Hypothermia in Trauma: Helpful or Hindrance?

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Overview

• Rationale
• Data for cardiac arrest
• Controversies
• Recommendations
• Potential use for traumatic arrest
• Conclusions and future directions
Trauma Deaths

- Within the first 6 hours: 75% of penetrating deaths
  
  *Velmahos, J Trauma, 2004*

- Within the first 3 hours: 54% of blunt trauma deaths
  
  *Marson, J Trauma, 2001*
The Trimodal Distribution Of Trauma Deaths

The group that matters
Trauma Deaths - Today

- RCT - 274 hospital, 40 countries, >20K patients
- Most died on the day of randomization
- Deaths due to MOF <2.5%

CRASH-2 trial
Lancet 2010
Massive blood loss and no pulse

Emergency Department
Thoracotomy
Traumatic arrest

- Dismal outcome
- Potentially reparable injuries
- Futility of conventional strategies
- Limiting factor - cerebral ischemia time
- Need for a new approach - organ preservation during ischemia
- Therapeutic hypothermia - EPR
Hypothermia

- Decrease in metabolic rate - $Q_{10}$
- $Q_{10}$ whole body=2, brain=4.6
- Attenuation of reperfusion injury
- Modulation of inflammation
- Genes and proteins - multiple pathways
- Commonly used in elective surgery
TREATMENT OF COMATOSE SURVIVORS OF OUT-OF-HOSPITAL CARDIAC ARREST WITH INDUCED HYPOTHERMIA


MILD THERAPEUTIC HYPOTHERMIA TO IMPROVE THE NEUROLOGIC OUTCOME AFTER CARDIAC ARREST

The Hypothermia after Cardiac Arrest Study Group*
A decade later

• 5 studies
• 481 patients
• Data support induction of mild therapeutic hypothermia to improve survival and neurological outcomes after cardiac arrest
In summary, we recommend that comatose (i.e., lack of meaningful response to verbal commands) adult patients with ROSC after out-of-hospital VF cardiac arrest should be cooled to 32°C to 34°C (89.6°F to 93.2°F) for 12 to 24 hours (Class I, LOE B). Induced hypothermia also may be considered for comatose adult patients with ROSC after in-hospital cardiac arrest of any initial rhythm or after out-of-hospital cardiac arrest with an initial rhythm of pulseless electric activity or asystole (Class IIb, LOE B). Active rewarming should be avoided in comatose patients who spontaneously develop a mild degree of hypothermia (>32°C [89.6°F]) after resuscitation from cardiac arrest during the first 48 hours after ROSC. (Class III, LOE C).
Why not for trauma?

- Not the same as elective surgery (limited time, uncontrolled conditions, pre vs. post-ischemia)
- Different from v-fib arrest
- Induced vs. spontaneous hypothermia
- Coagulopathy
- Delayed complications?
Hypothermia in trauma

- Induced vs. Spontaneous hypothermia
  - Therapeutic vs. marker of tissue ischemia
  - CABG vs. Traumatic hypothermia
  - Shivering

- Effect on coagulation
  - Platelets
  - Clotting factors

All dead pts are cold, but cold pts are not all dead

Translational barriers and opportunities for emergency preservation and resuscitation in severe injuries

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Diagram:
- Normal cell functions
- ATP
- Aerobic metabolism
- Gene transcription
- ADP + heat
- O₂ + Substrates

Caption:
- Normal physiological function
To complicate the issue further...

- Effects of hypothermia are influenced by
  - Depth
  - Duration
  - Organ/cells
  - Clinical conditions
  - Active or passive re-warming
  - Adjunct therapies
So, is hypothermia in trauma good or bad?
The Ultimate Resuscitation Strategy
Race against time. In cardiac arrest, stroke, and trauma, hypothermia may buy time and save lives.

The Big Chill

10 AUGUST 2007 VOL 317 SCIENCE

Crude beginnings. A bathtub full of ice was one of the earliest ways doctors induced hypothermia in the 1950s.
Feasibility

• Cerebral protection during arrest  Safar et al
  • 28°C ~ 30 min
  • 20°C ~ 60 min
  • 15°C ~ 90 min
  • 10°C ~ 90-120 min

• Profound hypothermia via thoracotomy  Rhee et al. J Trauma 1999;48:439-449

Questions

• Rate of induction?
• Depth?
• Rate of re-warming?
• Immunologic consequences?
• Severity of shock?
• Impact of associated injuries?
• Techniques and devices?
• Maximum safe duration?
Pittsburgh model

Intra-aortic Preservation-Resuscitation
Poly-trauma models

- Large animals
- Closed circuit cooling and re-warming
- Vascular injuries above and below the diaphragm (100% lethal)
- Additional injuries (solid organ and bowel)
- Long-term survival: organ dysfunction and cognitive evaluation
Hemorrhage

Time (minutes)
0 50 100 150 200 350 400

MAP mmHg
0 20 40 60 80

Iliac injury
Aortic injury
Induction of hypothermic arrest on CPB
Re-warming
Off CPB
Temperature changes

- Normothermic shock
- Induction of hypothermia on CPB
- Profound hypothermia maintained on low flow CPB
- Warming

Graph showing temperature changes over time.
Cardiac output & oxygen delivery

- Cardiac Output (L/min)
- Oxygen Delivery (mL/min)

- No cooling
- Slow cooling
- Medium cooling
- Fast cooling

* p<0.05
Putting Life On Hold—For How Long? Profound Hypothermic Cardiopulmonary Bypass in a Swine Model of Complex Vascular Injuries

Hasan B. Alam, MD, Michael Duggan, DVM, Yongqing Li, MD, PhD, Konstantinos Spaniolas, MD, Baoing Liu, MD, Malek Tabbara, MD, Marc deMoya, MD, Elizabeth A. Sailhac and George C. Velmahos, MD

Profound hypothermia is superior to ultraprofound hypothermia in improving survival in a swine model of lethal injuries

Surgery
August 2006
Profound Hypothermic Cardiopulmonary Bypass Facilitates Survival Without a High Complication Rate in a Swine Model of Complex Vascular, Splenic, and Colon Injuries

Role of hypothermia in hemorrhagic shock

Journal of Organ Dysfunction, 2008; 4: 151–160

FAHAD SHUJA, JOSÉ PEDRO ALMEIDA and HASAN B. ALAM

Hypothermia in multisystem trauma

Eugene Y. Fukudome, MD; Hasan B. Alam, MD, FACS
Hypothermia: Emergency Preservation & Resuscitation (EPR)

- Rate of induction – Fast (2°C/minute)
  Alam et al. J Trauma 2004

- Optimal Depth – Profound (10°C)
  Alam et al. Surgery 2006

- Rate of re-warming – (0.5°C/minute)
  Alam et al. J Trauma 2006

- Duration – short (60 minutes)
  Alam et al. J Trauma 2008

- Poly-trauma – feasible without complications
  Sailhamer et al. JACS 2007
Development and testing of portable, battery operated, disposable CPB equipment

Developed at the Cleveland Clinic Foundation


Non-metabolic effects extend far beyond the period of hypothermia.
Non survivable injury-now what?

Hypothermia and hemostasis in severe trauma: A new crossroads workshop report

Hasan B. Alam, MD, Anthony E. Pusateri, PhD, Andrei Kindzelski, MD, PhD, Debra Egan, MPH, Keith Hoots, MD, PhD, Matthew T. Andrews, PhD, Peter Rhee, MD, MPH, Samuel Tisherman, MD, Kenneth Mann, PhD, Jaroslav Vostal, MD, PhD, Patrick M. Kochanek, MD, Thomas Scalea, MD, Virgil Deal, MD, Forest Sheppard, MD, George Sopko, MD, MPH, and on behalf of the HYPOSTAT workshop participants, Boston, Massachusetts
Challenges

- Indications
- Limitations
- Logistical issues
- Early adverse effects
- Potential for delayed problems (e.g. survival with poor neurological status)

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Avoid spontaneous hypothermia
EPR may become the new CPR
Emergency Preservation and Resuscitation (EPR) for Cardiac Arrest From Trauma (EPR-CAT)

This study is not yet open for participant recruitment.

Verified August 2011 by University of Pittsburgh

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History of Changes
Hypothermia To Save Lives? Doctors To Try Deep-Chilling Trauma Patients

Doctors are ready to test temporary 'suspended animation' to save people with severe injuries

Docs test 'suspended animation' as potential battlefield treatment

Killing a Patient to Save His Life

Patients to be frozen into state of suspended animation for surgery

Freezing A Body For Surgery Could Save Lives
The difficulty lies, not in the new ideas, but in escaping from the old ones..

John Maynard Keynes (1883-1946)
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