“The cold never bother me anymore”
Is that really true?
Definition and classification
Effect of hypothermia
Physiology
Hypothermia prevention
Guidelines
Definition and classification

- Core temperature less than 36.0°C (96.8°F).
- Severity of hypothermia (core temperature):
  - Mild: 35.0 - 35.9°C
  - Moderate: 34.0 - 34.9°C
  - Severe ≤ 33.9°C.
Effect of hypothermia

Table 3: Adverse effects of hypothermia

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-35</td>
<td>Physiological attempts to increase temperature, generation of heat: Shivering, peripheral vasoconstriction</td>
</tr>
<tr>
<td>≤36-&gt;35</td>
<td>Tachycardia</td>
</tr>
<tr>
<td>≤35</td>
<td>Bradycardia, low platelet count, impaired platelet function, impaired coagulation cascade, altered clearance of various medications</td>
</tr>
<tr>
<td>≤33</td>
<td>ECG changes: Increased PR-interval, widening of QRS-complex, increased QT interval</td>
</tr>
<tr>
<td>≤32</td>
<td>Mild arrhythmias</td>
</tr>
<tr>
<td>≤30-31</td>
<td>Depressed consciousness, lethargy, coma</td>
</tr>
<tr>
<td>≤30</td>
<td>“Hibernation:” Shivering ceases, marked decrease in rate of metabolism</td>
</tr>
<tr>
<td>≤28-30</td>
<td>Increased risk of tachyarrhythmias, beginning with atrial fibrillation</td>
</tr>
</tbody>
</table>

ECG = Electrocardiography
The Effects of Mild Perioperative Hypothermia on Blood Loss and Transfusion Requirement

Suman Rajagopalan, M.D.,* Edward Mascha, Ph.D.,† Jie Na, M.S.,‡ Daniel I. Sessler, M.D.§

(36.6°C) Normothermia vs (35.6°C) Mild hypothermia

Cardiac and non-cardiac surgery
Effect of hypothermia: blood loss

16% lower blood loss in normothermic group
(p=0.009, 95% CI 4%-26%)

Effect of hypothermia: transfusion

22% less risk of transfusion in normothermic group
(p=0.027, 95%CI 3%-37%)

Effects of hypothermia

• Delayed drug clearance
• ↑ wound infection
• Thermal discomfort and shivering
• Myocardial damage
Why? and How?
Hypothermia under anesthesia

Conduction
Evaporation
Convection
Radiation

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Physiology

Hypothalamus

Thermal receptor
- hypothalamus
- other parts of brains
- spinal cord
- deep thorax, abdomen
- skin surface

Behavioral regulation

Autonomic regulation

Temperature Homeostasis
Autonomic Thermoregulation

Threshold temperature

- Shivering
- Non-shivering thermogenesis
- Vasoconstriction

Mean body temperature (°C)

- <36 °C
- <36.5 °C
Autonomic Thermoregulation

Interthreshold range

Under anesthesia
Hypothermia under anesthesia

1. Initial rapid decrease
2. Slow linear reduction
3. Plateau
Prevention
Hypothermia prevention

Maintenance of body temperature in a normothermic range is recommended for most procedures other than during periods in which mild hypothermia is intended to provide organ protection (Class I, Level B)

American Society of Anesthesiologists, 2015
Hypothermia prevention

- Temp. Monitoring
- Preoperative warming
- Theatre suite temp.
- Fluid warming
- Cutaneous warming
- Postoperative warming
ASA Standard II Body temperature

Every patient receiving anesthesia should have temperature monitoring when clinically significant changes in BT are intended, anticipated, suspected

American Society of Anesthesiologists
Hands up!!
Temperature monitoring

Survey on intraoperative temperature management in Europe.

Torossian A¹; TEMMP (Thermoregulation in Europe Monitoring and Managing Patient Temperature) Study Group.

- 801 surgical procedures, 17 European countries
- Temperature monitoring is done in 19.4%
Temperature monitoring

• None of the existing guideline specify the best tools
• Electronic thermometers are accurate & inexpensive
• The site and device selection depend on physicians, type of surgery, and accessibility of monitoring site
• The least invasive modalities with a reliable assessment are preferred
Temperature monitoring

Core body temperature should be measured

- GA longer than 30 min
- RA when changes in body temperature are intended, anticipated, suspected

*NICE pathway on inadvertent perioperative hypothermia*
Sites for temperature monitoring

Core
- Pulmonary artery
- Distal esophagus
- Tympanic membrane
- Nasopharynx

Intermediate
- Oral
- Rectum
- Bladder

Skin
- may reflect core temperature
Hypothermia prevention

- Temp. Monitoring
- Preoperative warming
- Theatre suite temp.
- Fluid warming
- Cutaneous warming
- Postoperative warming
Preoperative warming

↑ peripheral heat content

↓ redistribution hypothermia

Higher core temperature
# Preoperative warming

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Method</th>
<th>N</th>
<th>Setting</th>
<th>Intervention</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossum</td>
<td>2001</td>
<td>RCT</td>
<td>100</td>
<td>OPD GA for 1-3 hr</td>
<td>FAW 38±3°C &gt; 45 min Cotton blanket</td>
<td>↑ pre-op core T</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Better maintain peri-op T</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Similar shivering</strong></td>
</tr>
<tr>
<td>Wong</td>
<td>2007</td>
<td>RCT</td>
<td>103</td>
<td>Major abd Sx</td>
<td>On/off warming mattresses 2 hr</td>
<td><strong>Higher intra-op core T</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Same core T after 2 hr</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Less blood loss in prewarm</td>
</tr>
<tr>
<td>Andrzejowski</td>
<td>2008</td>
<td>RCT</td>
<td>68</td>
<td>Spine Sx</td>
<td>FAW 38°C x 1 hr Linen gown</td>
<td><strong>Smaller ↓ core T intra-op</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>More pt maintain core T &gt; 36°C</td>
</tr>
<tr>
<td>Horn</td>
<td>2012</td>
<td>RCT</td>
<td>200</td>
<td>GA 30-90 min</td>
<td>FAW 44°C x 10, 20, 30 min Insulation</td>
<td><strong>Higher intra-op core T</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Same core T in all FAW groups</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>More pt maintain core T &gt; 36°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower shivering in all FAW gr</td>
</tr>
</tbody>
</table>

FAW: Forced air warmer

P<0.00001
• Adult, ASA I-III, non-cardiac surgery under GA 1-6 hr  
  n = 200

• **FAW ≥ 41°C and ≥ 30 min** vs warmed blanket on request

• Intraoperative hypothermic **magnitude** (AUC for T < 36°C)
• Pre-warming time > 30 min
  NO further effect on magnitude of hypothermia (P = 0.39)

• Every minute of delay between the end of the pre-warming period and initiation of intraoperative warming increased the magnitude of hypothermia (P<0.001)
Preoperative warming

• Active prewarming **30 min** likely prevents considerable redistribution*

• Prevent the sudden decrease in core temperature during the **first hour**

• Effect on post-op shivering is **controversy**

• **Minimize gap** between pre-warming period and intraoperative warming

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Hypothermia prevention

- Temp. Monitoring
- Preoperative warming
- Theatre suite temp.
- Fluid warming
- Cutaneous warming
- Postoperative warming
Theatre suite temperature

- At least 21°C
- May reduce after active warming is established

NICE pathway on inadvertent perioperative hypothermia
Hypothermia prevention

- Temp. Monitoring
- Preoperative warming
- Theatre suite temp.
- Fluid warming
- Cutaneous warming
- Postoperative warming
Warm fluid before use: Warming cabinet

Warm fluid before use: Blood warmer

Plasmatherm

https://www.marlinmedical.com.au
Actively warm fluids while being administered: Dry heat technology

3M™ Ranger™ Blood/Fluid Warming Unit

https://www.3m.com
Actively warm fluids while being administered: Hotline fluid warmer

https://www.marlinmedical.com.au
Warming intravenous fluid

• Intravenous fluids (500 ml or more) and blood products should be warmed to 37°C
• No clinically difference among fluid warmers
• Considered in trauma patients

Keeping patient warm is more important than warming blood (WHO guideline)
Hypothermia prevention

- Temp. Monitoring
- Preoperative warming
- Theatre suite temp.
- Fluid warming
- Cutaneous warming
- Postoperative warming
Cutaneous warming

Passive insulation

Active warming
Passive cutaneous warming
Forced air warmer
Circulating water mattress
Cutaneous warming

- **Passive insulation alone is insufficient**
- Under-the-body warming is less effective
  - little heat loss from back
  - Poor perfusion + heat >> heat necrosis/burn
- **Forced air warmer is superior** to circulating water mattresses in maintaining normothermia
Hypothermia prevention

Temp. Monitoring
Preoperative warming
Theatre suite temp.
Fluid warming
Cutaneous warming
Postoperative warming
Postoperative warming therapy

- Forced air blankets and radiant heater are most commonly used
- Low efficacy and takes long time
- **Intraoperative warming is ideal**
✓ Definition and classification
✓ Effect of hypothermia
✓ Physiology
✓ Hypothermia prevention
☐ Guidelines
☐ Take home messages
<table>
<thead>
<tr>
<th></th>
<th>ASA, 2015</th>
<th>NICE, 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preparation:</strong></td>
<td>-</td>
<td>Preparation: patient's temperature should be ≥ 36°C before transferred to OR</td>
</tr>
<tr>
<td></td>
<td>2 or more of the following</td>
<td>Monitor temp: when anesthesia &gt; 30 min or Higher risk of inadvertent hypothermia</td>
</tr>
<tr>
<td></td>
<td>- ASA class II to V</td>
<td>Record:</td>
</tr>
<tr>
<td></td>
<td>- Preoperative BT &lt; 36.0°C</td>
<td>Every 30 min intraoperative</td>
</tr>
<tr>
<td></td>
<td>(and preoperative warming is not possible)</td>
<td>Every 15 min at RR</td>
</tr>
<tr>
<td></td>
<td>- Combined GA and RA</td>
<td>Goal:</td>
</tr>
<tr>
<td></td>
<td>- Major or intermediate surgery</td>
<td>maintain BT ≥ 36.5°C</td>
</tr>
<tr>
<td></td>
<td>- At risk of cardiovascular complications</td>
<td>Method:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- FAW set at maximum and then adjusted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- If FAW is unsuitable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;&gt; resistive heating mattress/blanket</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- IV fluid &amp; blood products: warm to 37°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Irrigate fluid: warm to 38-40°C</td>
</tr>
</tbody>
</table>
Take home messages

• **Effect of hypothermia**
  Alter drug metabolism, bleeding, wound infection, thermal discomfort, morbid myocardial outcome

• **Mechanism of heat loss**
  Radiation > convection > evaporation > conduction

• **Temperature monitoring**
  Standard II ASA monitoring // NICE recommendation

• **Active prewarming**
  30 min before intra-op active cutaneous warming
  >> reduce hypothermia
Take home messages

• Set OR temperature $\geq 21^\circ$C

• IV fluids and blood products warmed to 37$^\circ$C

• Forced air warmer is effective
even in patient undergoing large operation

• Postoperative warming therapy
low efficacy and takes long time
STOP HYPOTHERMIA

PREVENTION OF HEAT LOSS
KEEP PATIENTS WARM INTRAOPERATIVELY
"The cold will never bother you and your patients anymore."