PATIENT CARE THEORY 2

UNIT 10, PART 2: Environmental Emergencies
Heat and Cold

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Learning Objectives

- Identify how the human body interacts with the environment
- Identify and discuss the following Environmental Emergencies
  - Heat-related illness (Heat stroke, fever, etc.)
  - Cold-related illness (Hypothermia, frostbite)

Homeostasis

- The process or tendency for the human body to maintain a relatively stable internal state/environment
- We interact with the environment to obtain; O2, nutrients and thermoregulation
- environmental conditions that challenge the body's ability to maintain this state and result in decompensation are Environmental Emergencies

Thermoregulation

- Normal body temperature (Core temp) 37.0 Celsius

Examples of Body Temperature Measurement Ranges

Method	Fahrenheit	Celsius
Rectal	97.9°F – 100.4°F	36.1°C – 38.0°C
Tympanic (inner ear)	96.4°F – 100.4°F	35.8°C – 38.0°C
Oral	95.9°F – 99.5°F	35.5°C – 37.5°C
Axillary (Armpit)	94.5°F – 99.1°F	34.7°C – 37.3°C
Forehead	95.0°F – 100.4°F	35.0°C – 38.0°C

Normal Body Temperatures and Age

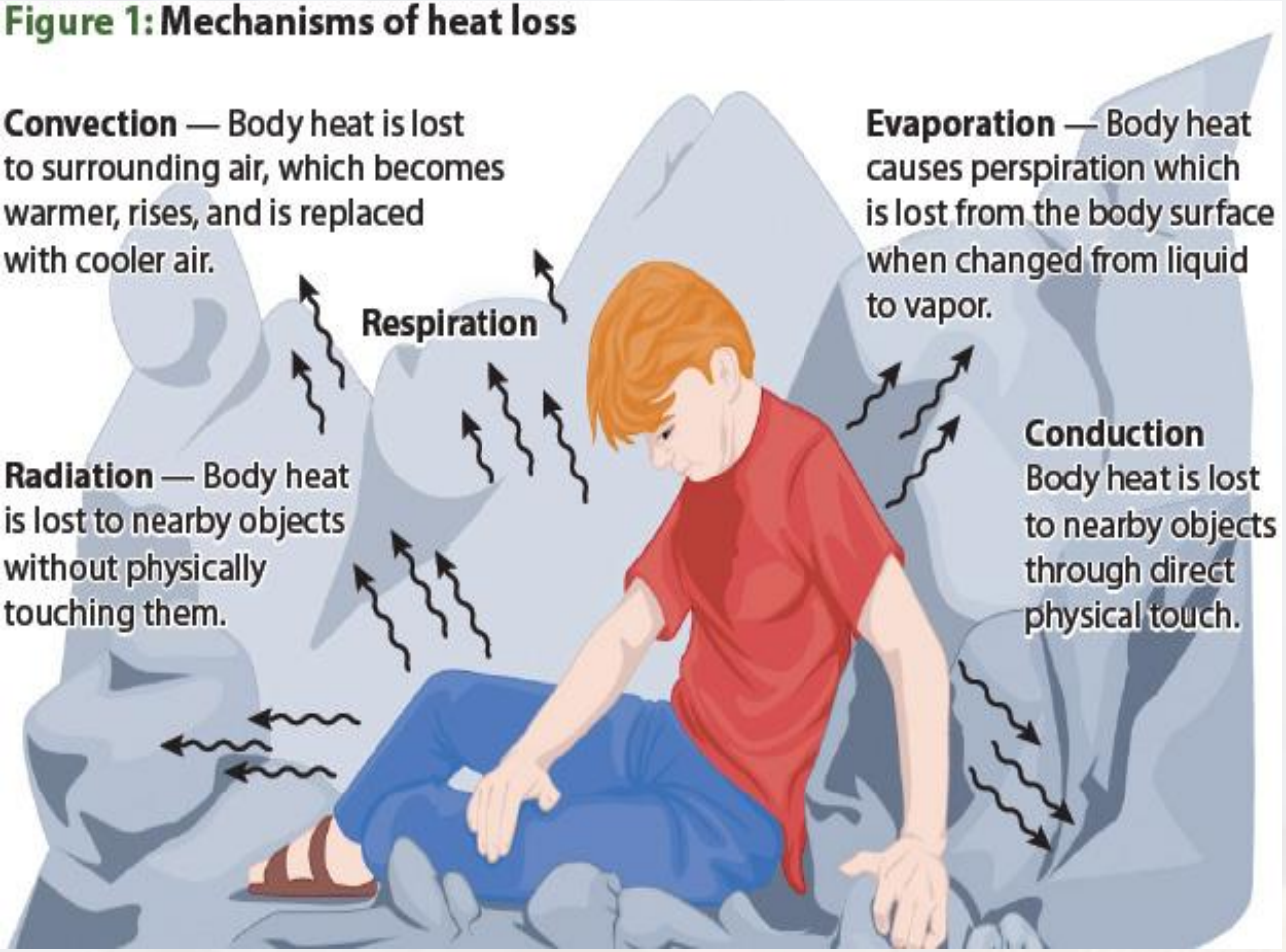
Age	Fahrenheit	Celsius
0 to 2 years	97.5°F – 100.4°F	36.4°C – 38.0°C
3 to 10 years	97.0°F – 100.0°F	36.1°C – 37.8°C
11 to 65 years	96.6°F – 99.7°F	35.9°C – 37.6°C
65 years and older	96.4°F – 99.5°F	35.8°C – 37.5°C

Heat Production - Thermogenesis

- heat production results from intracellular metabolic processes (basal metabolic activity)
- absorption of heat from external sources
- normal heat production of the body is 60 to 70 kcal/h
- Work-induced thermogenesis
  - strenuous physical activity increases body heat production up to 900 kcal/h
  - Shivering
- Thermoregulatory Thermogenesis (endocrine system)
  - Epinephrine and norepinephrine ⇧ cellular metabolism
- Metabolic or diet-induced thermogenesis
  - Processing of food and nutrients

Heat Loss/Gain

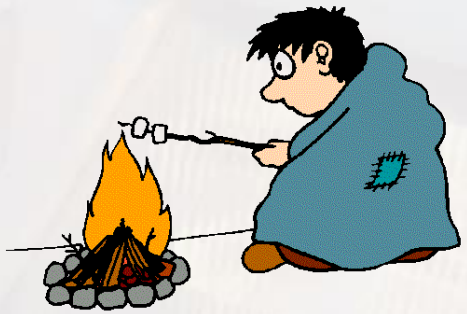
- Radiation
- Convection
- Conduction
- Evaporation
- Respiration*



Jems - https://www.jems.com/patient-care/identifying-and-managing-accidental-hypothermia/

Radiation

- heat transfer to the surrounding environment
  - when the air temperature is lower/higher than body temperature
- radiant heat loss accounts for 65% of cooling
  - vasoconstriction: response to cold
- when the air temperature is greater than body temperature, radiation is be a source of major heat gain
  - vasodilation: facilitates heat loss by radiation
  - blood flow to the skin can increase by up to 20 X



Convection

Energy transferred by *mass motion of molecules*

- Air or liquid passing by the body
- once air temperature exceeds skin temperature, heat is gained by the body
- convection (air) accounts for about 10 to 15 percent of heat loss of the body and is greatly affected by wind speeds
- as the wind speed increases so does the rate of convection and heat loss
- loose-fitting clothing maximizes convective heat loss (provides exit routes for the heat to escape)

Conduction

- Direct physical contact
- accounts for 2 percent of body heat loss under normal conditions
- Conversely, immersion in cool water can enhance heat loss by 32 times

Evaporation

- conversion of a liquid to a gas (vapour)
- Our primary means of evaporative heat loss is sweat from the skin
- Effective sweat evaporation ceases when the relative humidity reaches 75%
- ~ 600mL of Water evaporates from the skin and lungs*
- under ordinary circumstances, radiation and evaporation are the major mechanisms by which the body can eliminate heat

Respiration

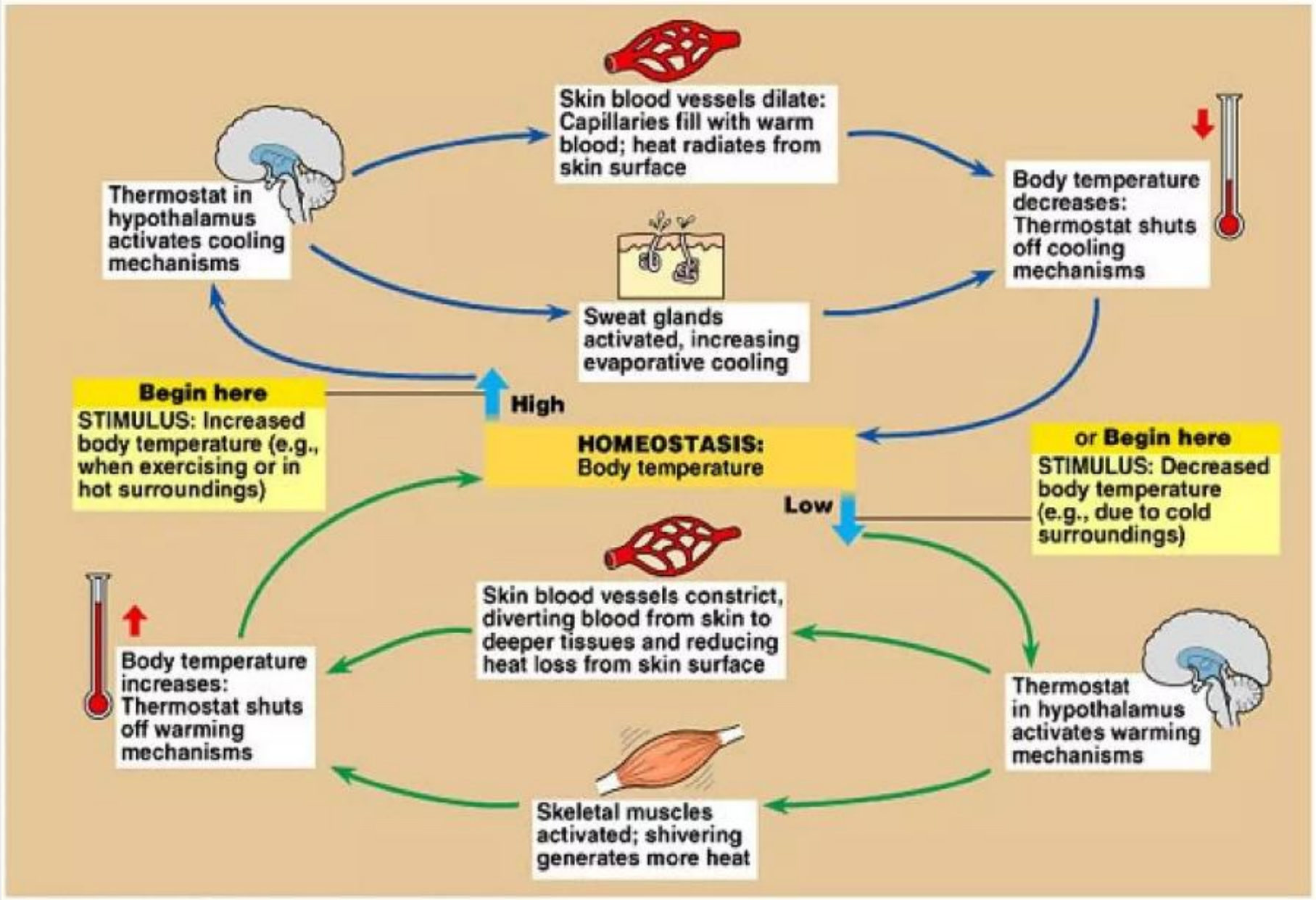
- Combines both convection, radiation, and evaporation to facilitate heat loss
  - Heat is transferred to inspired air via convection and radiation
  - Evaporation allows the humidified air to be released on exhalation

Physiology

- body's temperature-regulating system generally functions well in the face of diverse metabolic and environmental conditions
- responses controlled by the hypothalamus
  - mediated by the autonomic nervous system, neuromuscular activity, and the endocrine system

Physiologic Adaptation

- we adapt through acclimatization
- Occurs over days to weeks
  - primarily involves alterations of sodium and water balance mediated by aldosterone
  - ***Negative feedback mechanisms*** through the nervous system(i.e. the hypothalamus shuts off cooling mechanisms like sweating when decreased body temperatures are sensed)
- acute exposure to heat and humidity results in sodium and water are loss through sweating
- blood is shunted to the skin to aid in heat dissipation
- In cold environments skeletal muscle contraction (shivering) and hair erector muscles attempt to trap warm air next to the skin



HEAT RELATED ILLNESS

Pathogenesis of heat related illness

Three primary mechanisms

1. **exogenous heat gain**
2. **increased endogenous heat production**
3. **decreased heat dispersion**

Any factor that increases the amount of

- **heat produced** or
- diminishes the amount of **heat dissipated**

can potentially exceed the capacity of the body to adjust to these heat stressors and produce a heat illness

Exogenous Heat Gain

- high ambient temperature
- high ambient humidity
- heat waves predispose to heatstroke epidemics
- best indicator of environmental heat stress is the “wet-bulb globe temperature”, which factors the effect of humidity on the temperature
- many agencies, including the military, utilize the wet-bulb globe temperature as a guide for recommended activity levels (see Table)

Wet Bulb Globe Temperature Category Work/Rest and Water Intake

08/07/15

Unacclimated and Acclimated Work/Rest and Water Intake Chart

Heat Risk Category		Wet Bulb Globe Temp	Light Work		Moderate Work		Heavy Work	
			Work/Rest	Water Intake (quart/hr)	Work/Rest	Water Intake (quart/hr)	Work/Rest	Water Intake (quart/hr)
No Risk	Unacclimated	78 – 79.9	50/10 min	½	40/20 min	¾	30/30 min	¾
	Acclimated	78 – 79.9	continuous	½	continuous	¾	50/10 min	¾
Low	Unacclimated	80 – 84.9	40/20 min	½	30/30 min	¾	20/40 min	1
	Acclimated	80 – 84.9	continuous	½	50/10 min	¾	40/20 min	1
Moderate	Unacclimated	85 – 87.9	30/30 min	¾	20/40 min	¾	10/50 min	1
	Acclimated	85 – 87.9	continuous	¾	40/20 min	¾	30/30 min	1
High	Unacclimated	88 – 90	20/40 min	¾	10/50 min	¾	avoid	1
	Acclimated	88 – 90	continuous	¾	30/30 min	¾	20/40 min	1
Extreme	Unacclimated	> 90	10/50 min	1	avoid	1	avoid	1
	Acclimated	> 90	50/10 min	1	20/40 min	1	10/50 min	1

Adapted from: 1) USGS Survey Manual, Management of Occupational Heat Stress, Chapter 45, Appendix A. 2) Manual of Naval Preventive Medicine, Chapter 3: Prevention of Heat and Cold Stress Injuries. 3) OSHA Technical Manual Section III: Chapter 4 Heat Stress. 4) National Weather Service Tulsa Forecast Office, Wet Bulb Globe Temperature.

Wet-Bulb Globe Temperature vs Heat Index

The **Wet-Bulb Globe Temperature** (**WBGT**) is a measure of heat stress level on humans in direct sunlight and takes into account many different elements!

VS

Heat index is calculated in the shade and only takes into account temperature and humidity.

Parameters	WBGT	Heat Index
Measured in the sun	✓	✗
Measured in the shade	✗	✓
Uses Temperature	✓	✓
Uses Humidity	✓	✓
Uses Wind Speed	✓	✗
Uses Sun Angle	✓	✗
Uses Cloud Cover	✓	✗

For more info on Wet-Bulb Globe Temperature (WBGT) please visit https://toolkit.climate.gov/nihhis/. For more info on heat safety please visit https://www.weather.gov/safety/heat.

Increased Endogenous Heat Production

- *febrile illnesses*
  - increased metabolic rate = increased heat production
  - e.g. hyperthyroidism may predispose to heat illness
- *physical activity*
  - increases endogenous heat production
  - If the environment impedes heat loss, exercise can increase core temperature by 1°C (1.8°F) every 5 min
- *pharmacologic agents*
  - e.g. anaesthetics in patients with malignant hyperthermia, neuroleptics (antipsychotic)

Increased Endogenous Heat Production

- pharmacologic agents
  - e.g. Cocaine, amphetamines, and tricyclic antidepressants can increase endogenous heat production by directly stimulating the hypothalamus and by increasing muscle contractions
  - In cocaine poisoning, hyperthermia can result from convulsions
  - Lysergic acid diethylamide (LSD) and phencyclidine act on the central nervous system to induce a hypermetabolic state
  - Monoamine-oxidase inhibitors can cause muscular hyperactivity, HTN and hyperthermia
  - Salicylates and parachlorophenol (antibacterial agent) increase metabolic heat production

Decreased Heat Dispersion

- There are seven primary factors that impair the body's ability to disperse or dissipate heat:
  1. dehydration
  2. cardiovascular disease
  3. extremes of age
  4. obesity
  5. improper clothing
  6. skin diseases
  7. drugs

Minor Heat Illness

Heat Edema

- self-limited process
  - mild swelling and tightening of the hands and feet
  - Appears first few days of exposure to a hot environment
- most commonly in elderly non-acclimatized individuals who are physically active after a prolonged period of sitting e.g. car, bus, plane
- seen in healthy travelers just arriving from a colder climate
- rarely, pitting edema of the ankles may develop
- resolves spontaneously in days - may last 6 weeks
- no special treatment is necessary

Heat Cramps

- painful, involuntary, spasmodic contractions of skeletal muscles
- Fingers. Arms. calves, thighs, and abdomen
- sweating is perfuse & person drinks water or other hypotonic solutions
- cramps may occur during exercise or after a latent period of several hours.
- considered to be self-limiting
- the pain associated with them can readily result in an emergency department visit.
- exact pathogenesis of heat cramps is not known
  - a relative deficiency of sodium, potassium, and fluid at the muscle level is generally accepted

Heat Cramps

- **Presentation**:
  - Skeletal muscle cramps
  - Mentally alert (may complain of weakness, dizziness or faint)
  - Normal Vital signs (normal or slightly elevated temp)
- **Treatment**:
  - Rest
  - Move to a cool environment
  - fluid and salt replacement
  - Many electrolyte drinks are commercially available**
  - more severe cases of heat cramps will respond to intravenous rehydration with normal saline.

Heat Syncope

- a variant of postural hypotension - vaso-vagal
- most commonly in un-acclimatized individuals
- does not necessarily represent significant volume depletion
- Assessment: We cannot R/O serious neurologic, metabolic, or CVS disorders
- patient should also be examined for any injuries
- Treatment: remove from the heat source
  - oral or intravenous rehydration (salt containing solutions)
  - rest
- Transport & monitor ECG

Heat Exhaustion

- dizziness, weakness, malaise, lightheadedness, fatigue, nausea, vomiting, headache, and myalgias
- syncope, orthostatic hypotension, sinus tachycardia, tachypnea, diaphoresis, and hyperthermia
- core temperature is variable and can range from normal to 40°C (104°F)
- mental status remains normal
- heat exhaustion is characterized by a combination of salt and water depletion.

Heat Exhaustion

- Treatment:
  - immediately move the patient to a cooler environment
  - remove as many layers of clothing as possible
  - turn air conditioner to high, or fan patient
  - Wet cloths can be used to promote heat loss – be careful *NOT TO INDUCE SHIVERING*
  - rest and volume and electrolyte replacement (oral rehydration).
  - Rapid administration of moderate amounts of intravenous fluids (1 to 2 L of saline solution)

Heat Stroke - Life-threatening

- Hypothalamic temperature regulation is lost
- Body temperature of at least 40.6°C (+/-)
- Excessive heat denatures proteins, destabilizes phospholipids and lipoproteins, and liquefies membrane lipids, leading to cardiovascular collapse, multi-organ failure, and, ultimately, death

Heat Stroke

- heatstroke was defined as the triad of
  - hyperpyrexia [usually core temperature > 40.6°C
  - CNS dysfunction
  - Anhidrosis - However, lack of sweating, is not an absolute diagnostic criterion(*sweat may still be present from earlier compensation mechanism*)
- should be suspected in anyone with heat exposure, hyperthermia, and CNS dysfunction, such as syncope, irritability, bizarre behavior, combativeness, hallucinations, or coma
- the cerebellum is highly sensitive to heat, and ataxia is an early finding

Heat Stroke

- presence of sweating doesn't exclude the diagnosis
- Heatstroke is a total breakdown of thermoregulation
- two forms of heatstroke have been described: nonexertional and exertional
- Classic, or nonexertional, heatstroke usually occurs during summer heat waves. The poor, the very young, the elderly, and the chronically ill are at greatest risk
- Exertional heatstroke usually strikes a younger patient
- Individuals who perform physical labor or exercise in a hot, humid climate
- If unsure whether your patient has heat exhaustion or heat stroke – treat for heat stroke

Heat Stroke - Treatment

- Initiate immediate cooling measurements – Remove the patient from the Environment
- Protect the airway +/- c-spine precautions
- SpO2; High-flow supplemental oxygen; PPV prn
- ECG
- Oral fluids if practical
- cold packs to the axillae, groin, neck and head
- Cover patient with sheets soaked in tepid water (be careful not to overcool or induce shivering)
- Intravenous access
  - fluid administration should be cautious (ICP & cerebral edema)
- serial monitoring of the patient's temperature

Cold-related Illness

Cold-related Injuries/Illness

- Hypothermia
- Non-freezing (dry or wet)
  - Chilblains
  - Trench foot
- Freezing
  - Frostnip
  - Frostbite

Heat Conservation Mechanisms

- Vasoconstriction
- Shivering
- Hypothermic micturation

Chilblains

- are small lesions caused by the inflammation of tiny blood vessels after exposure to cold air.
- nonfreezing injury caused by prolonged and repeated exposure of bare skin to air temperatures above freezing (> 0°C but < 15°C)
- Can also be caused by lupus and Reynaud's
- capillary walls may break, and the tissues swell
- can develop in only a few hours
- most commonly affected areas: cheeks, ears, nose, fingers, and toes
- area appears as red, swollen. skin is tender and may itch
- can worsen to aching, prickly (pins and needles) sensation, then numbness
- In severe cases, open sores or bleeding lesions may result from continued exposure

Chilblains

Chilblains

Management

- warm affected area gently with direct body heat:
  - put bare hands over the affected area on the face
  - put affected areas against armpits or stomach of another person
- do not massage or rub affected areas.
- do not wet the area or rub it with snow or ice.
- do not expose affected area to open fire, stove, or any other intense heat source.
- Transport not usually indicated - only required if evaluation of tissue damage is needed
  - S&S of tissue damage may be slow to appear

Trench foot

- Caused by exposure to cool wet conditions for long periods of time (several hours/ 1-2 days)
- Resembles a partial thickness burn
- Pain, Blisters, redness, blotchy, wrinkled skin
- Circulation becomes compromised and nerve function is affected
- Cellular breakdown occurs
  - Ensure feet are dry and warm;
  - Clean socks when needed
  - Elevate to promote circulation
  - Inspect for open wounds or broken blisters (infection)

Frostbite

- Environmentally induced freezing of body tissues
  - ice crystals form within the cells
  - Water drawn out of cells
  - Crystals expand causing destruction of cells
  - Damage to blood vessels causes loss of vascular integrity
  - Tissue swelling and loss of nutritional flow

Degrees of Frostbite

- Superficial frostbite (frostnip)
  - Freezing of epidermal (outer tissue may be hard but underlying tissues still soft)
  - Redness followed by blanching and diminished sensation
- Deep frostbite
  - Freezing of epidermal and subcutaneous layers
  - White, frozen appearance
  - May be hard (frozen) on palpation
  - Loss of sensation

Degrees of Frostbite

Frostbite

- Management
  - ***Do not*** attempt to thaw if there is the possibility of refreezing
  - ***Do not*** rewarm any frozen feet if required to walk out of any hazardous situation
  - ***Do not massage*** or rub area – ice crystals may cause further damage to already damaged tissue
  - If practical, thaw area by immersion in 39-40°C water (water temp may fall rapidly requiring addition of more warm water)
  - Elevate, immobilize and cover any thawed part with sterile dressing
  - Remove any jewelry

Hypothermia

- A state of low body temperature (core body temp of <35°C)
- Compensatory mechanisms to conserve and generate heat
  - Piloerection (goose bumps) hair stands up to prevent convection of heat)
  - Shivering
  - Peripheral vasoconstriction with increased heart and respiratory rate

Hypothermia - Mechanism

- Conduction
- Convection
- Radiation
- Evaporation
- Respiration
- Heat loss increased by:
  - Removal of clothing
  - Wet clothing
  - Air movement
  - Contact with cold or **cold water immersion**

Predisposing Factors

- Age (very young, elderly)
- Health
- Medications (narcotics, alcohol, barbiturates, antiepileptics, antihistamines, sedatives etc.)
- Prolonged or intense exposure
- Coexisting weather conditions (high humidity with high winds, or rain and cold winds)

Degrees of Hypothermia

- Mild
  - Core temp >35°C with signs and symptoms
  - Shivering
  - Lethargic, somewhat dulled mentally
  - Muscles stiff and uncoordinated
  - Early rise in BP, HR, RR
  - Pale, cold, dry skin

Management

Mild

- remove wet garments (if sheltered)
- protect against further heat loss
- Passive re-warming; Cover with blankets
- Increase ambient temp to at least 24°C
- supine position
- monitor temperature
- Monitor SpO_2 and ECG
- O_2
- transport

Degrees of Hypothermia

Moderate

- Core Temp 28° - 32°
- Shivering (watch for hypoglycemia)
- Initial rise in HR, RR, BP begins to slow
- Decreased coordination and ability to reason
- Further deterioration of muscle function

Management

- Passive re-warming (remove from environment; remove all wet garments and protect against further heat loss if not already done)
- actively rewarm – hot packs in axilla, neck, other (however be careful not to put directly on the skin – this can lead to skin burns/damage)
- IV fluids – prn – however consider temperature of fluids
- No food or drink; no standing or walking; keep horizontal and handle gently

Degrees of Hypothermia

- Severe
  - Core temp <28° with signs and symptoms
  - Shivering usually stopped
  - Disoriented to unconscious
  - Muscles rigid and stiff
  - Dysrhythmias especially bradycardia
  - Increased risk of VF below 30° C (with impaired response to defibrillation)

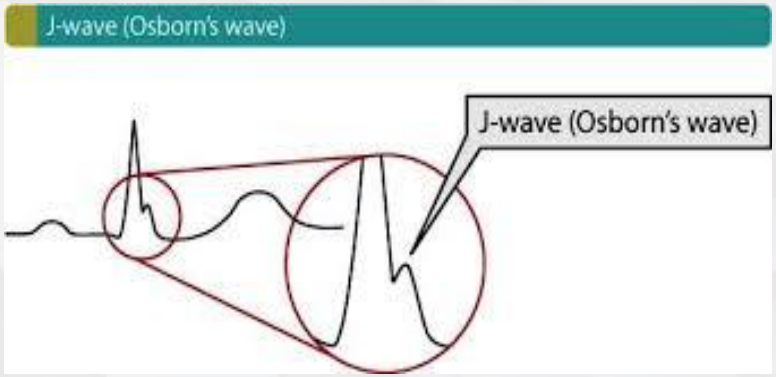
Management

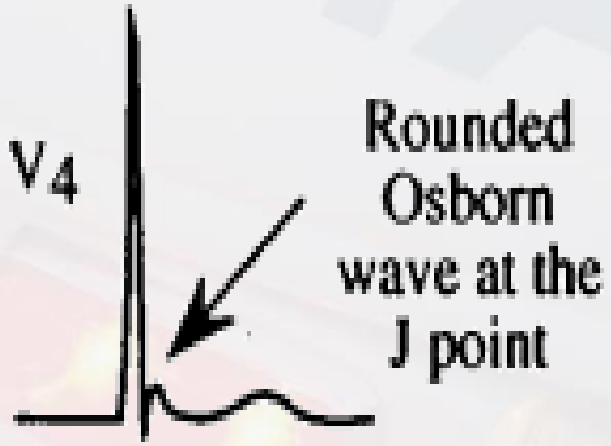
Severe

- remove wet garments (if sheltered)
- protect against further heat loss (warm blankets/increase ambient temp)
- supine position - avoid rough handling (this can trigger dysrhythmias)
- monitor temperature, SpO_2 and ECG
- O_2
- IV access
- Blanket…but – **DO NOT ACTIVELY REWARM** unless transport time to hospital is more than 15 minutes (patch)

ECG changes in Severe Hypothermia

- Bradycardia
- “Osborn or J Wave”





Rewarming Shock

Why we don't actively rewarm severe hypothermia

- Reflex peripheral vasodilation
- Cold and acidotic blood trapped in the periphery returned to core → dysrhythmias
- Afterdrop
  - Further decreases of core temperature

Hypothermic cardiac Arrest

- Longer than normal pulse check
- “they’re not dead until they’re warm and dead”
  - Hypothermia is neuroprotective and patients can survive many hours after initial arrest when core temps are low
- Generally the heart will not respond to defibrillation attempts until the core temp is at least 30°C
- 1 analysis then transport to definitive care
- Resuscitation efforts will continue until the patient is rewarmed to >35°C

QUESTIONS?