HYPOTHERMIA IN TRAUMA

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DISCLOSURE

- No Financial conflicts of interest
- Member of the Wilderness Medical Society
  - Diploma in Mountain Medicine
  - Fellowship in the Academy of Wilderness Medicine
• Typically when we think hypothermia we imagine…
HISTORY
HYPOTHERMIA IN MEDICINE

• Hippocrates advocated the packing of wounded solders in Ice and snow
• Napoleonic war surgeons noted warm officers had worse outcomes than the cold infantryman
• 1950’s first application in modern medicine during brain surgeries
• In the 80’s more extensive research into mild hypothermia 32-34°C
• Dog models demonstrated hypothermia had positive effects after brain ischemia.
• In 2002 2 studies published positive effects of mild hypothermia following cardiac arrest.
• This has lead to the ILCOR and AHA recommendations of hypothermia after cardiac arrest.
• Since then numerous studies have demonstrated positive effects of hypothermia following brain injury.
PRIMARY VS. SECONDARY HYPOTHERMIA

• Primary Hypothermia
  • Due to environmental exposure,
  • no underlying medical condition causing disruption of temperature regulation.

• Secondary Hypothermia
  • Low body temperature resulting from a medical illness
  • e.g., trauma.
PRIMARY HYPOTHERMIA DEFINITIONS

- Cold Stress = >35C
- Mild hypothermia = 35C – 32C
- Moderate Hypothermia = 32C – 28C
- Severe / Profound hypothermia = <28C

(WMS Practice Guidelines for Hypothermia - Wilderness and Environmental Medicine 2015)
INJURY SEVERITY SCORE

- The Injury Severity Score (ISS) is an anatomical scoring system that provides an overall score for patients with multiple injuries.
- Takes values from 0 – 75
- Severe injury 15+
Hypothermia played a roll in altering clotting factors (thromboxane b2)

Local warming and cooling of the bleeding site changed bleeding times.

Cold skin (27C) had significantly increased bleeding times.

Warming the skin reversed the effects.
• Prior to transfusions attempts should be made to normalize skin and wound temperatures

• Do not cool wounds with ice/snow to cause vasoconstriction in an attempt to control bleeding.
IF HYPOTHERMIA WORSENS BLEEDING, THEN:

Does hypothermia worsen outcome in trauma?
Study of 71 severely traumatized patients (ISS >24)

Increased mortality if temperature <34C

100% mortality temperature <32C regardless of ISS

Decrease in core temperature correlated with increase in blood or crystalloid administration (>5 liters)
LUNA ET AL
“INCIDENTS AND EFFECTS OF HYPOTHERMIA IN SERIOUSLY INJURED PATIENTS” 1987

- Study included intubated patients in ICU
- 66% (63/94) patients enrolled were hypothermic (<36°C)
- 43% mild and 23% severe
• Higher trauma scores (ISS)
• Required more blood
• Majority of severely injured patients are hypothermic
• Hypothermia is detrimental to physiology except conditions causing cerebral edema.
• Severely injured patients are unable to thermoregulate
• Severely hypothermic patients become hypothermic in the following ways:
  • Alcohol may cause blunting of the vasoconstriction response
  • Immobility trauma causes increases heat loss and decreases heat production
  • Injuries may impair thermoregulation
  • Evaluation, resuscitation, treatments may aggravate heat loss (paralytics / fluids)
Risk factors that can threaten thermostability:

- Impaired shivering
- Inactivity
- Acute spinal cord transection
- CNS failure or neurologic abnormalities
- Pharmacological causes
DANZI D, POZOS R. “ACCIDENTAL HYPOTHERMIA” THE NEW ENGLAND JOURNAL OF MEDICINE - 1994

- CNS trauma
- Exposure (assessment)
- Cold infusions
- Environmental causes
- Multisystem trauma
- Shock systemic acidosis
WE CAN CAUSE HYPOTHERMIA

- Exposure of patient during examination
- Spinal precautions,
- Analgesia
- Sedation

Kirkpatrick et al 1999
ALL ABOUT NUMBERS

• Rutherford et al  
  “hypothermia in critically ill trauma patients” 1998  
  • 7045 patients ICU admissions 661 were hypothermic (9.1%)  

• Martin et al  
  “injury-associated hypothermia: an analysis of the 2004 national trauma databank” 2004  
  • 701,491 National trauma registries cases reviewed. 11,026 were hypothermic (<35C) - 1.5%  

• Shari et al  
  “Is hypothermia simply a marker of shock and injury severity or an independent risk factor for mortality in trauma patients? Analysis of a large national trauma registry” 2005  
  • 35,550 patients enrolled 3267 (9.1%) presented with hypothermia (<35C)  

• Wang et al  
  “Admission hypothermia and outcome after major trauma” 2005  
  • 38,520 patients enrolled of which 1921 were hypothermic (5%)
• (Rutherford) Mean temperature of survivors was 34°C versus those that died was 33.1°C

• No correlation of seasons.

• ICU length of stay increased (doubled)

• Length of ICU stay for survivors was double that of normothermic patients

• Increase mortality, acidosis, severity of injury, ICU admissions and ventilator days.

• Morbidity plateaus at 32°C
• Hypothermia is an independent predictor of mortality
• No apparent protective effect of hypothermia in trauma patients
• Hypothermia is independently associated with increase mortality and severity of injuries
• As injury severity increases so does occurrence of hypothermia
• “Aggressive attempts to prevent and treat hypothermia are warranted”
## Definition of Traumatic Hypothermia

<table>
<thead>
<tr>
<th>(secondary) Traumatic Hypothermia</th>
<th>(primary) Accidental Hypothermia</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Normal &gt;36°C</td>
<td>• Cold Stress = &gt;35°C</td>
</tr>
<tr>
<td>• Mild = 35.9°C – 34°C</td>
<td>• Mild hypothermia = 35°C – 32°C</td>
</tr>
<tr>
<td>• Moderate = 34°C – 32°C</td>
<td>• Moderate Hypothermia = 32°C – 28°C</td>
</tr>
<tr>
<td>• Severe = &lt;32°C</td>
<td>• Severe / Profound hypothermia = &lt;28°C</td>
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Arthurs et al, WMS Guidelines
• Demonstrated that 18% of patients were hypothermic
• Hypothermic patients presented with: lower BP’s
  • Tachycardia,
  • hypotension,
  • lower GCS,
  • hemocrits,
  • pH, and
  • high base deficits
• higher bleeding control surgery,
• Blood and factor VIIa administration
• Spent more time in the ICU
• significantly higher mortality rates

• Independently, penetrating trauma, GCS <8 or shock (BP<90mmHg) were all predictive of patients arriving hypothermic.
89% of hypothermic patients presented with temperatures between 34°C – 36°C

Although only 18% of presentations accounted for:

- 50% of packed blood,
- 56% of fresh frozen plasma,
- 60% of whole blood and
- 63% of factor VIIa use.
• 100% mortality with a temp <33 (similar to Jurkovitch et al)
• 40% mortality if temperatures were above 33C
• Using rapid rewarming techniques mortality, fluid requirements and morbidity can be altered.
DoD Response

- CoTCCC approves new hypothermia guidelines Nov 2005
  - Hypothermia Prevention Management Kit (HPMK)
  - Greater emphasis on TIH in the PHTLS 6th edition, 2006
  - Significant reductions of hypothermia cases arriving from battlefield

- Assistant Secretary of Defense of Health Affairs

- Medical Director, Joint Theater Trauma System

Beekley et al 2008 and Eastridge et al 2009
• Application of these (measures) has made it (hypothermia) an uncommon finding.

• Holcomb J et al – The Journal of Trauma Feb 2007
Wade et al. 
“ADEMISSION HYPO OR HYPTHERMIA AND SURVIVAL AFTER TRAUMA IN CIVILIAN AND MILITARY ENVIRONMENTS” 2011

- 4093 civilians 382 hypothermic (9.3%) 92 hyperthermic (2.2%)
- 4394 military 263 hypothermic (6.0%) 327 hyperthermic (7.3%)

- Hypothermia is detrimental in trauma patients
- Hyperthermia (>38C) could also be detrimental to outcome.
Hypothermia:

- May occur from many different reasons
- Mild traumatic hypothermia is as high as 36°C
- Severe traumatic hypothermia is <32°C.
- Effects coagulopathy preventing clot formation
- Increases ICU stay
Hypothermia:

- Increases blood, blood product and crystalloid administration
- No correlation to seasons and hypothermia
- An independent predictor of negative outcome
- Increases mortality, morbidity in trauma patients
- Effects may be reversed with warming
HYPOTHERMIA AND ACIDOSIS

• Metabolic causes of acidosis includes:
  • Lactate generation from shivering and hypoperfusion
  • Impaired hepatic metabolism
  • Impaired acid excretion
Hypothermia inhibits fibrin generation at the initiation phase

Acid imbalance further effects thrombin and increases fibrinogen breakdown.

Thrombin generation is thermally regulated

Coagulopathy resulting from hypothermia and acidosis is a major contributor to mortality and morbidity in trauma
TRIAD OF DEATH

Pillars

- Hypothermia (<35°C)
- Acidosis (<7.1)
- Coagulopathy (INR > 1.5)

- “In the most severely injured casualties, when the lethal triad are present, death is imminent”

- Bleeding patients with these findings have up to 90% mortality rate.

Kirkpatrick A et al Canadian Journal of Surgery 1999
Holcomb J et al The Journal of Trauma 2007
Sayad M et al Emergency medicine International 2013
ACUTE TRAUMATIC COAGULOPATHY

- Holcomb J. Et al
  Damage Control Resuscitation: Directly addressing the early coagulopathy of trauma – 2007

- Firth D. et al
  Acute Traumatic coagulopathy – 2012

- Davenport
  Pathogenesis of acute traumatic coagulopathy - 2013
Acute Traumatic coagulopathy (ATC)

- driven by tissue injury and shock (hypoperfusion)
- Associated with increased mortality and worse outcomes
- ATC causes Protein C activation which leads to rapid anticoagulation and fibrinolysis

- Clotting dysfunction begins at the moment of traumatic impact
- Physiological responses are initiated producing “acute traumatic coagulopathy (ATC)”
• Blood samples within 25min of injury found 56% had coagulopathy
• >3L of crystalloid administration pre-hospital are independently associated with a worse ED coagulation profile
• ATC is an impairment of all components of haemostasis
• It is exacerbated by hypothermia, acidosis and fluid resuscitation.
• ATC is most commonly evident in the presence of tissue hypoperfusion

• Remoteness may prolong shock, hypothermia and increase volume depletion. This may potentiate ATC or functions independent mechanisms of coagulopathy.
• My question.

• In the austere environments is hypothermia treatment as effective as fluid and blood product therapy in severely injured patients?
DETERMINING HYPOTHERMIA
It is crucial to accurately measure the body temperature.
Whilst massive hemorrhage continues to be a major cause of mortality, it is often reversible.

It can be managed by early identification and prevention of the lethal triad.
### Description of Decision Options/Interventions and the Level of Recommendation

<table>
<thead>
<tr>
<th>Temperature Measurement Device</th>
<th>Adult</th>
<th>Adult Febrile</th>
<th>Adult Hypo-Thermic</th>
<th>Adult Critically Ill /Intubated</th>
<th>Pediatrics 0-3 Months</th>
<th>Pediatrics 3 Months – 3 Years</th>
<th>Pediatric 3 Years – 18 Years</th>
<th>Pediatric Febrile</th>
<th>Pediatric Hypo-Thermic</th>
<th>Pediatric Critically Ill /Intubated</th>
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</thead>
<tbody>
<tr>
<td>Oral</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>N/R</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>N/E</td>
<td>N/R</td>
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<tr>
<td>Tympanic</td>
<td>I/E</td>
<td>N/R</td>
<td>N/E</td>
<td>I/E</td>
<td>N/R</td>
<td>I/E</td>
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<tr>
<td>Temporal Artery</td>
<td>A</td>
<td>N/R</td>
<td>N/E</td>
<td>I/E</td>
<td>N/R</td>
<td>I/E</td>
<td>A</td>
<td>A*</td>
<td>N/E</td>
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<tr>
<td>Chemical Dot</td>
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<td>I/E</td>
<td>N/E</td>
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<tr>
<td>Axillary</td>
<td>B</td>
<td>N/R</td>
<td>N/E</td>
<td>I/E</td>
<td>N/R</td>
<td>I/E</td>
<td>B</td>
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**Level A (High) Recommendation:** Based on consistent and good quality of evidence; has relevance and applicability to emergency nursing practice.

**Level B (Moderate) Recommendation:** There are some minor inconsistencies in quality evidence; has relevance and applicability to emergency nursing practice.

**Level C (Weak) Recommendation:** There is limited or low-quality patient-oriented evidence; has relevance and applicability to emergency nursing practice.

**N/R:** Not recommended based upon current evidence.

**I/E:** Insufficient evidence upon which to make a recommendation.

**N/E:** No evidence upon which to make a recommendation.
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SHOULD OUT OF HOSPITAL TRAUMA CARE INCLUDE MORE DIAGNOSTIC INSTRUMENTS?

I-Stat

EG8+ cartridge (or similar)

Profound acidosis (<pH 7.1) appears necessary for coagulation dysfunction
Davenport 2013
RECOMMENDED TREATMENTS FOR SECONDARY HYPOTHERMIA

• ATLS guidelines stress temperature control with aggressive efforts to avoid and treat hypothermia - Kirkpatrick et al 1999

• Reverse acidosis and prevent hypothermia –Holcomb J et al – 2007
“in addition to treating life threatening conditions, early application of adequate insulation to prevent cooling is an important part of pre-hospital trauma care.”

- It compares using a single wool blanket to a blanket plus:
  - clothing removal,
  - vapour barrier or
  - second blanket.
A wool blanket plus a vapour barrier or 2\textsuperscript{nd} blanket will:

- Improve metabolic rate,
- skin temp,
- heart rate and
- cold discomfort.

- Clothing removal and single warm blanket has similar results except for cold discomfort
- The extra steps has 15\% reduction in metabolic rate which could be significant in trauma/shock
ACTIVE VS. PASSIVE

• Passive warming prevents further heat loss:
  • Covering patients
  • Warming the resuscitation room

• Active warming involves:
  • Covering with warming blankets
  • Administering warm intravenous fluid

Sayad M. et al - 2013
Etiology

Hypothermia is defined as a core body temperature of less than 35°C. It can be caused by excessive cold stress, inadequate body heat production, or both. In early hypothermia, the body attempts to raise its temperature by shivering, increasing muscle tone, peripheral vasoconstriction, and increases in respiratory rate and cardiac output. When these mechanisms no longer compensate for heat loss, body temperature falls. When treating a victim of hypothermia, don't forget to protect yourself from the factors that have caused your patient's condition.

It is extremely difficult to accurately measure a true core temperature in the out of hospital environment; tympanic, oral, and temporal thermometers are not accurate at extremes of temperature.

1. Mild hypothermia
   a. Feels cold
   b. Shivering
   c. Slight confusion
   d. Lethargy
   e. Poor judgement
   f. Loss of fine motor coordination
   g. Ataxia

2. Moderate hypothermia
   a. Stupor
   b. Delirium
   c. Slow reflexes
   d. Dysrhythmias

3. Severe hypothermia
   a. Shivering stops
   b. Coma / unresponsiveness
   c. Hypotension
   d. Undetectable respirations and pulse
   e. Asystole

Patient Safety Considerations

- Ensure that underlying and treatable medical conditions (e.g., overdose, hypoglycemia, seizure) and/or trauma are not present
- If patient bradycardic, transcutaneous pacing is not indicated as bradycardia may be a physiological response in severe hypothermia.

Studies have shown that removing people from cold water can decrease aortic blood pressure and central venous pressure which may lead to inadequate coronary blood flow and myocardial ischemia.

12-leads are important due to the potential cardiac dysrhythmias that occur secondary to hypothermia.

Frostbite is a localized cooling of body temperature to the point of crystal formation in the extracellular tissues causing injury. It may be classified as:
AHS PROTOCOL

Mild Hypothermia

Passive rewarming

Transport and consider pre-notification
Continue treatment until transfer of care complete

Moderate to Severe Hypothermia

Passive rewarming
Active external rewarming of truncal areas only
Interventions

Rewarming

1. Passive rewarming:
   a. Gently remove any wet clothing, cutting is preferred
   b. Protect against further heat loss and wind chill
   c. Cover with blankets and insulation
   d. Turn on heater in rear of ambulance

2. Active external rewarming:
   a. Apply radiant heat and/or warm blankets (if available) to core
   b. Use warmed IV fluids (where available) for fluid resuscitation, do not fluid overload

Treatment of Frostbite

1. Rapid rewarming of acute frostbite is impractical in the prehospital setting; therefore, rapid transport with wrapping of the affected parts in a blanket is the appropriate treatment
2. Refreezing a thawed extremity significantly increases tissue damage and subsequent need for amputation
3. When rewarming actual frozen limbs or body parts, hot packs are not to be used
Alcohol and TBI may cause hypothalamic dysfunction
Which blunts protective vasoconstrictive and shivering responses.
Hypotension may also reset hypothalamic set-point for shivering.
Paralytics, sedation, spinal injury, ATP depletion…

Kirkpatrick et al
hypothermia in the trauma patient
Canadian journal of surgery - 1999
• 28C is the ambient temperature in which and unclothed normothermic human will neither gain nor lose heat

• A severely injured patient should be treated early and aggressively with active rewarming prevent hypothermia (<35C)

• In this patient population (trauma) external warming methods are only capable of reducing further heat loss.

Taylor E. et al 2008
WMS consensus guidelines for the treatment of hypothermia - 2015
Passive warming should be applied at the scene.

Rapid extrication and transport times minimized

Best therapy is active rewarming

Avoid cold fluids

All trauma patients should be treated for hypothermia (passively)

Patients who are moderately or severely hypothermic must get actively rewarmed
Figure 1-6. Package containing Blizzard Wrap, Ready Heat Blanket, and reflective cap.
Ready-Heat™ Blankets

Three Sizes:
1, 4, 6 heat panels

15-30 min to peak temp

Peak temp. of
104° F/40° C

Last 8 hours

Courtesy Dr. Brad Bennett PhD NREMT-P
Hypothermia “burrito” Wrap

- Use items on any on-the-water or backcountry trip
- Waterproof outer layer (tarp, tent fly, rain canopy),
- Sleeping pads (foam type) for insulation from the ground
- Sleeping bags (or blankets, dry clothing, etc.)
Hypothermia Prevention and Management Kit™

Contents:
1 x Heat Reflective Skull Cap
1 x Self Heating, Four Cell Shell Liner
1 x Heat Reflective Shell

Dimensions: 7.5” x 9.5” x 3”
Weight: 2.5 lbs.
Part Number: 80-0027
NSN: 6515-01-532-8056

North American Rescue Products
Improved Blizzard Bag

Contents:
1 x Heat Reflective Shell with built-in hood
1 x Self-heating shell liner
1 x Plastic vacuum bag

Dimensions:
Packaged (HPM K®): H 6.75 in. x W 10.5 in. x D 5 in.
Weight (HPM K®): 3 lb. 8 oz.
Heat Reflective Shell (Open): L 78 in. x W 43 in.

Cost: Approx. $110
www.narescue.com

Courtesy Dr. Brad Bennett PhD NREMT-P
THANK YOU

- Questions?