HYPOTHERMIA IN INJURY CARE

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Sydney
HYPOTHERMIA

- Neuroprotective
- Cold cardioplegia
- Pediatric heart anomalies
- Environmental exposure: prolonged survival (drowning)

- Trauma
- Randomized, prospective
- 392 patients from 7 level I centers
- Isolated major brain injury

<table>
<thead>
<tr>
<th></th>
<th>37 °C</th>
<th>33 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor outcome (%)</td>
<td>57</td>
<td>57</td>
</tr>
<tr>
<td>Mortality (%)</td>
<td>27</td>
<td>28</td>
</tr>
<tr>
<td>Complications (%)</td>
<td>70</td>
<td>78</td>
</tr>
</tbody>
</table>

Better outcome:
1. age < 35
2. hypothermia on arrival to ED

Clifton, Miller, Sung, et al. Lack of Effect of Induction of Hypothermia after Acute Brain Injury
NEJM 2001
NEUROPROTECTION

Hypothermia:

- reduces intracranial pressure
- diminishes harmful biochemical cascade

neurologic outcomes

<table>
<thead>
<tr>
<th>improved</th>
<th>worse / no better</th>
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<tbody>
<tr>
<td>Marion - 1997</td>
<td>Shiozaki - 1993</td>
</tr>
<tr>
<td>Jiang - 2000</td>
<td>Clifton - 1993</td>
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</tbody>
</table>
NEUROPROTECTION after CARDIAC ARREST

Induction of hypothermia within one hour in survivors of cardiac arrest resulted in significantly improved neurologic outcomes.

- Bernard, Gray, Buist, et al. NEJM 2002
- Holzer. NEJM 2002

We need a study of hypothermia as a neuroprotectant in traumatic brain injury with induction beginning < 1 hour of injury.
GRADES OF HYPOTHERMIA

- **Mild**: tachycardia, tachypnea, diuresis, apathy, vasoconstriction, shivering
- **Moderate**: cardiac conduction disturbances, hyperventilation, hallucinations
- **Severe**: severe dysrrhythmias, ↓renal bl. flow, decreased metabolism, areflexia, shivering stops
- **Profound**: asystole
4 MECHANISMS OF HEAT LOSS

- Conduction: direct contact with cold surface (60%)  
- Convection: heat loss to overlying air currents (25%)  
- Evaporation: heat loss to vaporization of water (7%)  
- Radiation: heat loss to surrounding objects (7%)
CARDIAC OUTPUT & BLOOD PRESSURE

↓ myocardial compliance = ↑ filling pressures required
MYOCARDIUM

- Slowing of depolarization
- QRS widening
- PR prolongation
- T inversion
- J waves
- a-fibrillation, bradycardia
- Low threshold for V-fib
- Asystole
HYPOTHERMIA AND COAGULATION

Hypothermia impairs:

1. intrinsic pathway, (APTT)
2. extrinsic pathway, as measured by the (PT)
3. common pathway as measured by the Thrombin Time
4. platelet function as measured by the Bleeding Time

Clotting times performed at 37 C per lab protocol

NL. LAB CLOTTING STUDY ≠ NL. IN VIVO CLOTTING
TEMPERATURE EFFECTS on PLATELET FUNCTION

% of value at 37°C

Temperature (°C)

ADHESION
AGGREGATION

Wolberg, et al, J Trauma, June 2004
RECOMBINANT FACTOR VIIa

Stem the flow
RECOMBINANT FACTOR VIIa

rFVIIa → Xa → THROMBIN → platelet

Fibrinogen → Fibrin

Will rFVIIa work in cold trauma patients?
RECOMBINANT FACTOR VIIa

Decreasing the pH of the reactions decreased the rate of FXa formation by the FVIIa/TF complex.

Meng et al, J Trauma, Nov 2003
Rate of FX activation by rFVII was actually increased by falling temperature

Meng et al, J Trauma, Nov 2003
RECOMBINANT FACTOR VIIa

"RFVIIa should be effective in enhancing hemostasis in hypothermic patients... however... its efficacy may be reduced in acidotic patients."

Meng et al, J Trauma, Nov 2003
HEMATOLOGIC EFFECTS of HYPOTHERMIA

1. Increased blood viscosity
   - microcirculatory flow
   - $O_2$ delivery

2. Hgb $P_{50}$: shift to left

3. Diminished clotting function
   - platelets
   - clotting factors

- tissue hypoxia
- continued hemorrhage
Lethal Triad

- Acidosis
- Hypothermia
- Coagulopathy
HYPOTHERMIA IN TRAUMA: PREDICTOR OF SURVIVAL?

<table>
<thead>
<tr>
<th>ISS</th>
<th>CORE TEMP (°C)</th>
<th>MORTALITY (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 50</td>
<td>&lt; 32</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>32-33</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>&gt; 33</td>
<td>25</td>
</tr>
<tr>
<td>25-29</td>
<td>&lt; 32</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>&gt; 32</td>
<td>3</td>
</tr>
</tbody>
</table>

Jurkovich GJ, et al
J. Trauma 27:1019, 1987
PREVENTION

1. Avoid cold fluids
2. Avoid cold rooms
3. Avoid wet surfaces
4. Cover the patient
5. Treat shock well and quickly
PREVENTION

Minimize exposure heat loss
PREVENTION

Control Your Thermostat
REWARMING TECHNIQUES

ACTIVE CORE REWARMING

1. warm intravenous fluids
2. airway rewarming
3. warm peritoneal / pleural lavage
4. continuous arteriovenous rewarming
5. continuous venovenous rewarming
6. cardiopulmonary bypass
Standard Rewarming vs. CAVR

- Randomized, prospective
- 57 hypothermic patients
- 85% blunt trauma

CAVR
- Faster rewarming
- Less fluid requirements (24 vs. 32 L)
- Lower early mortality

But no overall mortality advantage or differences in complication rates

Gentilello, et al, J Trauma, 1997
REWARMING TECHNIQUES

Forced air convection blankets
aka: BAIR Hugger

IV Fluid warmers
HOW HOT is TOO HOT?

- Anaesthetized beagles cooled to 30 °C and shocked to MAP of 40 mm Hg
- Ringer’s Lact. Soln via central vein

60 °C vs. 40 °C

No difference in:
- RBC destruction (as measured by osmotic fragility or plasma free hb)
- endothelia cell damage
- Faster warming (3.6 °C / hr. vs. 1.9 °C / hr)

Hyperthermic crystalloid is safe and faster

Thank you