Environmental Heat & Cold Related Illness

Christopher Holstege, MD
Professor
Emergency Medicine & Pediatrics
University of Virginia

ch2xf@virginia.edu

Christopher P. Holstege, MD

Disclosure

No relevant financial relationships

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The Last Run

Young, fit, and competitive, Kelly Watt went for a run at the hottest part of the day at the hottest time of the year. What happened to him serves as a warning to all runners.

By Amby Burfoot *(Google+)*; Image by Erika Larsen
Published January 19, 2007

The day of Kelly Watt's final run last July 26 started out great: He got to sleep in. Most

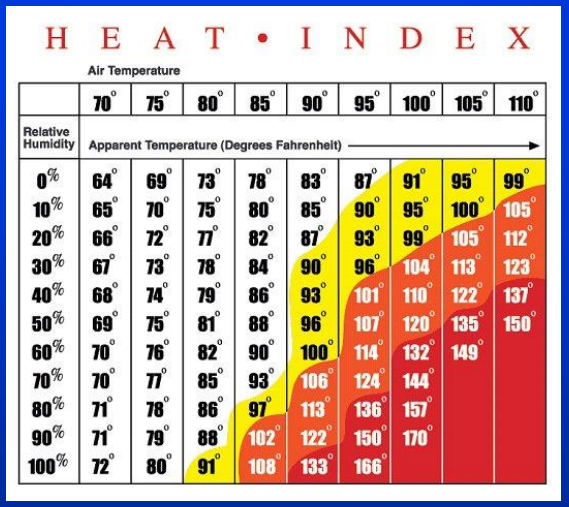
http://www.runnersworld.com/runners-stories/last-run?page=single

Case 1

- An 18 year old cross country runner decides to go for an evening 10 mile run in preparation for his freshman year of college.
- He drives to a remote rural region, different than the area that he told his parents.
- Temperature 95^{o} with a humidity of 80%

18:00
0:00

Heat Index



H E A T • I N D E X

Air Temperature

Relative Humidity	Apparent Temperature (Degrees Fahrenheit) →								
	70°	75°	80°	85°	90°	95°	100°	105°	110°
0%	64°	69°	73°	78°	83°	87°	91°	95°	99°
10%	65°	70°	75°	80°	85°	90°	95°	100°	105°
20%	66°	72°	77°	82°	87°	93°	99°	105°	112°
30%	67°	73°	78°	84°	90°	96°	104°	113°	123°
40%	68°	74°	79°	86°	93°	101°	110°	122°	137°
50%	69°	75°	81°	88°	96°	107°	120°	135°	150°
60%	70°	76°	82°	90°	100°	114°	132°	149°	
70%	70°	77°	85°	93°	106°	124°	144°		
80%	71°	78°	86°	97°	113°	136°	157°		
90%	71°	79°	88°	102°	122°	150°	170°		
100%	72°	80°	91°	108°	133°	166°			

Definition: An index combining air temperature & humidity to give an apparent temperature (i.e. how hot it "feels").

http://www.wpc.ncep.noaa.gov/html/heatindex.shtml

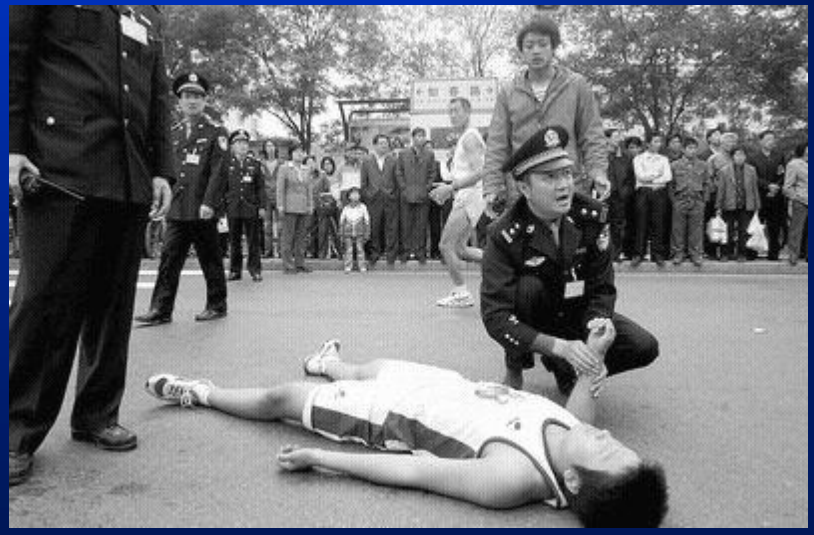
Heat Illness

1. **Heat edema**
   - Dependent edema in unacclimatized individuals
   - Transient peripheral edema with orthostatic pooling
   - Treat with leg elevation, exercise, acclimatization, NOT diuretics

2. **Heat cramps**
   - Painful spasms of skeletal muscles
   - Replace fluids and sodium loss

Heat Illness

1. **Heat syncope**
   - Loss of consciousness (i.e. prolonged standing)
   - Inadequate cardiac output and postural hypotension
   - Place supine, legs elevated and replenish fluids



2. **Heat exhaustion**
   - T> 37^{o} C but < 40.5^{o} C
   - Removal from heat, cooling, hydration

Desert Heat

Associated Press, August 7, 2015

Sheriff: French pair who died in US desert likely saved son

Aug. 7, 2015 6:01 PM EDT

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ALAMOGORDO, N.M. (AP) — A French couple who died during an afternoon hike across the searing New Mexico desert likely saved their 9-year-old son by giving him two sips of water for each one they took before the supply ran out, a sheriff said Friday.

The boy was dehydrated but in remarkably good shape when he was found alongside his dead father on a trail in the White Sands National Monument, Otero County Sheriff Benny House said.

The father and son were found Tuesday about an hour after park rangers found the

Desert Heat

Associated Press, August 7, 2015

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Desert Heat

Associated Press, August 7, 2015

- **White Sands National Monument, New Mexico**

Desert Heat

Associated Press, August 7, 2015

- Two park service employees on patrol Tuesday discovered the mother first, according to Marie Sauter, superintendent of the White Sands National Monument.
- They called the Otero County Sheriff's Office, which sent deputies and emergency responders, but 51-year-old Ornella Steiner already was dead.
- "They were trying to figure out why she was on the trail by herself," Sheriff Benny House told CNN.
- Looking at Steiner's camera for clues, the deputy saw photos of a man and boy at the park's entrance. They were unaccounted for, House said, so deputies then extended their search.
- Deputies found the father and son about 45 minutes later, slightly off the trail. David Steiner, 42, was dead. The son, whose name was not given, was with him.
- "He wasn't crying," House said, but "he was dehydrated and of course he was upset."

Desert Heat

Associated Press, August 7, 2015

- From what the boy told investigators, the sheriff said, the family got about a mile and a half down the 4.6-mile-loop trail when the mother, who already wasn't feeling well, tumbled and aggravated a previous knee injury.
- She headed back to the trailhead but made it only about 300 feet before collapsing.
- The son and father continued walking for another 2,000 feet, unaware of the mother's collapse, but the father grew delirious and "started to make some bad decisions for the child," the sheriff said.
- "He kept telling the son that the vehicle is 'right over here, right over here,'" House said. He was disoriented, and "the heat was affecting his judgment."

Desert Heat

Associated Press, August 7, 2015

- Alkali Flat Trail takes visitors through the scenic white sand dunes to the edge of the Alkali Flat, a lakebed that dried up thousands of years ago, after the last ice age. There is no shade among the dunes, the highest of which rises about 60 feet, and sparse short shrubs are the only vegetation.
- It's not the most heavily used trail at the park because it's strenuous and long, going up and down for 2.5 miles before it loops back around, Sauter said.
- "It's a trail that you want to take half a day to do," she said.
- The trail's path isn't visible in the sand. Instead, the way is marked by white posts with orange reflective tape, planted 3-to-4-feet deep in the sand and set varying distances apart but intended to be visible from post to post. Hikers walk from one trailpost to the next.
- With the blowing wind and sand, park employees frequently have to check that the markers haven't fallen down. Visitors are told to turn back if ever they can't see the next one.
- On the day the Steiners died, the high temperature was 101 degrees under sunny skies, Sauter said.

Desert Heat

Associated Press, August 7, 2015

- Once hikers get into the dunes, "there is no shade. There is no cover. You are out exposed to the sun, the wind, the heat, the reflection of the sun off the white sand. It's a harsh desert environment."
- On the White Sands National Monument website, the Park Service warns visitors that heat-related illness is common in warm weather and can be fatal. It advises people to hike during cool times.
- "Carry food and at least two liters of water each," it says. "Rest, eat and drink when tired. Drinking water is available only at the Visitor Center. The white sand reflects sunlight. Protect all exposed skin from sunburn. Protect your eyes by wearing sunglasses. We recommend that you do not hike alone."
- "It was the perfect storm for this family. They started off the trek with two 20-ounce (.6 L) bottles of water. When we got there, there was no water left in the bottles."
- He added, "I just think they weren't prepared for that type of heat. I just think they underestimated the desert."

Desert Heat

Associated Press, August 7, 2015

- **White Sands National Monument, New Mexico**

Desert Heat

Associated Press, August 7, 2015

- **White Sands National Monument, New Mexico**

Heat Stroke

- **Definition:**
  - T > 40.5º C
  - Mental status changes
  - Organ dysfunction
  - Failed sweating
- **Too simplistic**

Heat Stroke

Two types:

- **Classic heat stroke**
  - Caused by high environmental temperatures
- **Exertional heat stroke**
  - Due to strenuous physical exercise
  - Usually along with high environmental temperatures and /or conditions of high humidity

Epidemiology

- CDC
  - 1979-1999 = 8015 deaths in the U.S.
  - Precise incidence is unknown
- Mortality rate for heat stroke
  - 10-70%
  - Greatest numbers of deaths occur when treatment is delayed for > 2 hours
- Heat wave
  - 3 or more consecutive days of air temp > 32.2^{o} C (90^{o} F)
- Critical Thermal Maximum
  - Body temp 41.6^{o} C to 42^{o} C for between 45 min and 8 hrs
  - > 49^{o} C, all cellular structures are destroyed < 5 min

Predisposing Factors

- Alcoholism
- Cardiovascular disease
- Dehydration
- Extremes of age
  - <15 yrs or > 65 yrs
- Skin altering conditions
  - Psoriasis, eczema, burns
- Lack of air conditioning in the home
- Living in a multistory building
- Low socioeconomic status
- Obesity

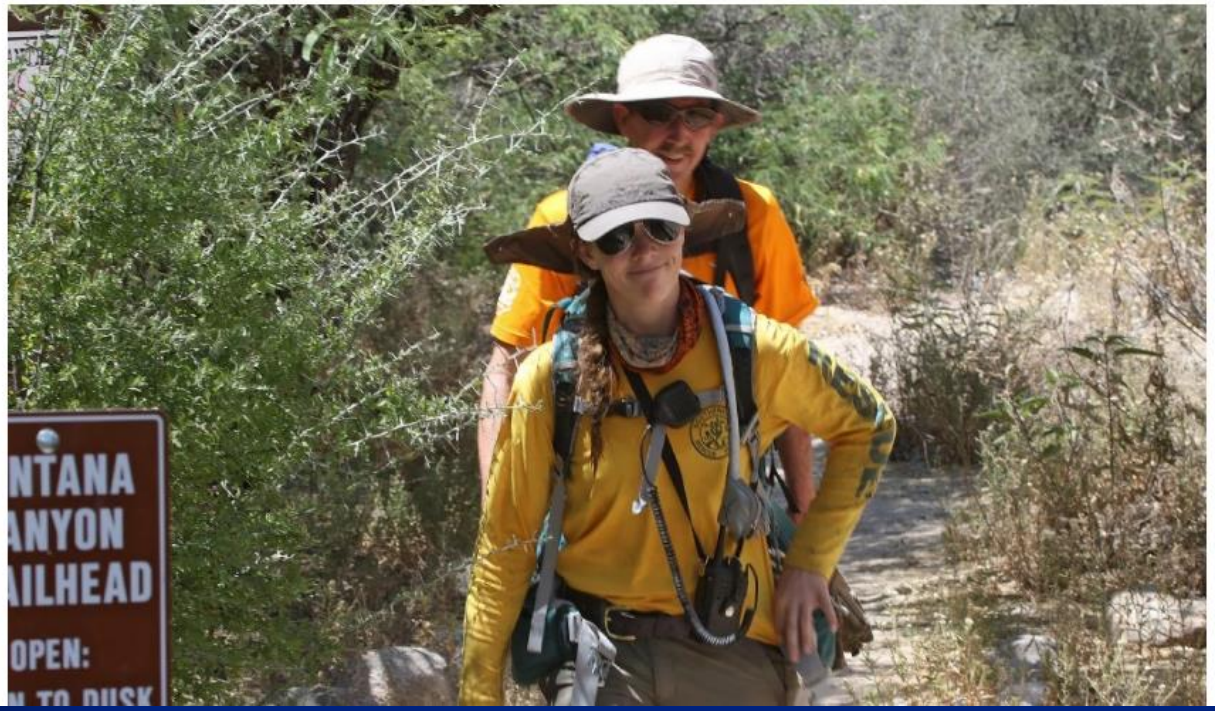
Predisposing Factors

- Occupations or prolonged exertion
  - Athletes, military, miners, firefighters, disaster workers
- Medications
  - Impair thermoregulation
    - » Diuretics, beta blockers, anticholinergics, alcohol
  - Increase metabolic heat production
    - » Sympathomimetics
- Previous history of heat related illness
- Prolonged sun exposure
- Wearing excessive clothing
- Sickle cell trait

Morning Mix

‘100 percent avoidable’: Hiker deaths mount in blazing Arizona heat wave

By Fred Barbash and Travis M. Andrews June 22 at 6:59 AM



•The Washington Post, June 22, 2016

Hiker deaths mount in blazing Arizona heat wave

The Washington Post, June 22, 2016

- The Pima County Sheriff's Department said Tuesday that after a day-long search in heat-scorched Ventana Canyon they had recovered the body of 33-year-old Marcus Turowski. He was one of three men from Germany who set off hiking over the weekend, only one of whom returned alive.
- They were hiking on the Ventana Canyon Trail in the Santa Catalina Mountains just north of Tucson on Sunday, but heat in Arizona soared dramatically. That day, for example, temperatures rose to 120 degrees, breaking the record in Yuma, Ariz., set in 1960 by 5 degrees.
- As temperatures began cresting above 115 degrees in the mountains, the heat drained the hikers and their strength so insidiously that only one could walk to summon help. The others lay helpless, baking on the trail.

Pathogenesis

- Genetic polymorphisms

- Thermoregulatory failure
  - Maintain body temp of 37º C
  - Excess heat through skin and respiratory systems
  - Thalamic thermoregulatory center stimulated by 1º C rise
    - » Sweating and tachypnea
  - 1.7 ml sweat = 1 kcal of heat energy dissipated
    - » Dehydration and salt loss occur concurrently
  - Skin blood flow
    - » Increase from 0.2-0.5 L/ min to 7-8 L/min

Pathogenesis

- **Acute Phase Response to Heat**
  - **Pathophysiologic sequence of events is similar to sepsis**
    - » **IL-1, IL-6, TNF-a, leukocytosis, acute phase proteins**

- **Heat-Shock Proteins**
  - **Controlled at the level of the DNA**
  - **Produces a transient tolerance to heat stress**

GI Bleeding

Hyperthermia effects:

- **Opening tight junctions**
  - **Can occur at temps as low as 38.3ºC**
  - **Large molecules penetrate with temp > 41.5ºC**
- **Damaging cell membranes**
- **Stimulates production of nitric oxide**
- **Stimulates production of free radicals**
- **Secretion of pro inflammatory cytokines**
  - **i.e. IL-1, TNFα**

GI Bleeding

GI Barrier Dysfunction after EHS-Induced Collapse

- **Reperfusion injury**
  1. **Free radicals**
  2. **Increased release of cytokines**
  3. **Migration of macrophages**
  4. **Increased free radicals**
- **GI Bleeding**
- **Translocation of gut bacteria**

Time

- **Even with return of core body temperature to normal, heat stroke victims status may continue to decline.**
  - **Disseminated intravascular coagulation**
  - **Rhabdomyolysis**
  - **Hepatic failure**
  - **Acute renal failure**
  - **Heart failure**
  - **Pulmonary injury**
  - **Endocrine disarray**

Differential Diagnosis

- Delirium tremens
- Encephalitis
- Hyperthyroidism
- Thyroid storm
- Meningitis
- Septic shock
- Hypothalamic infarct
- Typhoid fever

Differential Diagnosis

- **Drug induced**
  - **Anticholinergic**
  - **Uncoupling of oxidative phosphorylation**
  - **Malignant hyperthermia**
  - **Serotonin syndrome**
  - **Neuroleptic malignant syndrome**
- **Drug withdrawal**

Clinical Management

- **Prompt fluid resuscitation with crystalloid**
  - **Isotonic sodium chloride**
  - **NOT Ringer's Lactate**
    - » **Liver unable to metabolize lactate effectively**
- **Continuous temp monitoring**
  - **Rectal or foley temp probe**
- **Dantrolene**
  - **Questionable benefit**
- **NSAIDS, ASA, APAP**
  - **Potentially dangerous**

Clinical Management

- **Rapid cooling**
  - **Decreasing the core temp < 38.9° C within 30 min**
    - » **Improves survival and minimizes end-organ damage**
    - » **Shoot for 0.2° C/ minute**
  - **Water immersion**
    - » **Water conduction is 25 times that of air**
    - » **Goal is < 39° C (102° F)**
  - **Evaporative cooling**
    - » **Spraying water over nude body with fanning**
      - **3 fold lower cooling rates**
  - **Ice pack application**
    - » **Additive with evaporative cooling**
  - **Iced peritoneal lavage and gastric lavage**
    - » **Not superior to evaporative cooling**

Missing hiker found dead in Fayston

Posted: May 06, 2014 6:02 PM EDT
Updated: May 08, 2014 5:00 PM EDT

FAYSTON, Vt. - Tragedy on the trails in Fayston. A missing 22-year-old hiker has been found dead off the Long Trail. Police say Monday night the hiker called his family for help saying he was drenched, cold and missing a shoe. They feared he may be hypothermic and tried to save him on their own.

"It's just a tragic event, it's terrible, and it's just too bad," said Capt. Bob Cushing of the Vermont State Police.

Police say the 22-year-old hiker headed out Monday for a 3-5 day trek. They tell us his journey started on the Hedgehog Trail off Big Basin Road in Fayston. His plan was to connect with the Long Trail 2 miles from his starting point. But around 10 p.m. that night, authorities say he called his dad.

"He reached out to family members via cellphone and basically said that he was cold and wet. Family members tried to guide him out of the woods via cellphone and initiated a search on their own looking for him," Cushing said.

Authorities say communication cut out between the hiker and his family, and his loved ones were unable to find him. Tuesday morning they called police for help.

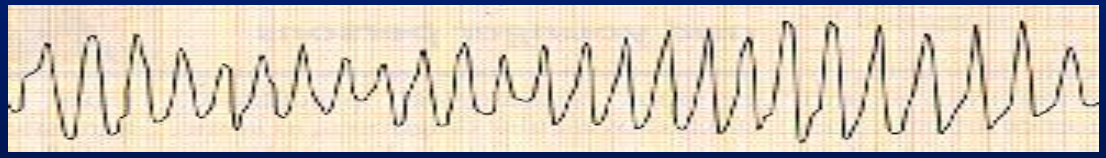
"We initiated a search for the gentleman and late [Tuesday] afternoon a helicopter from the National Guard located him," Cushing said.

From the air, the hiker's body was spotted in the backcountry off the Long Trail. Investigators say he was carrying 70 pounds of gear prepared to camp overnight, but was not in a tent or shelter when rescuers found him dead. They say his equipment and experience may not have been enough for the conditions.

- http://www.wcax.com/story/25446236/missing-hiker-found-dead-in-fayston

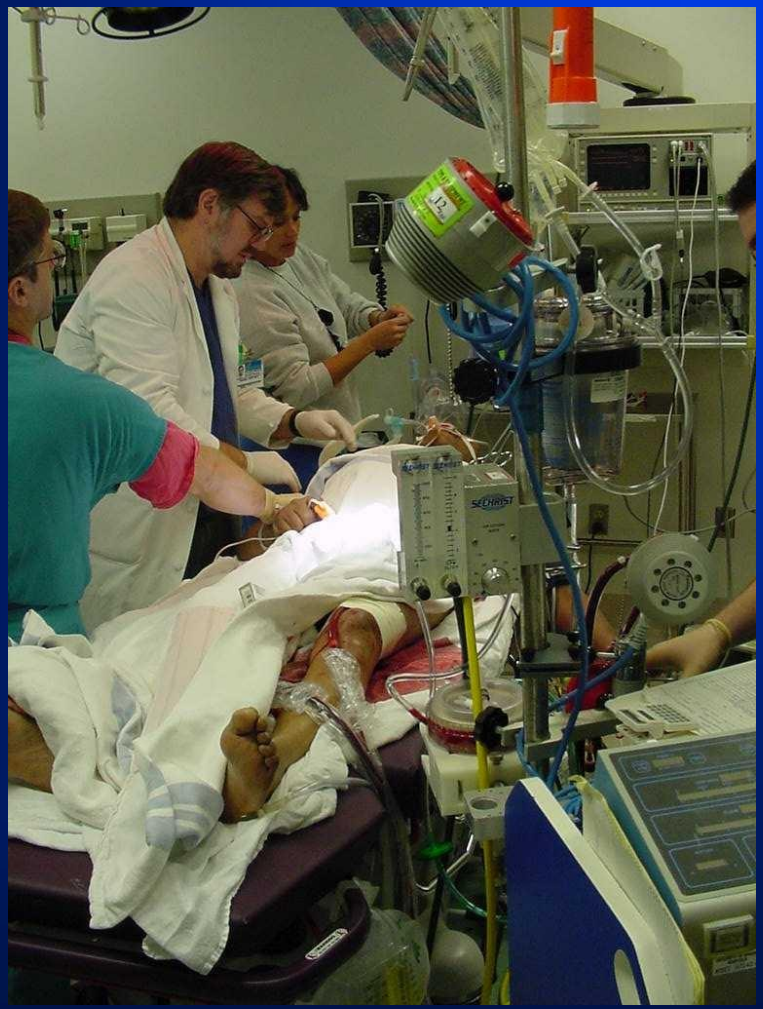
Case 2

- December 7th, 2001 - shift change 0700
- Stretcher passes by with unresponsive male
- History of ethanol abuse
- Found on sidewalk, unknown time down
- Upon transferring to ED stretcher, the patient goes into a wide complex dysrhythmia.
- Doppler blood pressure of 50.



Now what?

Case 2



Cold illness

Baron Dominique Larrey, Napoleon's military surgeon, while on retreat from Moscow, 1812:

"The natural heat is absorbed and a discharge of calorick takes place, the pores close, and the capillary vessels fall into a state of contraction: the fluids are condensed and flow more slowly."

Cold illness

Frostnip

- Definition
  - » Nonfreezing injury of the skin tissues
- Usually involves the fingers, toes, ears, cheeks, and chin.
- Numbness and tingling may be present
- No tissue injury occurs.
- Full recovery is the rule.

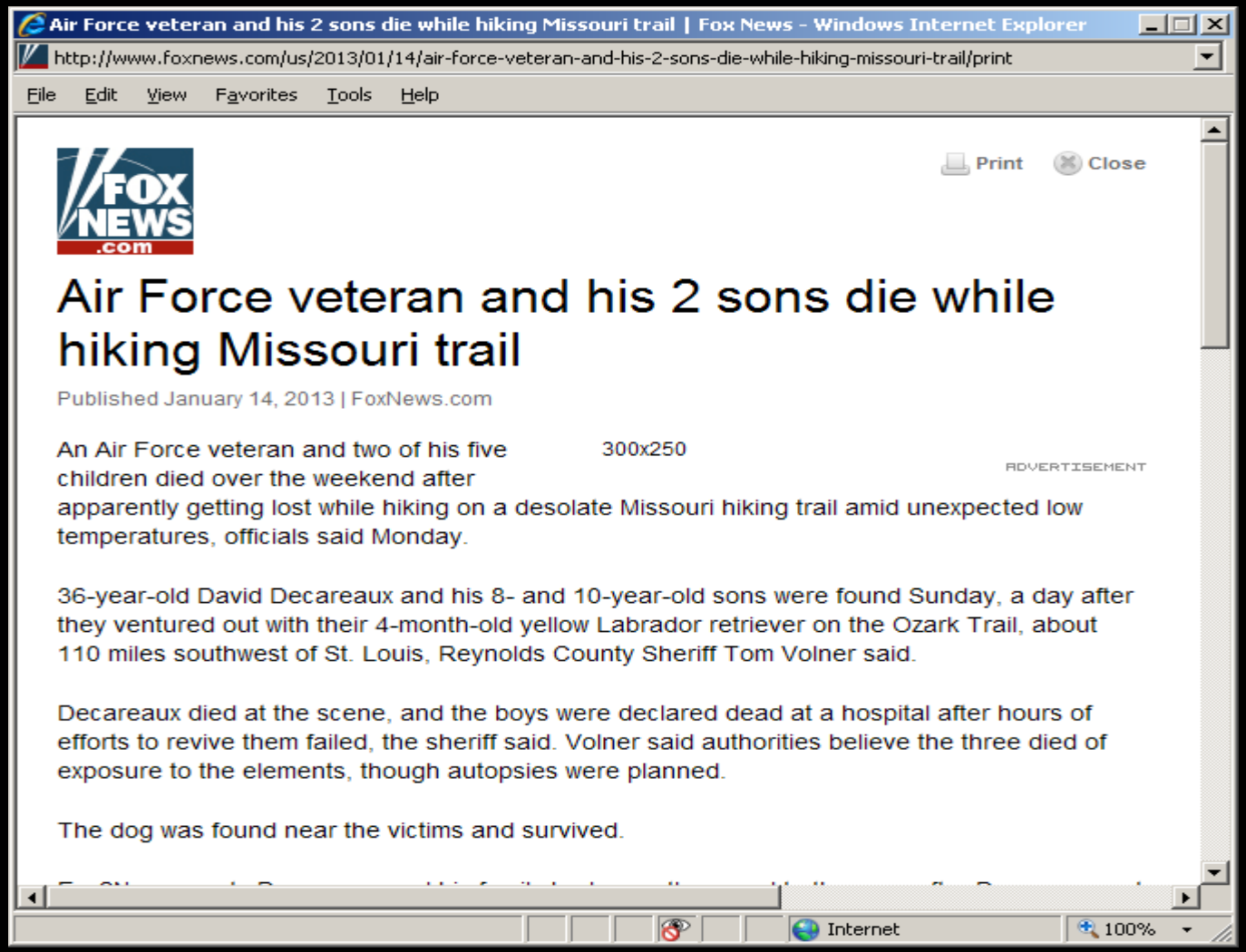
Cold illness

Cold illness

Chilblains (pernio)

- Red, pruritic lesions
- Prolonged exposure to above freezing temperatures in the presence of high humidity
- Self-limited without injury

Cold illness



- http://www.foxnews.com/us/2013/01/14/air-force-veteran-and-his-2-sons-die-while-hiking-missouri-trail/

Air Force veteran and his 2 sons die while hiking Missouri Trail

By Jim Suhr 03/16/2013

- On a weekend trip that was a surprise anniversary gift for his wife, an outdoors-loving Air Force veteran ventured out with two of his sons for a hike on a remote trail. Clad only in light jackets and sweaters, the three apparently didn't know how rapidly the weather would turn ugly, and that proved deadly.
- Searchers found the soaked bodies of 36-year-old David Decareaux and the two boys – ages 8 and 10 – on the Ozark Trail on Sunday, a day after Decareaux declined a passerby's offer of a ride back to the lodge where they had been staying. The cold had killed them.
- Only the family's 4-month-old yellow Labrador retriever survived the hike. He was found near Decareaux, who died at the scene, and the two boys, who were declared dead at a hospital after hours of efforts to revive them failed.

•http://www.huffingtonpost.com/2013/01/14/david-decareaux-and-2-son_n_2474411.html?

Air Force veteran and his 2 sons die while hiking Missouri Trail

By Jim Suhr 03/16/2013

- It was nearly 60 degrees Saturday morning when Decareaux and his sons set out on the popular trail that runs through a sparsely populated area of southeast Missouri.
- Decareaux was wearing only a light jacket, while one of his sons was clad in a fleece pullover, and the other a sweater, Volner said.
- They were ill-equipped as the temperature sank into the 40s, and a storm that would drop 2 inches of rain set in, making the trail all but impassable.
- Volner said there are no caves or other places of refuge along the trail. Although Decareaux had a cellphone and flashlight with him, both devices lost power at some point.

Air Force veteran and his 2 sons die while hiking Missouri Trail

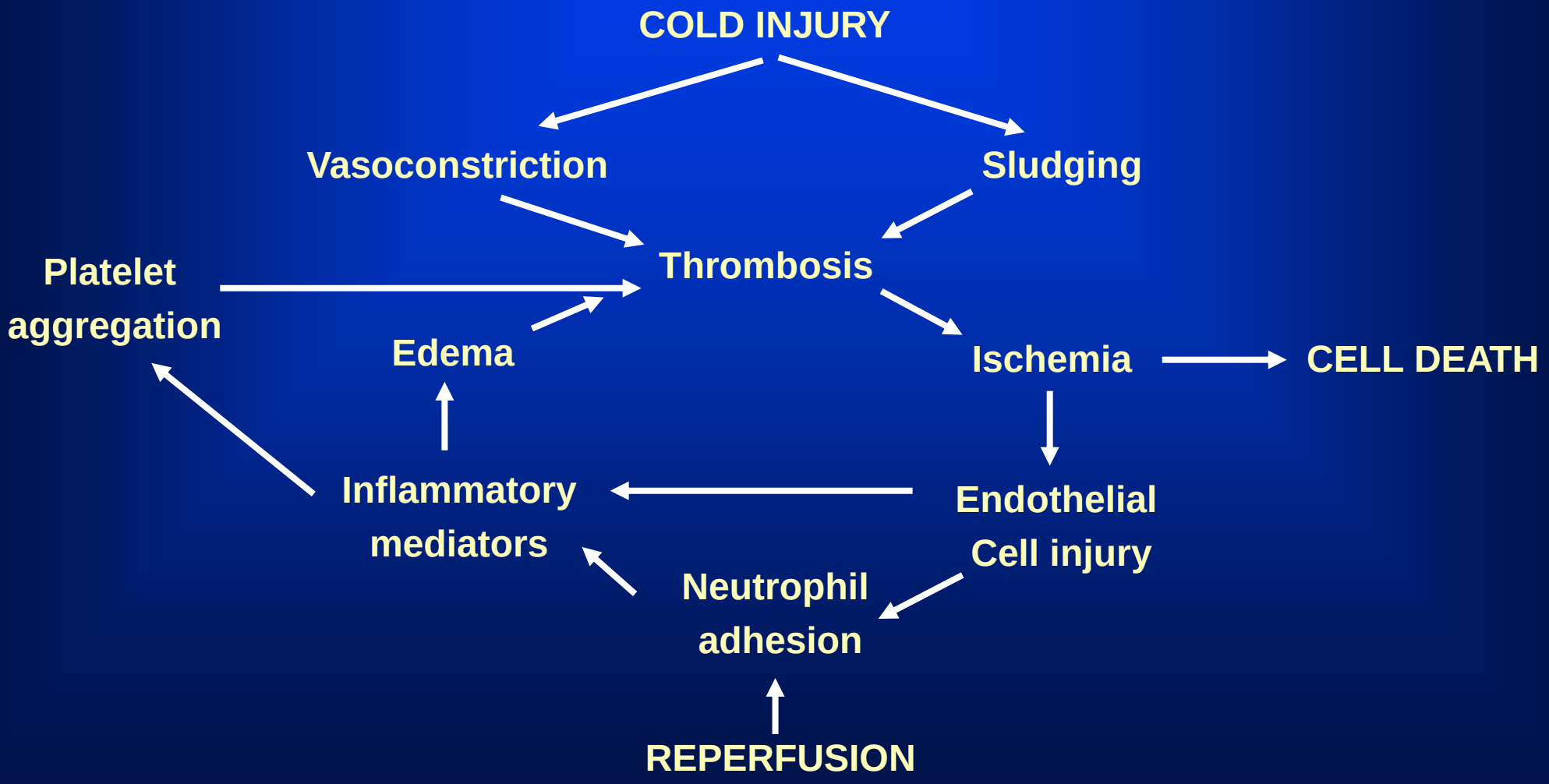
By Jim Suhr 03/16/2013

- A passer-by spotted the hikers more than 3 hours into their journey and asked if they needed a ride back to the Brushy Creek Lodge near Black, where Decareaux's wife and their three other children – ages 12, 4 and 2 – were staying. But Decareaux declined, telling the man they could make it back, the sheriff said.
- "They just missed their turn back to the lodge," the sheriff said. "By that time, their light played out. You don't have any ambient light down here because there are no cities or towns. When it's dark you can't see the back of your hand."
- Officials at the lodge called the sheriff's department about 7 p.m. Saturday, concerned that the hikers had not returned. A search involving more than 50 volunteers on foot, horseback and in vehicles lasted until about 12:30 a.m. Sunday, when flash-flooding in creeks forced searchers to back off until daylight.
- By then, it was freezing, and the temperature had dipped to the upper 20s by sunrise.
- It wasn't long after that their drenched bodies were found, dog beside them.

Frostbite

- **Definition**
  - The acute freezing of tissues when exposed to temperatures at or below the freezing point of intact skin.
- **Epidemiology**
  - Valnicek SM Plast Resonstr Surg 1993;92:633
  - 12-year time period:
    - 46% ethanol consumption
    - 17% psychiatric illness
    - 19% vehicular trauma
    - 15% vehicular failure
    - 4% drug misuse
- **The degree of irreversible damage is related to the length of time the tissue remains frozen.**

Pathophysiology



Frostbite

Classification:

- **First Degree**
  - **Numb central white plaque with surrounding erythema**
- **Second Degree**
  - **Blister formation with surrounding erythema**
- **Third Degree**
  - **Hemorrhagic blisters result in eschar 2 weeks later**
- **Forth Degree**
  - **Complete necrosis and tissue loss**

Frostbite

Classification:

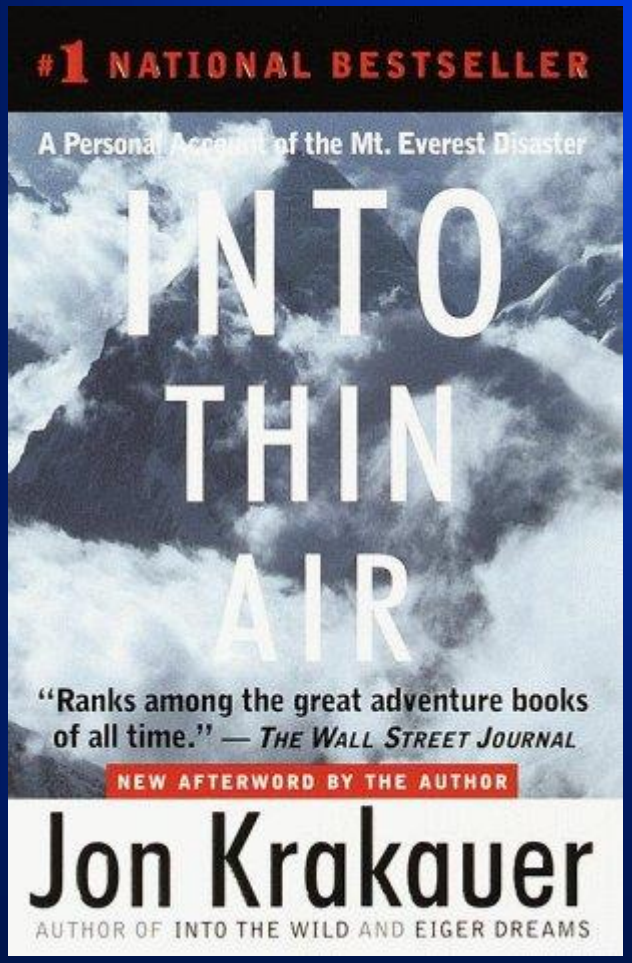
- **Superficial (1º & 2º)**
  - affects skin and subcutaneous tissues
  - rewarmed skin has clear blisters
  - retained sensation

- **Deep (3º & 4º)**
  - affects bones and tendons
  - rewarmed skin has hemorrhagic blisters
  - nonblanching cyanosis
  - loss of sensation

- ***Not proven useful in predicting the extent of damage or clinical outcome***
- ***Management initially is the same***

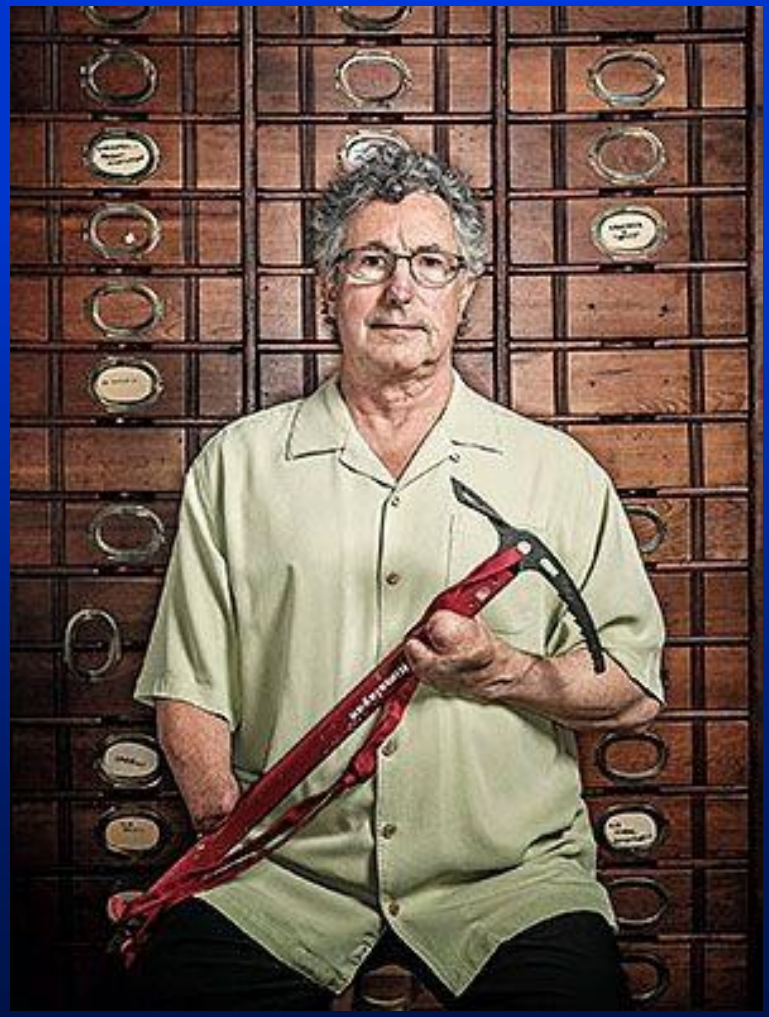
Frostbite

Frostbite



Beck Weathers

Frostbite



Frostbite

Frostbite

Frostbite

Frostbite Treatment

- Remove non-adherent wet clothing
- Avoid rubbing affected tissue
  - worsens damage
- Rapid rewarming of frostbitten extremity
  - Water temp between 40^{o}C – 42^{o}C for 30 minutes
- Aloe vera application every 6 hours
- Elevate affected part(s) with splinting
- Administer antitetanus
- Ibuprofen 400 mg every 12 hours
- Prohibit smoking
- Blisters – excision is controversial

Frostbite Research

- Low-molecular weight Dextran
  - Decrease the sludging
- Anticoagulation
  - No evidence that heparin alters outcome
- Vasodilators
  - Rapid rewarming was as effective as any drugs
- Thrombolysis
  - TPA, studies early but potential benefit
- Hyperbaric oxygen
  - Controversial

FACEBOOK

Kate Matrosova and her husband Charlie Farhoodi.

New Hampshire mountain hiker who activated beacon found dead

Posted: Feb 16, 2015 6:45 PM EST
Updated: Feb 16, 2015 6:45 PM EST

LANCASTER, N.H. (AP) - A hiker who activated an emergency personal locator beacon in New Hampshire's White Mountains amid brutal weather conditions has been found dead.

The state's Fish and Game Department says New York City resident Kate Matrosova's body was found Monday afternoon between Mount Madison and Mount Adams near Star Lake.

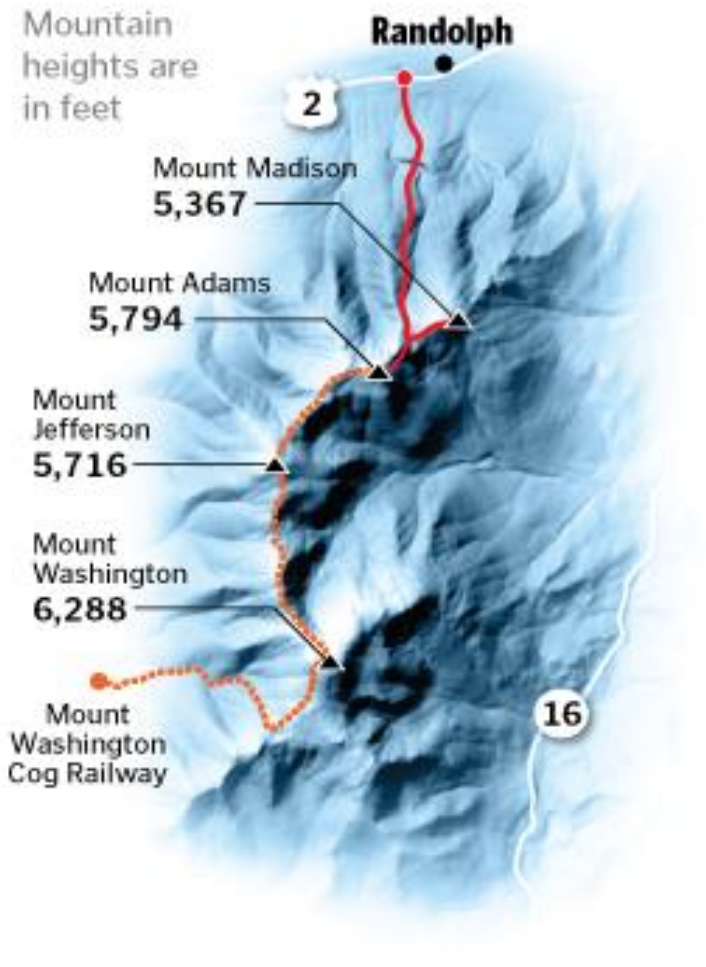
Matrosova activated the beacon Sunday. Search and rescue crews couldn't reach the area overnight because of extreme wind and subzero temperatures. A National Guard crew flew over the area with a helicopter Monday morning but couldn't see anything because of blowing snow.

A team made up of Fish and Game officers, Mountain Rescue Services members and Androscoggin Valley Search and Rescue members braved 108 mph winds and subzero temperatures to reach the area. They say it appears Matrosova died of exposure to the extreme temperatures.

- http://www.wcax.com/story/28122108/new-hampshire-mountain-hiker-who-activated-beacon-found-dead
- http://www.bostonglobe.com/metro/2015/02/21/the-young-woman-and-mountain/SEBPucaGpA1Fun4R5uoj7K/story.html

Matrosova's planned hike The Northern Presidential Traverse is a path that runs along the summits of the northernmost mountains of the Presidential Range in the White Mountains and includes Madison, Adams, Jefferson, and Washington mountains.

FACEBOOK



The young woman and the mountain

Boston Globe, Nestor Ramos, February 22, 2015

- http://www.wmur.com/news/rescuers-search-for-missing-hiker-near-mt-adams/31294362

MATT BOWMAN/AVSAR

An Androscoggin Valley Search and Rescue team and Mountain Rescue Service team searched for Matrosova. Her body was found 22 1/2 hours after her distress call.

PAUL HAYES FOR THE BOSTON GLOBE

Signs at the start of the trail warn potential hikers about the dangers and lack of shelter ahead.

During winter in the Whites, the narrowest line is the one between life and death.

PAUL HAYES FOR THE BOSTON GLOBE

Hypothermia

Hypothermia

- Defined as core temperature of less than 35° C

- **Mild**
  - Core temp 32° C - 35° C
- **Moderate**
  - Core temp 28° C - 32° C
- **Severe**
  - Core temp < 28° C

Cold Related Illness

- **Sources**
  - Social (i.e. homeless, inadequate heating)
  - Occupational
  - Recreational
  - Iatrogenic
  - Criminal
- **Epidemiology**
  - Unknown
  - Hospital data “tip of the iceberg”

Factors that Increase the Risk

- Infancy
  - High ratio of body surface area to mass
- Advanced age
  - Decreased capacity for metabolic heat production & vasoconstriction
- Malnutrition/Exhaustion
  - Decrease in fat/muscle and less food available for heat generation
- Drug use
  - Ethanol – impairs judgment and shivering, causes vasodilation
  - Sedatives – impairs judgment
  - Clonidine & neuroleptics – inhibit shivering
- Hypothyroidism
  - Decreased metabolic heat production
- Diabetes
  - Peripheral & autonomic neuropathy

Factors that Increase the Risk

- Peripheral vascular disease
- Peripheral neuropathy & Spinal cord damage
  - Impaired nociception, vasoconstriction
- Trauma
  - Unable to extricate
- Sepsis

Pathophysiology

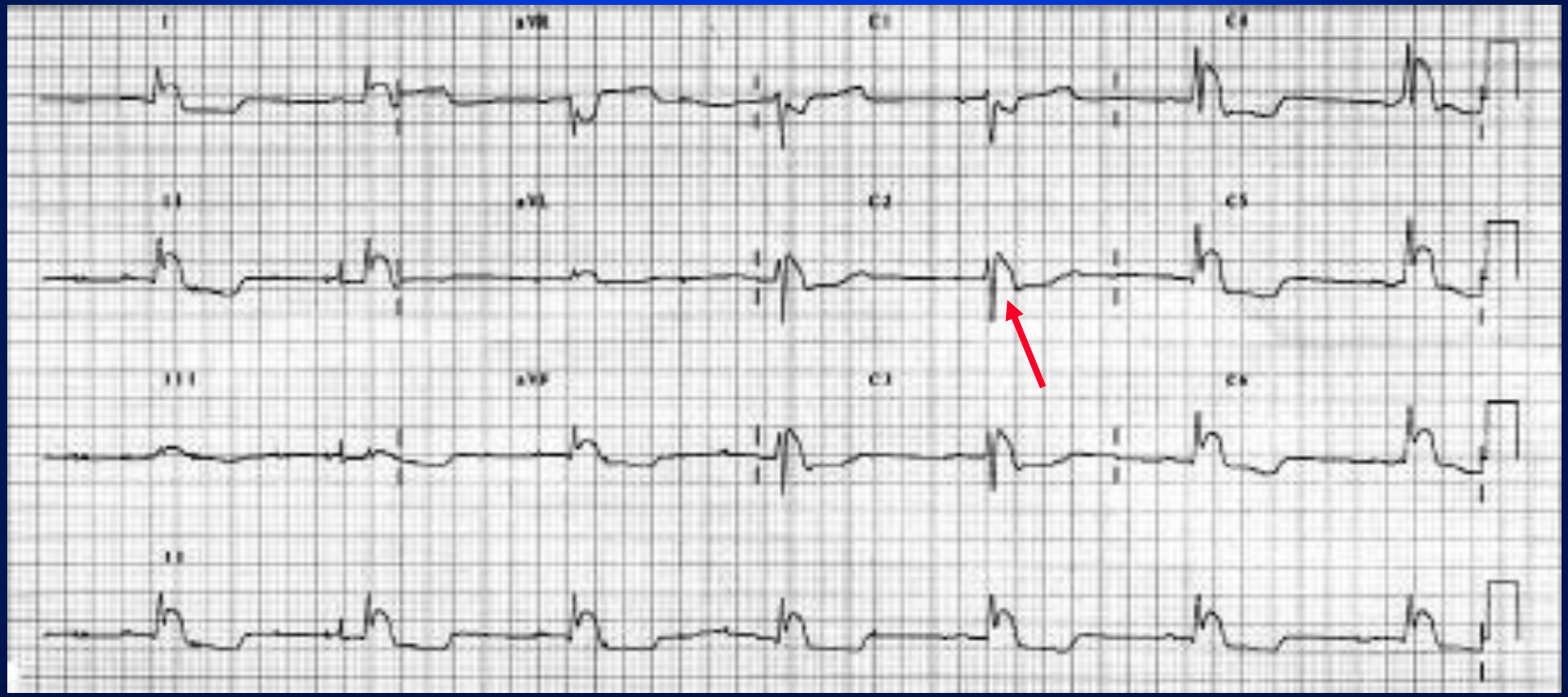
- **Preoptic hypothalamus**
  - controls heat conservation, triggers sympathetic activity
- **Cellular effects**
  - Intracellular water crystallization
  - Temperature induced protein changes
    - » Cooling crystallizes extracellular water, drawing water out of the cell, altering intracellular electrolyte concentrations, and damaging protein structure.
  - Membrane damage
- **Vascular insufficiency**
  - Vasoconstriction
  - Endothelial injury
  - Thromboembolism

Pathophysiology

- “Cold diuresis”
  - defect in distal tubular sodium and water reabsorption, cold induced glycosuria, or inhibition of antidiuretic hormone.
- Acidemia
  - Lactic & respiratory acidosis
- Shock
  - Decreased cardiac contractility
  - Volume depletion
  - Fluid sequestration in tissues

Electrocardiogram

J or Osborn waves



Electrocardiogram

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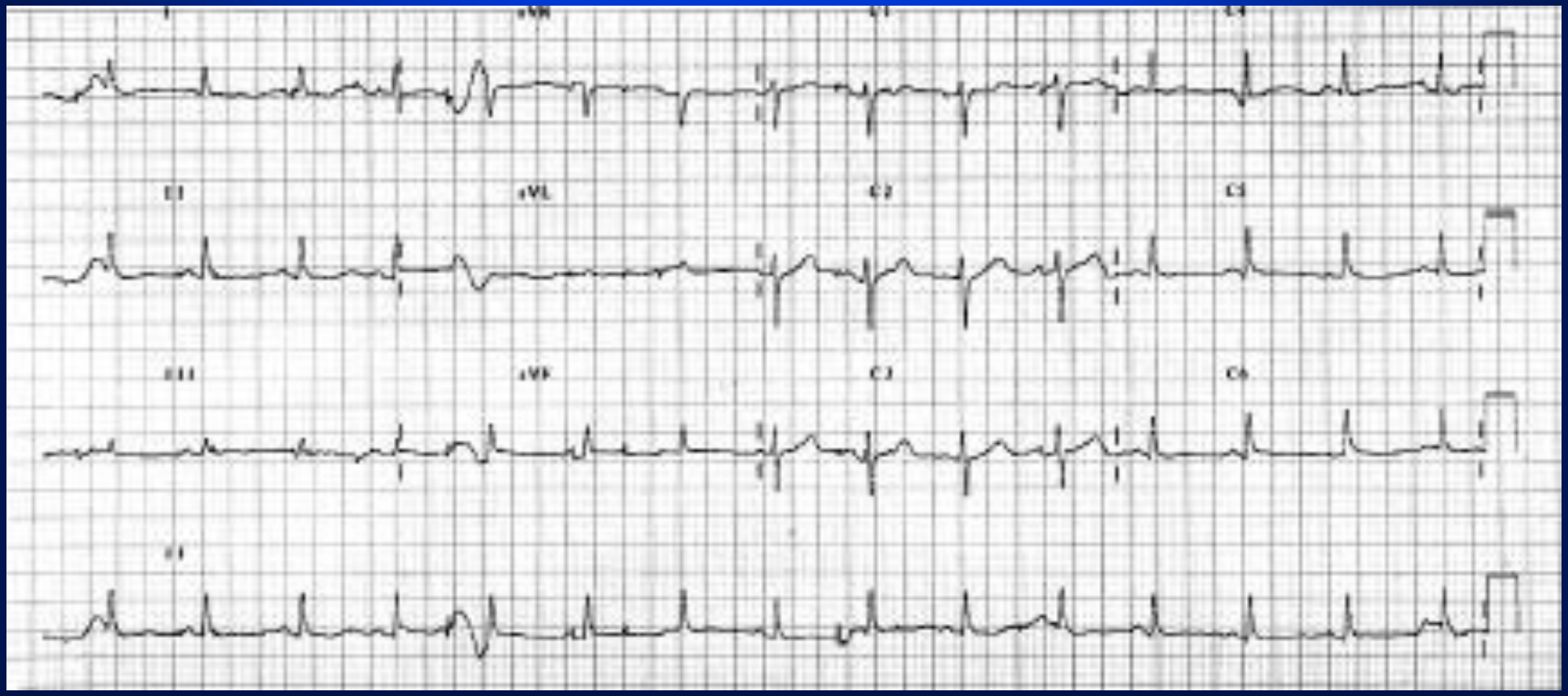

Rewarming Techniques

- **Paucity of controlled trials of rewarming techniques in accidental hypothermia**
  - **Intraoperative hypothermia, experimental hypothermia, case series, case reports**
- **Passive rewarming (mild hypothermia)**
  - **Blankets and shivering**
  - **Rate of rewarming is 0.5^{o} C – 2^{o} C per hour**

Rewarming Techniques

Active rewarming

- **External (mild and moderate hypothermia)**

  Heating blankets

  – Kober A. Mayo Clin Proc 2001;76:369-75

  – Randomized trial 80 patients with minor trauma and hypothermia, heating blankets warmed at rate of 0.8^{o} C/hr.

  Heated forced air

  – Steele MT. Ann Emerg Med 1996;27:479-84

  – Randomized trial of 16 patients with moderate to severe hypothermia, forced air systems heated 1^{o} C per hour faster than cotton blankets.

Rewarming Techniques

Active rewarming

- **Internal (severe hypothermia)**

  Simple techniques (1°C – 2°C per hour)

  – **Warmed intravenous fluids (43°C)**

  – **Warmed oxygen**

  Heated irrigation techniques (1°C – 4°C per hour)

  – **Peritoneal exchange**

  – **Thoracostomy lavage**

  – **Esophageal warming tubes**

  Extracorporeal (1°C – 2°C per hour)

  – **Arteriovenous or venovenous rewarming**

  – **Heated hemodialysis**

  – **Cardiopulmonary bypass (cardiac arrest cases)**

To build a fire

Jack London