Temperature Management: All Shook Up! Managing Shivering In Normothermia

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All Shook Up! Managing Shivering During TTM

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Objectives
- Identify key factors related to maintaining normothermia
- Describe the use of the Bedside Shivering Assessment Scale
- Provide interventions to manage shivering in the Neuro patient population.

Session Goal
Implement tools to assess shivering in normothermia and hypothermia and apply evidence-based strategies to control shivering.

Session Topics
- Definition of Targeted Temperature Management (TTM) and target populations for its use
- The consequence of shivering
- Tools to assess shivering at the bedside
- Pharmacologic and non-pharmacologic strategies to control shivering

Forms of Target Temperature Management
- Controlled normothermia: Reduce core temperature, maintain at 36.0°C - 37.5°C
- Therapeutic Hypothermia: Intentionally reduce core temperature below 36.0°C (32°C - 35°C)

<table>
<thead>
<tr>
<th>Mild</th>
<th>Moderate</th>
<th>Moderate/Deep</th>
<th>Deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>35.0°C</td>
<td>35.5°C</td>
<td>36.0°C</td>
<td>&lt;35.0°C</td>
</tr>
</tbody>
</table>

Question: What is your temperature threshold for intervention?
1. 37 degrees C
2. 38 degrees C
3. 38.5 degrees C
4. 39 degrees C

Speaker Disclosures
- Neurocritical Care Society
- Vice President/Board of Directors
- Honorarium
- Bard
- Medical Advisory Board
- Brain Trauma Foundation
- Neuroptics/Cerebrotech
- Ceribell
- Stock Options
- Neuroptics/Cerebrotech/Ceribell

Situation: Your patient is a 48 year old female status post ruptured cerebral aneurysm (coiled), Grade IV Hunt and Hess. Day 6 – team is trying to control temperature that has elevated to 38 degrees C. Pt is intubated/sedated on propofol/fentanyl, ICP is 20-25 mm Hg. Interventions include Acetaminophen, ice bags, and cooling measures. The patient is shivering and the temperature is escalating.

Question: What is your temperature threshold for intervention?
The Good... The Bad... The Ugly... of Temperature

Evidence: Hyperthermia and Outcomes

- In critically ill neurosurgical patients
  - 71% of patients had febrile episodes with a mean of 4.7 febrile episodes/patient
  - Fever seen in 39% of patients who had ICU LOS >15 days
- Elevated body temperature is an independent factor of increased mortality and disability
  - Increased ICU and hospital stay
  - Higher mortality rate
  - Worse hospital disposition

Fever Burden & Modified Rankin in SAH

- Study evaluated prevalence of fever in the first 48 hours after cardiac arrest and impact on outcomes
  - Methods
    - Records from 1/2005-6/30/2010 reviewed for presence of Fever (T>38°C)
    - 336 patients mean age 60 years
    - 63% Out of hospital CA (shockable rhythm 40%)
    - Fever present in 42% of subjects post arrest with median onset of 15 h in non-TH cohort and 36 h in TH cohort
    - Fever development
    - Fever is associated with death in non-TH patients
    - TH treatment may mitigate the effect

Presence of hyperthermia post CA

- Risk factors for post rewarming rebound hyperthermia in CA patients undergoing TTM
  - Presence of rebound hyperthermia was associated with an increased risk of in-hospital mortality:
    - 40 of 99 patients (40.4%) without rebound hyperthermia experienced any cause in-hospital death
    - 27 of 42 patients (64.3%) patients who experienced rebound hyperthermia had increased risk of in-hospital mortality

Rebound hyperthermia post HACA

- Rebound hyperthermia is associated with increased neurologic morbidity as measured by the modified Rankin scale, the two-sided Mann-Whitney U test between the two groups of patients gave p = 0.013, suggesting that there is a statistically significant difference in neurologic morbidity as measured by a modified Rankin scale between patients that experience rebound hyperthermia and those that do not.
Presence of hyperthermia post HACA

2004-2010: 270 patients resuscitated after OHCA and survived 24 hours
TH (32-34°C)

- Group 1: Peak Temperature > 38.5°C within 36h of rewarming
- 36% 30 day mortality rate
- Group 2: Peak Temperature < 38.5°C within 36h of rewarming
- 22% 30 day mortality rate
- Maximum temperature & duration of PHF independent predictors of 30 day mortality

Max temperature (38.5°C or above) 39°C C (39°C C 1.4°C 5°C); p 0.0001; and the duration of PHF (3h 1h per B) (30C C I.5h 10h); p 0.0001 were also independent predictors of 30-day mortality in multivariate models. Good neurological outcome (GNI) versus unfavorable outcome (GUN) at hospital discharge was found in 31% vs. 9% in the PHF group compared to 71% vs. 9% in the NPH group. A mortality of 36% was associated with poor neurological outcome. Post-hyperthermic fever > 38.5°C is associated with increased 30 days mortality. Fever after neurological assessment of underlying factors. Absolute of PHF in survivors target should be evaluated in prospective randomized trials.

Question: Does controlling temperature help???

Fever Reduction to decrease systemic oxygen consumption

Hata et al 2007
- Prospective randomized study 10 ICU brain injured patients with T > 38 degrees C
- Treated with acetaminophen
- 1 hour indirect calorimetry baseline and 4 hours during cooling method with pad system
- Reduced temperature from 38.6°C to 36.3°C
- No Shivering present: VO2 (oxygen consumption) significantly reduced
- Shivering present: VO2 unchanged
- Conclusion: Reducing fever in BI appears to significantly reduce systemic VO2 but is dependent on shivering

Evidence: Induced Normothermia Improves Outcomes

- Reduces cerebral metabolic distress (patients with subarachnoid hemorrhage irrespective of ICP)
- Reduces fever burden
- Attenuates secondary injury
- Reduces intracranial hypertension burden

Evidence: Induced Normothermia Improves Outcomes


Table 2. Alteration of Central Metabolic Distress by Induced Normothermia: Relationship With Patient Outcome

- Induced Normothermia Attenuates Central Metabolic Distress to Patients With Intracranial Hemorrhage and Rebound Hyperthermia

Differences between Induced Normothermia vs Control

Induced Normothermia Attenuates Intracranial Hypertension and Reduces Fever Burden after Acute Traumatic Brain Injury
TTM: Target Populations for Normothermia in ICU

<table>
<thead>
<tr>
<th>Neurological Injury</th>
<th>Post Cardiac Arrest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traumatic brain injury</td>
<td>7</td>
</tr>
<tr>
<td>Ischemic stroke</td>
<td>7</td>
</tr>
<tr>
<td>Intracerebral hemorrhage</td>
<td>7</td>
</tr>
<tr>
<td>Subarachnoid hemorrhage</td>
<td>≤ 14</td>
</tr>
<tr>
<td>Spinal cord injury</td>
<td>7</td>
</tr>
</tbody>
</table>

Neurological injury (targeted duration: # days)

- Traumatic brain injury: 7
- Ischemic stroke: 7
- Intracerebral hemorrhage: 7
- Subarachnoid hemorrhage: ≤ 14
- Spinal cord injury: 7

Post cardiac arrest

- Once patient returns to 37°C following hypothermia treatment
- 72 hours in duration

Hypothermia Induction assistance

- Iced saline (30 ml/kg) at 4°C
- Surface external adhesive pads
- Surface blanket devices
- Intravascular devices

Normothermia

- Acetaminophen IV or per rectum
- Cool room, wet towels, ice bags
- Iced saline 20 ml/kg at 4°C bolus over 30 min x 1
- Surface external adhesive pads
- Surface blanket devices
- Intravascular devices

TTM Implementation

Success is Dependent on adequate:

- Temperature gradient (actual-37°C)
- Sedation/analgesia
- Associated conditions (ie, ICP elevated)

Shivering is identified as one of the most frequent consequences of TTM

<table>
<thead>
<tr>
<th>Surface cooling n = 92</th>
<th>Core cooling n = 75</th>
</tr>
</thead>
<tbody>
<tr>
<td>24%</td>
<td>27%</td>
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</table>

Table 2. Acute Neurologic Impairment


Who experienced more shivering?

Question: Energy expenditures for patients shivering in their arms/legs is estimated at how many kilocalories/day?

1. 1400 kcal/day
2. 2000 kcal/day
3. 3000 kcal/day
4. 3600 kcal/day

Normothermia

- Maintaining temperature at 36-37 degrees C


TTM: Targeting Temperature Management for Therapeutic Hypothermia

Hypothalamus: Set Point

- Thermoreceptors sense temp increase
- Warm sensitive neuron ↑ firing rate
- Signal heat loss effector neurons
  - Vasodilation
  - ↑ blood flow

Thermoreceptors sense temp decrease
- Cold sensitive neuron ↑ firing rate
- Signal heat production effector neurons
  - Vasosconstriction
  - SHIVERING

Normal body temp 37°C

Shivering is associated with increased energy expenditure and metabolic rates during TTM.

Metabolic Impact of Shivering During Therapeutic Hypothermia in Humans

- Maintaining temperature at 36-37 degrees C

1. 1400 kcal/day
2. 2000 kcal/day
3. 3000 kcal/day
4. 3600 kcal/day
Effect of Shivering on Brain Tissue Oxygenation
During Induced Normothermia in Patients with Severe Brain Injury

The occurrence of shivering is associated with significant reduction of $\text{PbtO}_2$.

Shivering Assessment Methods

1. Subjective:
   - Observe for piloerection (goosebumps)
   - Bedside Shivering Assessment Scale (BSAS)
2. Objective:
   - Bispectral index (BIS) monitoring

Question: What types of technology used at the critical care bedside is helpful in detecting shivering?

1. EEG
2. Bispectral Index Monitor
3. Train of 4
4. Shiverometer

CBF, Brain Oxygen, and Shivering

1. Subjective: BSAS

Type of Shivering

- No shivering: No shivering is detected on palpation of the masseter, pectoralis, deltoids, or quadriceps muscles
- Shivering localized to neck and/or chest
- Shivering involving arms and neck and/or chest
- Intermittent generalized shivering involving all 4 extremities

Prevent rigorous shivering
Assess every hour
Use BSAS: Goal ≤1

Type of Shivering

1. Mild
2. Moderate
3. Severe

2. Objective: BIS Shivering Assessment:
Pre-intervention

Patient sedation with midazolam and fentanyl. Hypothermia at 33°C
BIS <33
EMG = Max BSAS = 0

Post-intervention

Patient bolused with norcuron
BIS = 33
EMG = 0
BSAS = 0
In neurocritical care patients undergoing TTM, should shivering be assessed using standardized tools?

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Comments</th>
<th>Overall Quality of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badjatia</td>
<td>Cohort</td>
<td>BSAS validation using energy expenditure measurements</td>
<td>MODERATE</td>
</tr>
<tr>
<td>Olson</td>
<td>Cohort</td>
<td></td>
<td></td>
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</tbody>
</table>

- BSAS only measurement tool identified in literature
- Additional data regarding impact on length of stay or long-term outcome lacking

Other Interventions

- Water temperature and trend indicator
- Foley temperature probe position
- Esophageal temperature probe correct placement
- Microshivering
- Check BIS and watch EMG line for activity
- Look for elevated goosebumps or feel for raised bumps

Good Practice Statements

Clinicians should treat shivering promptly.

We suggest a step-wise approach to shivering which prioritizes non-sedating interventions (acetaminophen, counterwarming, magnesium) over narcotic analgesics, sedatives, or paralytics.
Prevention of Shivering During TTM: The Columbia Anti-shivering Protocol

<table>
<thead>
<tr>
<th>Step</th>
<th>Intervention</th>
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<tbody>
<tr>
<td>0</td>
<td>Baseline</td>
</tr>
<tr>
<td>1</td>
<td>Mild sedation</td>
</tr>
<tr>
<td>2</td>
<td>Moderate sedation</td>
</tr>
<tr>
<td>3</td>
<td>Deep sedation</td>
</tr>
<tr>
<td>4</td>
<td>Neuromuscular blockade</td>
</tr>
</tbody>
</table>

- Acetaminophen
- Buspirone
- Magnesium sulfate
- Skin counter warming

- Dexmedetomidine or opioid
- Dexmedetomidine and opioid
- Propofol
- Vecuronium

18% of TTM patients had shivering controlled with:
- Counterwarming
- Acetaminophen
- Magnesium

50% of time added dexmedetomidine infusion then
- Propofol (10% of time)

Factors influence use of antisshivering agents:
- Age
- Gender
- BSA: may be associated with muscle mass
- Young man — higher muscle mass

Columbia Group Experience: TTM patients

The Implementation of Targeted Temperature Management: An Evidence-Based Guideline from the Neurocritical Care Society

Guidelines to Assist with Hospital Based Guidelines

Question: Which of the following should be used first to counter shivering?

1. Paralytic
2. Warmed Normal saline
3. Meperidine
4. Forced warm air devices/bath blankets

Nonpharmacological Management of Shivering

- Why does counterwarming work?

Baseline mean skin temperature contributes approximately:

- Insulation of cutaneous thermoreceptors on hands, feet, and head
- Hot packs to palms of hands and soles of feet
- Socks
- Head wrap (towel)
- Bair Hugger

Shivering Management

STEP 1
- Acetaminophen 650 mg PT q 4 hs
- Skin counter-warming
- Magnesium sulfate 4 gm IV bolus, goal 34 mg/l

STEP 2
- Naloxone 12-25 mg IV/PT q 4 hs
- Dexmedetomidine infusion 0.2 mcg/kg/hr
- Ventilator tidal volume 25 ml/kg

STEP 3
- Paralytic
- Pain medications

Nonpharmacological Management of Shivering
### Cases: Shivering Response During Rewarm

**Core Patient Temperature °C**

- **Shivering:** temp up and down
- **Good control during rewarm**

#### Diagrams:
- **Graphs showing patient temperature trends**
- **Comparison of medication effects**

### Guidelines to Assist with Hospital Based Guideline

**Temperature Management and Nursing Care of the Patient With Acute Ischemic Stroke**

**Guidelines to Assist with Hospital Based Guideline**

**Table:** Summary of Recommendations

<table>
<thead>
<tr>
<th>Recommendation (Rule/Reference)</th>
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<th>Evidence</th>
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**Guidelines for the Management of Anomalous Subarachnoid Hemorrhage**

**Guidelines for the Management of Spontaneous Intracerebral Hemorrhage**

**Guidelines for the Early Management of Patients With Acute Ischemic Stroke**

**2018 Guidelines for the Early Management of Patients With Acute Ischemic Stroke**

**TRAMATIC BRAIN INJURY: ACS 2015**

#### Summary

- Targeted temperature management is aimed at limiting the cascade of damage following injury
- Both normothermia and targeted hypothermia are important strategies to limit damage; both can cause shivering
- Assess the patient hourly with subjective and objective methods: the Bedside Shivering Assessment Scale (BSAS) and BIS and EMG monitoring
- Identify and treat shivering as early as possible to prevent rigorous shivering and worsening neuro insult

**Graphs:**
- **Core patient temperature trends**
- **Comparison of medication effects**

**Table:** Summary of Recommendations

- **Dexmedetomidine**
- **Norcuron**

**References:**

- [Rule/Reference 1](#)
- [Rule/Reference 2](#)