Methods of cooling: Practical aspects of therapeutic temperature

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Crit Care Med 2009 Vol. 37, No. 7

Date: 2010/07/07
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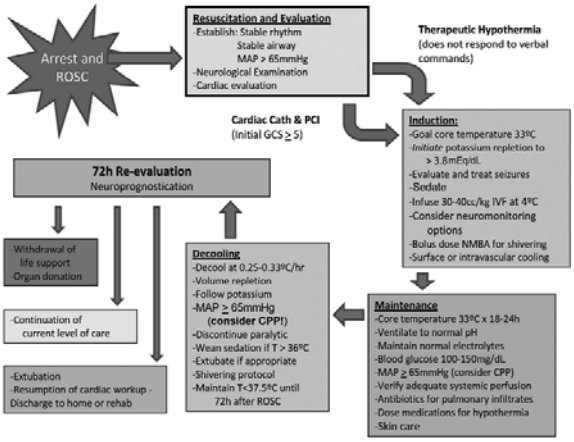
Therapeutic Hypothermia

- Support initiation of cooling as soon as possible after return of spontaneous circulation (ROSC)
- In adults is routinely performed:
  - after cardiac arrest,
  - patients awaiting liver transplant with cerebral edema from acute liver failure,
  - for the control of refractory elevated ICP

Therapeutic Hypothermia

- Among cardiac arrest survivors, it is standard to perform in all patients, unless:
  - The patient can follow verbal commands;
  - More than 8 hrs have elapsed since ROSC;
  - There is life-threatening bleeding or infection;
  - Cardiopulmonary collapse is imminent, despite vasopressor or mechanical hemodynamic support;
  - An underlying terminal condition exists.

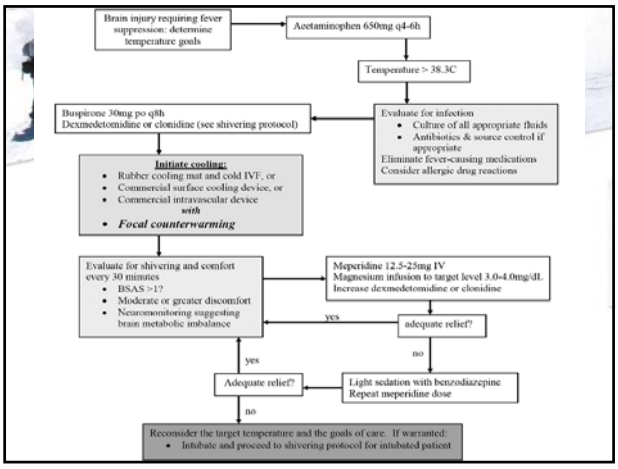


"Postresuscitation" Syndrome

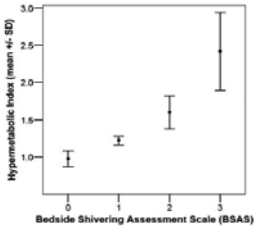
- increased inflammatory cytokine levels, vasodilation, and hypotension
- exacerbating the cutaneous vasodilation routinely associated with decooling, and myocardial dysfunction related to AMI, defibrillation injury, or cardiomyopathy

Control of Postcooling Fever

- "Rebound" fever is common and harmful
- maintain normothermia after decooling and until 72 hrs have elapsed since ROSC
- Commercial cooling device
  - easily achieved by resetting target temperature
- Conventional cooling techniques
  - require particular nursing vigilance



Bedside Shivering Assessment Scale (BSAS)



Score	Definition
0	None: no shivering noted on palpation of the masseter, neck, or chest wall
1	Mild: shivering localized to the neck and/or thorax only
2	Moderate: shivering involves gross movement of the upper extremities (in addition to neck and thorax)
3	Severe: shivering involves gross movements of the trunk and upper and lower extremities

Fundamental

1. serum potassium should be aggressively replaced if <3.8 mEq/dL, and reassessed every 3 to 4 hrs during the induction phase
2. continuous core temperature measurement must guide TTM, preferably by bladder, rectal, central venous, or esophageal measurement
3. a rapid and thorough neurological examination should precede NMB administration.
4. no device is currently approved for treatment of hypoxicischemic encephalopathy after cardiac arrest
5. prophylactic antibiotics for pneumonia (30% and 50% in intubated cardiac arrest survivors treated with Hypothermia)

Fundamental

6. Continuous EEG monitoring for seizure (incidence 19-34%)
7. hemodynamic instability and shock manegement, intravenous isotonic fluids
8. When NMBA is provided, corticosteroids should be avoided due to the risk for critical illness myopathy and prolonged neuromuscular weakness

10. Focal counterwarming reduces shivering and discomfort

Cooling Methodologies

Conventional Surface Cooling and Cold Fluids

- cold saline or Ringer's lactate solution (4°C) is administered at a dose of 30 to 40 mL/kg
- ice packs applied to the neck, groin, and axillae, and with widely available rubber cooling blankets or mats
  - lack of an internal feedback loop
  - high incidence of overcooling
  - the need for extreme nursing vigilance and experience to maintain the goal temperature
  - difficulty in controlling the rate of decooling

Commercial Surface Cooling Devices

- Arctic Sun device:
  - heat-exchange pads and hydrophilic gel cover approximately 40% of the body surface area
  - CoolBlue
  - KoolKit
  - ThermoWrap
- The fastest cooling system- Thermosuit System
  - cool human-sized swine to 33°C in only 30 to 45 mins
  - for induction only

Commercial Intravascular Cooling

- Complications of central venous catheterization
- The Alsius temperature management system
  - allowing for the administration of vasopressors and caustic medications
  - blood draws
  - monitoring of central venous pressure,
  - intermittent ScvO2 analysis
- The Celsius Control System (Inner-cool Therapies)

Less Commonly Used Cooling Techniques and Devices

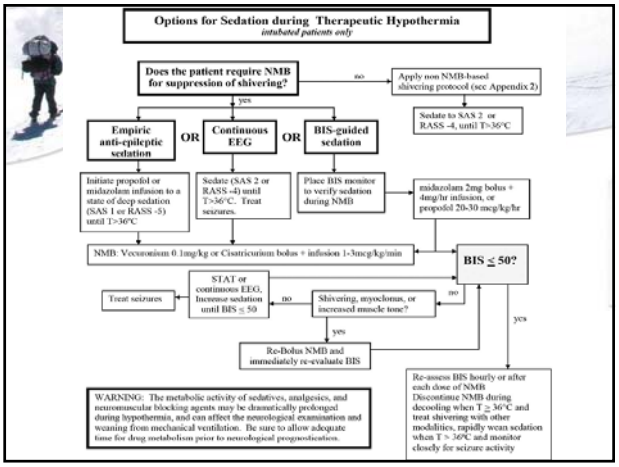
- medications (such as neurotensin)
- extracorporeal circuits
- body cavity lavage
- whole-body ice water immersion
- continuous veno-venous hemofiltration
- and air-conduction hypothermia devices
- cooling helmets

Neuromonitoring During Therapeutic Hypothermia

Modality	Rationale for Use	Advantages	Disadvantages
Continuous EEG	Convulsive and nonconvulsive seizures are common in HIE Neuromuscular blocking agents may obscure seizures	Immediate identification of seizures Early identification of shivering Prognostication	Requires expertise and continuous attention to monitor
BIS monitoring	Less severely injured patients may be aware during TH and paralysis	Titration of sedation Early identification of shivering Prognostication Ease of use	Shivering confounds processed EEG signal
ICP monitor	Elevated ICP is common after cardiac arrest ICP rises during decooling and may exacerbate HIE	Titrate MAP to appropriate CPP Monitors ICP during decooling	Invasive Slight elevation in procedural bleeding risk due to TH
Partial pressure of brain oxygen ($PbtO_2$)	Measure of the adequacy of cerebral perfusion	Accuracy of direct measurement No increased morbidity when bundled with ICP monitor	Invasive
Brain temperature	Brain temperature and systemic temperature often correlate poorly	Measures brain temperature directly during decooling and after TH No increased morbidity when bundled with ICP monitor	Invasive
Microdialysis	LPR is a direct measure of brain ischemia	Titrates therapy to drive down the LPR No increased morbidity when bundled with ICP monitor	Invasive
Jugular oximetry ($SjvO_2$)	Verifies adequacy of CBF during TH and decooling Cerebral oxygen extraction is a surrogate for metabolic activity	Titrates MAP to $SjvO_2$ >60% Prognostication Low morbidity	Multiple confounders Requires expertise to interpret readings

Seizures

- hypothermia is probably antiepileptic
- most hypothermia
- protocols include continuous infusions of propofol or benzodiazepines
- must either monitor with continuous EEG, unavailable in most centers
- or treat empirically during the period of neuromuscular blockade with antiepileptic sedation



Conclusion

- cardiac arrest patients should routinely be transferred to cardiac arrest centers, where urgent cardiac revascularization, appropriate neuromonitoring, and aggressive neuroprotective therapies can be rapidly initiated.