld co-oximeter or serum carboxyhemoglobin level
- Rx: Oxygen, oxygen, oxygen
  - May start to see emergence of isocapnic hyperpnea
Ethylene Glycol & Methanol

- Ethylene Glycol: conventional antifreeze
- Methanol: Windshield washer fluid
- Both are very toxic by volume
- Oral ingestion produces profound metabolic acidosis
- Dx: Serum levels or osmolar gap
- Sxs:
  - Methanol: Blurred vision, blindness
  - Ethylene glycol: Flank pain, hematuria
  - Both: Coma, seizures, hypotension, sedation, "intoxication"
- Rx: Oral/IV ethanol, Fomepizole

Tricyclic Antidepressant (TCA)

- Can be a "1 pill killer" in children
- Becoming increasingly rare, but may be prescribed to people with severe depression (highest risk); Also used for chronic pain, etc.
- Severe overdose can cause seizures, coma, arrhythmias
  - Frequently fatal
- Monitor for widened QRS or prolonged QTc on EKG
- RX:
  - Aggressive life support measures for severe exposures
  - Serum alkalization for arrhythmias with NaHCO3

Salicylate/Aspirin

- Found in many common topical preparations
- Small ingestions in children can cause significant toxicity (methyl salicylate, Icy Hot, BenGay, etc.)
- Serum ASA level very useful and can guide treatment; Most useful 6 hours post ingestion.
  - >150mg/L ag toxic
  - >40mg/dL
  - Chronic exposures become toxic at lower levels
- Sxs: Tinnitus, N/V, somnolence, tachypnea, Massive metabolic acidosis
- Rx: Dialysis, alkalinize urine, MDAC, useful post management if intubated (avoid intubation if possible; must match minute ventilation), supportive Rx.
Poison Control Center

1-800-222-1222

Thank you!