Hypothermia in the Trauma Patient

Friend or Foe?

Clark Hayward EMTP, AWLS

10/2/10

Hypothermia in Trauma What happens?

"From the time of injury, trauma itself alters the normal central thermoregulation and blocks the shivering response."

Betty J. Tsuei*, Paul A. Kearney, *Hypothermia in the trauma patient* Injury, Int. J. Care Injured (2004) 35, 7 15

"Based upon our findings, accidental hypothermia poses a relevant problem in the prehospital treatment of trauma patients. It is not limited to a special season of the year."

From: Helm M, Lampl L, Hauke J, Bock KH. Accidental hypothermia in trauma patients. Is it relevant to preclinical emergency treatment? *Anaesthesist* 1995;44(2):101-107

Hypothermia in Trauma

"It is estimated that as many as 66% of all trauma patients arrive into the emergency room with hypothermia."

Baylor University Medical Center

A critical element of trauma care is to prevent hypothermia in the injured patient.

"Most traditional methods of maintaining trauma patient temperature during prehospital transport appear to be inadequate."

From: Watts DD, Roche M, et al. The utility of traditional prehospital interventions in maintaining thermostasis. *Prehosp Emerg Care* 1999;3(2)115-122

Objectives

- Review physiology of thermoregulation
- Discuss complications of hypothermia in injured patients
- Discuss the pathophysiology of the "Lethal Triad"
- Review current prehospital prevention and treatment
- Discuss Therapeutic Hypothermia

Outcomes

• Recognize the importance of early identification of at-risk/high susceptibility trauma patients

•Describe the pathophysiology of the "Lethal Triad" and its significance in trauma mortality and morbidity

•Use the knowledge gained to improve outcomes for trauma patients

Case Study

04:35 - Dispatched to a rural area for a 34 YO male, self inflicted GSW, patrol enroute.

04:51 - Arrive to find scene secured by PD, male victim supine in parking area of popular local hunting spot, attended by companion (local VFD EMT) holding direct pressure to upper right thigh area. Obvious significant blood loss.

Case Study

Victim states that he leaned his rifle against car and bent over to tighten boots when the rifle fell over and discharged with bullet striking him in right thigh.

Case Study

You assist with DP and additional dressings while partner applies O2 NRB takes initial vitals and prepares for vascular access.

Vital signs @ 04:55

- LOC = A&O
- Skin = pale, moist, cool
- P = 128 R
- BP = 102/74
- R = 26 S

Case Study

Bleeding continues despite DP and you adjust area of pressure after visualization of wound area, bleeding slows. Partner has gained IV with NS wide open. Pt. is moved to backboard, secured and loaded to stretcher, moved to rig and you begin transport to trauma center @ 05:09.

Physiology of Thermoregulation

Physiology of Thermoregulation

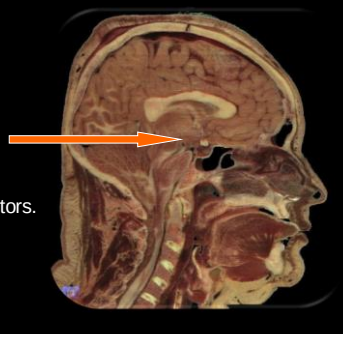
- Homeostasis requires constant body temp of 98.6F.
- Humans are tropical animals.
- Mechanism for losing heat is more efficient than mechanism for retaining heat.

Physiology of Thermoregulation

- Thermoregulation is controlled by 2 primary mechanisms.
  1)Hypothalmus
  2)Peripheral Thermoreceptors in tissues of skin, muscle, bone.

Physiology of Thermoregulation

The ***Hypothalmus*** is just superior to the *Pituitary Gland* and monitors blood temp and feedback from peripheral thermoreceptors.

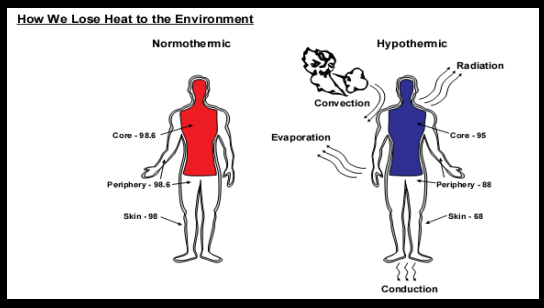


Temperature Homeostasis

- Opposition of Heat Loss
  - Hypothalamus
    - Stimulation of sympathetic nervous system if temp below 'set point' of 98.6F.
  - Behavioral responses
    - Wearing clothes when it's cold
    - Leaving cold environment
- Heat Gain
  - Shivering
  - "Non-shivering thermogenesis", metabolism of fats and carbs.

Heat Loss

- Conduction
  - Transfer of heat by direct contact down temperature gradient.
- Convection
  - Transfer of heat by movement of heated material. (i.e. wind)
- Radiation
  - Loss of heat from non-insulated areas.
- H_2O Evaporation
  - Loss of heat when moisture evaporates from skin.
- Respiration



Populations at Risk for Hypothermia

- Elderly
- Very young
- Intoxicated individuals
- People involved in cold weather outdoor activities
- Trauma patients

Populations at Risk for Hypothermia

All those at risk categories can also be trauma patients!

Hypothermia

- **Epidemiology**
  - Defined as temp <35^{O} C (<95^{O} F)
  - >700 die each year in US from hypothermia
  - ½ of those are 65+ years old
  - Individuals at age extremes and those with AMS are at greatest risk

Specific Risk Factors

- Immobility
- Wet clothing
- Windchill
- Lying on a cold surface
- Any conditions that cause loss of consciousness, immobility, or both (eg., hypoglycemia, seizure disorders, stroke, drug or alcohol intoxication, trauma) are common predisposing factors.

Etiology of Hypothermia

- Accidental
  - Immersion and non-immersion cold exposure
    - Cold, wet, wind (*"E-C-C-R-R"* heat loss)
- Metabolic
  - Hypoendocrine states (hypothyroid, hypoadrenalism, hypopituitarism)
  - Hypoglycemia
- Tumor – can interfere with thermoregulatory response.
- Trauma – can alter clotting mechanisms

Etiology of Hypothermia (cont.)

- Wernicke's Disease
- Drug induced
  - Alcohol *(majority of hypothermic pt's in US are intoxicated!)*
  - Sedatives
  - Tricyclics
  - Insulin
- Sepsis

Etiology of Hypothermia (cont.)

- Severe dermal disease
  - Burns
  - Exfoliative dermatitis
- Acute incapacitating illness
  - Severe infections
  - DKA
  - Psychotic disorders
  - Other conditions causing impaired thermoregulatory function
- ***Resuscitation with room temperature fluid!!***

Hypothermia Classes

- Mild hypothermia (32-35° C)(90-95F)
  - Lethargy
  - Confusion
  - Shivering
  - Loss of fine motor coordination
- Moderate hypothermia (28-32° C)(82-90F)
  - Delirium
  - Loss of gross motor coordination
- Severe hypothermia (<28° C)(<82F)
  - Very cold skin
  - Unresponsive
  - Coma
  - Difficulty breathing
  - Abnormal heart rhythms
  - Frozen chest

Pathophysiology

- **Mild hypothermia** (32-35° C) – "*Excitation Phase*"
  - Between 34-35° C, most people shiver vigorously from all extremities.
  - As the temperature drops below 34° C, a patient may develop altered judgment, amnesia.
  - Respiratory rate may increase.
  - At 33° C, ataxia and apathy may start.
  - Patients generally are stable hemodynamically and able to compensate for the symptoms.

Hypothermia

- **Moderate hypothermia** (28-32° C) "*Adynamic phase*"
  - Oxygen consumption decreases, and the CNS depresses further.
  - Most patients with temperatures of 32° C or lower present in stupor.
  - As the core reaches temperatures of 31° C or below, the body loses its ability to generate heat by shivering.
  - At 30° C, patients become at risk for arrhythmias. Atrial fibrillation and other atrial and ventricular rhythms may present. The pulse continues to slow progressively, and cardiac output is reduced.
  - Between 28-30° C, pupils may become markedly dilated and minimally responsive to light, a condition that can mimic brain death.

Hypothermia

- **Severe hypothermia** (<28° C)
  - At 28° C, the body becomes markedly susceptible to ***ventricular fibrillation*** and further depression of myocardial contractility.
  - Rigidity
  - Apnea
  - No pulse
  - Areflexia
  - Unresponsiveness
  - Fixed pupils

Pathophysiology (cont.)

- Excitation Phase
  - Sympathetic response (HR, BP, and Cardiac Output all rise).
- Adynamic Phase
  - HR, CO, BP decrease due to negative ino/chronotropic (force/rate) effects of hypothermia, ECG changes.

Pathophysiology (cont.)

- **Hypothermic ECG changes**
  - Osborne or J waves
  - T-wave inversion
  - Prolonged PR, QRS, QT intervals
  - Arrhythmias may include bradycardia, slow AF, **VF**, or asystole

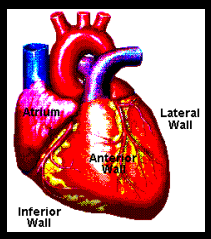
ECG Changes in Hypothermia

Localization of ECG Pathology

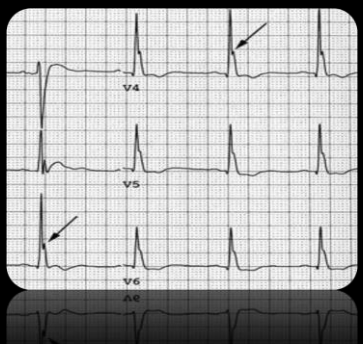
Inferior: leads II, III, and F (called the inferior leads) indicate pathology on the inferior or diaphragmatic surface of the heart.

Lateral: Leads I, F, and V5-V6 are called lateral leads. Abnormality in these leads indicates pathology on the lateral, upper surface of the heart.

Anterior: Anterior pathology is seen in leads V1-V4, and often in lead I.



Osborn "J" Wave



HYPOTHERMIA

In the Trauma Patient

Special Considerations

The Problem

Under-recognized

Under-treated

PHTLS

Major Concerns in Trauma Pt.

Body temperature

A low body temperature could indicate or precipitate syndromes that lead to the death of the patient.

Hypothermia in Trauma

Hypothermia is an ominous predictor of survival in trauma patients!

"Once hypothermia occurs it is difficult to correct. Efforts should be started in the field and continued as an integral part of the resuscitation process."

Peng RY, Bongard FS 1999 June *Journal of the American College of Surgeons*

Hypothermia in Trauma

Devastating consequences of hypothermia in trauma patients:

- *Cardiorespiratory compromise*
- *Decreased clotting mechanisms*
- *Decreased oxygen delivery*
- *Decreased metabolism*
- *Acidosis*
- *Increased risk of infection*

Adverse Effects of Hypothermia in Trauma

Cardiorespiratory

- Cardiac depression
- Myocardial ischemia
- Arrhythmias
- Peripheral vasoconstriction
- Impaired tissue oxygen delivery
- Elevated oxygen consumption during rewarming
- Blunted response to catecholamines
- Increased blood viscosity
- Metabolic acidosis
- Bleeding diathesis
  - Decreased kinetics of coagulation factors
  - Reduced platelet function

Adverse Effects of Hypothermia in Trauma

Reduced Clearance of Drugs

- Decreased hepatic blood flow
- Decreased hepatic metabolism
- Decreased renal blood flow

Adverse Effects of Hypothermia in Trauma

Increased risk of infection

- **Decreased white blood cell number and function**
  - Impaired cellular immune response
  - Thermoregulatory vasoconstriction

Wound infection

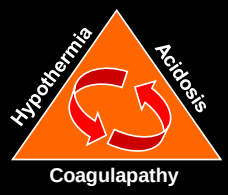
- Decreased subcutaneous oxygen tension
- Impaired oxidative killing by neutrophils
- Decreased collagen deposition
- Pneumonia
- Sepsis
- Insulin resistance with hyperglycemia

Consequences of Hypothermia in Trauma

The Lethal Triad

- *Hypothermia*
- *Acidosis*
- *Coagulopathy*

The Lethal Trauma Triad



Hypothermia – Trauma Pt.

The three mechanisms that contribute to hypothermia-induced coagulopathy in trauma:

1. Platelet Dysfunction
2. Enhanced Fibrinolytic Activity
3. Alteration In Enzyme Functions

Hypothermia – Trauma Pt.

- **Platelet Dysfunction**
  - Inhibition of Thromboxane B2 production causes the normal response of platelet aggregation to decrease. The platelets are therefore stored in the spleen and liver, and left unavailable for use**.**

Hypothermia – Trauma Pt.

- **Enhanced Fibrinolytic Activity**
  - Trauma-induced hypothermia causes a "heparin-like" substance to be released, thus causing a disseminated intravascular clotting (DIC)-like syndrome.
  - This is marked by an increase in prothrombin (PT) and partial thromboplastin times (PTT).

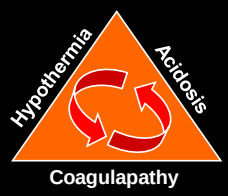
Hypothermia – Trauma Pt.

- **Alteration In Enzyme Functions**
  - Hageman Factor and Thromboplastin are needed to form clots at the site of injured endothelium.
  - Hypothermia alters the function of these enzymes and others, therefore increasing bleeding and clotting times.

Hypothermia – Trauma Pt.

- **Coagulopathy – Perpetuated**
  - Blood transfusions/fluid resuscitation may lead to or exacerbate hypothermia.
    - *Silbergleit et al* report that room (or ambient) temperature IV fluids, used in resuscitation, increase hypothermia or may actually cause secondary hypothermia in trauma patients.
    - Crystalloids dilute the availability of coagulation factors.

The Lethal Trauma Triad



Hypothermia in Trauma

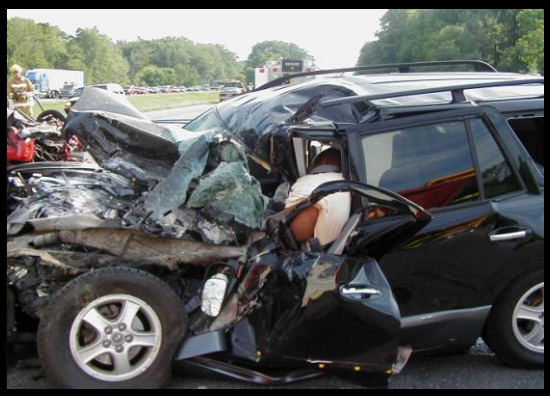
Mortality rates of Hypothermic Patients

Core temps (T)

- less than 34C (93F) = 40%
- less than 33C (91F) = 69%
- less than 32C (90F) = 100%

Whereas mortality if core T is greater than or equal to 34C (93F) = 7%

Jurkovich JG, Greiser WB, Luterman A, Curreri PW. Journal of Trauma. 1987 pgs. 1019-1024 ***Hypothermia in trauma victims: an ominous predictor of survival.***



Treatment

Prevention!

Prevention!!

Prevention!!!

Treatment

- Be aggressive
- Recognize MOI & potential
- Better to preserve as much warmth as possible
- If you're losing the battle, treat early

Treatment

- Remove wet clothing
- Place in warm blankets, hypo wrap etc.
- Place hypo wrap within vapor barrier
- Hot packs - neck, axilla, groin

Rewarming Tx.

- **Methods of Rewarming:**
  - Passive Rewarming
  - Active External Rewarming
  - Active Internal Rewarming

Rewarming Tx.

Passive Rewarming	Active Core Rewarming In-Hospital
▪ Removal from environment ▪ Insulation	▪ Inhalation rewarming ▪ Heated IV fluids ▪ GI tract lavage ▪ Bladder lavage ▪ Peritoneal lavage ▪ Pleural lavage ▪ Extracorporeal rewarming ▪ Mediastinal lavage
Active External Rewarming	
▪ Warm H_2O Immersion ▪ Heating blankets ▪ Heated objects ▪ Radiant Heat ▪ Forced air	

Rewarming Tx.

- **Active Rewarming of MILD Hypothermia:**
  - Active external methods:
    - Warm blankets
    - Heat packs
    - Warm water immersion (with caution)
  - Active internal methods:
    - Warmed IV fluids

Rewarming Tx.

- **Active Rewarming of SEVERE Hypothermia:**
  - Active external methods:
    - Warm blankets
    - Heat packs
    - Warm water immersion (with caution)
  - Active internal methods:
    - Warmed IV fluids
    - Warmed, humidified oxygen

Rewarming Tx.

- Maintain horizontal position
  - Vertical position may compromise cerebral and systemic perfusion
- Avoid rough movements and activities
- Handle victim gently during CPR, intubation, BVM ventilation, vascular access

Rewarming Tx.

- Rewarming of the SEVERE hypothermia patient is best carried out in the Emergency Department using a pre-defined protocol, unless travel time exceeds 15 minutes.
- Most patients who die during active rewarming die from ventricular fibrillation.

Rewarming Issues

- **Rewarming Shock:**
  - Occurs due to peripheral reflex vasodilation.
  - Causes the return of cooled blood and metabolic acids from the extremities.
  - May cause a paradoxical afterdrop in the core temperature further worsening hypothermia.

After-drop Phenomenon

Initial active external rewarming leads to

Peripheral vasodilation (BP drops)

Cold blood from dilated peripheral vessels carries high lactic acid levels to core vessels

Cold acidotic blood causes drop in core temp

Temperature drop and acidosis provoke serious arrhythmias

Rewarming Issues

- **Rewarming Shock:**
  - Can be prevented in the prehospital setting by using warmed IV fluids during active rewarming.

Pre-Hospital Treatment Devices

- Portable IV fluid heaters are available in the United States and Canada.
- Devices fit in-line and are powered by DC power sources.

Pre-Hospital Treatment Devices

- The device is single-use and remains with the patient in the hospital (both the ED and on the floor).

Pre-Hospital Treatment Devices

- The HOT IV is powered from a Physio-Control battery or from a DC converter plugged in to an AC outlet.

Pre-Hospital Treatment Devices

Charcoal Heater

External Heat Source

Pre-Hospital Treatment Devices

ResQAir

Warmed humidified oxygen

Benefits of IV Fluid Warming

- Maintains body temps
- Increases patient comfort
- Prevents shivering

Benefits of IV Fluid Warming

- Prevents cold-induced dysrhythmias
- Decreases hemorrhage in abdominal trauma patients
- Decreases the incidence of infectious complications in abdominal trauma patients

Benefits of IV Fluid Warming

- Allows active internal rewarming to begin in the prehospital setting.
- Less labor-intensive, freeing emergency personnel to manage other, more pressing care needs.

Having said all that…

Patients who received hot pack rewarming showed a mean increase in body temperature during transport (+1.36−F/0.74 −C),

And…

- All other groups (no intervention, passive rewarming, reflective blankets, warmed IV fluids, warmed IV fluid plus reflective blanket) showed a mean decrease in temperature during transport [-0.34 to -0.61−F (-0.2 to -0.4− C); p < 0.01]

Dorraine D. Watts[1], Margie Roche[2], Ray Tricarico[4,5], Frank Poole[6], John J. Brown[6], George B. Colson[3,5], Arthur L. Trask[1] and Samir M. Fakhry[1]

The utility of traditional prehospital interventions in maintaining thermostasis 1999, Vol. 3, No. 2 , Pages 115-122

Other hypothermia concerns

- Hypothermia complicates prehospital monitoring/treatment capabilities
  - Drug metabolism and elimination are temp dependent
  - Hypothermia prolongs duration of action in some drugs ie. benzos and muscle relaxants
  - Pulse oximitry

Survival from Hypothermia

- 59.2º F (15.2º C) - Lowest reported infant survival from accidental exposure.
- 60.8º F (16º C) - Lowest reported adult survival from accidental exposure.
- 48.2º F (9º C) - Lowest reported survivor from therapeutic exposure.

Other Clinical Issues

- Hypothermia is common, even in persons with minor trauma.
- Hypothermia can worsen infectious complications of abdominal trauma.
- Hypothermic trauma patients suffer increased blood loss compared to normothermic patients.

What about Therapeutic Hypothermia?

History of Therapeutic Hypothermia

1939-used for pain control in metastatic disease Dr. Temple Fay

1941-Treatment of schizophrenia

1940-1950-pioneered use during cardiopulmonary bypass

1954-1959-used in management of traumatic brain injury

1970-1980 TBI and SCI

Therapeutic Hypothermia

Sudden Cardiac Arrest

TBI

SCI

Therapeutic Hypothermia

- Therapeutic hypothermia in trauma
  - Shown to be possible beneficial in the absence of significant hemorrhage

Back to our Case Study

05:40 - Arrival at trauma center, pt. TOT ED staff with report. Temp on arrival 94F, LOC = unconscious. ED staff provides infused blood products and attempts surgical repair of wound w/o success. Pt. moved to OR at 06:15.

Back to our Case Study

15 min into OR procedure pt. goes into VF arrest. After 40 minutes of resusitation pt pronounced dead @ 07:22.

Conclusions

Hypothermia in trauma is common. Friend or foe? Generally foe.

Anticipate injury severity and expect hypothermia based on MOI.

Rapid assessment and early recognition of severity.

Conclusions

Minimize patient exposure to the environment.

Rapid initial treatment/packaging & movement of patient to a warm environment.

ALS - warm IV fluids, heat packs, caution with analgesics.

Questions?

Thank you!

Adirondack Wilderness Medicine
Wilderness, EMS & Rescue Medicine