Weather and Environmental Emergencies: Summer's Heat ad 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)**

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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

Marchigiani R, Gordy S, Cipolla J, et al. Wind disasters: A comprehensive review of current management strategies. International Journal of Critical Illness and Injury Science. 2013;3(2):130-142. doi:10.4103/2229-5151.114273.

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

Hurricane Injury Patterns

- 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)

Tornados

- Tornados usually develop during intense "supercell thunderstorms".
- From updrafts created by solar warming of earth's surface. Updrafts then develop into vortex with strong rotary winds and violent pressure changes.
- Due to brief or absent warning, little time to prepare or seek shelter
  - Morbidity & mortality higher compared to other WDs.

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.

Images Courtesy: NOAA

Tornado Injury Patterns

- 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.

Tornado Injury Patterns

- 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).

Author: Aaronjayjack
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Heat-Related Illness

Photo: N. Kman, MD

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

Atha WF. "Heat-Related Illness." Emerg Med Clin N Am 31 (2013) 1097-1108.

Four Mechanisms of Heat Regulation

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

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- 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.

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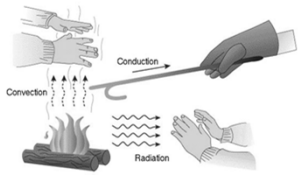
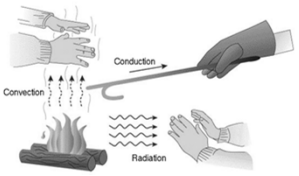
Four Mechanisms of Heat Regulation

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



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



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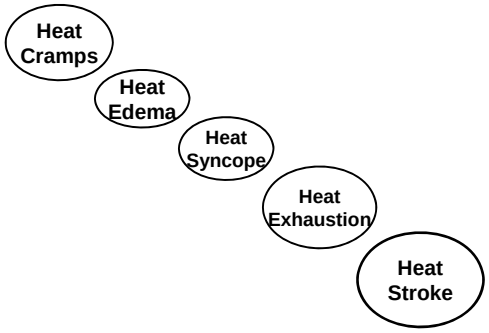
Spectrum of Heat Illness



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

Heat Stroke: Exertional

- Intrinsic heat production plays major role
- All types of weather
- Profuse sweating
- Athletes
- Respiratory alkalosis and lactic acidosis

Classic

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

Heat Stroke

- Tachycardia
- Orthostatic changes, hypotension
- Hyperventilation
- Bleeding due to coagulation disorders, including DIC
- Classic – respiratory alkalosis
- Exertional – respiratory alkalosis and lactic acidosis

Images provided courtesy of Korey Stringer Institute.

Multi-Organ Dysfunction

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

Treatment

- Immediate cooling
- Support of organ-system function

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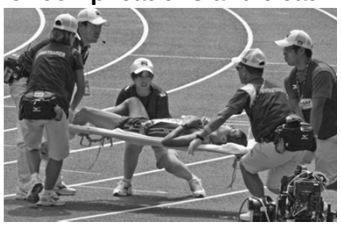
Cooling

- 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



Author: Eckhard Pecher (Arcimboldo) CC BY 2.5

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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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

Author: M. G. Loppé
Source:NOAA

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

6 Mechanisms of Injury

4. Ground current (Step Voltage)
- Current spreading on ground flows through body, a better conductor than dirt
  - Up one leg and down the other
  - A common etiology for multiple victims, livestock

5. Injury by weak, upward streamer
  - Streamer that heads upward but does not reach sky
  - Not as strong as a direct strike

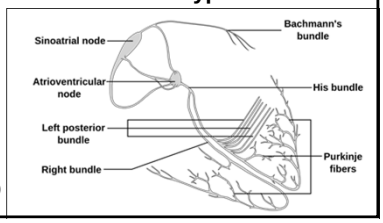
6. Blunt injury
- Concussive force of strike itself
- Being thrown due to extreme muscular contraction from electrical charge

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



Author: of original files - Madhero88)
Author: of this version Angelito7

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

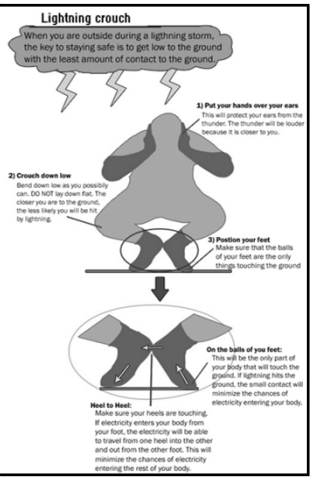
- Reverse Triage
  - Care for those who appear dead first
  - Initiate CPR
  - Those with spontaneous breathing or movement will recover
  - Those not breathing may recover their heartbeat and succumb to the secondary respiratory arrest
- Stop CPR if no recovery in 20 to 30 minutes

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!"**

Assume the Position!



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**

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Drowning

Author: Sgt. Mark E. Morrow

The NEW ENGLAND JOURNAL of MEDICINE

REVIEW ARTICLE

CURRENT CONCEPTS

Drowning

David Szpilman, M.D., Joost J.L.M. Bierens, M.D., Ph.D., Anthony J. Handley, M.D., and James P. Orlowski, M.D.

From the Adult Intensive Care Unit, Hospital Municipal Miguel Couto, and Corpo de Bombeiros Militar — both in Rio de Janeiro (D.S.); the Society to Rescue People from Drowning, Amsterdam (J.J.L.M.B.); the Royal Life Saving Society UK, Broom (A.J.H.); and Florida Hospital and the University of South Florida — both in Tampa (J.P.O.). Address reprint requests to Dr. Szpilman at Av. das Américas 3555, Bloco 2, Sala 302, Barra da Tijuca, Rio de Janeiro, 22631-003 Brazil, or at david@szpilman.com.

ACCORDING TO THE WORLD HEALTH ORGANIZATION (WHO), 0.7% OF ALL deaths worldwide — or more than 500,000 deaths each year[1] — are due to unintentional drowning.[2] Since some cases of fatal drowning are not classified as such according to the codes of the *International Classification of Disease*, this number underestimates the real figures, even for high-income countries,[3] and does not include drownings that occur as a result of floods, tsunamis, and boating accidents.

Drowning is a leading cause of death worldwide among boys 5 to 14 years of age.[2] In the United States, drowning is the second leading cause of injury-related death among children 1 to 4 years of age, with a death rate of 3 per 100,000,[4] and in some countries, such as Thailand, the death rate among 2-year-old children is 107 per

LLSA: Szpilman D, Bierens J, Handley A, Orlowski J. Drowning. N Engl J Med. 2012;366(22):2102-10.

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**

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

LLSA: Brown DJ, Brugger H, Boyd J, Paal P. Accidental hypothermia. N Engl J Med. 2012;367(20):1930-8.

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**

Causes of Hypothermia

- **Decreased heat production – endocrine derangements, malnutrition, neuromuscular inefficiencies**

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- **Impaired thermoregulation – CNS trauma/tumors, strokes, toxic and metabolic derangements, ICH**
- **Other – sepsis, uremia, multiple trauma**

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

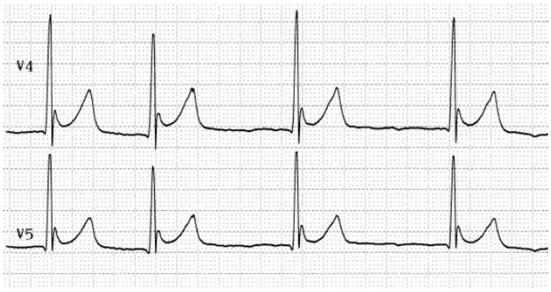
Hypothermic Patients with No Vitals

- 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

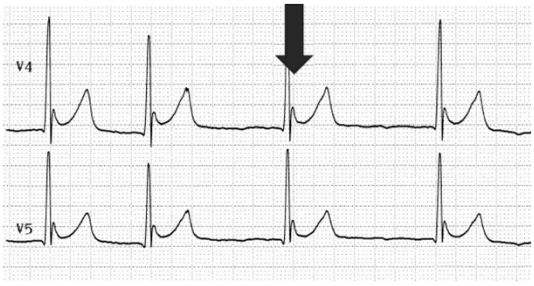
- **Bradycardia and atrial fibrillation (normal)**
- **Decreased cardiac output**
- **Hypotension**
- **Risk of ventricular fibrillation greatest <22 C**
- **If coding, give 1 dose of epi and 1 shock; If it doesn't work, wait until they warm up 3 to 5 degrees C and then try one more dose.**
- **Then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

J wave or Osborne wave



http://lifeinthefastlane.com/ecg-library/basics/hypothermia/ CC BY-NC-SA 4.0

J wave or Osborne wave



http://lifeinthefastlane.com/ecg-library/basics/hypothermia/ CC BY-NC-SA 4.0

Diagnostics

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

Treatment

- Handle all victims carefully
- Prevent further heat loss
- Anticipate an irritable myocardium and hypovolemia
- Treat hypothermia before treating frostbite

Treatment

- Immobilize c-spine if any question of trauma
- Airway – intubate if necessary; be ready for dysrhythmias
- Breathing – provide warm oxygen
- Circulation – IV NS; avoid LR initially
- Disability – record quick neurologic exam
- Expose – remove wet clothes, look for injuries

Treatment

- Measure temperature with low-reading esophageal, rectal or bladder thermometer
- Consider thiamine, D50, narcan
- Use fluids before vasopressors
- Look for hidden trauma
- Look for potential cause
- Watch for “Rescue Collapse”

Rewarming

- Active Rewarming necessary for Moderate to Severe
- Passive external
- Active external
- Active internal (core)

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**

Author: Eli-Rainey

Hypothermia Review

	Temperature	Clinical Presentation
Mild hypothermia	32° to 35°C (92° to 95°F)	Hypertension Tachypnea Tachycardia Skin pale and cold Uncontrollable shivering Urinary frequency Impaired judgment
Moderate hypothermia	28° to 32°C (82° to 90°F)	Hypotension Bradycardia Bradypnea Stop shivering Dilated pupils Slurred speech Decreased level of consciousness Dysrhythmias
Severe hypothermia	<28°C (82°F)	Apnea Fixed pupils Muscle rigidity Pulmonary edema Life-threatening dysrhythmias Death

Brown DJ, Brugger H, Boyd J, Paal P. Accidental hypothermia. N Engl J Med. 2012;367(20):1930-8.
AWLS Textbook 8th Edition