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

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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)
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?
JURKOVITCH ET AL
“HYPOTHERMIA IN TRAUMA VICTIMS: AN OMINOUS PREDICTOR OF SURVIVAL” 1987

- 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)
• Majority of severely injured patients are hypothermic
• Required more blood
• Hypothermia is detrimental to physiology, except conditions causing cerebral edema.
• Severely injured patients are unable to thermoregulate
Severely hypothermic patients may 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

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

6 Martin et al
“injury-associated hypothermia: an analysis of the 2004 national trauma databank” 2004
- 700,304 National trauma registries cases reviewed. 11,026 were hypothermic (<35C) - 1.5%

7 Shafi 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
- 38,550 patients enrolled 3267 (8.5%) presented with hypothermia (<35C)

8 Wang et al
“Admission hypothermia and outcome after major trauma” 2005
- 38,520 patients enrolled of which 1921 were hypothermic (5%)
• Thought to occur as a result of a combination of shock, altered thermogenic response, environmental exposure and unwarmed resuscitation fluids.  

• Mean temperature of survivors was 34°C versus those that died was 33.1°C.  

• No correlation of seasons.  

• 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 \(^6,7,8\)
• Hypothermia is independently associated severity of injuries. \(^6\)
• As injury severity increases so does occurrence of hypothermia \(^6\)
• No apparent protective effect of hypothermia in trauma patients. \(^7\)
• Aggressive attempts to prevent and treat hypothermia are warranted \(^6,7\)
DEFINITION OF TRAUMATIC HYPOTHERMIA

(secondary) Traumatic Hypothermia

• Normal >36°C
• Mild = 35.9°C – 34°C
• Moderate = 34°C – 32°C
• Severe = <32°C

(primary) Accidental Hypothermia

• Cold Stress = >35°C
• Mild hypothermia = 35°C – 32°C
• Moderate Hypothermia = 32°C – 28°C
• Severe / Profound hypothermia = <28°C
Demonstrated that 18% of patients were hypothermic

Hypothermic patients presented with:

- tachycardia,
- hypotension,
- lower GCS,
- lower hemocrits,
- lower pH, and
- high base deficits
• higher bleeding control surgery,
• higher 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 34C – 36C

• 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.
“ADMISSION HYPO OR HYPERTHERMIA 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 (>38°C) could also be detrimental to outcome.
HYPOTHERMIA AND ACIDOSIS

• Metabolic causes of acidosis includes: ⁹
  • Lactate generation from shivering and hypoperfusion
  • Impaired hepatic metabolism
  • Impaired acid excretion

• Hypothermia affects Base Deficit ⁶,⁷,⁹,¹¹
Hypothermia inhibits fibrin generation at the initiation phase and fibrinogen generation.

Acid imbalance further affects 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 9,12,13,14,17,18

Pillars

• Hypothermia (<36C)
• 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.
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 25 min 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.
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
- Increases blood, blood product and crystalloid administration
- No correlation to seasons and hypothermia
• Hypothermia:
  • An independent predictor of negative outcome
  • Increases mortality, morbidity in trauma patients
  • Effects may be reversed with warming
  • Part of the triad of death
  • Worsens hypoperfusion
  • Effects acidosis
  • May worsen acute traumatic coagulopathy
DETERMINING HYPOTHERMIA
It is crucial to accurately measure the body temperature.

“Aggressive rewarming has been shown to reduce mortality during resuscitation of hypothermic trauma patients”
# CLINICAL PRACTICE GUIDELINE: NON-INVASIVE TEMPERATURE MEASUREMENT IN THE EMERGENCY DEPARTMENT

<table>
<thead>
<tr>
<th>Temperature Measurement Device</th>
<th>Adult</th>
<th>Adult Febrile</th>
<th>Adult Hypothermic</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>
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<td>A</td>
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<td>N/R</td>
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<td>Tympanic</td>
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<td>N/R</td>
<td>N/E</td>
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<td>Temporal Artery</td>
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<td>N/E</td>
<td>I/E</td>
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<td>Chemical Dot</td>
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<td>B</td>
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**Description of Decision Options/Interventions and the Level of Recommendation**

- **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.
<table>
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<tr>
<th>Temperature Measurement Device</th>
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<th>Adult Hypo-Thermic</th>
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<td>Temporal Artery</td>
<td>A</td>
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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
- Rapid correction of low body temperature may independently decrease mortality 6
- Ther presence of hypothermia or hyperthermia should be considered in the initial treatment of the patient with traumatic injuries and corrected to the normal range. 11
“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
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…
• 28C is the ambient temperature in which an unclothed normothermic human will neither gain nor lose heat

• A severely injured patient should be treated early and aggressively with active rewarming to 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
• Prevention of hypothermia is simpler and more effective than treatment
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
3M RANGER

- Blood and Fluid warmer
- Should be used in all trauma fluid resuscitations
- AHS is receiving, EMS should take with them on transfer.
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