Environmental Emergencies

May 2021 Mercyhealth Prehospital and Emergency Services Center

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COVID-19 Update

- US Vaccines with EUA
  - Moderna
  - Pfizer
  - Johnson and Johnson
- Positivity Spike
- Variants
  - Monoclonal Antibodies
- PPE Update

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Reminder

- The Medical Control Line is Recorded!
- Do not say anything you would not like replayed in court!
- This can be an asset or liability!

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Objectives

- Describe methods of heat transfer
- List physiological responses of the human body to hypothermia
- State treatment modalities for mild, moderate, and severe hypothermia
- List the signs, symptoms, and treatment for heat cramps, heat exhaustion, and heat stroke
- Discuss treatment for venomous snakes in our area
- Discuss electrical injuries and their treatments
- Discuss common envenomations

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Temperature Regulation

- Balance between heat production and heat loss
- Heat Production
  - Metabolism
  - Work Done on Environment
- Heat transfer/loss
  - Radiation
  - Convection
  - Conduction
  - Evaporation

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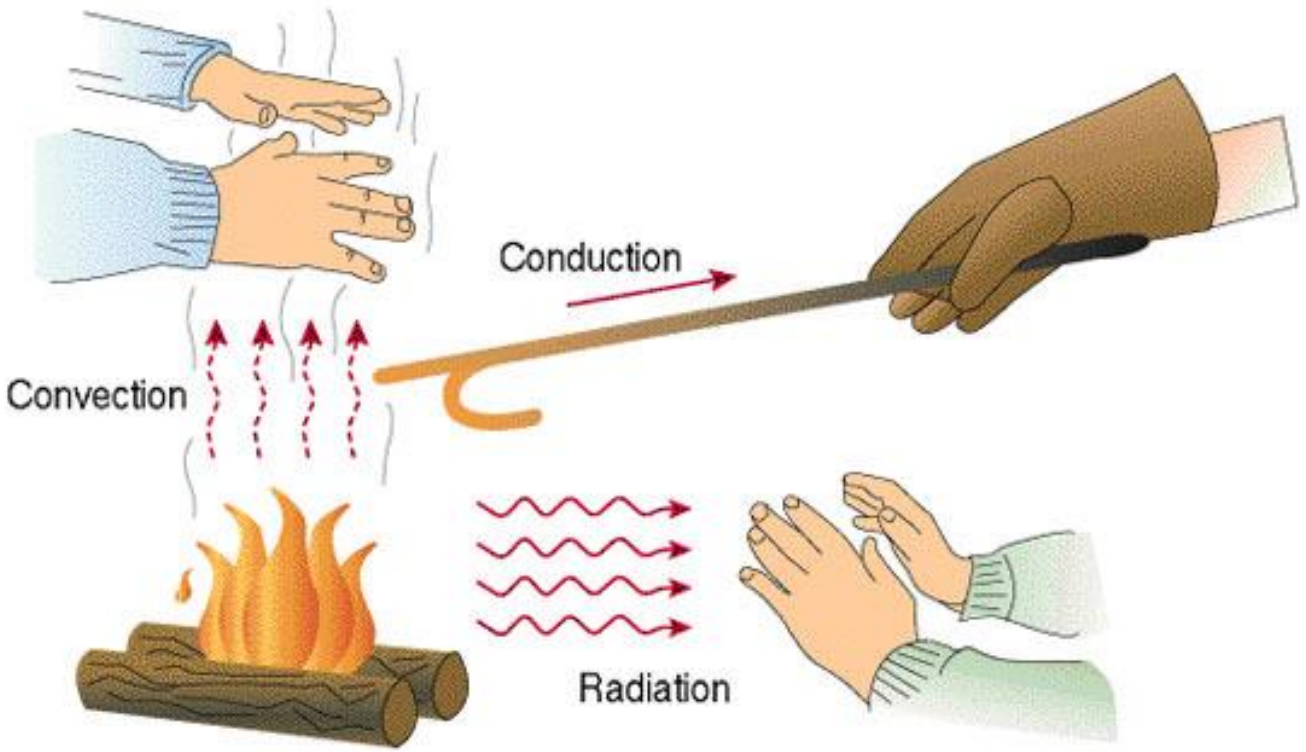
Methods of Heat Transfer

- Radiation
- Conduction
- Convection
- Evaporation



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Radiation

- Heat transfer through photons in air through electromagnetic waves
  - Sun Light
  - Accounts for up to 60% of heat loss in cool environments
    - Direct heat loss from skin emitting heat
  - Can results in heat gain in if the ambient temperature is higher than body temperature
  - Direct contact is not needed

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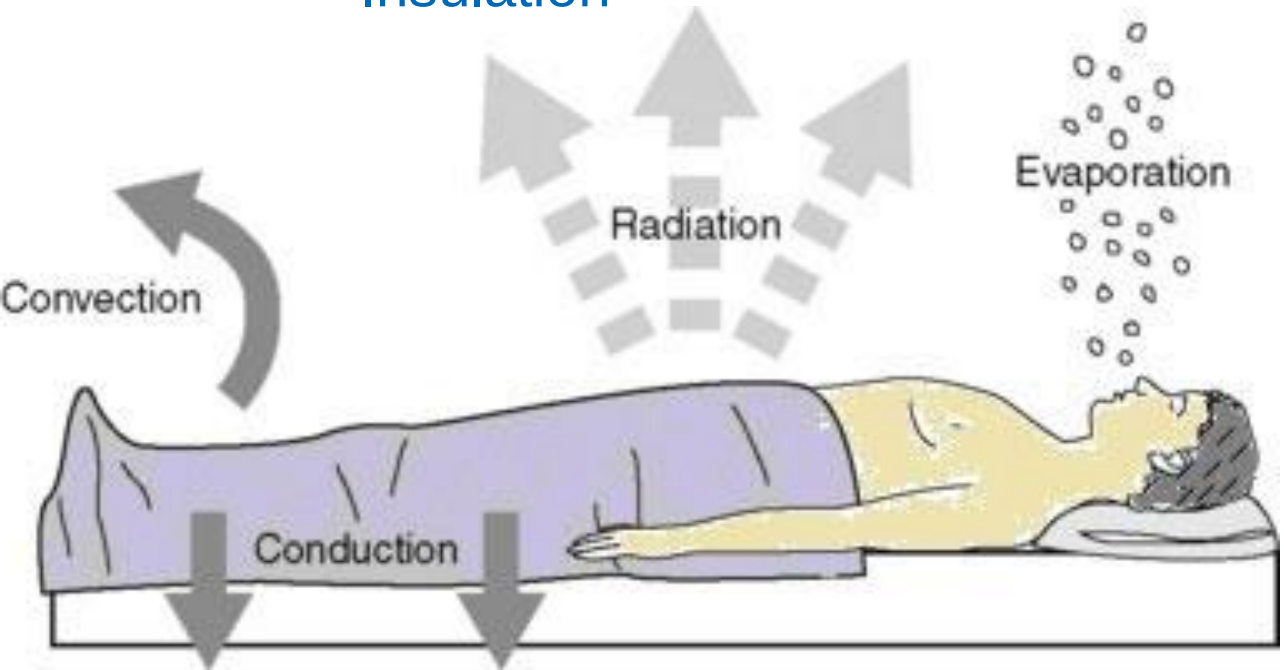
Conduction

- Direct transfer of heat from the body in contact with the skin
  - Heat loss by conduction into water
    - 32X >than air
    - Damp clothing Hot/Cold
  - Insulation



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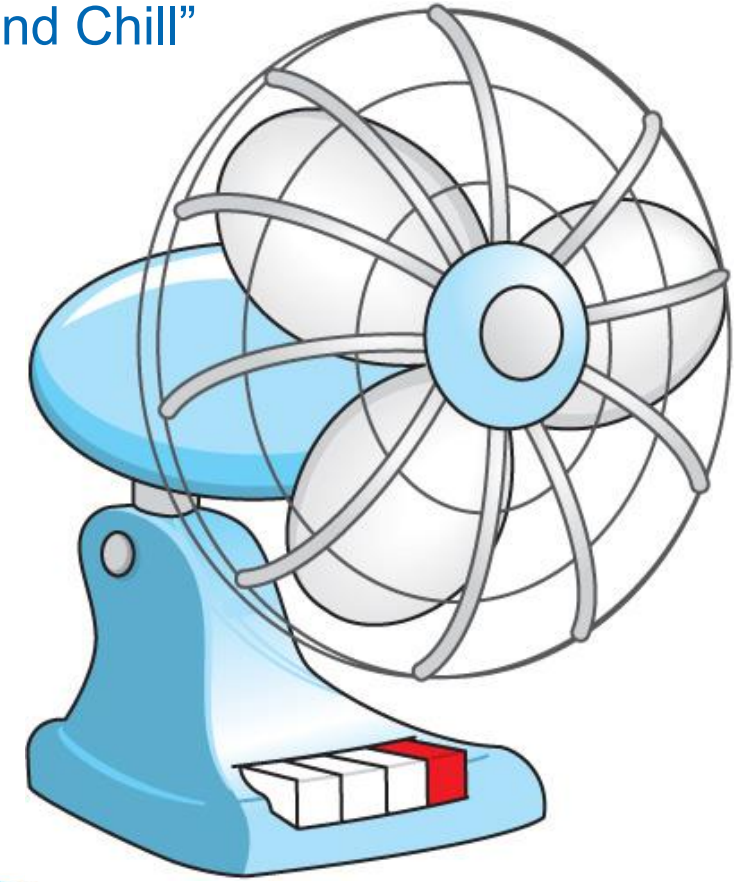
Convection

- Transfer of heat by water or air
  - Air Velocity
    - “Wind Chill”



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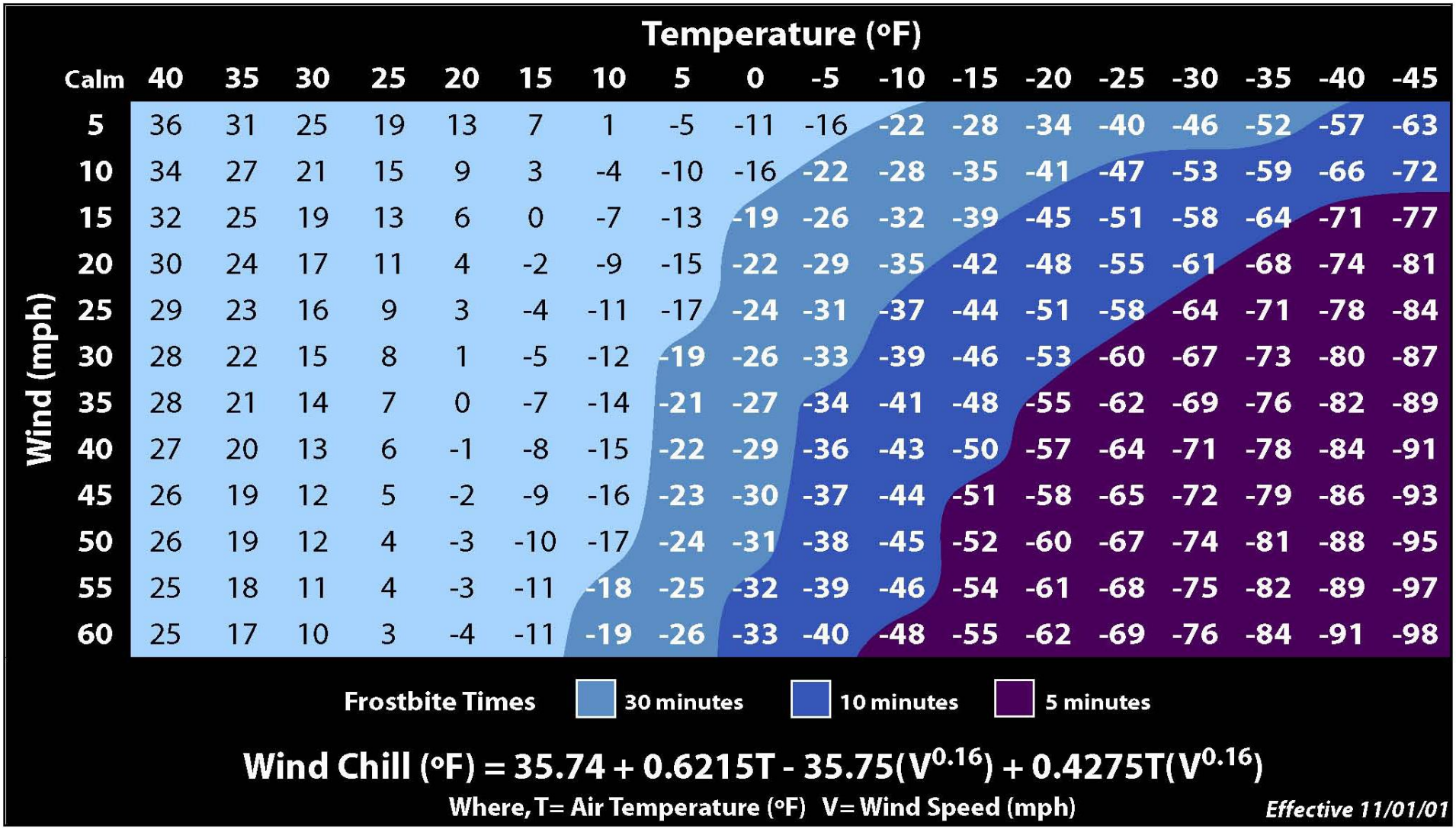
Wind Chill Chart



$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

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Evaporation

- Loss of heat when liquid water turns to gas
- Primary method of heat loss
  - 25% in a cool environment
  - Approaches 100% in high heat
  - Significantly less effective in high humidity

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Respiration

- Combines evaporation and convection
  - Evaporation-moisture in lungs, mucous membranes
  - Convection- displacement of warm air in lungs to external environment
  - Heated Humidified 02 as method of warming

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Humidified Oxygen

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Temperature Regulation Physiology

- In hot conditions
  - Sweat (Hypotonic) Evaporation
    - Marathon Hyponatremia
      - Excessive Water Intake
  - Vasodilation
    - Skin Parameters
      - Hot
      - Flushed
      - Skin is major heat loss organ

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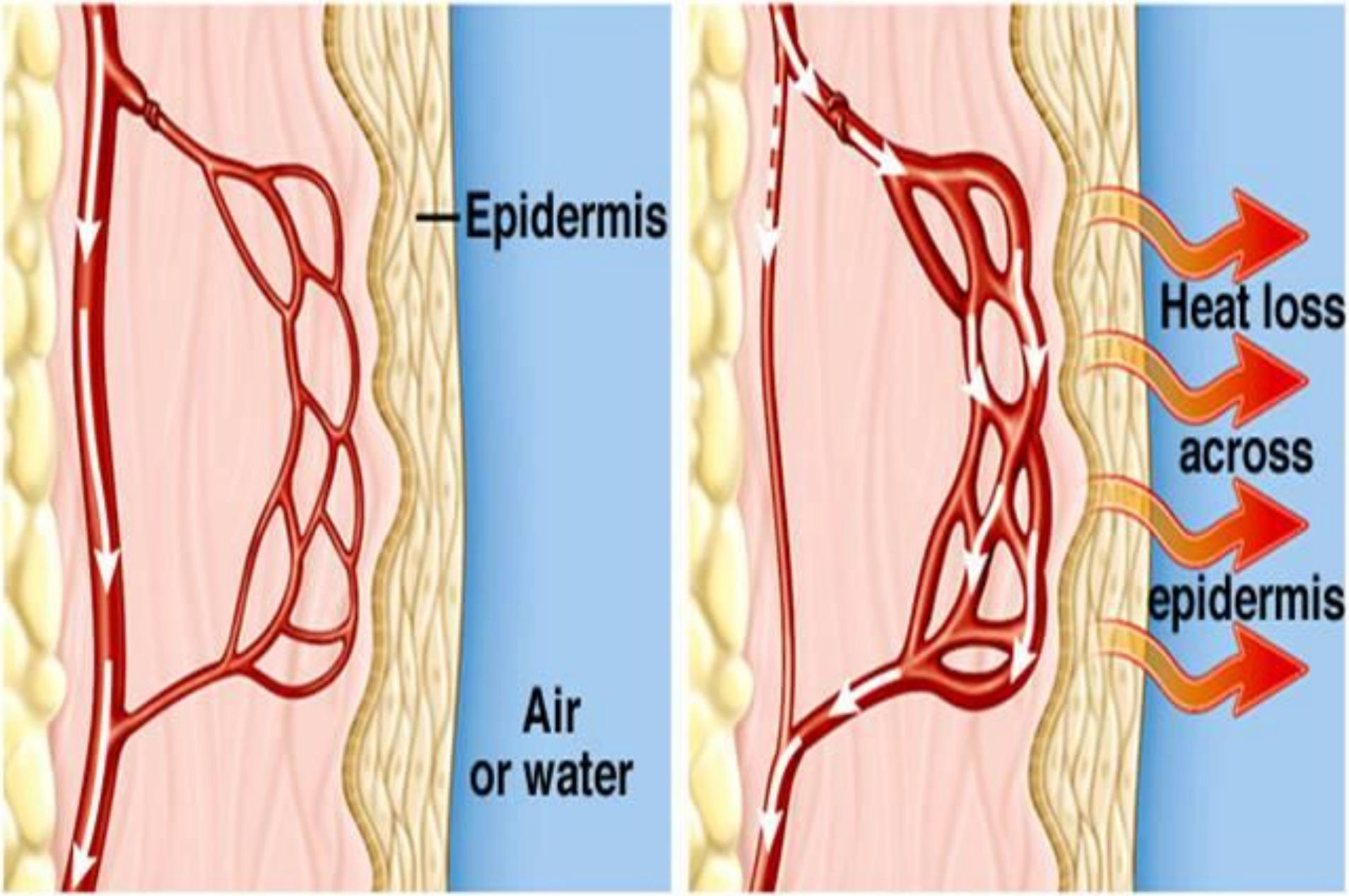

Vasoconstriction

Vasodilation

Temperature Regulation Physiology

- In cold conditions
  - Decreased sweat production
  - Vasoconstriction
    - “Life over limb physiology”
  - Piloerection (convection)
    - Withdrawal Symptoms
  - Shivering (last line)

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Hypothermia Risk Factors

- Age (Young/Old)
- Social Factors
- Preexisting disease
  - Cardiovascular Disease
  - Endocrine-diabetes, hypothyroidism, adrenal
  - Mental illness
- Medications- BB, Clonidine, Sedatives
- Alcohol
  - Sedation
  - Delay Shivering
  - Vasodilation

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Hypothermia and Trauma

- Assess and treat traumatic injuries
- Properties of “Normal” Saline
  - Acidotic pH 5.5
  - No ability to carry hemoglobin
    - Dilutes Clotting factors
  - Not body temperature
    - Leads to hypothermia

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Hypothermia and Trauma

- When blood leaves the body heat leaves with it
  - Hemorrhage control
  - Heat like blood very difficult to replace once gone
- Hypothermia Coagulopathy
  - Impairment of coagulation cascade
  - Decreased platelet function
  - Decreased clot formation

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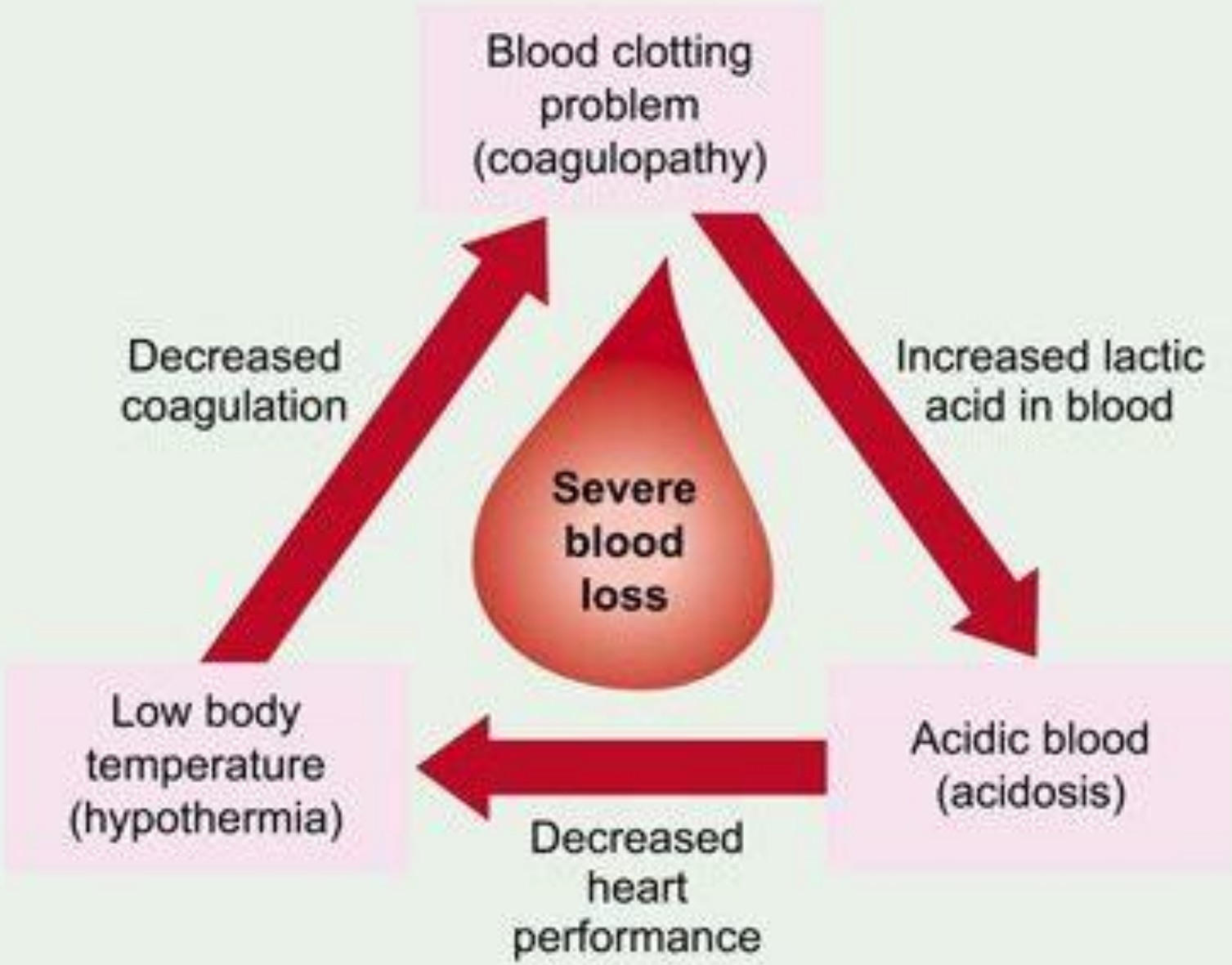
Trauma Triad of Death



Mild Hypothermia

- 90-95 Degrees (Core Temperature)
  - Considerations
- Clinical Features
  - Shivering
  - Impaired Judgment
  - +/-tachycardia and hypertension
  - Vasoconstriction
  - Ataxia

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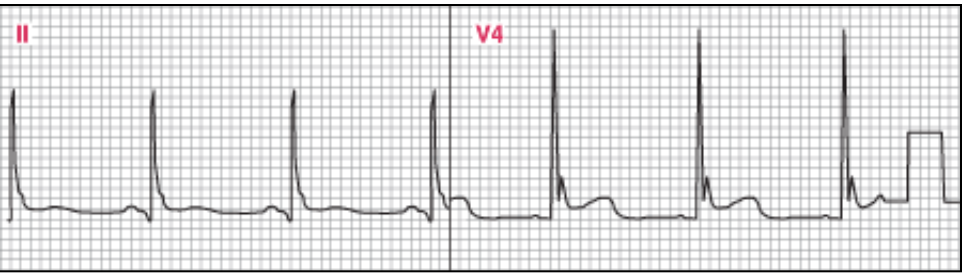
Moderate Hypothermia

- 82-89 degrees
  - Clinical Features
    - Worsening Mental Status
    - Loss of Shivering
    - ECG Changes (J Wave), Susceptible to V-Fib, A-fib, bradycardia



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Severe Hypothermia

- <82 Degrees
- Clinical Features
  - Bradycardia
  - Hypotension
  - Pulmonary Edema
  - Unresponsive
  - Dilated Pupils (not a marker of death)

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Hypothermia

- General Considerations
  - Rough handling can precipitate arrhythmias
  - When checking pulses, check for up to 60 seconds
    - Vasoconstriction considerations
  - Remove from environment
  - Remove wet clothing and dry

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Cardiac Arrest and Hypothermia

- "Not dead until warm and dead"

> The patient has an unwitnessed cardiac arrest, is in asystole, and no bystander CPR has been started. (This does not apply if exposure hypothermia, drowning, or drug overdose plays a role in the arrest).

- Do not initiate CPR if Pulse Present
- When to terminate?
  - Do not cease resuscitation in field***
  - Patient is Warm >89 Degrees
  - Chest Wall is frozen solid
  - Ice obstructs airway
  - Typical signs of death may be unreliable

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Wrongful Death Suite

- “Family of Minnesota teen who froze to death sues responders’
- 19 y/o M Found outside after being in 0 degree for approx 5 hours
  - No resuscitation undertaken at scene
  - Each responder individually sued for not initiating resuscitative efforts
  - https://www.ems1.com/airway-management/articles/family-of-minn-teen-who-froze-to-death-sues-responders-hnKXMWyGwjjPXnV5/

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Hypothermic Cardiac Arrest

- Which came first the hypothermia or the arrest?
- Rate at which cooling occurred?
- Hypothermia is neuroprotective
  - Preformed intentionally post-ROSC
- Survival after 6.5 hours of CPR with active internal rewarming has been reported (Lexow 1991)
- Survival from Core temp of 48 degrees has been reported (Vassallo 2015)
- Consider transport to appropriate facility

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Defibrillation and Hypothermia

- Defibrillate once
  - Controversial
- Subsequent defibrillations when temp >86 degrees
- Avoid pacing until >86 degrees

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Hypothermia ACLS

- Bradycardia
  - Not vagal mediated
  - Unresponsive to atropine, pacing, epi
- IV/IO Access
  - Warmed Saline
- Airway
  - Heated Humidified Oxygen
  - `Avoid Succinylcholine if Hyperkalemia
- Medications
  - Administer one round of ACLS medications
    - Toxic levels of resuscitation medications may pool in peripheral circulation
  - Do not repeat until >86 Degrees

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Hypothermia and Submersion

- Drowning is the 5th leading cause of accidental death in US
- Factors that impact of survival with prolonged submersion
  - Water Temperature*
  - Duration of Submersion*
  - Age of Victim
- Did drowning or cooling come first?

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Hypothermia and Submersion

- Resuscitation 2011, 82:7
- Water temp > 42^0F
  - Survival/resuscitation unlikely if submersion >30 minutes
- Water temp <42^0F
  - Survival/resuscitation unlikely if submersion >90 minutes

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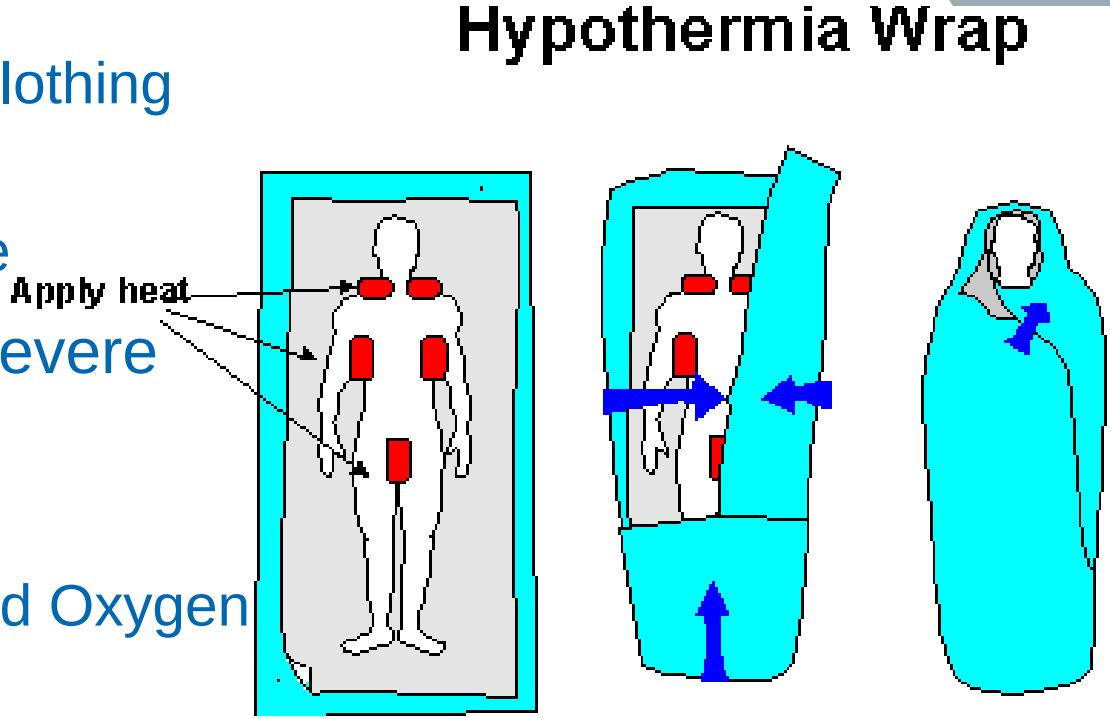
Rewarming

- IF can tolerate PO give glucose to support thermogenesis
- Passive- Mild
  - Removal of wet clothing
  - Blankets
  - Warm Ambulance
- Active- Moderate/Severe
  - Warmed IV fluid
  - Hot Packs
  - Heated Humidified Oxygen



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Warming Crystalloid

- Avoid LR, unable to be metabolized in hypothermic state
- Non-Dextrose non-Medication can be warmed in microwave (Annals of Emergency Medicine 1985)
  - 2 Minutes
    - Ensure evenly mixed
    - Goal temp <104 degrees
- Hot Packs
- Dash
- Inside Coat
- Fluid Warmers

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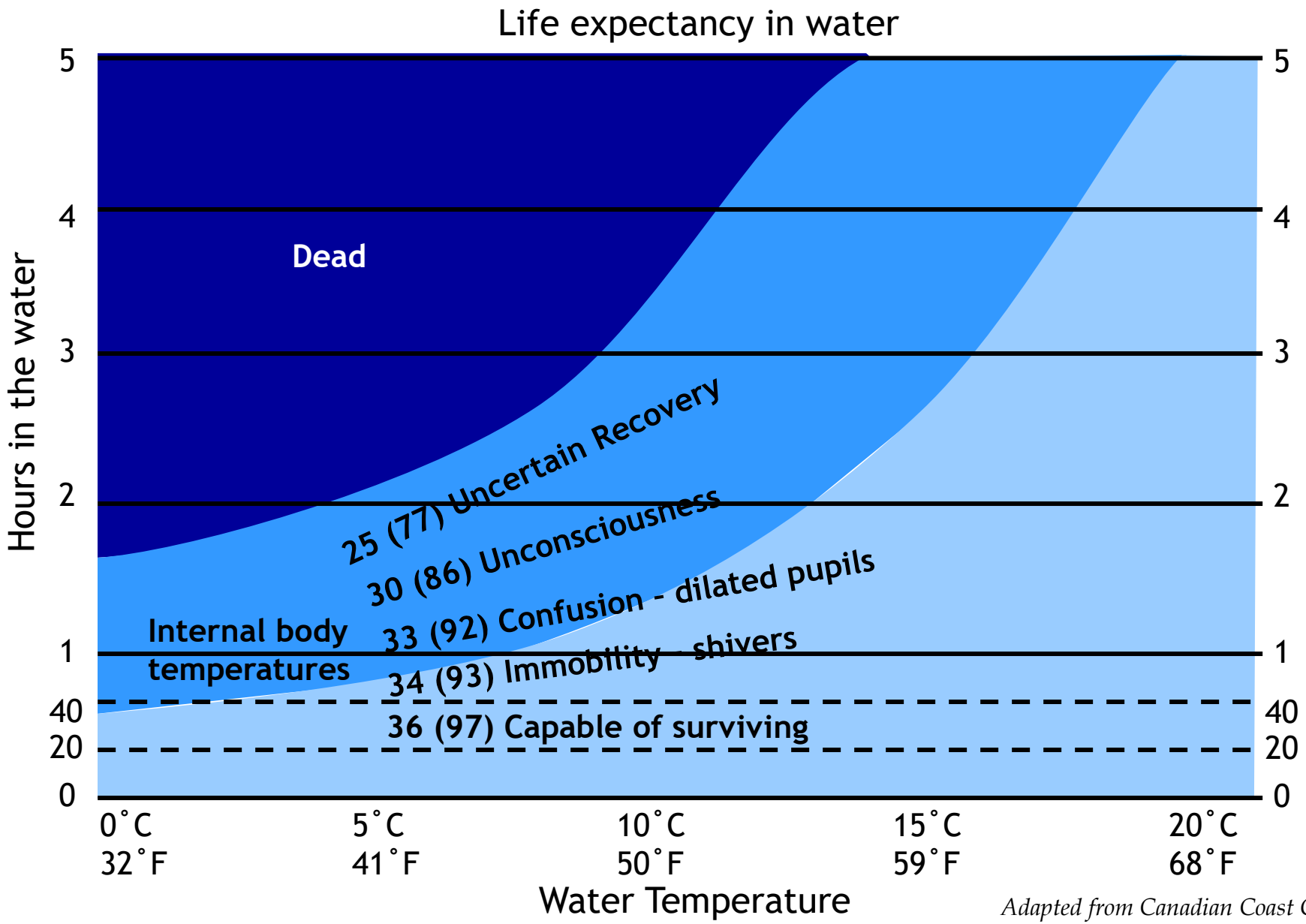
Survival times as a function of water temperature (assuming no cold protection)



Adapted from Canadian Coast Guard

Wind Chill Chart

Wind (mph) \ Temperature (°F)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes | 10 minutes | 5 minutes

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Where, T= Air Temperature (°F) V= Wind Speed (mph)

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Local Cold Injuries

- Frost nip- transient numbness and tingling which occurs with rewarming, contrast to frost bite as no tissue destruction occurs
- Frost bite
  - Pathophysiology
    - Increased Blood Viscosity
    - Ice Crystal Formation
    - Ischemia
  - Symptoms
    - Based on degree/depth of tissue destruction (similar to burns)
    - Most Common Symptoms is numbness
  - Nose/Ears/Fingers/Toes

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Frost Bite

"Freeze in January amputate in June"

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Local Cold Injuries Management

- Remove wet and constrictive clothing
- Prevent further cold injury
- Rewarming in the field should only be undertaken if risk for re-cooling/freezing is minimal
- Rewarming can be painful prepare to treat pain
- Do not rub tissues/air dry
- Rewarm with warm water no hotter than 102.2
- Place dressings between toes/fingers

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Heat related illness

- Risk Factors
  - Extremes of Age
    - Limited Mobility
  - Alcohol- inhibition of AHD increased urination
  - Medications
    - Antipsychotics- CNS heat regulation centers
    - Anticholinergic- diphenhydramine
    - Sympathomimetics- caffeine, cocaine, PCP, Meth
    - Cardiac Medications- BB, CCB
      - Cardiac output increases around 3L/min for each 1 degree C above core temp
      - Requires increased in HR peripheral vasodilatation

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Toxidromes- Anticholinergic

Examples: Atropine, Scopolimine, H1 Blockers (Diphenhydramine), TCAs, Jimsonweed, some mushrooms, Norflex

Mental Status- Delirious

Temperature- Hot

Eyes- Dilated

Lungs- Clear

HR/BP- Increased

Bowel/Bladder- Urinary Retention

Skin- Dry

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Toxidromes- Anticholinergic
Jimsonweed

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Toxidromes- Anticholinergic

Dry as a Bone

Hot as a Hades

Red as a Beet

Blind as a Bat

Mad as a Hatter

Treatment

- Supportive
  - IVFs
  - Versed for agitation

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Heat Illness

- Working in hot environments
  - High osmolality fluids inhibits gastric emptying; osmolality of less than 200 mOsm/L is optimal
    - Gatorade=360mOsm/L-dilute with water
  - 0.5 to1 quart/hour water
- Fire ground rehab considerations

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Heat Cramps

- 99-101.3 F
- Large Muscle Groups Affected- abdomen, extremities
- Typically Salt Depletion/Muscle Fatigue/Dehydration
- Treatment: Commercial Electrolyte replacement therapies/sports drink
  - Salt tablets are gastric irritants, delay gastric emptying not recommended

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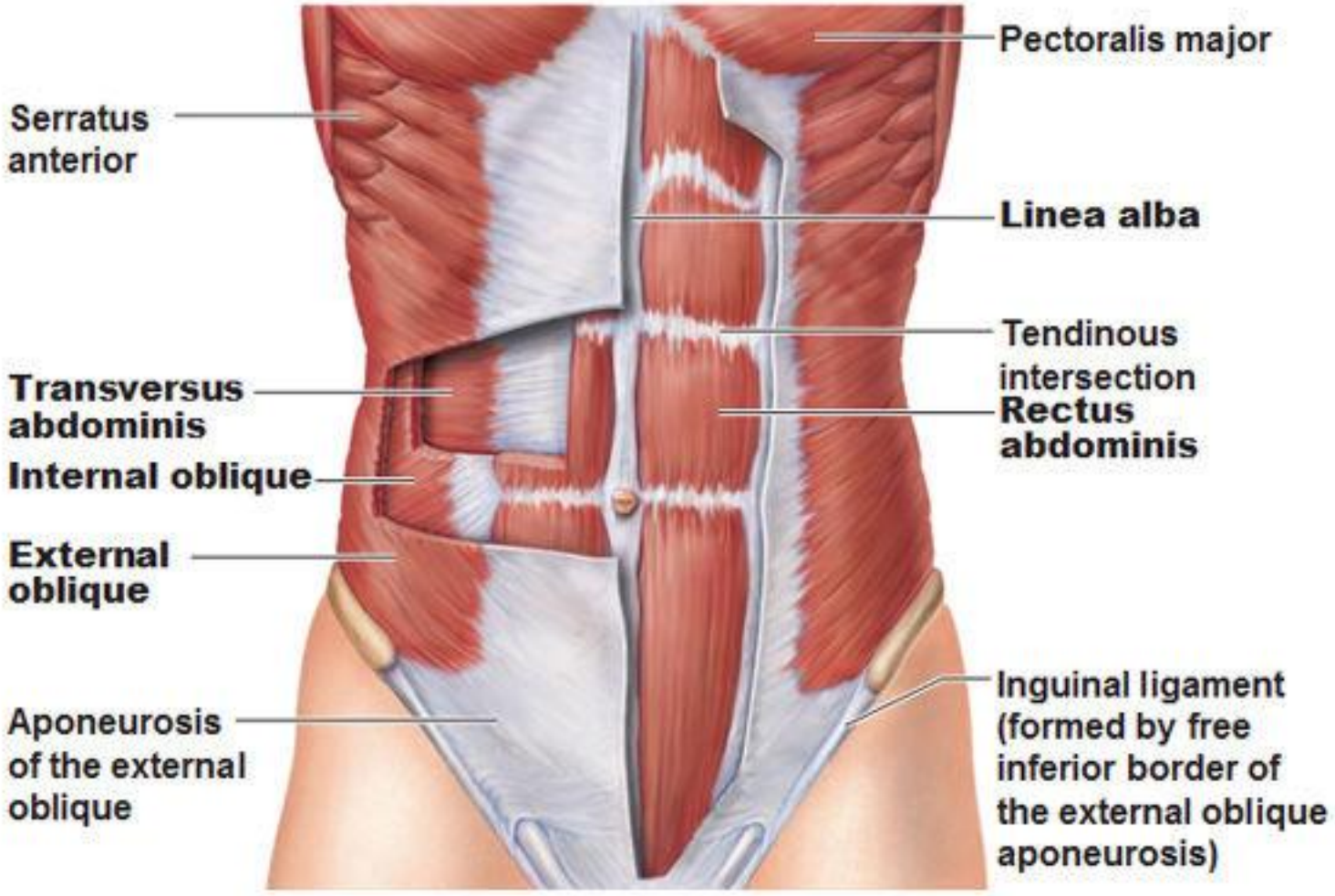
Abdominal Muscles



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Heat Exhaustion-Spectrum

- Volume depletion + Heat Stress
- Symptoms Weakness, headache, Nausea, Syncope
- Signs: tachycardia, +/-**sweating,** tachypnea, +/- ALOC (anxiety, lethargy, irritability)
  - 99-104 F
  - Skin findings unreliable
  - Absence of severe CNS abnormalities

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Heat Stroke Spectrum

- Failure of Compensatory Mechanisms
- Heat stress and CNS effects
  - Coma, Seizures, Delirium
- Core temp > 104 F
- Skin findings unreliable
- Hypotension
- Renal/Liver Dysfunction

High Temperature Differential Diagnosis

- Delirium Tremens
- Drugs
  - PCP, Cocaine, Salicylate (Aspirin), Sympathomimetic, Anticholinergic, neuroleptics, serotonic syndrome
- Infection
- Metabolic
  - Thyroid Storm, DKA
- CNS
  - Seizures, Cerebral Hemorrhage

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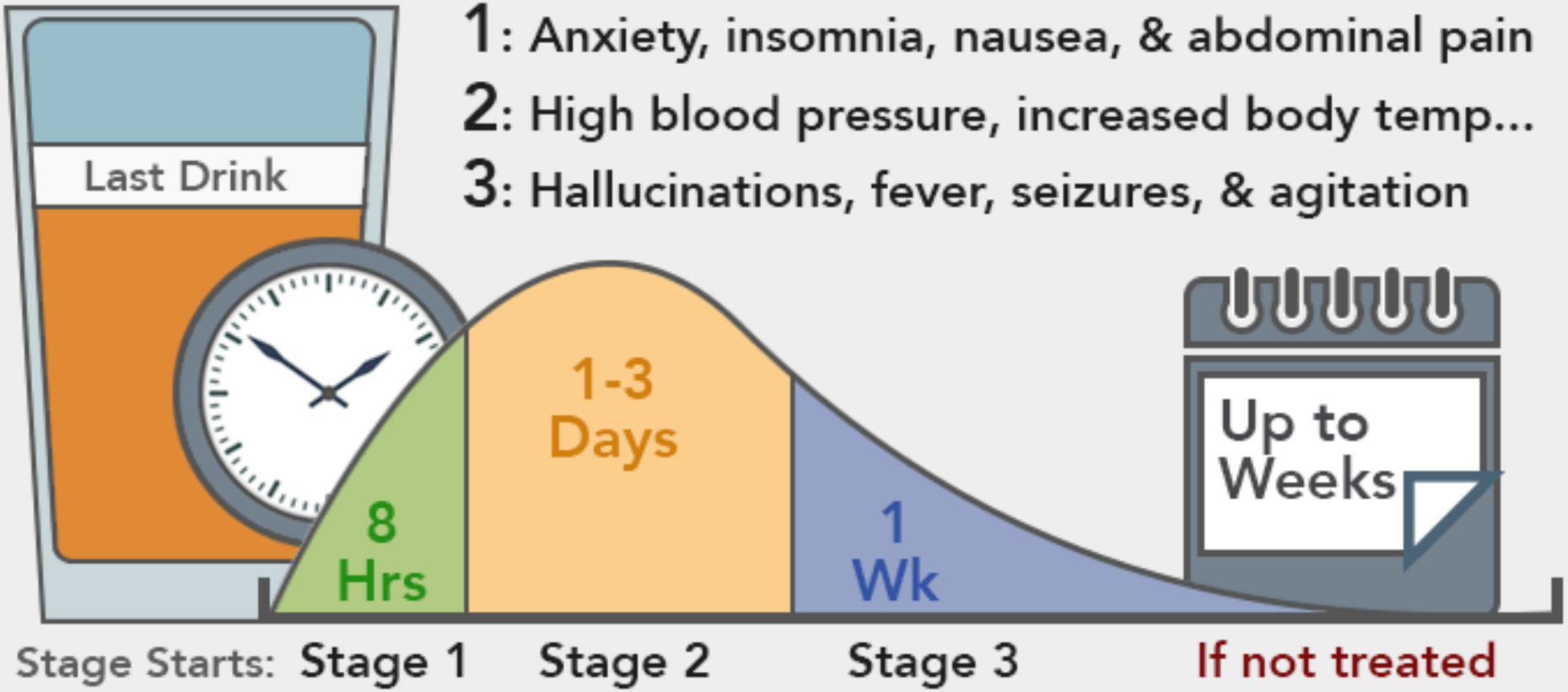
Alcohol Withdrawal Timeline



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Treatment Goals

- High Mortality Rate 10-63%
- End Heat Challenge- Remove from environment
- Increase Health loss from
  - Conduction
  - Convection
  - Radiation
  - Evaporation
- Support ABCDs

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Conduction/Convection-Heat Illness

- Conduction Direct transfer of heat from the body in contact with the skin
- Convection Transfer of heat by water or air
- Treatment
  - Remove Excessive Clothing
  - Air conditioning
  - Protect patient from hot surfaces (i.e asphalt)
  - Ice to groin, arm pits, hands, feet
  - Fans/Air movement
  - Cover patient with cool/wet sheet (be aware of insulation)
  - Fluids IV/PO

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Radiation- Heat Illness

- Heat transfer through photons in air through electromagnetic waves
- Remove patient from sun light
  - Shade

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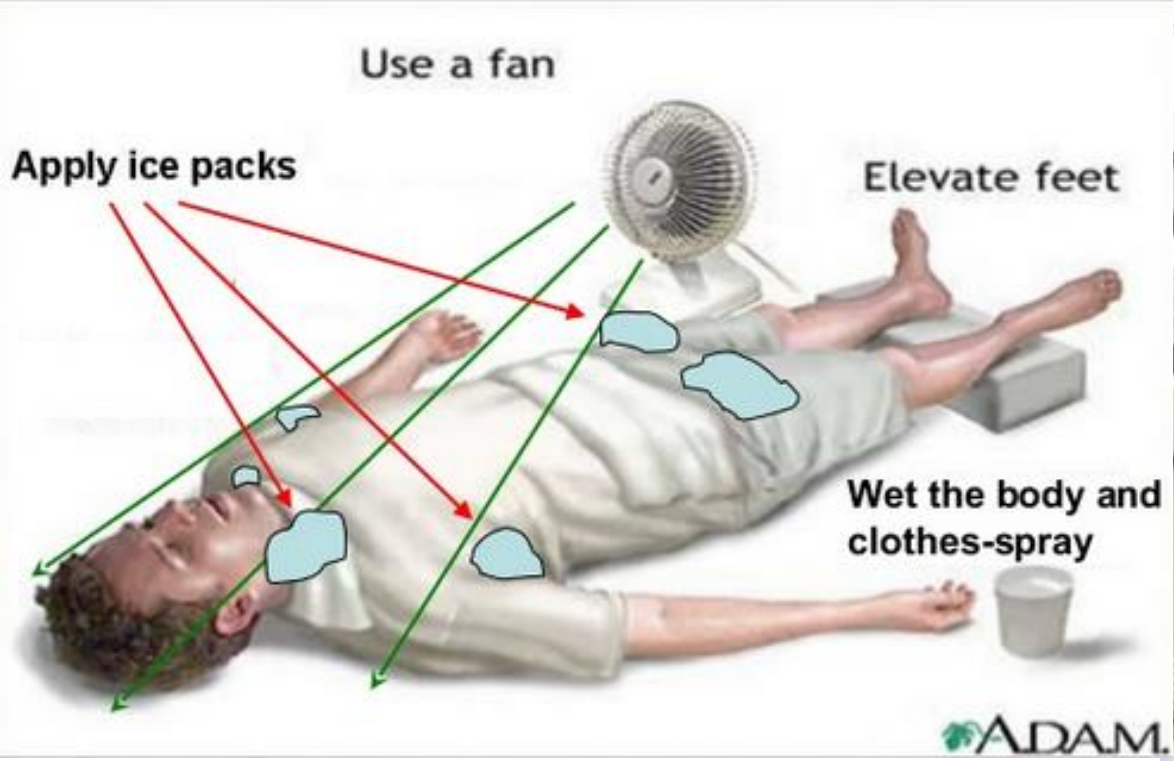
Evaporation Heat Illness

- Loss of heat when liquid water turns to gas



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Heat Illness Treatment

- abcD
  - Hypoglycemia frequent finding
- Avoid Over cooling
  - Shivering = Heat Production
- Do not delay treatment, start treatment on scene

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Snake Bites

- Venomous Snakes are rare in our response areas
- Viperade Family
  - Eastern Massasaguga Rattle Snake
  - Timber Rattle Snake
  - Venomous
    - Protelytic
      - Tissue Necrosis
      - Hemolysis
      - DIC
      - Local Necrosis
  - Assume “Wet Bite” effects can be delayed

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Eastern Massasaguga Rattle Snake

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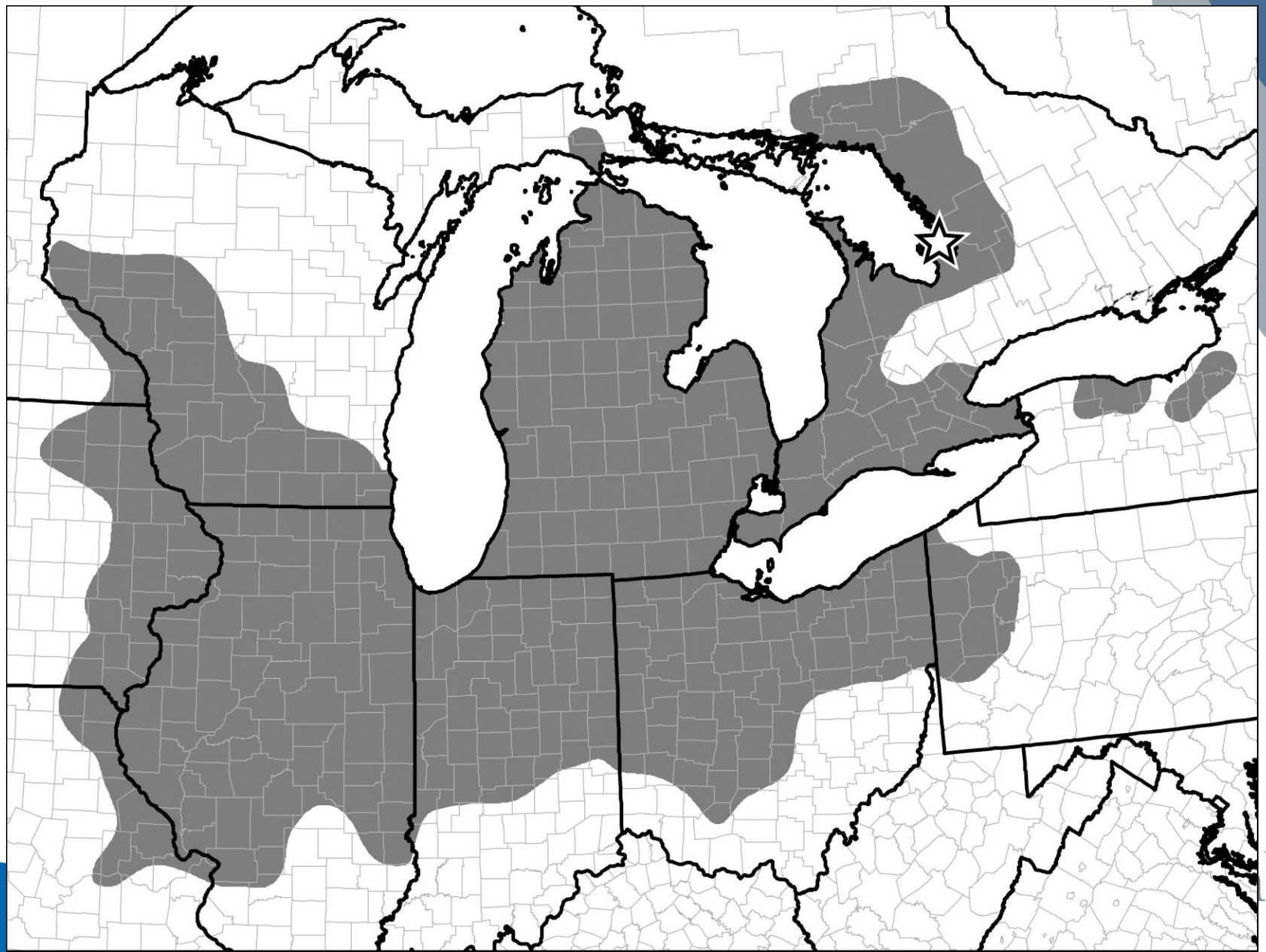
Eastern Massasaguga Rattle Snake



Timber Rattle Snake

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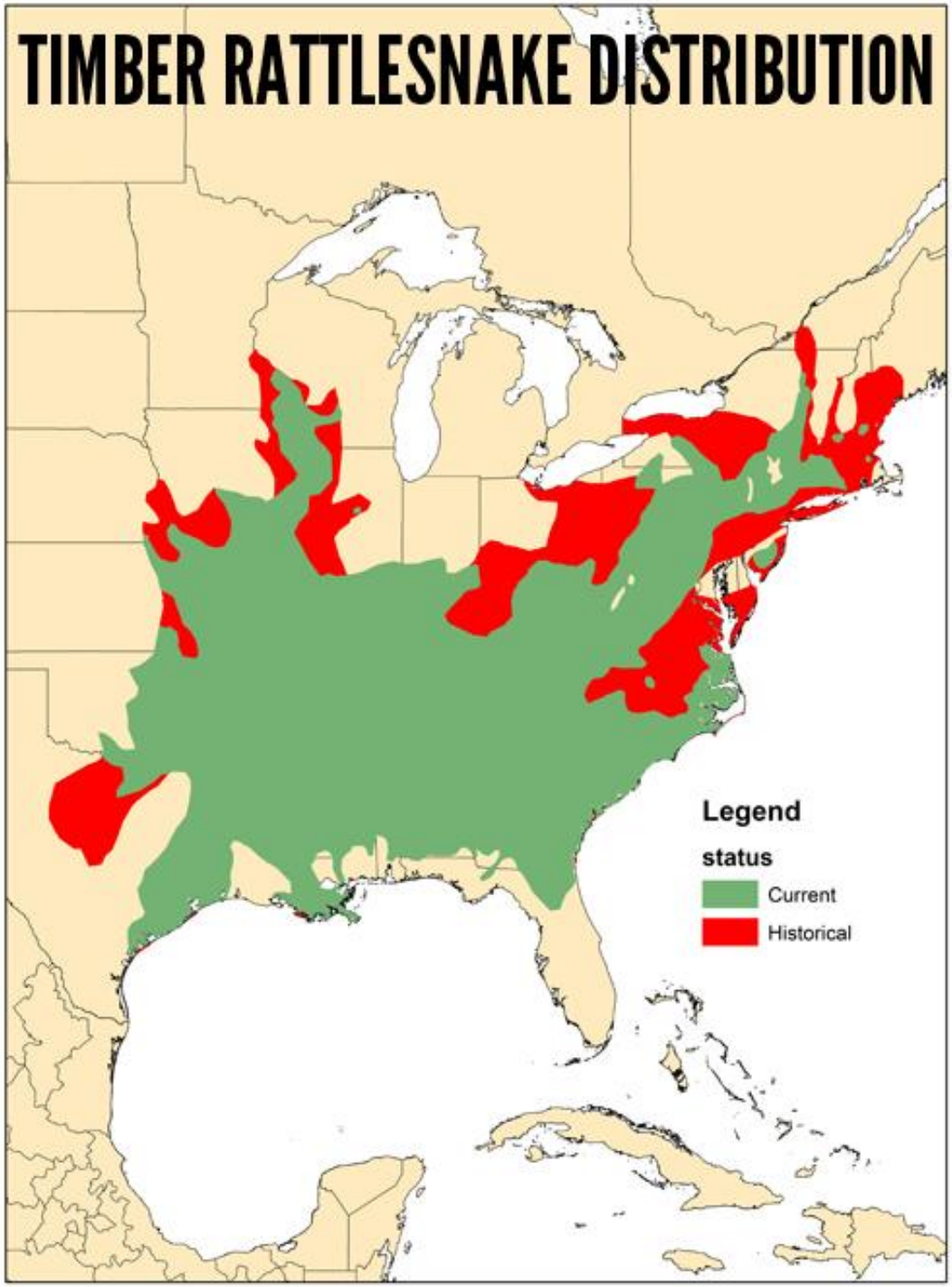
TIMBER RATTLESNAKE DISTRIBUTION
Legend
status
Current
Historical

Snake Bite Treatment

- **Don't** attempt to capture kill snake unless trained
  - Pictures/Description adequate
  - Dead snakes can still envenomate
- **Don't** incise/use suction
- **Don't** apply TQ
- *Do* minimize activity
- *Do* mark leading edge of redness with time
- *Do* treat pain (IV not on same limb)
- *Do* remove jewelry, tight fitting clothing
- *Do* contact poison control (Antivenom locations)

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Electrical Injuries

- Basics
  - Amperage- Measure of Electric Current-amount of energy that flows through an object
    - TASER - 2.1-3.6 Milliamps
    - Incandescent Light Bulb - 4 amps
  - Alternating Current (AC)
    - Electrical Outlet
    - Typically More Dangerous
      - Muscle Tetany
      - Arrhythmias
  - Direct Current (DC)
    - Batteries
    - Single Muscle spasm- possibly thrown from the current

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Electrical Injuries

- Voltage- Difference in electrical potential between two points
  - TASER - 50,000 Volts
  - Static electricity on a door knob - 35,000-100,000 Volts
  - Home Voltage 110 (Known Fatalities)
  - Phone Line 24V (No recorded fatalities)
  - Low Voltage <1000 V
    - ½ Injuries and deaths
    - ½ of all deaths have no burns (Arrythmias)
  - High Voltage >1000 V

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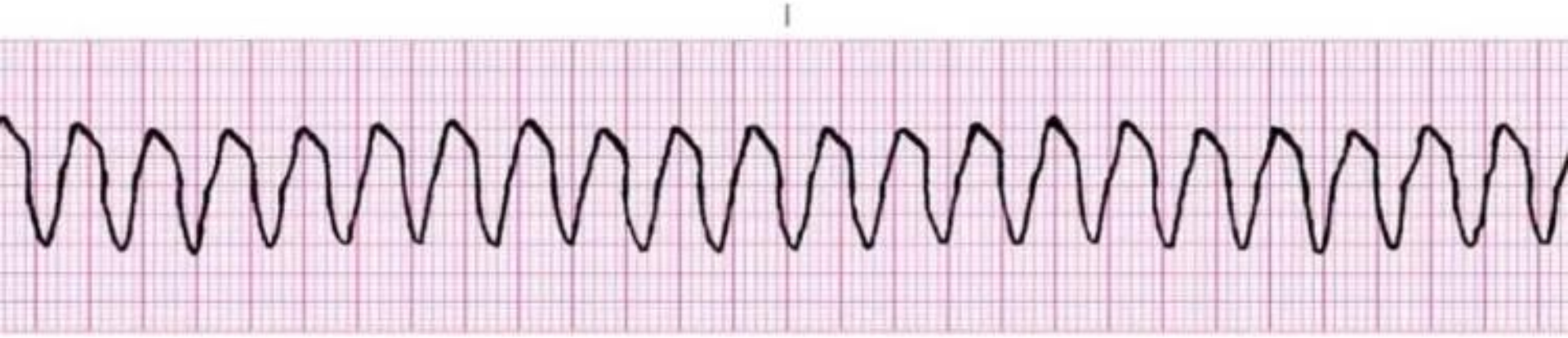
Electrical Injuries

- Joules-Unit of Work- one Joule is the work needed to move one amp (current) through one ohm of resistance
  - TASER - 0.36-1.76 Joules per pulse
  - Safety threshold for inducing V-Tach - 15-42 Joules



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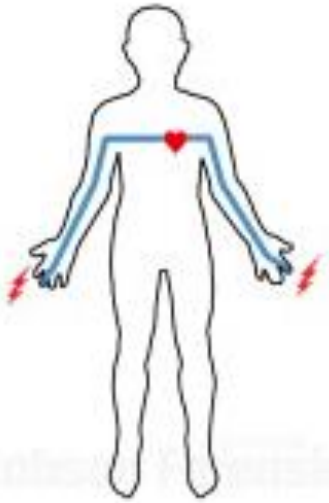
Hand & Hand Contact

thru hands, arms and chest

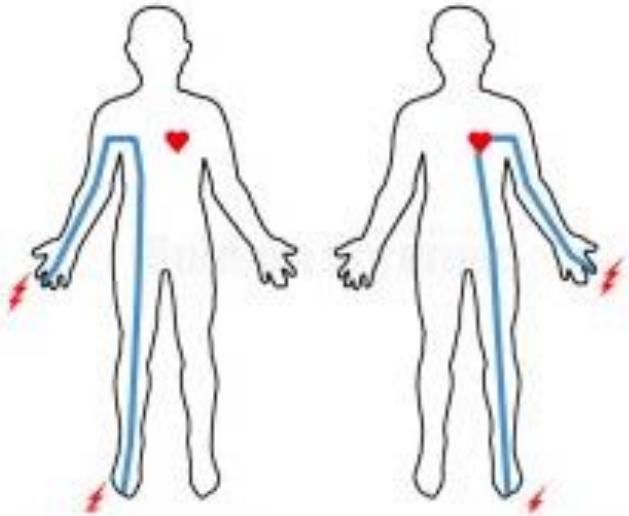


Hand & Arm Contact

thru hand and arm

Hand & Foot Contact

thru hands, arm, chest, abdomen, leg and foot



Hand & Head Contact

thru hand, arm, neck and head

Lightning

- DC (2 Million to 200million Volts)
- Strike can occur 10 miles ahead of storm
- May travel though pipes, wires, etc
- Fixed Dilated Pupils= transient autonomic disturbances
- Trauma/Thermal Injuries
- Paralysis 50% of victims
- Reverse Triage
  - Cardiac/Respiratory arrest
    - Total Myocardial depolarization= asystole
  - Treat those with no signs of life first

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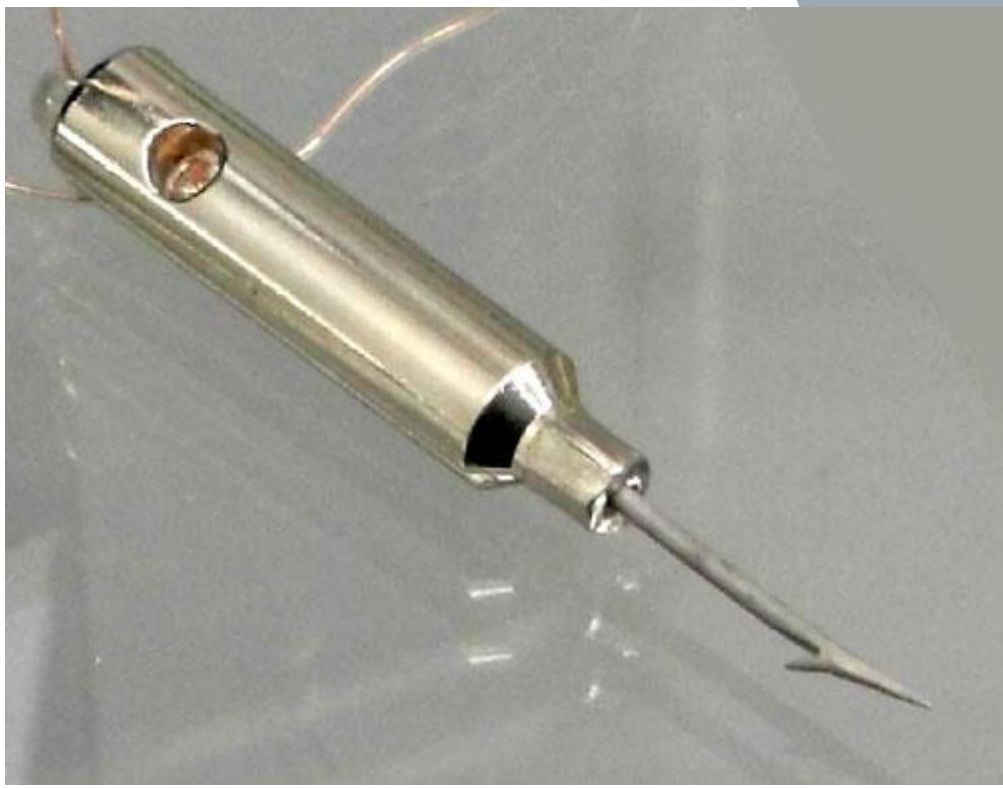
TASER Basics

- **T**homas **A**. **S**wift's **E**lectronic **R**ifle (1911) **TASER**
  - High Voltage But Low Amperage
  - Fires 2 Probes
- 25-55% of TASER deaths are estimated to be from Excited Delirium

TASER

- High Voltage Low Amps = Intense Muscle Contractions
  - Stress fractures
  - Muscle/tendon tears
  - Injuries from fall
  - Burns from arcing
  - Penetration injuries



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TASER Barb Removal

- Scene Safety
  - BSI
  - LEO on scene
- Barb Removal
  - Brisk Pull
    - Stop for significance resistance
    - Avoid removal if in sensitive area or deeply imbedded (eyes, groin, face etc)
      - Leave in place
      - Cut wires
    - Cleanse and apply bandage, Tetanus?
- Be aware of and assess for other injuries

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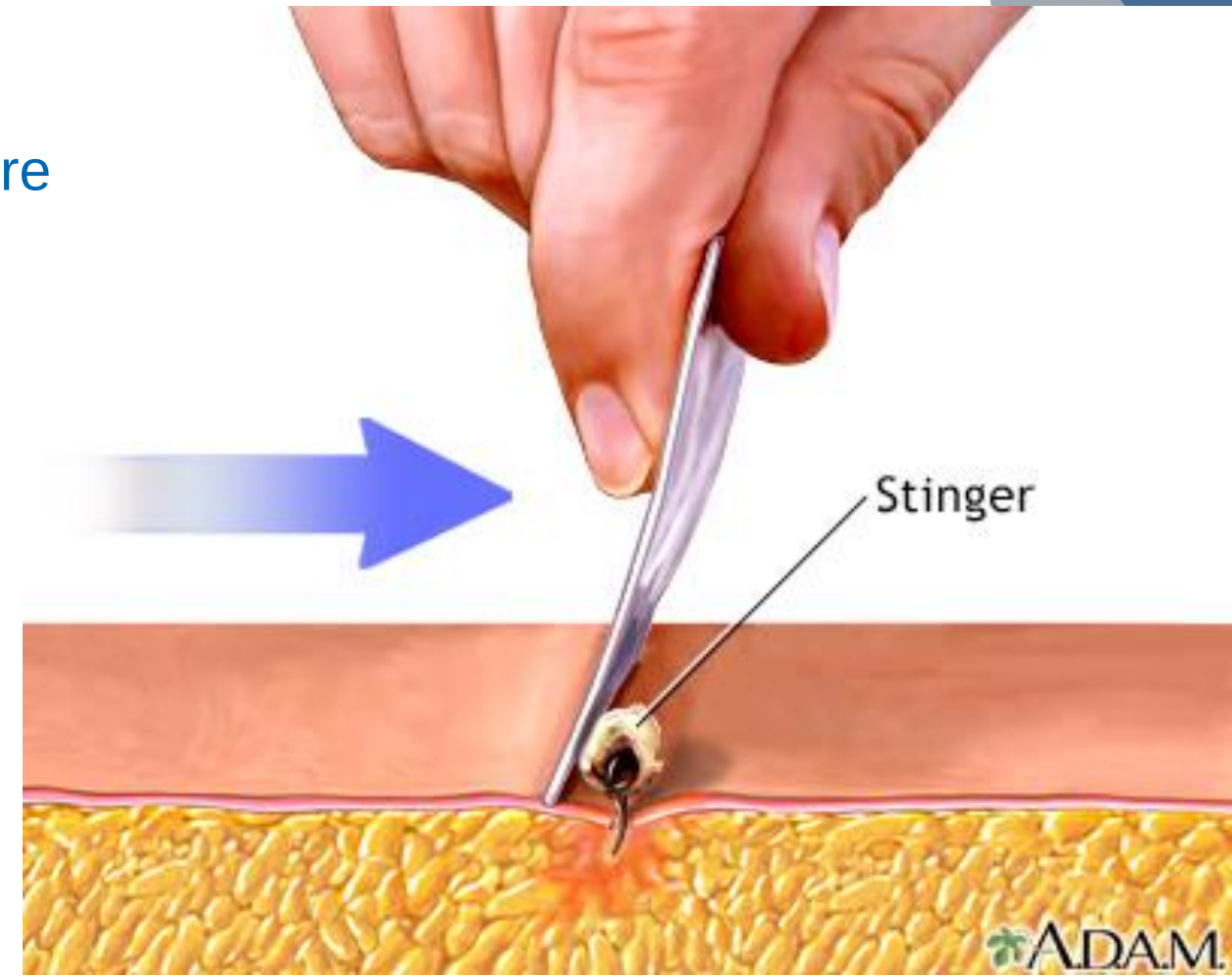
Bee Stings

- Hymenoptera
  - Bees, Wasps, Fire Ants
- Signs/Symptoms
  - Local Reaction
  - Anaphylaxis
  - Identify severity
- Treatment
  - Remove Stinger
  - Local Reaction
  - Anaphylaxis



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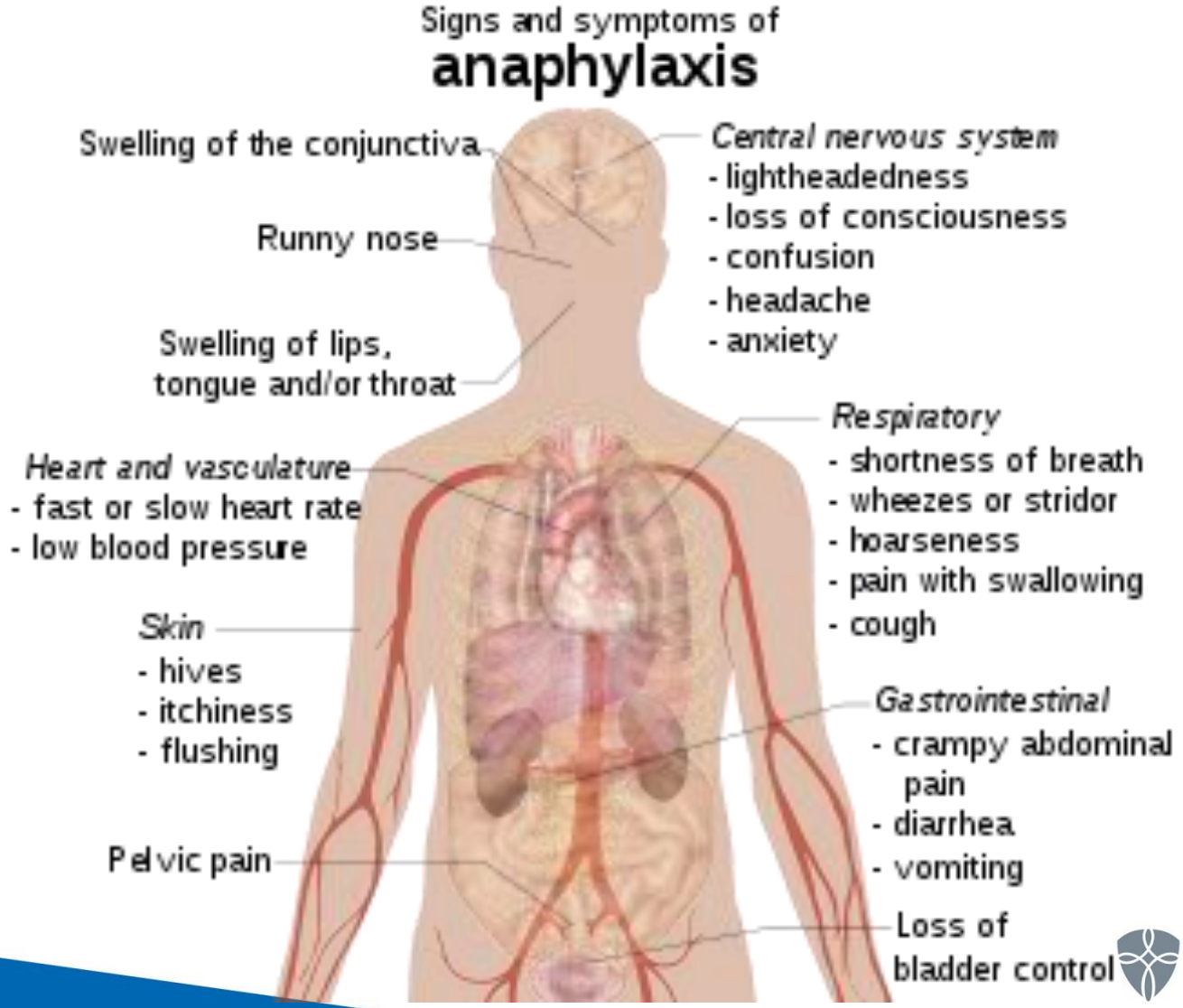
Anaphylaxis



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Case 5 ALS/BLS

Called to a 11 y/o female with shortness of breath

Mothers states that the child has hx of allergy to bee stings, was just stung, no treatment PTA

HR 120, BP 78/40, SPo2 90% on Room Air RR 28

Diffuse hives, wheezing in all fields, pt. c/o nausea, some lip swelling and mother states that the child sounds “hoarse”

Pt weights 77lbs (35kg)

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Pediatric Vital Signs?

- Lowest 5th Percentile Systolic Blood Pressure
- 70mmhg + (2 x Age in years) =

PALS

Vital Signs in Children

Normal Heart Rates* (beats/min)

Age	Awake Rate	Sleeping Rate
Neonate	100-205	90-160
Infant	100-180	90-160
Toddler	98-140	80-120
Preschooler	80-120	65-100
School-aged child	75-118	58-90
Adolescent	60-100	50-90

Normal Respiratory Rates (breaths/min)

Age	Rate
Infant	30-53
Toddler	22-37
Preschooler	20-28
School-aged child	18-25
Adolescent	12-20

Normal Blood Pressures

Age	Systolic Pressure (mm Hg)†	Diastolic Pressure (mm Hg)†	Mean Arterial Pressure (mm Hg)‡
Birth (12 h, <1000 g)	39-59	16-36	28-42§
Birth (12 h, 3 kg)	60-76	31-45	48-57
Neonate (96 h)	67-84	35-53	45-60
Infant (1-12 mo)	72-104	37-56	50-62
Toddler (1-2 y)	86-106	42-63	49-62
Preschooler (3-5 y)	89-112	46-72	58-69
School-aged child (6-7 y)	97-115	57-76	66-72
Preadolescent (10-12 y)	102-120	61-80	71-79
Adolescent (12-15 y)	110-131	64-83	73-84

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Case 5 BLS/ALS

- Classify severity based on below
- If Problem with A, B, C give Epi!

FOOTNOTES:

[1] Severity of Allergy/Anaphylaxis

- Mild Allergic reaction: localized or generalized Urticaria, without swelling of oral or pharyngeal structures, difficulty breathing, hypotension or ALOC
- Moderate Allergic Reaction: oral or pharyngeal swelling is present, mild to moderate difficulty breathing and wheezing are present
- Severe Allergic Reaction (Anaphylaxis): moderate to severe difficulty breathing is present, hypotension is present and ALOC may occur

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BLS/ALS Treatment

EMERGENCY MEDICAL RESPONDER

- If altered level of consciousness or no radial pulse, position patient supine with legs raised
- **EPI-Pen(>66lbs/30kg)** IM (0.3mg in 0.3ml) or **EPI-Pen Jr(<66lbs/30kg)** IM (0.15mg in 0.3ml) to lateral mid-thigh for moderate or severe reactions). Hold in place for 10 seconds and massage area for 10 seconds after injection.
- Oxygen 10-15 LPM by non-rebreather mask
- Alternative medical director approved epinephrine auto injectors may also be used.
- Assist with patient-prescribed medications
    - **Albuterol Sulfate** MDI 2 Puffs
- Nebulizer Therapy: If wheezing
    - **Albuterol Sulfate** Unit Dose (2.5 mg in 3 ml) administer per hand held nebulizer or mask; May repeat X 2 additional doses

EMT

- Administer Nebulizer Therapy: **Albuterol Sulfate** 2.5mg in 3 ml with **Ipratropium Bromide (Atrovent)** 0.5mg in 2 ml administer per hand held nebulizer, mask or in-line nebulizer; May repeat albuterol X 2 additional doses
  ** If patient is under 3 years of age, do not use Ipratropium Bromide (Atrovent), use only Albuterol via HHN
- **Diphenhydramine (Benadryl)** 50 mg PO if greater than 50kg(peds dose liquid or chewable 1mg/kg max 50mg) for mild, moderate, or severe reactions
- **EPI-Pen(>66lbs/30kg)** IM (0.3mg in 0.3ml) or **EPI-Pen Jr(<66lbs/30kg)** IM (0.15mg in 0.3ml) to lateral mid-thigh for moderate or severe reactions). Hold in place for 10 seconds and massage area for 10 seconds after injection.
- Alternative medical director approved epinephrine auto injectors may also be used.
- Epi Safe syringe system may only be used by departments trained and authorized by medical director.

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ALS Treatment

PARAMEDIC

- Initiate IV/IO 0.9% NS @ KVO
- If the patient is Hypotensive, run wide open for 500ml after verifying lung sounds not wet
- If loss of consciousness or loss of gag reflex occurs, consider non-visualized airway or endotracheal intubation See *Respiratory Distress Guideline*
- **Epinephrine 1:1,000** 0.3 mg (0.3ml) (peds 0.01mg/kg) IM for moderate to severe reactions. Repeat every 10 – 15 minutes X3 if patient is not improving, or as ordered per Medical Control
- **Diphenhydramine (Benadryl)** 50 mg IM/IV/IO (peds 1mg/kg) for mild, moderate or severe reactions
- **Glucagon** 1 mg IV/IO/IM if the patient is taking Beta Blockers and is not responding to Epinephrine, repeat every 10 minutes, until you run out of glucagon
- **Methylprednisolone (Solu-Medrol)** 125 mg IV/IO (peds 2mg/kg) for moderate to severe reactions
- **Push Dose 1:100,000 Epinephrine per section 5.42**

What would your initial fluid bolus be?

What would your diphenhydramine IV/IM dose be?

- What volume would you draw up?

What would you solumedrol dose be?

- What volume would you draw up?

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