Weather and Environmental Emergencies: Summer’s Heat and Winter’s Cold

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Objectives

- Discuss Epidemiology, Presentation and Treatment of following Weather and Environmental Emergencies:
  - Wind/Storm Related (4 minutes)
  - Heat Related Illness (12 minutes)
  - Lightning Injuries (7 minutes)
  - Drowning (8 minutes)
  - Hypothermia (12 minutes)

General Environmental Pearls

- Very young and very old are most at risk
  - Due to lack of or loss of protective adaptations
- Underlying disease, medications, poor nutrition
- “Multiple system” injuries
- Most are largely preventable and respond to common sense treatment
- Increased exposure correlates with increased risk

Thanks, Dan!
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Wind/Storm Emergencies


Hurricanes

- Most mortality originates from secondary disasters (storm surges, flash flooding, and tornados) triggered by original event.
- In coastal regions, level of hurricane’s storm surge is strong predictor of mortality.
- Winds are 2nd deadliest aspect.
- Most common non-fatal traumatic injury pattern in a hurricane consists of superficial lacerations from airborne glass and/or other debris.

Hurricane Injury Patterns

- Prior to impact:
  - “Handyman”-type injuries sustained by inexperienced laborers preparing for storm.
    - Contusions, falls, lacerations, and fractures
- Motor vehicle accidents during evacuation
- Impact phase:
  - Lacerations, blunt trauma, & puncture wounds (lower extremities)
  - Drowning during storm surge
  - Injuries related to structural collapse, downed power lines, & fires
### Hurricane Injury Patterns

- **Immediate post-impact phase:**
  - Cleanup-related injuries
    - Puncture wounds, lacerations, falls
  - Electrocutions from downed power lines
  - Blunt trauma from falling trees and structures
  - Motor vehicle crashes due to traffic signal malfunction, poor visibility, & roadway damage
- **Violence**
  - Crime, suicide, & child abuse

- **Long-term post-impact phase:**
  - Infections- poor hygiene & damaged sanitation infrastructure.
  - Loss of public health programs & healthcare delivery systems
  - Exacerbation of chronic disease (asthma, diabetes, cardiac conditions, etc)
  - Long-term psychiatric sequelae (depression, post-traumatic stress disorder, etc)

### Tornado Associated Injuries

- Most fatalities die at scene
  - In exposed areas or in mobile homes.
- Risk factors for injury and death during a tornado include:
  - Poor building anchorage
  - Occupant location other than a basement
  - Age over 70 years
  - High wind strength
Tornado Injury Patterns

Prior to impact:
- All individuals in the path of the tornado “funnel cloud” should seek appropriate shelter.

Impact phase:
- When shelter is not available, traditional construction home (especially basement or lower level core area) is safest.
- Due to improvements in design, being in car may be safer than being in mobile home or ditch.
- Commonly injured areas include extremity, head, chest, & abdomen.
- Soft tissue wounds & fractures predominate.
- Injury severity increases when victim is thrown rather than struck by flying debris.

Post-impact phase:
- Post-storm cleanup phase: falls, contusions, lacerations, crush injuries, & mechanical equipment-related trauma.
- Short- and long-term psychiatric sequelae can be seen (depression, post-traumatic stress disorder, etc).

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Heat-Related Illness

Statistics

• USA: on average, 500 die each year
• Specific heat wave mortality:
  – 1995 Chicago, IL: 800+ died
  – 2003 Europe: at least 70,000 died
  – 2006 Netherlands: 1000+ heat-related deaths
  – 2015 India: 2200+ died
• 2005-2009: highest incidence of heat-related sports deaths ever recorded in the United States


Four Mechanisms of Heat Regulation

• Evaporation: most efficient
  – 30% body cooling (at average temperatures) is due to evaporation
  – Cannot occur if humidity >75%

Four Mechanisms of Heat Regulation

• Evaporation: most efficient
  – 30% body cooling (at average temperatures) is due to evaporation
  – Cannot occur if humidity >75%
• Radiation: transfer of heat between body and environment via electromagnetic waves.
  – Accounts for >50% of cooling, as long as ambient air temperature is lower than body temperature.
**Four Mechanisms of Heat Regulation**

- **Conduction:** Direct transfer of heat between two objects in contact
  - Important when lying on cold ground or immersed in water

- **Convection:** Heat transfer between body and a moving gas or liquid – typically air
  - Think of a fan in a hot bedroom

**Spectrum of Heat Illness**

- Heat Cramps
- Heat Edema
- Heat Syncope
- Heat Exhaustion
- Heat Stroke

**Mechanism of Heat Illness**

- **Physiologic response to heat**
  - Vasodilation
  - Sweating
  - Behavioral changes

- **Pathophysiologic pathway to heat illness**
  - Increased heat production or gain
  - Decreased heat dissipation (radiation and evaporation)
  - Impaired thermoregulation (illness, drugs, and behavior)
Heat Cramps

- Painful spasmodic cramps that usually occur in heavily exercised muscles (Large Groups, Calves)
- Onset may be during exercise or after
- Likely the result of water and sodium loss
- Oral rehydration with water and electrolytes
- Rest in cool environment
- Stretch and massage

Heat Syncope

- Orthostatic hypotension resulting from volume depletion, peripheral vasodilatation, & decreased vasomotor tone.
- Trendelenburg
- Cool victim and administer oral fluids – carbohydrate-containing fluids absorbed up to 30% faster (dilute Gatorade)

Heat Exhaustion

- Flulike symptoms – intense thirst, malaise, headache, weakness, nausea, anorexia, vomiting
- Tachycardia, orthostatic hypotension
- Sweating is generally present
- Core Temperature is < 104 F
- Mental status and neurologic exam are normal

Heat Exhaustion

- Cool shaded environment
- Oral rehydration if capable but may need IVF due to large amounts of volume lost as sweat
- Active cooling measures – ice packs to neck, axillae, groin
- Spray with tepid water and fan – one of the most effective ways to cool
# Heat Stroke

- Medical Emergency!
- Temperature generally > 104°F
- MENTAL STATUS CHANGES
  - Delirium
  - Seizures
  - Coma
- Skin is usually hot and dry
- Classic versus Exertional

## Classic

- Intrinsic heat production plays major role
- Environment plays major role
- Linked to heat waves
- Dry skin
- Elderly
- Respiratory alkalosis

## Exertional

- All types of weather
- Profuse sweating
- Athletes
- Respiratory alkalosis and lactic acidosis

# Multi-Organ Dysfunction

- Encephalopathy
- Rhabdomyolysis
- Acute renal failure
- Acute respiratory distress syndrome
- Myocardial/hepatocellular/pancreatic injury
- Intestinal ischemia/infarction
- Hemorrhagic complications – DIC

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Images provided courtesy of Korey Stringer Institute.
### Treatment

- Immediate cooling
- Support of organ-system function

### Cooling

- Ice packs on neck, axillae, chest wall, and groin
- Spray with tepid water and fan rapidly to cool by evaporation; massage the skin
- Immersion in cool water, if vital signs are otherwise stable
- Stop active cooling at core temperature of 102 F
- Internal cooling rarely needed/used

### Treatment

- Resuscitation (ABCs)
- Isotonic IV fluids—treat volume depletion
- Benzodiazepines to avoid seizures/shivering
- Dantrolene and antipyretics are ineffective
- Monitor for complications and treat

### Good Prognosis

- Recovery of central nervous system function during cooling
- Expected in the majority of patients who receive prompt and aggressive treatment
**Poor Prognosis**

- Coagulopathy with liver hepatocyte damage
- Lactic acidosis in classic form
- Rectal temperature > 108 F
- Prolonged coma of more than 4 hours
- Acute renal failure
- Hyperkalemia
- AST > 1000 U/L

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**Lightning Injuries and Prevention**

Crew: Firefighter struck by lightning today; game reschedule for today
By Adam Jardy, The Columbus Dispatch, June 29, 2014

Author: Michael Barera
Epidemiology

- Lightning is the 2nd leading environmental cause of death in the United States (flash floods is first)
- 50 to 300 deaths annually
  - 3-5x more survive being struck
- Florida has the most casualties

6 Mechanisms of Injury

1. Direct strike - Patient is hit directly by the bolt
   - 5% of strikes, most deadly
   - Usually strikes people who are caught in an open area
2. Side splash - Lightning strikes an object (tree, etc)
   - 1/3 of lightning injuries (most common)
   - Current flow jumps from its pathway
   - May splash indoors from metal objects such as plumbing or telephones
   - May occur from person to person
3. Contact
   - Touching an object that is struck

Pathophysiology

- Unidirectional massive current impulse
  - Neither a DC or AC current
  - Flow of electrons over and through body for short period of time
  - Up to 2 billion volts (or 1.21 gigawatts)!
- Injuries occur from “short-circuiting” body’s electrical systems
- Not well studied, especially in humans
- In body tissues, follows path of least resistance: order of least to greatest resistance: nerve < blood < muscle < skin < fat < bone.
Cardiovascular System

- Cardiopulmonary arrest is most common cause of death
  - Heart becomes asystolic
  - After a short time the heart begins contracting
  - If concomitant respiratory arrest there is delay in recurrence of breathing with resultant hypoxia
  - Secondary cardiac arrest due to hypoxia

Central Nervous System

- Respiratory center paralysis
  - Center is located adjacent to the 4th ventricle, in the brainstem
  - Current passes through the orifices of the head
- Coagulation necrosis of the brain
- Epidural & subdural hematomas
- Intraventricular hemorrhage
- Those who suffer cranial burns are 4x more likely to die than those without burns

Autonomic Nervous System

- Instability for several hours but resolves
- Lower extremity paralysis (keraunoparalysis)
  - Pulseless, cold, clammy, mottled and insensate
  - Due to intense vascular spasm
  - Not thrombosis
  - Seen with ground current
- Less commonly, these symptoms may involve the upper extremity

Management of Lightning Victims: Initial Triage

- Reverse Triage
  - Care for those who appear dead first
  - Initiate CPR
  - Those with spontaneous breathing or movement will recover
  - Those not breathing may recover their heartbeat and succumb to the secondary respiratory arrest
- Stop CPR if no recovery in 20 to 30 minutes
Avoiding Lightning Strike

The 30-30 Rule

• If the time from seeing lightning and hearing thunder is 30 seconds or less then seek cover
• No outdoor activities until 30 minutes after the storm has passed
• “If Thunder roars, go indoors!”

Lightning Injuries Pearls

• “Resuscitate the dead”-Reverse Triage
• Massive fluid resuscitation seldom necessary
• Think about this in confused patient or unconscious patient with no shoes/clothes
• Entrance or exit wounds are rare, but look for Lichtenberg figure

Assume the Position!

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**Terminology**

- **Drowning**: Process resulting in respiratory impairment from submersion / immersion in liquid medium. Victim may live or die during or after process. The outcomes are classified as death, morbidity, and no morbidity.
- **The Drowning Process**: A continuum that begins when the victim's airway lies below the surface of liquid, usually water, preventing the victim from breathing air.
- **Drowned**: refers to a person who dies from drowning

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**Drowning**

- Second only to MVA as most common cause of accidental death in US
- **Risk factors**:
  - male sex
  - age <14 years
  - alcohol use/risky behavior
  - Low income/Poor education
  - rural residency
  - aquatic exposure
  - lack of supervision.
### Drowning Pathophysiology

- Most important abnormality of drowning is a profound HYPOXEMIA resulting from asphyxia.
- Sequence of cardiac rhythm deterioration is usually tachycardia followed by bradycardia, pulseless electrical activity, then asystole.

### Drowning Treatment

- Immediate and adequate resuscitation is most important factor influencing survival.
- For unconscious: in-water resuscitation may increase favorable outcome by 3 times.
- Drowning persons with only respiratory arrest usually respond after rescue breaths. If no response, assume cardiac arrest & start CPR.
- Full neurologic recovery is not predicted if victim has been submerged >60 min in icy water or >20 min in cool water.

### Predictors of Outcome

- Early BLS and ACLS improve outcomes (ABC’s)
- Duration of submersion and risk of death/severe neurologic impairment after hospital discharge
  - 0–5 min — 10%
  - 6–10 min — 56%
  - 11–25 min — 88%
  - >25 min — nearly 100%

### Prognosis

- Factors associated with unfavorable prognosis
  - Age <3 years
  - Prolonged submersion >5minutes
  - Delay in resuscitation >10 minutes
  - Comatose on arrival to hospital
  - Acidosis: pH <7.1
- Two or less factors = 90% recovery rate
- Three or more factors = <5% recovery rate
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Hypothermia and Frostbite

**Hypothermia**

- Yearly, about 1500 patients in US have hypothermia noted on death certificate.
- Exact incidence is unknown.
- Most cases occur in urban setting & related to exposure attributed to alcoholism, illicit drug use, mental illness, advanced age or homelessness
- Other affected groups include people in an outdoor setting for work or pleasure

**Definition**

- Accidental or intentional drop of body core temperature to 35°C or below
- 95°F corresponds to 35°C, and 82°F to 28°C, thresholds of mild and severe hypothermia.
  - Mild – 32-35°C
  - Moderate – 28-32°C
  - Severe - <28°C

**Hypothermia and Frostbite**

### Causes of Hypothermia

- Decreased heat production – endocrine derangements, malnutrition, neuromuscular inefficiencies
- Increased heat loss – immersion, vasodilatation from pharmacologic or toxic causes, burns
- Impaired thermoregulation – CNS trauma/tumors, strokes, toxic and metabolic derangements, ICH
- Other – sepsis, uremia, multiple trauma

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**Mild (32-35°C)**

- Cold temperature defense mechanisms are still working
- Shivering, pale and cold
- Lethargy, confusion, altered judgment
- Loss of fine motor coordination
- Ataxia
- Apathy

**Moderate (28-32°C)**

- BP, HR, and RR decreased
- Delirium
- Slowed reflexes
- Stop Shivering (require active rewarming)
- Stupor
- At risk for dysrhythmias
- Further CNS depression

**Severe (<28°C)**

- Unresponsive or comatose (look dead)
- Dysrhythmias common, including ventricular fibrillation (rewarming needed to convert)
- Rigidity
- Apnea
- Absent pulse
- Areflexia and fixed pupils

**Hypothermic Patients with No Vitals**

- Is CPR needed or do they have obvious signs of irreversible death?
  - Duration of CPR does not predict outcome.
  - Did they have arrest prior to cooling?
  - Frozen solid, K+ greater than 12, trauma, drowning, avalanche.
- Do you need to transfer to an ECMO center?
- Supportive care while transporting
### Cardiovascular Issues

- Bradycardia and atrial fibrillation (normal)
- Decreased cardiac output
- Hypotension
- Risk of ventricular fibrillation greatest <22 °C
- If coding, give 1 dose of epi and 1 shock; If it doesn't work, wait until they warm up 3 to 5 degrees C and then try one more dose.
- Then wait until they are above 32 degrees C.

### Diagnostics

- CBC, coagulation studies
- UA, BUN, Cr
- Electrolytes, glucose
- CXR
- ECG
- ABG – DO NOT CORRECT

### J wave or Osborne wave

![J wave or Osborne wave](http://lifeinthefastlane.com/ecg-library/basics/hypothermia/)
<table>
<thead>
<tr>
<th><strong>Treatment</strong></th>
<th><strong>Rewarming</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Handle all victims carefully</td>
<td>• Active Rewarming necessary for Moderate to Severe</td>
</tr>
<tr>
<td>• Prevent further heat loss</td>
<td>• Passive external</td>
</tr>
<tr>
<td>• Anticipate an irritable myocardium and hypovolemia</td>
<td>• Active external</td>
</tr>
<tr>
<td>• Treat hypothermia before treating frostbite</td>
<td>• Active internal (core)</td>
</tr>
<tr>
<td>• Immobilize c-spine if any question of trauma</td>
<td></td>
</tr>
<tr>
<td>• Airway – intubate if necessary; be ready for dysrhythmias</td>
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<tr>
<td>• Breathing – provide warm oxygen</td>
<td></td>
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<tr>
<td>• Circulation – IV NS; avoid LR initially</td>
<td></td>
</tr>
<tr>
<td>• Disability – record quick neurologic exam</td>
<td></td>
</tr>
<tr>
<td>• Expose – remove wet clothes, look for injuries</td>
<td></td>
</tr>
<tr>
<td>• Measure temperature with low-reading esophageal, rectal or bladder thermometer</td>
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<tr>
<td>• Consider thiamine, D50, narcan</td>
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<tr>
<td>• Use fluids before vasopressors</td>
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<tr>
<td>• Look for hidden trauma</td>
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<tr>
<td>• Look for potential cause</td>
<td></td>
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<tr>
<td>• Watch for “Rescue Collapse”</td>
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Passive Rewarming

- Passive external:
  - Remove wet clothing
  - Block the wind
  - Keep dry
  - Cover with dry insulating materials, i.e., clothes, blankets, sleeping bags, "space" blanket

Active External Rewarming

- Active Rewarming necessary for Moderate to Severe
- Active external
  - Apply hot water bottles, bags of saline to core areas, i.e., neck, axillae, groin – avoid thermal burns
  - Heat lamps or forced-air heating systems
  - Immersion in 104 F water (impractical for most of our ED patients)

Active Internal (Core) Rewarming

- Hypothermic patients with cardiac arrest have survival rate of 50% when treated in ECMO center but only 10% in non-ECMO center.
- Heated humidified oxygen via mask or ETT
- Heated IV fluids
- Thoracic lavage

Hypothermia Review

<table>
<thead>
<tr>
<th>Hypothermia</th>
<th>Temperature</th>
<th>Clinical Presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild hypothermia</td>
<td>32° to 35°C (92° to 95°F)</td>
<td>Hypotension, Tachypnea, Tachycardia, Skin pale and cold, Uncontrollable shivering, Urinary frequency, Impaired judgment</td>
</tr>
<tr>
<td>Moderate hypothermia</td>
<td>28° to 32°C (82° to 90°F)</td>
<td>Hypotension, Bradycardia, Bradypnea, Stop shivering, Dilated pupils, Burred speech, Decreased level of consciousness, Dysrhythmias</td>
</tr>
<tr>
<td>Severe hypothermia</td>
<td>&lt;28°C (82°F)</td>
<td>Fixed pupils, Muscle rigidity, Pulmonary edema, Life-threatening Dysrhythmias, Death</td>
</tr>
</tbody>
</table>
