The Cremation Of Sam McGee

There are strange things done in the midnight sun By the men who moil for gold;
The Arctic trails have their secret tales That would make your blood run cold;
The Northern Lights have seen queer sights, But the queerest they ever did see
Was that night on the marge of Lake Lebarge I cremated Sam McGee.

Robert W Service

Baby, It's Cold Outside

Hypothermia

DMU Grand Rounds

February 5, 2015

Presenters

- Thomas W Eales, DO-17
- Sarah Clayton, Assistant Prof, Physio/Pharm
- Jordan T Vorrie, DO-16
- Jenaya M Calderilla, DO-17
- Thomas Benzoni, DO, AOBEM, FACEP
  - DMU/COMS 1983

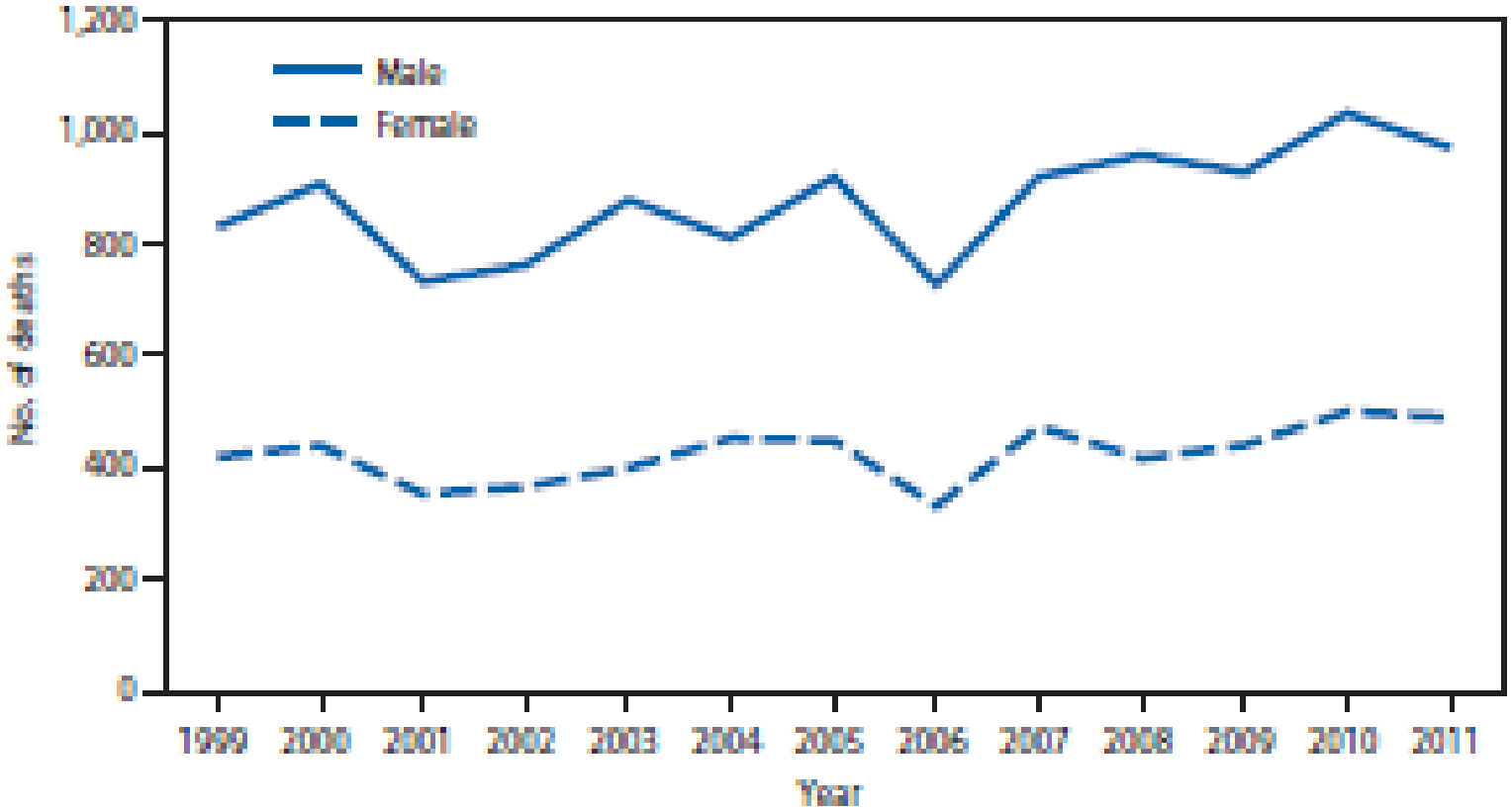
Objectives

- Understand the classification of hypothermia based on clinical signs and basic assessment.
- Know the basics of field and ED treatment of hypothermia.
- Recognize and be prepared to treat EKG findings of hypothermia.
- Become aware of ways to preserve their own function in harsh environments.

Case Study

- EMS is called for “Man Down”
  - Transporting 30-something male found outside
  - Poorly responsive, breathing slowly, weak pulse
- Background: NWIA, -7C/19F, 30 MPH, 2330H
- Initial assessment: Alive
  - Rectal temp: 31C/88F
  - HR = 40, Resp = 10, B/P = 80/p, Pain = 0/10
  - Fingers texture of frozen hotdogs

Number of Hypothermia-Related Deaths,* by Sex — National Vital Statistics System, United States,† 1999–2011§



* Deaths attributed to exposure to excessive natural cold as underlying and contributing causes of death, which were coded as X31, T68, and T69 according to the *International Classification of Diseases, 10th Revision*.
† U.S. residents only.
§ Data for 2011 are preliminary.

http://www.cdc.gov/mmwr/pdf/wk/mm6151.p

Definitions

- Swiss scale

Stage	Symptoms	Core temp	Treatment
1	Conscious, shivering	35 – 32C (95 – 89.6F)	Warm, feed, walk
2	Decreased LOC, not shivering	<32 – 28C (89.6 – 82.4F)	Gentle handling, external rewarming, warm environment, feed
3	Unconscious, not shivering, VS present	<28 – 24C (82.4 – 75.2F)	Stage 2 + intubate, ECMO/bypass
4	No vital signs	<24C (<75.2F)	Stage 3 + active central rewarming, CPR with epinephrine and defibrillation

High Alt Med Biol. 2003 Spring;4(1):99-103.

EMS Resuscitation

- Field
  - Scene safety: first, always
    - N+1 rule
  - Gentle transport
    - Start rewarming by warm (42C) humidified air
  - Communication
    - Lets ER ramp up
  - CPR

Literature review

- 1977 was a bad winter
  - O'Keeffe, KM, Denver General
    - Healthy/outdoors, non-healthy/indoors
      - Intoxicated, mentally , chronically ill at baseline
  - N = 59, < 35 C
    - 7 had specific EKG findings
    - 35 NSR; variety of other dysrhythmias
    - 90% rewarmed successfully by passive external
      - O'Keeffe KM: Accidental hypothermia. JACEP 6:491-496, November, 1977

Literature review

- 1977
  - Stine, RJ, Johns Hopkins
    - Reviewed risks, pathophysiology and treatments
    - Mortality 21 – 80%, primarily cardiac
    - Rapid cardiac rewarming
      - Active core rewarming
      - Active or passive peripheral rewarming
        - » Stine RJ: Accidental hypothermia, JACEP 6:413-416, September, 1977
  - Edwards, RD, Johns Hopkins
    - Overview
        - » Edwards RD: Accidental hypothermia, JACEP 6:426-427, September, 1977

Literature review

- Bizek et al., UCSD, 2008
  - N=35, 77% male, avg. 55 years
  - 50% EtOH, sedatives
  - Avg. temp 30.6C/87.5F
  - Unstable > 50%
  - CPR = 20%
    - Survival rate not given; inclusion criterion?
  - http://www.annemergmed.com/article/S0196-0644%2808%2901150-5/pdf

Pathophysiology of Hypothermia

Sarah C. Clayton, Ph.D.

Grand Rounds

5 February 2015

CORE temperature

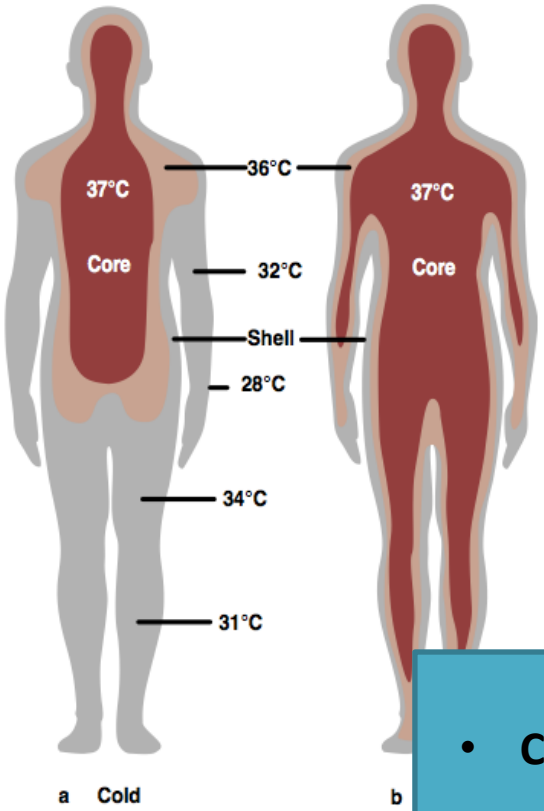


Fig. 2-2. Distribution of temperatures w
and division of the body into core and s
posure to (a) cold and (b) warm environm
peratures of the surface and the thickne
depend on the environmental temperatu
shell is thicker in the cold and thinne
Adapted with permission from Elizondo
of body temperature. In: Rhoades RA, Pf
Human Physiology. Philadelphia, Pa: Sau
Publishing; 1989: 823–840.

Modes of heat transfer:

1. Radiation: transfer of heat (infrared) waves to cold object
2. Conduction: transfer of heat by direct contact with cold object (water, air)
3. Convection: transfer of heat by current (wind, water)
4. Evaporation

Cold response:

- Cutaneous vasoconstriction
- Inhibition of sweating
- Activation of shivering and metabolism
- (Long term) thyroxine secretion

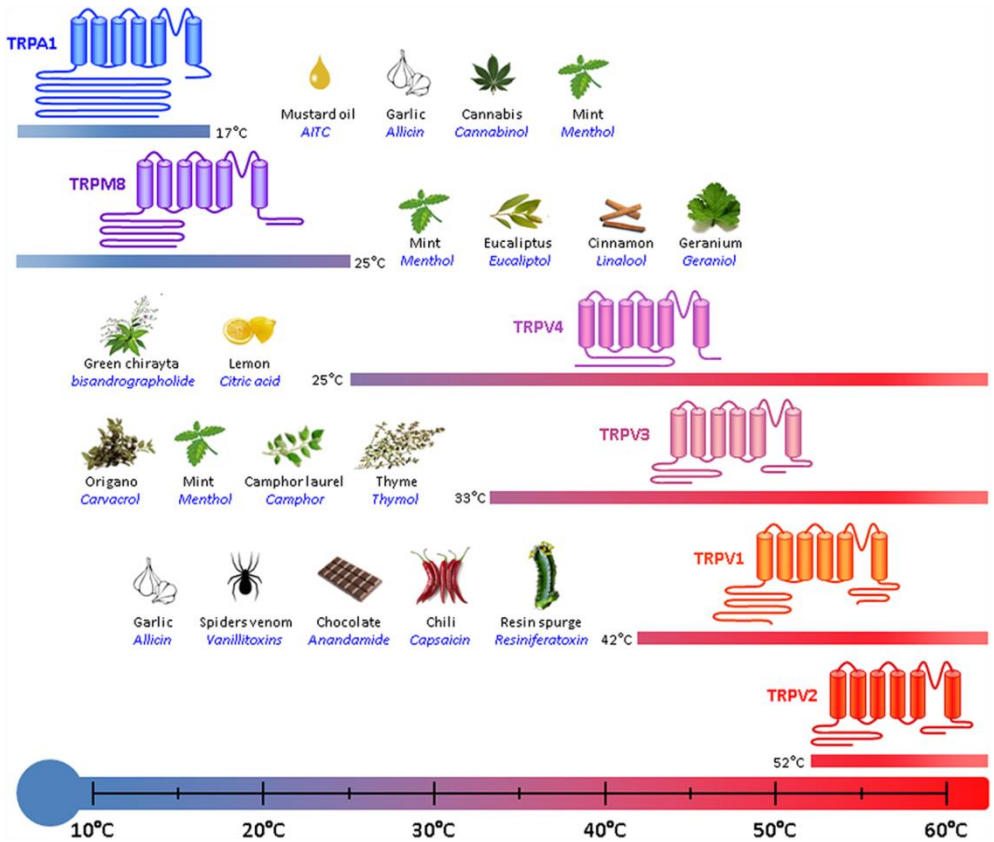
Heat response:

- Cutaneous vasodilation
- Sweating
- Inhibition of shivering and metabolism

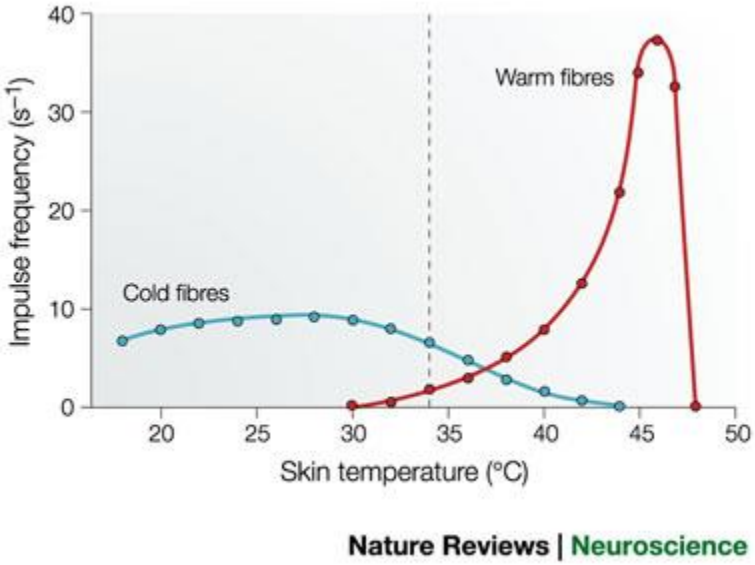
Thermoregulation in Cold Environment

- BALANCE of heat production with control of heat loss
  - Reduce heat lost from body into [cold] environment
- Activation of cold-temperature sensory receptors, inhibition of warm-temperature sensory receptors
- Cold blood reaches temperature-sensitive neurons in hypothalamus

Temperature-sensitive ion channels



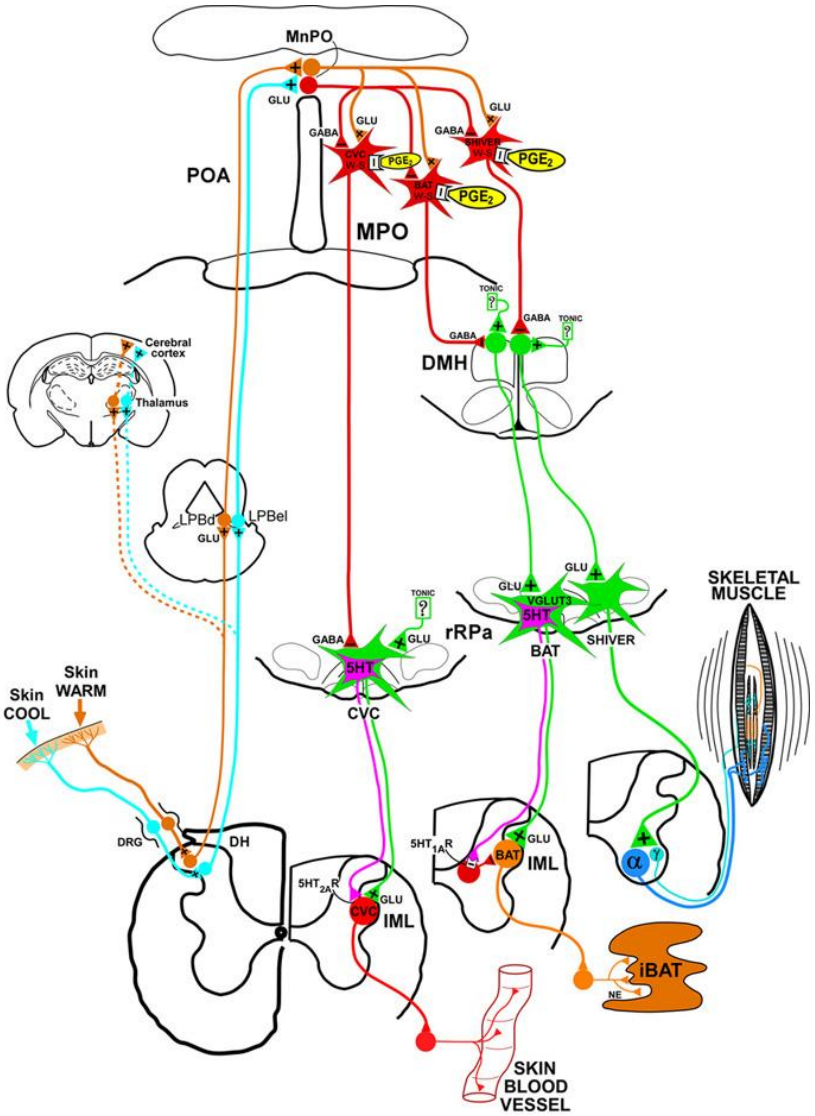
Chest. 2011;140(4):1040-1047. doi:10.1378/chest.10-3327



Nature Reviews Neuroscience 4, 529-539 (July 2003) doi:10.1038/nrn1141

Normal Responses to Cold Temperature

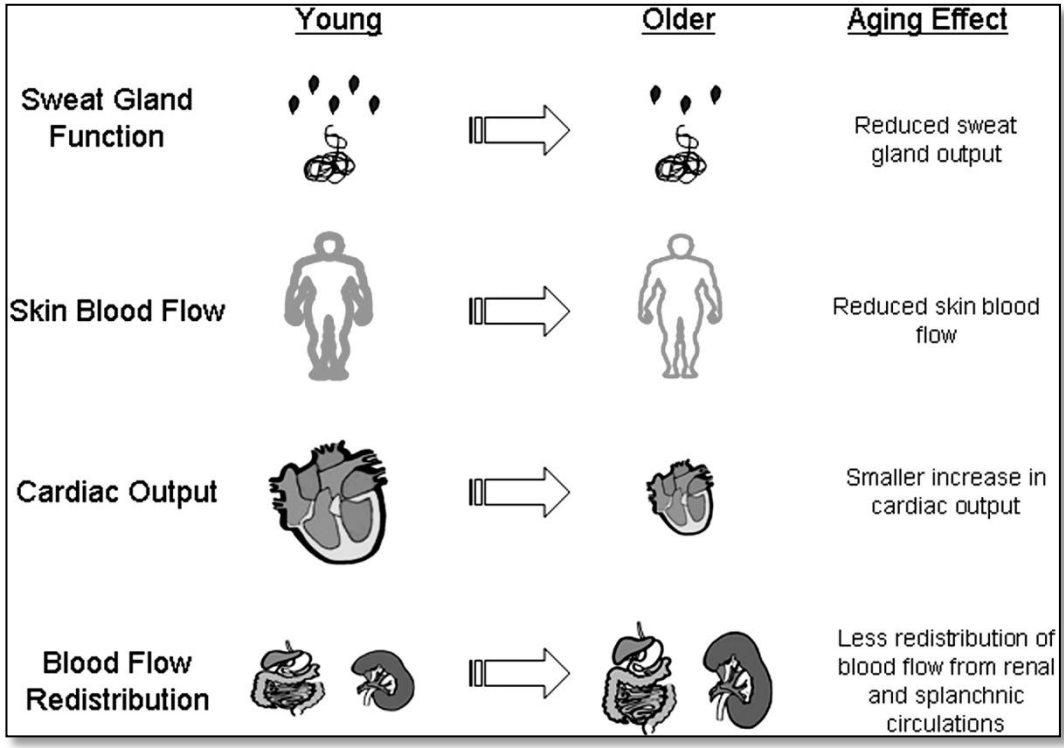
- Autonomic activation (immediate)
  - Cutaneous vasoconstriction
  - Motor neuron activation for shivering
- Endocrine activation (delayed)
  - Increase metabolic activity to generate internal heat
- Behavioral adaptation



Frontiers in Bioscience 16, 74-104, January 1, 2011

Changes in Thermoregulatory Capacity

- Old age
  - Reduced lean body mass
  - Impaired mobility
  - Reduced shivering
  - Vascular dysfunction
  - Less responsive temperature sensation
  - CNS dysfunction



http://jap.physiology.org/content/95/6/2598

Changes in Thermoregulatory Capacity

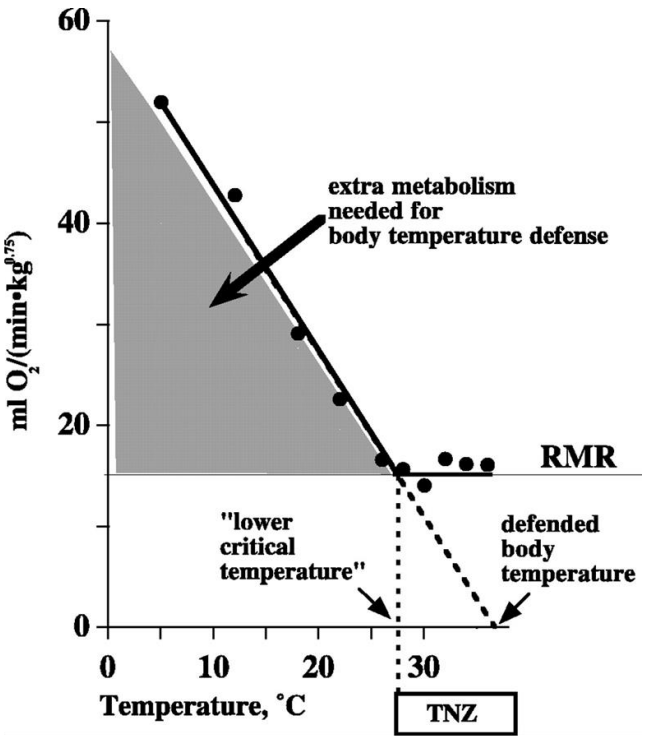
- Pharmacological agents
  - Impair central responses (i.e., antidepressants)
  - Impair peripheral responses (i.e., alpha blockers)
  - Can alter core temperature set-point (i.e., lithium)
  - Ethanol:
    - Peripheral vasodilation (lowered vasoconstriction threshold)
    - Impaired shivering
    - Hypoglycemia (impairs ability for the cells to generate heat)
    - Hypothalamic effects- POSSIBLE change in set point
    - Augments cold diuresis

Hypothermia = drop in core temperature

- Acute hypothermia: exposure to a cold environment in an otherwise healthy individual
- Chronic hypothermia: more prolonged exposure
- Predisposing factors also play a role
  - Prior CNS injury (i.e., stroke)
  - Sepsis
- Mild (33-35°C), moderate (~28-33°C), severe (<28°C) hypothermia

Metabolism varies with temperature

- Oxygen consumption decreases with decreasing temperature (@25°C, oxygen consumption decreased by 50%)
- Variable effects on organs
  - Liver: detoxification of drugs prolonged
    - Half life of morphine increased from 3.7 to 94 minutes
  - Heart rate slowed to ~40 bpm at 25°
- Can be more pronounced with underlying metabolic disturbances (i.e., hypothyroidism, hypoglycemia)



CANNON B , and NEDERGAARD J Physiol Rev 2004;84:277-359

Vasoconstriction

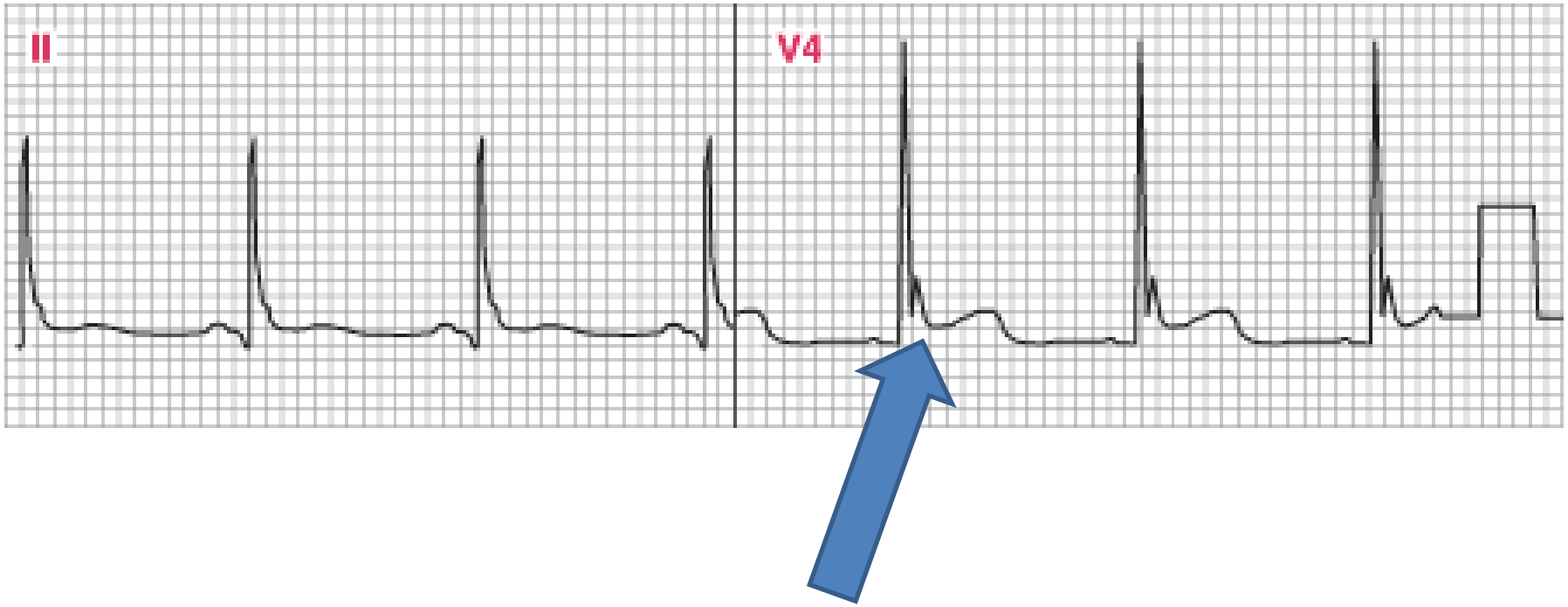
- Sympathetic nervous stimulation constricts all vessels
  - Will modify absorption of pharmacological agents, if given IM or SC
- Diuresis plus fluid leakage causes hypovolemia
- Vasoconstriction may mask hypovolemia
  - Can lead to shock during rewarming
- Frostbite
  - Formation of ice crystals in or between cells
  - Pain manifests as area rewarmed
  - Unfrozen adjacent tissue at risk from damaged cells releasing cytokines

Changes in ECG

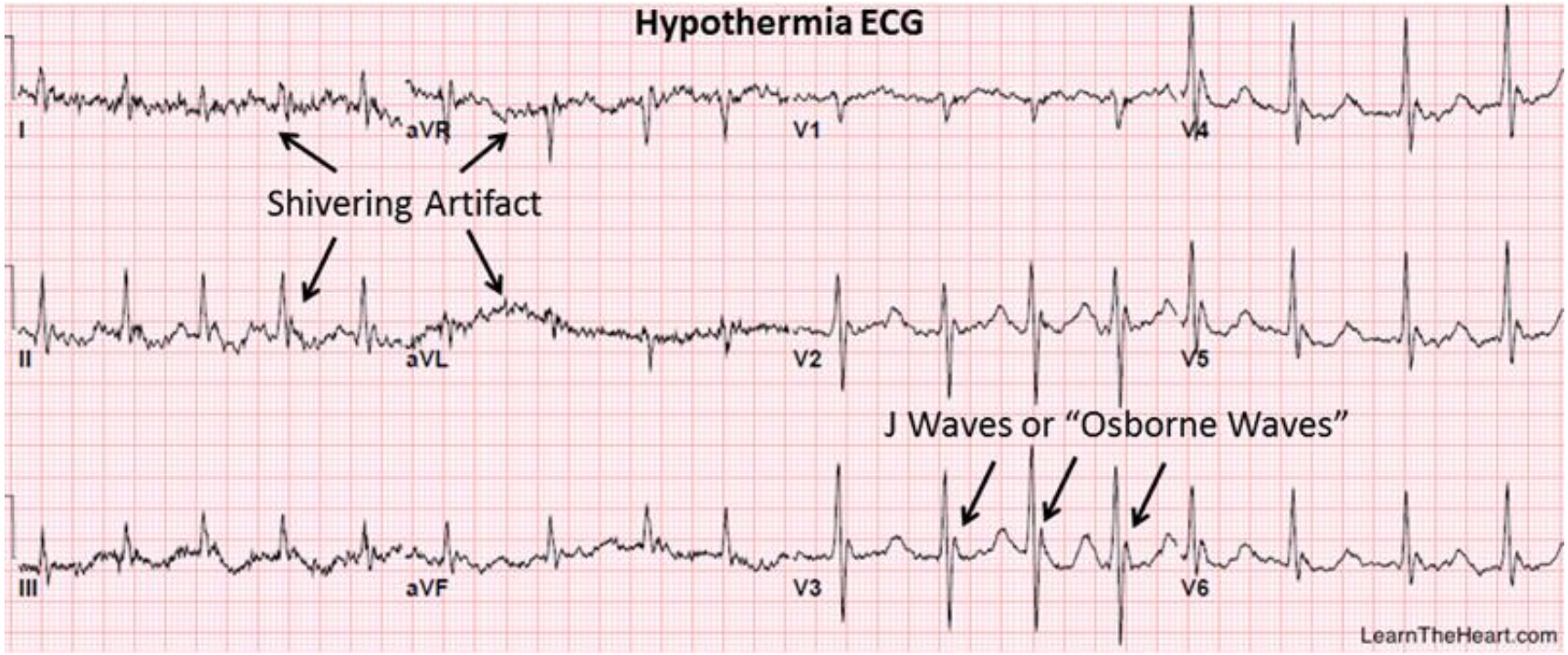
- Increased R to R interval (after initial tachycardia due to “stress response”)
- Decreased or absent P waves, possible atrial fibrillation or flutter
- Increased QRS interval
- Increased ST segment length (also can show elevation or depression)
- Prolongation or inversion of T waves
- Below 28°, heart block may occur and raise probability of ventricular ectopic
  - Ventricular fibrillation can occur, especially with physical movement, acid-base and/or oxygen/carbon dioxide imbalance
  - Below 24°C, there is a high risk of asystole. Alcohol MAY reduce this threshold.

- Warming will cause disappearance of symptoms in reverse order

J (Osborn) waves



Hypothermic Changes Captured by ECG



Changes in the Blood

- Reduced vascular permeability
  - Loss of fluid into interstitium
- Increased blood viscosity (low cardiac output), fibrinogen, and hematocrit
  - Can manifest as micro-infarcts in some tissues
- Cold also affects other enzymes involved in clotting
  - Can lead to coagulopathy (i.e., DIC)
- Increasing affinity of hemoglobin for oxygen as temperature decreases
  - Balanced by acidosis; severe hypothermia can cause a right-shift of Hb-O2 dissociation curve
  - Impact of hypoxia reduced due to reduced metabolic demand

Respiration

- Normal respirations can persist
  - Respirations will get more shallow as metabolic activity decreases, respiratory rate also decreases
  - Medullary carbon dioxide sensitivity decreases below 34°C
  - Below 24°C, spontaneous respiration ceases
  - Below 20°C, no response to hypoxia or hypercapnea
- Oxygen dissociation curve shifted to the left

CNS

- Nerve conduction slows with decreasing temperature
  - Impairs sensation of cold, so may stay in cold environment longer
- CNS dysfunction
  - Lethargy and clumsiness
  - Confusion, irritability, hallucinations
    - Impaired judgment can sometimes lead a patient to undress
  - Coma
- Cerebral blood flow reduced BUT decreased metabolic rate can buffer cerebral ischemia better at low temperatures
- Hypothalamus: reduced ADH and oxytocin secretion

Neuromuscular Effects

- Shivering will increase then decrease as temperatures continue to fall (activity lost 20°C)
- Stiffening of joints further impairs muscle movement due to increasing viscosity of synovial fluid
- Impaired nerve conduction
  - Orthostatic hypotension
- Really low skin temperature (12°C) will impair precapillary sphincters resulting in cutaneous vasodilation
  - “Lewis Hunting Reaction”: vasodilation- skin warms- precapillary sphincter activity restored- vasoconstriction- decreased skin temperature- precapillary sphincter activity abolished→

Renal Function

- Urinary output may be increased at 25°C
  - Decreased ADH leads to cold diuresis
  - Coupled with shift of volume to extravascular space causes hypovolemia
- Reduced tubular function coupled with diuresis can lead to electrolyte imbalance

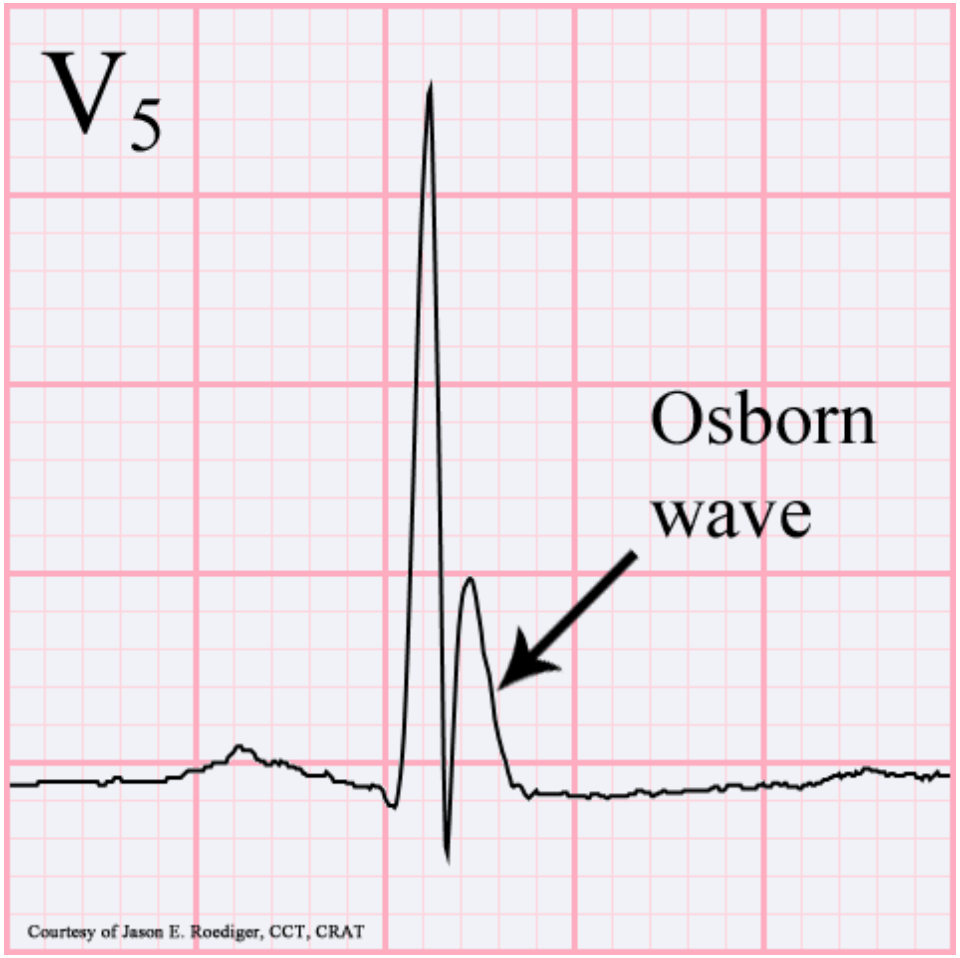
Gastrointestinal Tract Function

- Decreased motility below <34°C
  - Ileus below 28°C
- Increased gastric acid secretion and reduced duodenal bicarbonate secretion– mucosal damage

EKG Findings

- Osborn J wave
  - Tomaszewski, 1938
    - Described in accidentally frozen victim
  - Osborn, 1953
    - Volunteer dogs
    - Theorized not temperature but metabolic acidosis
      - Resolved with hyperventilation
  - Edelman and Joynt, 2010
    - 64 yo male, 92F, J waves present
    - J waves resolved with pH correction, temperature @ 92F

EKG Findings

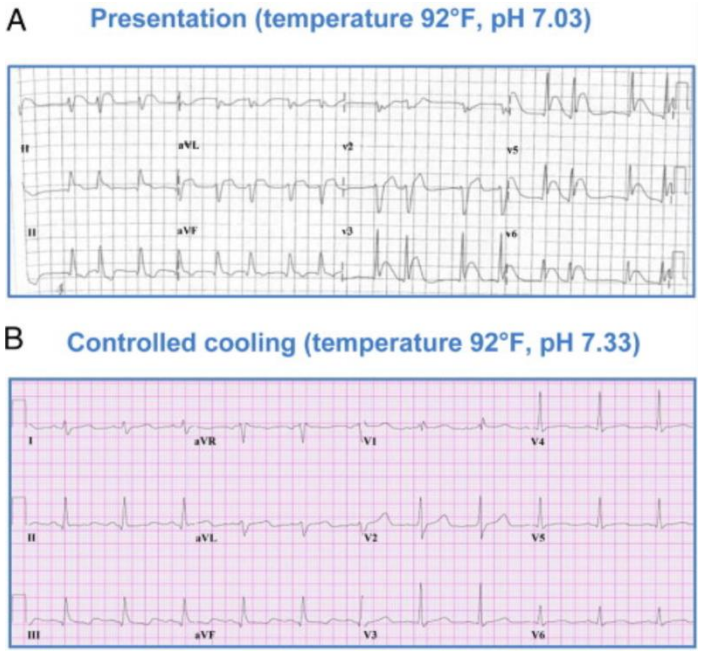


http://reference.medscape.com/features/slideshow/hypothermia?src=wnl_ref_critim#10

- ✓ What is the rhythm?
  - ✓ Gross/general, fine distinction
- ✓ What causes it?
- ✓ Why does the EKG look like that?
- ✓ What are you going to do about it?

From: J Waves of Osborn Revisited

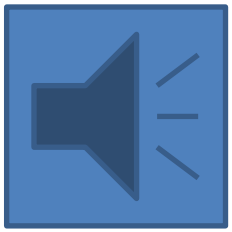
J Am Coll Cardiol. 2010;55(20):2287-2287. doi:10.1016/j.jacc.2009.06.071



A Presentation (temperature 92°F, pH 7.03)

B Controlled cooling (temperature 92°F, pH 7.33)

EKG Findings



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Mechanism of Cooling

- Energy Transfer:
  - Classical physics: high to low
- Bidirectional
  - Radiation: energy travel through still air
    - Sunshine, frigid ambient air
  - Convection: air moving over source or sink
    - Wind/breeze, air conditioner evaporator
  - Conduction: solid objects toughing
    - Ice cubes in water, cool concrete

ER Resuscitation

- Depends on level of hypothermia

Stage	Symptoms	Core temp	Treatment
1	Conscious, shivering	35 – 32C (95 – 89.6F)	Warm, feed, walk
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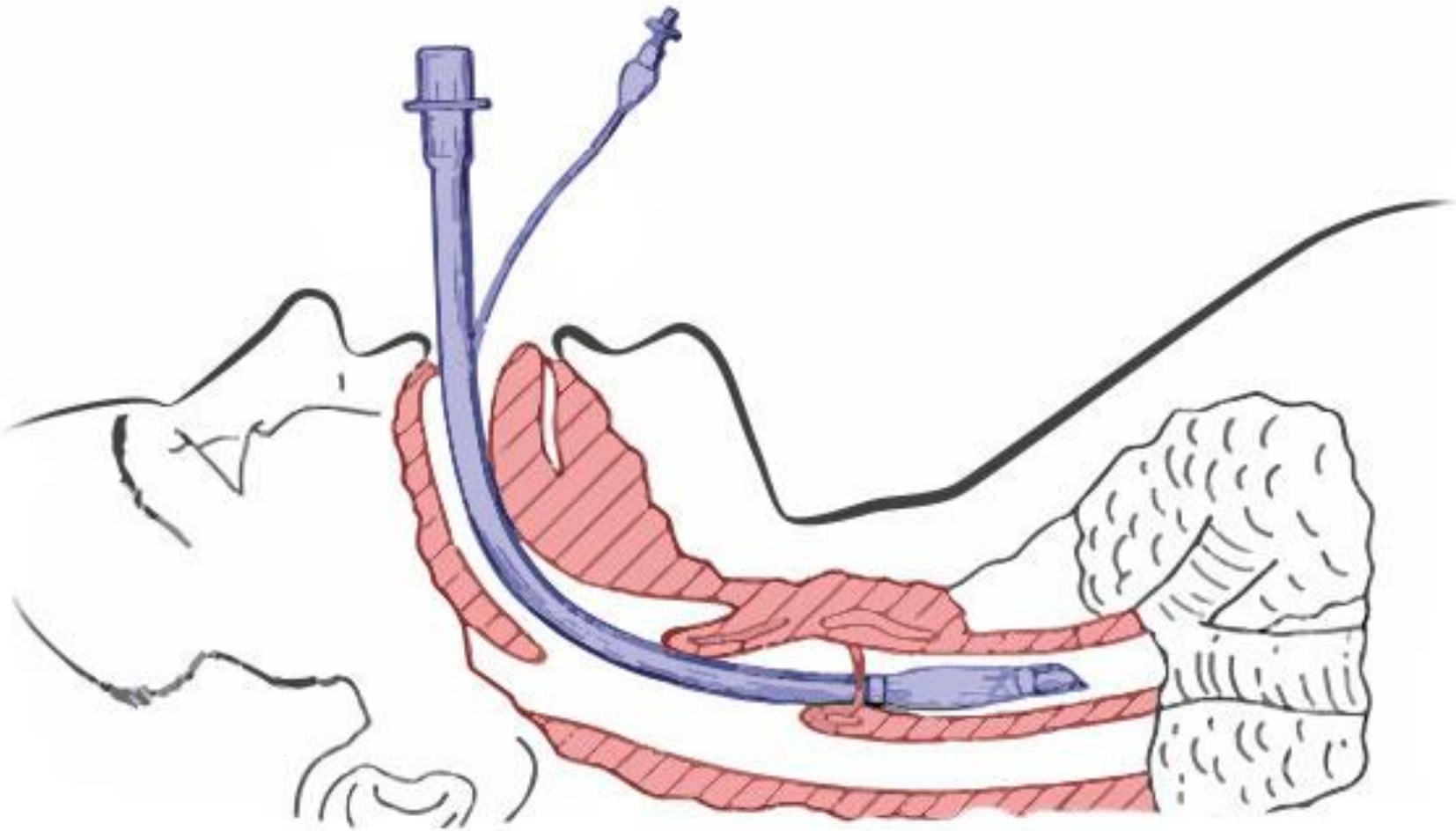
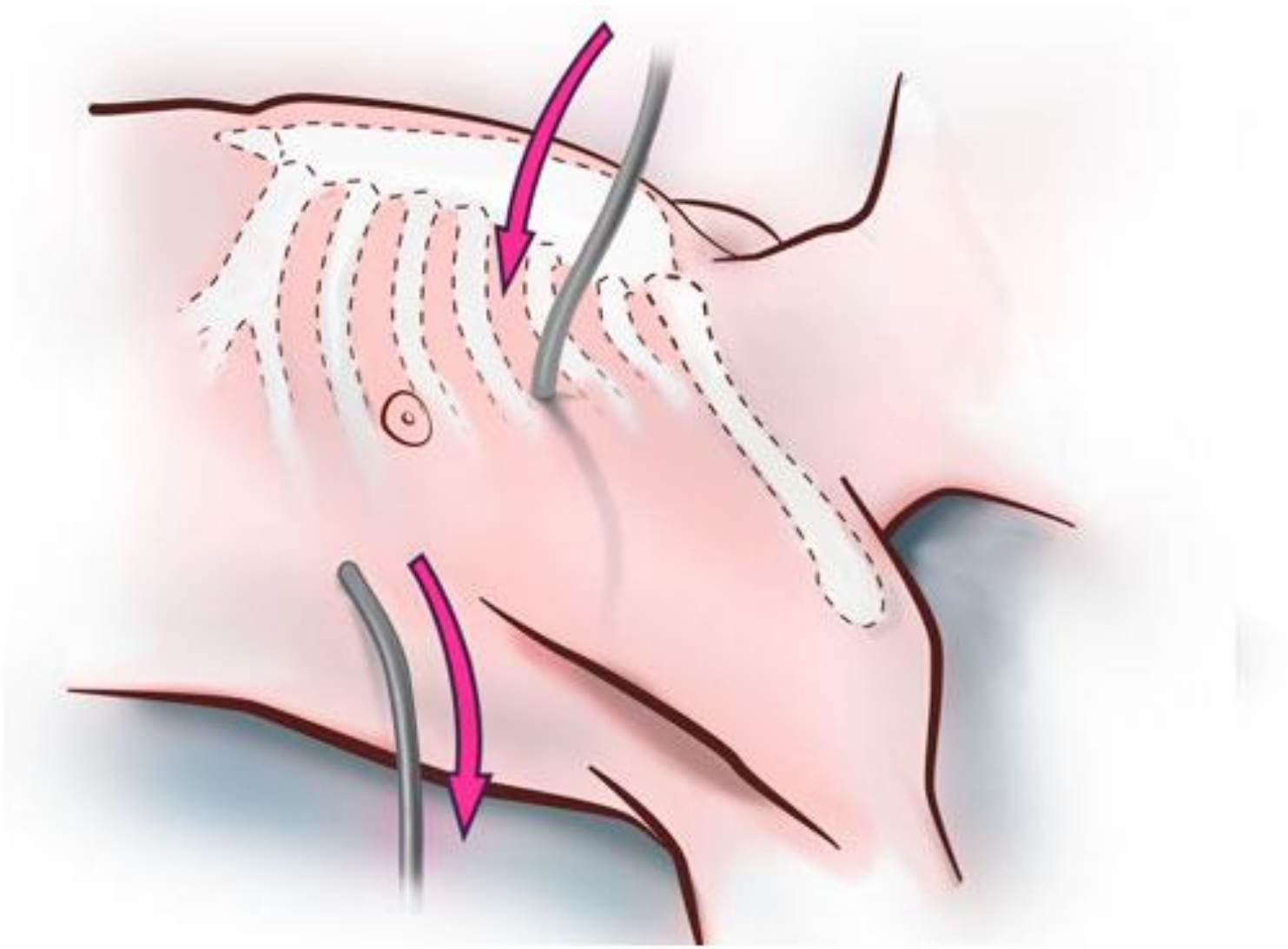
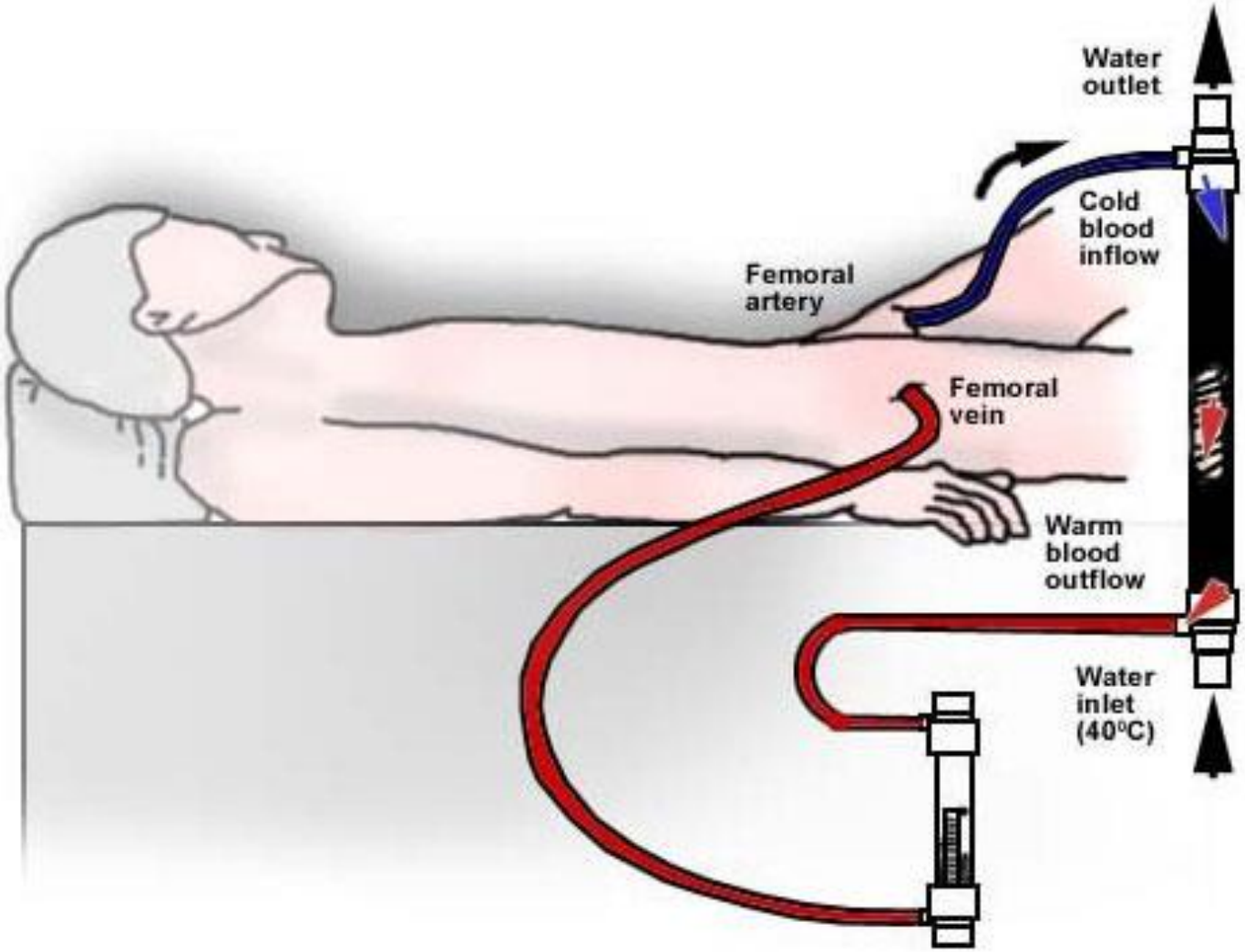


http://reference.medscape.com/features/slideshow/hypothermia?src=wnl_ref_critim#17

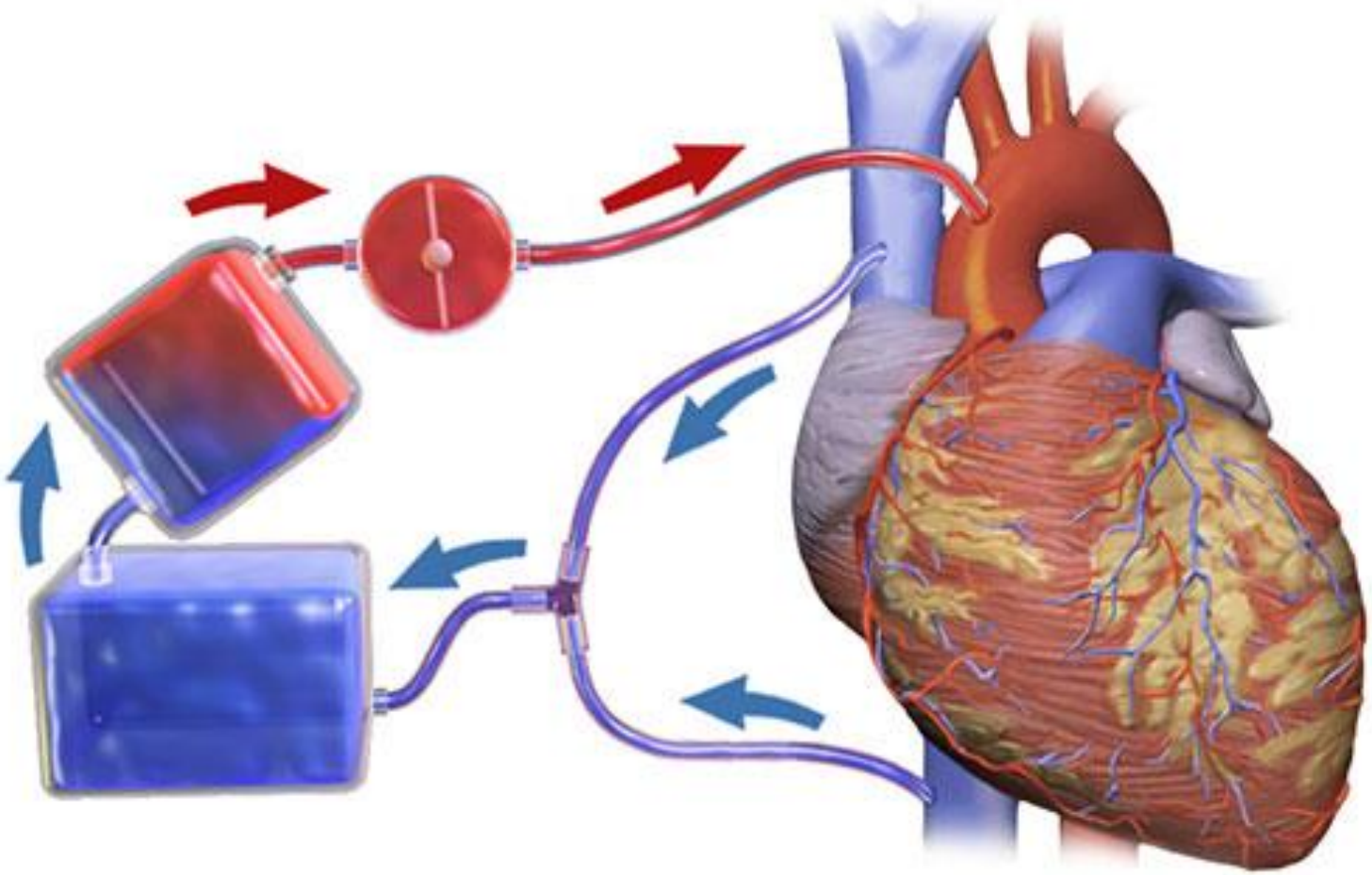


http://reference.medscape.com/features/slideshow/hypothermia?src=wnl_ref_critim#15



http://reference.medscape.com/features/slideshow/hypothermia?src=wnl_ref_critim#16

Cardiopulmonary Bypass



http://reference.medscape.com/features/slideshow/hypothermia?src=wnl_ref_critim#18

Resuscitation hazards

- Late rewarming syndrome
  - After-drop phenomenon
- Mechanism
  - Crush syndrome
- Quitting too early
  - Warm and dead

Hazard mitigation

- 101 uses for a safety pin
- http://www.acep.org/Content.aspx?id=70882

Outcome

- Central rewarming in ER
  - Warmed humidified O2
  - Warm fluids (42C)
  - Peritoneal lavage

Review

- We covered:
  - Population at risk
  - Patho-physiology
  - Detection and classification
  - Targeted interventions
  - Resuscitation hazards
  - Personal mitigation

Resources

- Osborn J.J.; Experimental hypothermia: respiratory and blood pH changes in relation to cardiac function. *Am J Physiol*. 175 1953:389-398.
- *Osborn J waves pH phenomenon. J Am Coll Cardiol*. 2010;55(20):2287-2287. doi:10.1016/j.jacc.2009.06.071
- *Case with echo and EKG's.* http://hqmeded-ecg.blogspot.com/2015/01/massive-osborn-waves-of-severe.html
- *Medscape series:* http://reference.medscape.com/features/slideshow/hypothermia?src=wnl_ref_critim#1

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