Brain Cooling in Traumatic Brain Injury and Stroke

Bridget Harris, PhD, RGN
Clinical Research Specialist, NHS Lothian
Research Fellow, University of Edinburgh
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• Therapeutic temperature reduction after acute cerebral insults - evidence and practice - normothermia, hypothermia

• Terminology and scope

• Systemic versus brain cooling – why brain cooling?

• Methods of non-invasive brain cooling – pros and cons

• Temperature measurement

• Effect of therapeutic brain cooling on temperature – clinical studies

• Future directions
Terminology and scope

• Selective brain cooling vs therapeutic brain cooling – terminology

• Therapeutic brain cooling methods
  – Invasive
    • neuroprotection during surgery e.g. antegrade cerebral perfusion for aortic arch surgery
  – Non-invasive
    • Nasal/pharyngeal cooling
    • External head cooling

• Therapeutic brain cooling – acute cerebral insults - global and focal – normothermia, hypothermia
Evidence for therapeutic temperature reduction in acute global cerebral insults

• Comatose survivors of cardiac arrest (VF), neonatal hypoxic ischaemic injury
  – therapeutic hypothermia reduces mortality, improves functional outcome

• In these conditions therapeutic hypothermia is recommended as part of standard care
Evidence for therapeutic temperature reduction in acute focal cerebral insults

Traumatic brain injury (TBI), stroke

- experimental evidence
  - improved outcome with normothermia and hypothermia
  - multifactorial neuroprotective effects (early)
  - prevention and reduction of secondary insults
    
    (Dietrich & Bramlett *Prog Brain Res* 2007;162:201-17; van der Worp et al. *Brain* 2007;130:3063-74)

- human evidence
  - increased temperature is common and associated with worse outcome - death and disability  
    (e.g. Greer et al. 2008 Stroke 39:3029-35)
  - insufficient evidence that therapeutic temperature modulation - normothermia or hypothermia - improves outcome
    
  - normothermia is standard practice +/- hypothermia for refractory raised intracranial pressure
    
  - shivering
Systemic cooling versus brain cooling – why brain cooling?

**Systemic methods** – drugs (e.g. acetaminophen), cooling blankets/pads, intravenous cooling catheters – side effects

**Brain cooling** – nasal/pharyngeal cooling and external head cooling – rationale

- Brain cooling has fewer side-effects than systemic hypothermia e.g. infection – some studies use body warming (Feigin et al. *J Clin Neurosci* 2002;9:502-7; Gluckman et al. *Lancet*;365:663-70; Harris et al. *J Neurosurg* 2009;110:1256-64)


- Preferential cooling of cortices (external cooling) of benefit (Wityk *Crit Care Med* 1994;8:1278-93)

- Little evidence in humans (Harris et al. *HTA* 2012;16;1-175)
Methods of non-invasive brain cooling – pros and cons

Nasal/pharyngeal cooling – induce heat loss from the upper airways by
- convection +/- evaporation e.g. nasal gas flow, nasal lavage
- conduction e.g. nasal or pharyngeal balloons

External head cooling – induce heat loss through the skull by
- convection +/- evaporation e.g. fanning,
- conduction e.g. circulating liquid cooling helmet (active), ice packs/frozen gel helmet (passive)

Pros and cons
Temperature

• Temperature measurement sites
  – Intracranial
  – Tympanic
  – Magnetic resonance spectroscopy
  – Core body – PA, oesophagus, bladder, rectum – best proxy

• Effectiveness of brain cooling in reducing temperature (Harris et al. HTA 2012;16(45)1-175)
### Summary of average temperature reduction with therapeutic cranial cooling
(studies reporting temperature reduction achieved)

<table>
<thead>
<tr>
<th>Head cooling method</th>
<th>Cooling duration</th>
<th>Intracranial temp reduction (total cooled pts)</th>
<th>Core body temp reduction (total cooled pts)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rhinochill</strong> (upper airways) (Andreas 2008, Busch 2010, Abou-Chebl 2011)</td>
<td>60 mins</td>
<td>1.4 °C (n=11)</td>
<td>1.1–1.3 °C* (n=106)</td>
</tr>
<tr>
<td><strong>Quickcool nasal balloons</strong> (Springborg et al 2013)</td>
<td>72 hr</td>
<td>~1 °C (n=6)</td>
<td>~1 °C (n=9)</td>
</tr>
<tr>
<td><strong>Nasal airflow + head fanning</strong> (Harris 2007)</td>
<td>30 mins</td>
<td>0.41 °C (n=12)</td>
<td>0.32 °C (n=12)</td>
</tr>
<tr>
<td><strong>Gel head and neck</strong> (Sovika) (Poli et al 2013)</td>
<td>~50 mins</td>
<td>0.36 °C (n=11)</td>
<td>0.25 °C (n=11)</td>
</tr>
<tr>
<td><strong>Circulating liquid head and neck</strong> (Wang 2004, Harris 2009, Gaida 2008, TraumaTec Neuro ICU study/Miller 2009)</td>
<td>1–24 hr</td>
<td>1–2 °C (n=34)</td>
<td>0.8 °C (n=6)</td>
</tr>
</tbody>
</table>

* includes mean and median data, all other temperatures are mean reductions
Rhinochill Intranasal Cooling Device
Benechill, Inc. USA
Mean temperature reductions during the 1-hour RhinoChill induction

Mean temperature reductions during 1-hour cooling with RhinoChill
ICT = intracranial temperature  (Abou-Chebl et al. Stroke 2011;42:2164-9)
QuickCool nasal balloons

QuickCool AB, Lund
Fig. 2 Median temperature in the cerebrum in the first 72 h of cooling. As indicated by the linear regression line a temperature level of 37°C was not reached within 72 h of cooling ($y = -0.012x + 38.814$, $R^2 = 0.111$, $p < 0.0001$) (n=6)

Springborg et al. *Neurocrit Care* 2013; 18(3):400-5
12 pts – traumatic brain injury or subarachnoid haemorrhage

Intracranial temperature reduction compared to baseline with:

1. no intervention
2. nasal airflow - twice minute volume (≤24 L) + 20ppm NO
3. bilateral head fanning (ambient air approximately 8 m s⁻¹)
4. airflow plus fanning

(Harris et al. *Br J Anaesth* 2007;98:93-9)
MedCool Device

Forced convective device - soft, fabric helmet

CoolSystem Discrete Cerebral Hypothermia Device

(Harris et al. J Neurosurg 2009;110:1256-64)
12 pts – traumatic brain injury – 12 head cooled, 13 controls
Mean intracranial temperatures in cooled (cap) vs not cooled (no cap)
After 24 hours, cooled group intracranial temperature 1.2°C lower than controls
(Harris et al. *J Neurosurg* 2009 110;1256-64)
Sovika head and neck cooling device (Sovika GmbH)

(Poli et al. Stroke 2013;44:708-13)
Brain, bladder, and tympanic temperatures – stroke patients

(Poli et al. *Stroke* 2013;44:708-13)
Future directions

• Non-invasive methods of measuring intracranial temperature – continuous measurement

• Device development

• Higher quality studies – temp reporting, outcome
  – complications of cranial cooling vs systemic cooling
  – cranial cooling to reduce intracranial pressure

• Standardardised terminology for therapeutic cranial cooling and methods
Thank you

Systematic review of head cooling in adults after traumatic brain injury and stroke

Harris, Andrews, Murray, Forbes, Moseley

*Health Technology Assessment* 2012;16(45):1-175

can be downloaded without charge from:

www.hta.ac.uk/1777

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