Therapeutic Hypothermia:

HOW TO CHILL OUT

Terrence Coulter MD, FCCM, FCCP
Department of Pulmonary, Critical Care, and Sleep Medicine
Ferrell-Duncan Clinic
Medical Director, Department of Respiratory Therapy and Critical Care
Cox Health System
Springfield, MO

Disclosures

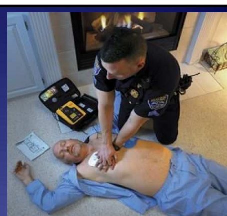
- None

Therapeutic Hypothermia = Targeted Temperature Management (TTM)

Learning Objectives

- Evolution of therapeutic hypothermia
- Use in ACLS guidelines
- Methods of cooling
- Various temperature management
- What to watch clinically during hypothermia procedure
- Uses beyond cardiac arrest

Cardiac Arrest



- 450,000 Americans/year
- 80% occur at home
- Rate of death is 90%
- In-hospital arrests have slightly better outcomes
  - Restoration of circulation in 44%
  - Survival to discharge in 17%

Young, G. Neurologic Prognosis after Cardiac Arrest. N Engl J Med 2009; 361:605-11.

Cardiac arrest: Fundamentals of therapy

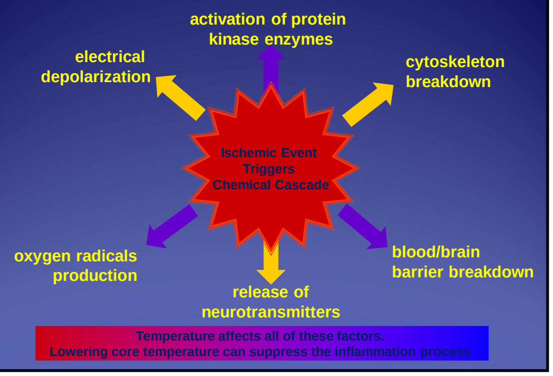
"Chain of Survival"

All of these advances have helped to achieve return of spontaneous circulation (ROSC)

Prompt Access	Early CPR	Early Defib	ACLS Care

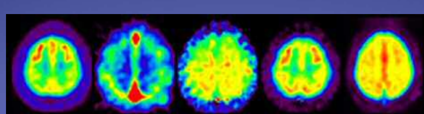
It still has not increased survivability or improved neurological outcomes

Cerebral Ischemia: What Happens?



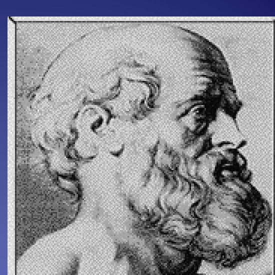
Basic principle

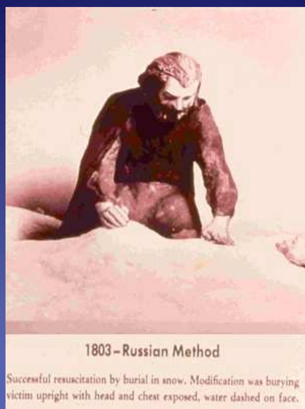
- Temperature dependent reductions in metabolism
- Decreased demand for oxygen and glucose
- Cerebral metabolism decreases by 6% to 10% for each 1^{o} C reduction in body temperature
- When core body temperature drops to 32^{o} C, the metabolic rate drops to 50%-65% of normal

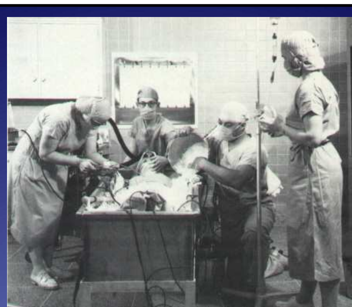


Hippocrates

- The Greek physician Hippocrates advocated the packing of wounded soldiers in snow and ice







Fay T:Observations on generalized refrigeration in cases of severe cerebral trauma. Assoc Res Nerv Ment Dis Proc 1945.

Fay T:Observations on human refrigeration. NY State J Med 1940

Williams GR: The clinical use of hypothermia after cardiac arrest. Ann Surg 1959.

Shortcomings of initial trials

- Believed needed large reduction in temperature to achieve efficacy
- Most treated with deep hypothermia (<30º C)
- Core temperature difficult to maintain
- Duration of cooling ranged from 2-10 days
- Rewarming methods not reliable
- Intensive care facilities not widely available

Back again

- Positive studies in the early 80's
- Realized outcomes could be improved with mild to moderate hypothermia (31-35º C)
- Advancements in technology
- Evolution of critical care units
- Understanding and anticipating side effects of cooling

2 Landmark Clinical Trials

European : HACA Trial

- 275 patients randomized to cooling or normal temps
- Cooling time: 6.5 hrs to 34ºC using surface cooling

Results:	Hypothermia	Normothermia	
Good Outcome	55%	39%	p=0.009
Mortality	41%	55%	p=0.02

Australian Study:

- 77 patients randomized
- Used ice packs to cool; Cooling rate .9 C/hour

Results:	Hypothermia	Normothermia	
Good Outcome	49%	26%	p=0.046
Mortality	51%	68%	P=NS

For every six patients treated, one life saved

The New England Journal of Medicine, 2002 Vol 346, no.8

Box. Glasgow-Pittsburgh Cerebral Performance Categories*

1. **Good Cerebral Performance** — HOME
Conscious: Alert, able to work and lead a normal life. May have minor psychological or neurological deficits (mild dysphasia, nonincapacitating hemiparesis, or minor cranial nerve abnormalities).

2. **Moderate Cerebral Disability** — REHAB
Conscious. Sufficient cerebral function for part-time work in sheltered environment or independent activities of daily life (dressing, traveling by public transportation, and preparing food). May have hemiplegia, seizures, ataxia, dysarthria, dysphasia, or permanent memory or mental changes.

3. **Severe Cerebral Disability** — LONG TERM FACILITY
Conscious. Dependent on others for daily support because of impaired brain function (in an institution or at home with exceptional family effort). At least limited cognition. Includes a wide range of cerebral abnormalities from ambulatory with severe memory disturbance or dementia precluding independent existence to paralytic and able to communicate only with eyes, as in the locked-in syndrome.

4. **Coma, Vegetative State** — LONG TERM FACILITY
Not conscious. Unaware of surroundings, no cognition. No verbal or psychological interactions with environment.

5. **Death** — SIX FEET UNDER
Certified brain dead or dead by traditional criteria.

*Adapted with permission from Cummings et al.[13]

What are the current Standards of care for cardiac arrest? (2005)

Evidence-based Practice

ROSC from VT/VF Cardiac arrest

- **32-34 degrees**
- **12-24 hours**

American Heart Association AHA Recommendations

Class IIa: Unconscious adult patients with return of spontaneous circulation (ROSC) after out-of hospital cardiac arrest should be cooled to 32°C to 34°C (89.6°F to 93.2°F) for 12 to 24 hours when the initial rhythm was ventricular fibrillation (VF).

Class IIb: Similar therapy may be beneficial for patients with non-VF arrest out of hospital or for in-hospital arrest.

International Liaison Committee on Resuscitation ILCOR Recommendations

Level I evidence

- Unconscious adult patients with spontaneous circulation after out-of-hospital cardiac arrest should be cooled to 32-34° C for 12-24 hours when the initial rhythm was ventricular fibrillation (VF).
- Such cooling may also be beneficial for other rhythms or in-hospital cardiac arrest.

Part 8: Post–Cardiac Arrest Care
2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

-Induce hypothermia for unconscious adult patients with return of spontaneous circulation (ROSC) after out-of-hospital cardiac arrest when the initial rhythm was ventricular fibrillation (VF) or pulseless ventricular tachycardia (pVT) (class I, level of evidence: B-R)

-Similar therapy may be beneficial for patients with non-VF/non-pVT (nonshockable) arrest out-of-hospital or with in-hospital arrest (class I, level of evidence: C-EO)

-The temperature should be maintained between 32ºC and 36ºC (class I, level of evidence: B-R)

-It is reasonable to maintain TTM for at least 24 hours (class IIa, level of evidence: C-EO)

The 2015 American Heart Association (AHA) guidelines:

- Routine prehospital cooling of patients with ROSC with intravenous (IV) rapid infusion is not advised (class III: no benefit; level of evidence A)
- It is reasonable to prevent fever in comatose patients after TTM (class IIb, level of evidence C-LD)
- Hemodynamically stable patients with spontaneous mild hypothermia (>33°C) after resuscitation from cardiac arrest should not be actively rewarmed

Inclusion criteria:

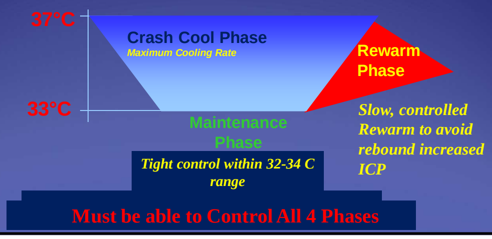
- Age greater than 18 years
- Intubated patients with treatment initiated within 6 hours after cardiac arrest (nonperfusing VT or VF)
- Patients able to maintain a systolic blood pressure above 90 mm Hg, with or without pressors, after cardiopulmonary resuscitation (CPR)
- Patients in a coma at the time of cooling

Exclusion criteria:

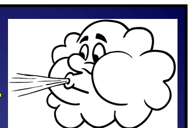
- The patient can follow verbal commands
- Recent major surgery within 14 days - Possible risk for infection and bleeding
- Systemic infection/sepsis - Small increase in risk of infection
- Coma from other causes (drug intoxication, preexisting coma prior to arrest)
- Known bleeding diathesis or with active ongoing bleeding - Hypothermia may impair the clotting system (however, patients may receive chemical thrombolysis, antiplatelet agents, or anticoagulants if deemed necessary in the treatment of the primary cardiac condition)
- In addition, hypothermia is inappropriate in patients with a valid do not resuscitate order (DNR).

Goals of the optimal cooling procedure:

- Rapid cool the body core to the target temperature
- Maintain target temperature for 24 hours
- Controlled rewarming
- Maintain normothermia (<37.5 C) until 72 hours after ROSC
- Proper management and prevention of known side effects



Mechanisms of Cooling



- Conduction
  - Thermal energy transfer between materials within direct contact with one another (ice packs)
- Convection
  - Thermal energy transferred by molecular movement within a gas or fluid (fans)
- Radiation
  - Heat transfer via electromagnetic radiation (cold room)
- Evaporation
  - Heat transfer with liquid to gas phase change (sweating)

How to Cool? -surface cooling

Limitations of Surface Cooling

- Difficult to achieve target temperature
  - 14% never achieved target and 70% of patients required additional cooling methods (the HACA study)*
- Difficult to maintain target temperature– overshoot
  - a 63% of chance of overcooling when using surface cooling methods**

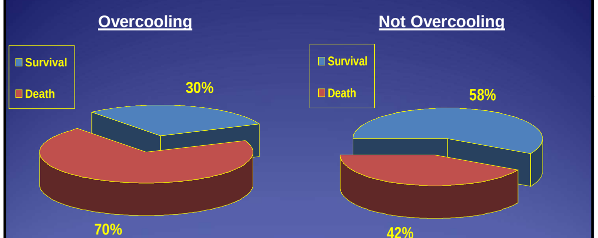
*HACA, New Eng J Med, 2002

**Raina M. Merchant, MD; Benjamin S. Abella, MD MPhil' Mary Ann Peberdy, MD; Jasmeet Soar, MD; marcus E. H. Ong, MBBS, MPH; Gregory A. Schmidt, MD; Lance B. Becker, MD; Terry L. Vanden Hoek, MD: Therapeudic Hypothermia After Cardiac Arrest: Unintentional Overcooling is Common Using Ice Packs and Conventional Cooling Blankets. Crit Care Med 2006 Vol. 34, No. 12

*** Mayer, Neurocrit Care. 2005

(Overcooling increases Mortality)

Death Rate: Overcooling vs. Not Overcooling



References

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- Uncontrolled rewarming – rebound ICP and hyperthermia
- Hindered access to patient (i.e during PCI procedure)
- Very nurse “Labor” intensive: often 2:1 ratio (nurses/pt)
- Skin monitoring and care required
- Increased shivering and paralytic usage ***

*HACA, New Eng J Med, 2002

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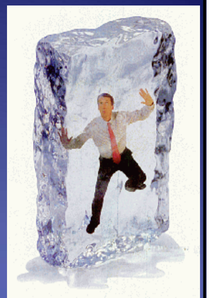
*** Mayer, Neurocrit Care. 2005

Cooling the Patient's Skin

- Skin is a temperature receptor for brain
- Brain/Hypothalamus tries to maintain homeothermia
- Therefore, cold applied to skin sends "cold" stress message to hypothalamus:
  - Triggers shivering → generates heat
  - Causes vasoconstriction→stops heat loss
- May cause thermal damage



Counterproductive cooling Therapy

Shivering is the Enemy

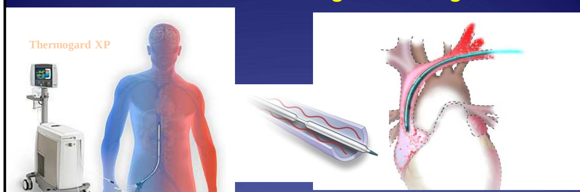
- Increased oxygen consumption
- Metabolic rate up to 600%
- Fights the cooling process
- Increasing Heart rate (HR), Respiratory rates (RR), Intracranial pressure (ICP)
  - Result in hypoxemia, myocardial ischemia
- Use of high doses of sedation and paralytics
  - Hypotension – ischemia
  - Cardiac depression – AMI
  - Prolong on ventilator – ARDS and Ventilator Associated Pneumonia
  - Reduced muscle tone is further associated with risk for skin breakdown

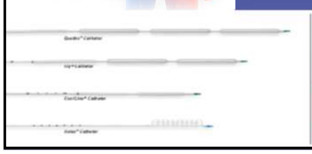
Cold IV Fluid

- Good way to get jump started
- Can be initiated pre-hospital, at ED or during transportation
- 30-40 cc/kg of 4°C NS
- Difficult to reach target temperature
- Difficult to maintain target temperature for 24 hours
- Limitation on the fluid quantities – due to heart condition

Kliegel A, et al: cold infusion alone are effective for induction of therapeutic hypothermia but do not keep patients cool after cardiac arrest. Resuscitation 2007.

Intravascular Temperature Management (IVTM™) For Precise Core Cooling or Warming

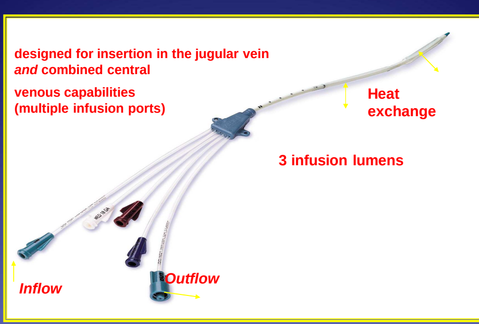


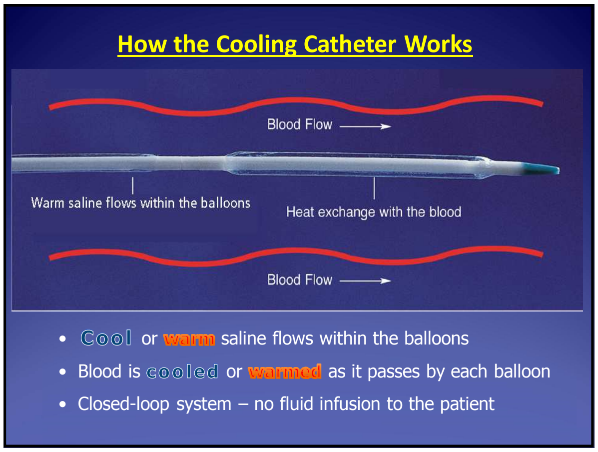


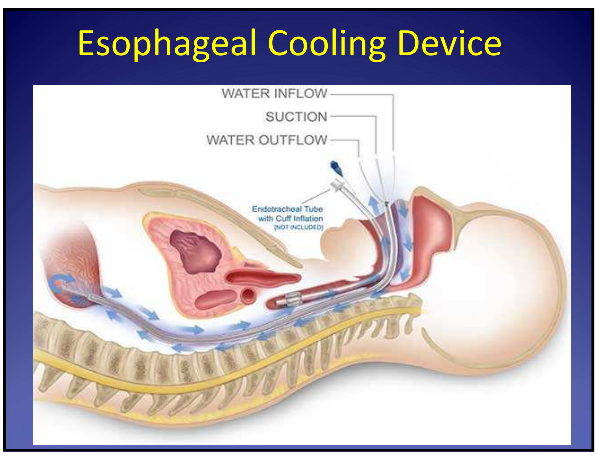
Vein Placement options:
- Femoral
- Subclavian
- Internal jugular

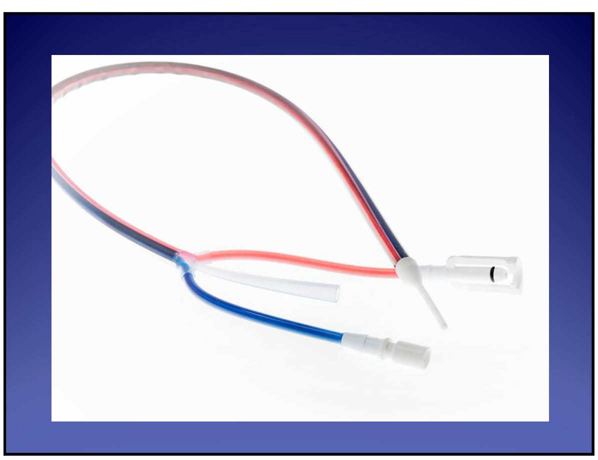
Alsius catheters provide triple-lumen central venous access.

Philips Electronics InnerCool RTx System for endovascular modulation of body temperature. The system gives surgeons and critical care specialists the ability to rapidly alter a patient's body temperature through the use of a catheter with an integrated temperature sensor, called Innercool Accutrol. Its closed-loop design circulates warm or cold saline without introducing liquid to the patient, and it provides faster cooling and warming rates than any currently available temperature management system, short of going on bypass




How the Cooling Catheter Works
Blood Flow
Warm saline flows within the balloons
Heat exchange with the blood
Blood Flow
• Cool or warm saline flows within the balloons
• Blood is cooled or warmed as it passes by each balloon
• Closed-loop system – no fluid infusion to the patient


Esophageal Cooling Device
WATER INFLOW
SUCTION
WATER OUTFLOW
Endotracheal Tube with Cuff Inflation (NOT INCLUDED)



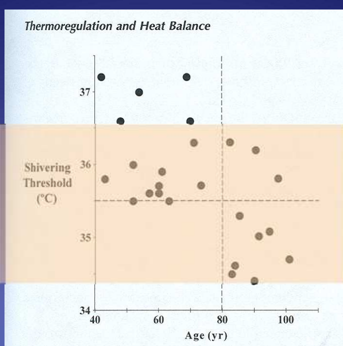
Key Benefits

- ✓ Rapid and precise core body temperature management
- ✓ System automatically maintains target temperature
- ✓ Software enables real-time temperature display, storage and download
- ✓ Easy-to-use, multi-function catheters
- ✓ "Hands free" operation reduces nursing time
- ✓ Improved access to patient
- ✓ Less shivering

Less shivering and less paralytics needed

Shivering occurs through a narrow band of temperature

The faster you cool



Less paralytic needed

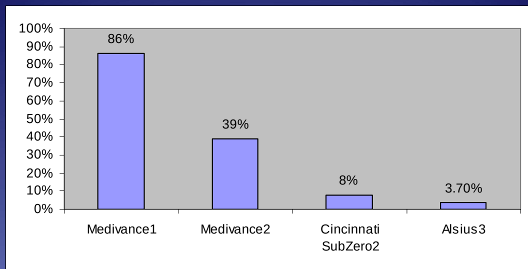
Vassilieff N, et al: The shivering threshold during sinal anesthesia is reduced in the elderly. Anesthesiology 1995; 83:1162-1166

The esophageal cooling device: A new temperature control tool in the intensivist's arsenal

Hegazy, Ahmed F. et al.
Heart & Lung: The Journal of Acute and Critical Care , Volume 46 , Issue 3 , 143 – 148
May-June, 2017

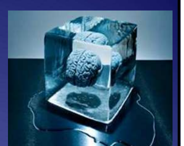
- A mean cooling rate of 0.42 °C/hr (SD ± 0.26) was observed. An average of 4 hr 24 min (SD ± 2 hr 6 min) was required to reach target temperature.

Shivering Rate Comparison



1. Treatment of Refractory Fever in the Neurosciences Critical Care Unit Using a Novel, Water-Circulating Cooling Device; Meratee et. al. ; Journal of Neurosurgical Anesthesiology; vol 15, No. 4, 313-318.
2. Clinical trial of a novel surface cooling system for fever control in neurocritical care patients; Commichau et al; Critical Care Medicine 2004; vol.32; No 12
3. Fever control (Diringer)

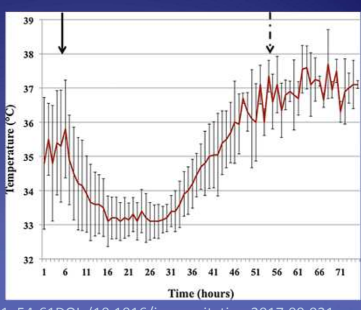
Advantages of Esophageal TM



-Compatible with multiple chiller brands
-Reduced risk of skin complications
-Reduced risk of needle sticks
-Reduced risk of CLABSI
-Reduced risk of blood clots (DVT and PE)
-Unobtrusive and maintains easy access to patient
-Non-sterile placement procedure
-Reduced shivering compared to surface devices
-Rapid placement via single provider

Targeted temperature management using the "Esophageal Cooling Device" after cardiac arrest (the COOL study): A feasibility and safety study

Cooling rate to reach the Target Temperature (33 °C-TT) was 0.26 °C/h [0.19-0.36].



Resuscitation 2017 121, 54-61DOI: (10.1016/j.resuscitation.2017.09.021

Tight control at target temperature

Alsius IVTM™ Proven Superior to External Methods

A recent study comparing the efficacy of commercially available cooling devices demonstrates the superior power and control of Alsius IVTM™ in reaching target temperature and keeping patients within the target range.[8]

		Alsius System ICY Catheter	Medivance Arctic Sun	Cincinnati Subzero Blanketrol II	Medeco Caircooler	Conventional
	Cooling Method	Intravascular Heat Exchange	External Gel-coated Pads	External Water Circulating Pads	External Air Circulating Pads	Cold Saline, Ice bags, etc.
More Power	Cooling Rate (°C/hr)	1.46	1.04	1.33	0.18	0.32
More Control	% of time Patient Temperature was out of range (> than 0.2°C from target temp)	3.2	44.2	50.5	74.1	69.8

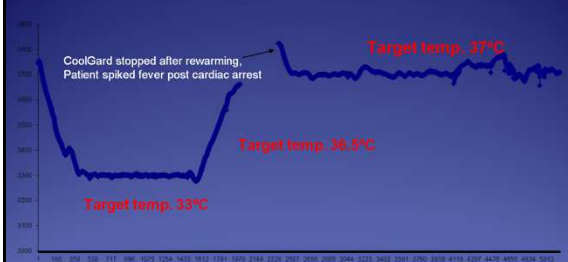
Comparison of different cooling methods to induce and maintain normo- and hypothermia in ICU patients: a prospective intervention study. Hoedemaekers CW , Ezzahti M, Gerritsen A, van der Hoeven JG. Critical Care 2007, 11:R91.

Targeted temperature management using the "Esophageal Cooling Device" after cardiac arrest (the COOL study): A feasibility and safety study

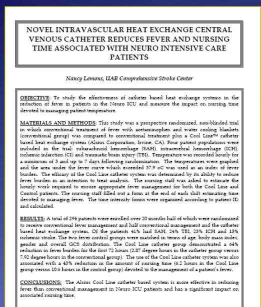
- Temperature deviation outside the TT during TTM-maintenance was 0.10 °C [0.03–0.20]. Time with deviation >1 °C was 0 h. Rewarming rate was 0.20 °C/h [0.18–0.22].

Resuscitation 2017 121, 54-61DOI: (10.1016/j.resuscitation.2017.09.021

Control rebound hyperthermia



Better Temperature Management = Saves Nursing Time



NOVEL INTRAVASCULAR HEAT EXCHANGE CENTRAL VENOUS CATHETER REDUCES FEVER AND NURSING TIME ASSOCIATED WITH NEURO INTENSIVE CARE PATIENTS

Nancy Lemons, UAB Comprehensive Stroke Center

OBJECTIVE: To study the effectiveness of catheter based heat exchange systems in the reduction of fever in patients in the Neuro ICU and measure the impact on nursing time devoted to managing patient temperature.

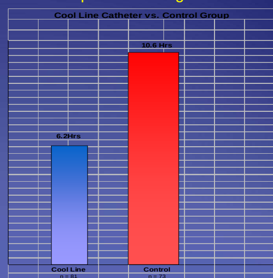
MATERIALS AND METHODS: This study was a prospective randomized, non-blinded trial in which conventional treatment of fever with acetaminophen and water cooling blankets (conventional group) was compared to conventional treatment plus a Cool Line™ catheter based heat exchange system (Alsius Corporation, Irvine, CA). Four patient populations were included in the trial: subarachnoid hemorrhage (SAH), intracerebral hemorrhage (ICH), ischemic infarction (CI) and traumatic brain injury (TBI). Temperature was recorded hourly for a minimum of 3 and up to 7 days following randomization. The temperatures were graphed and the area under the fever curve which exceeded 37.9 oC was used as an index of fever burden. The efficacy of the Cool Line catheter system was determined by its ability to reduce fever burden in an intention to treat analysis. The nursing staff was asked to estimate the hourly work required to ensure appropriate fever management for both the Cool Line and Control patients. The nursing staff filled out a form at the end of each shift estimating time devoted to managing fever. The time intensity forms were organized according to patient ID and calculated.

RESULTS: A total of 294 patients were enrolled over 20 months half of which were randomized to receive conventional fever management and half conventional management and the catheter based heat exchange system. Of the patients 41% had SAH, 24% TBI, 23% ICH and 13% ischemic stroke. The two fever control groups were matched in terms of age, body mass index, gender and overall GCS distribution. The Cool Line catheter group demonstrated a 64% reduction in fever burden for the first 72 hours (2.87 degree hours in the catheter group versus 7.92 degree hours in the conventional group). The use of the Cool Line catheter system was also associated with a 43% reduction in the amount of nursing time (6.2 hours in the Cool Line group versus 10.6 hours in the control group) devoted to the management of a patient's fever.

CONCLUSIONS: The Alsius Cool Line catheter based system is more effective in reducing fever than conventional management in Neuro ICU patients and has a significant impact on associated nursing time.

Abstract presentation for AACN Region 6 Meeting
September 27, 2004

43% Reduction
in nursing time required
for patient management



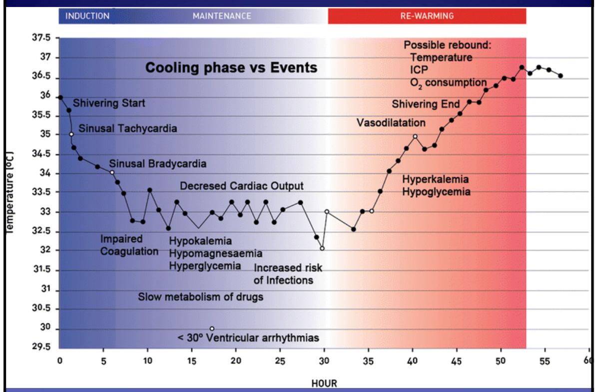
Better Temperature Management = Reduce Hospital Costs

IVTM reduces length of ICU stay
- IVTM group: 8.8± 3 days
- Surface cooling group: 12.9±6 days

4 extra ICU days = $20,000

Fink K. Schwab T, et al: Endovascular or surface cooling? Therapeutic hypothermia after cardiac arrest. Anesthetist 2008

Potential complications of Therapeutic Hypothermia



What to Watch For Clinically During Therapeutic Hypothermia

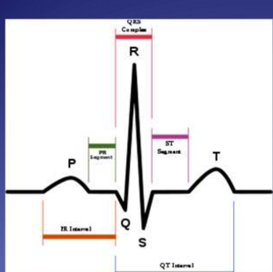
Hypothermia induction-maintenance phase

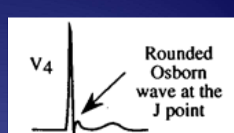
Avoid shivering
- Increases the metabolic demands of the brain, ↑oxygen consumption and decreases rate of cooling.
- Sedating and chemical paralyzing patient prior to cooling.

Avoid hypovolemia
- Hypothermia-induced diuresis

Avoid arrhythmia
- Bradycardia is common, transient, at early phase of cooling induction
- Do not let temperature go less than 32°C – lead to ventricular fibrillation

Osborn wave





What to Watch For Clinically During Therapeutic Hypothermia

Hypothermia induction-maintenance phase

Avoid hyperglycemia
- Hypothermia ↓ Insulin sensitivity and secretion
- Tight glucose regulation with high dose of insulin to maintain at normal level
- Finger stick is not reliable, draw blood from CVC or A line

Altered clearance of medications
- **Clearance of various drugs ↓**
  - Known drugs: muscle paralyzers, propofol, fentanyl, phenytoin, pentobarbital, verapamil, propanol and volatile anesthetics

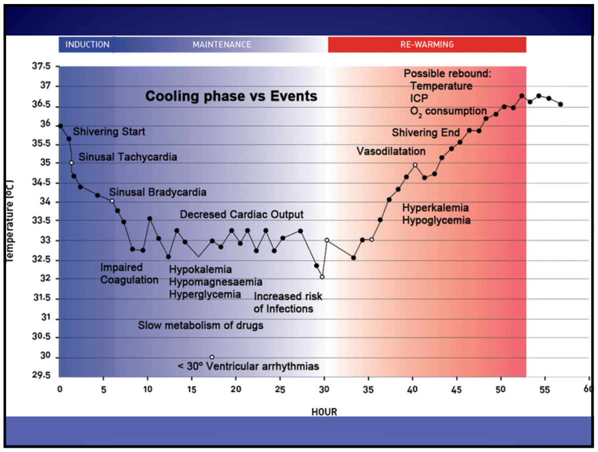
Prevent electrolyte disorders
- Potassium shifts intra cellular, monitoring and correct Potassium level

Ventilator management

- When core body temperature drops to 32º C, the metabolic rate drops to 50%-65% of normal
- Oxygen consumption and CO_2 production will decrease by the same percentage
- If vent settings left unchanged, then will lead to hyperventilation (resp alkalosis) which will cause cerebral vasoconstriction
- Need to adjust vent accordingly

Ventilator management

- Arterial line done ASAP
- Goal is normal pH
- Do not temperature correct ABG
- If can't get good finger pulse ox, try forehead
- Incidence of pneumonia is 30-50%
  - Usually due to aspiration at time of arrest
  - Immunosuppressive effects of hypothermia
  - If suspected, give prophylactic antibiotics



What to Watch For Clinically During Therapeutic Hypothermia

Rewarming phase

- Slow and controlled rewarming (< 0.5°C/ hr)
- Avoid rebound hyperthermia and ↑ICP
- Keep normothermia at least 48 hours
- Avoid hyperkalemia
  - Potassium shifts extra cellular
  - Potassium supplements should be stopped prior to rewarming
- Avoid hypotension and hypovolemia due to vasodilation

72 hour re-evaluation

- Extubate
- Continue supportive care
- Withdrawal of life support

Indications beyond Cardiac Arrest: Primary injury to the brain

- Contusion
- Blunt or Penetrating Trauma
- Diffuse Axonal Injury (DIA)
- Subarachnoid Hemorrhage (SAH)
- Stroke: ischemic vs. Hemorrhagic
- Intracranial Hemorrhage
- Subdural or Epidural Hematoma

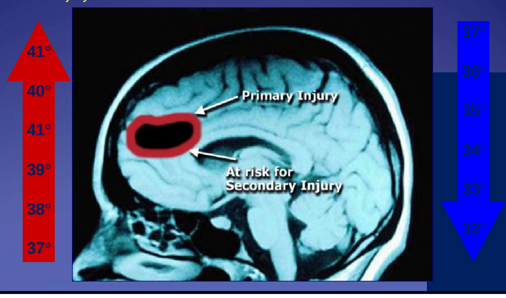
Secondary Brain Injury Matters

Major cause of death and disability for patients who have survived primary injury

FEVER Accelerates Injury

Why temperature matters?

HYPOTHERMIA Preserves Tissue



North American Brain Injury Study: Hypothermia

- Multicenter study of post-TBI hypothermia sponsored by the National Institutes of Health
- Hypothermia was induced to 33 degrees C buy 8 hours after insult and maintained to 48 hours
- Mortality was 28% with hypothermia and 27% with normothermia; poor outcomes equal at 57%

Lack of Effect of Induction of Hypothermia after Acute Brain Injury
Guy L. Clifton, M.D., Emmy R. Miller, Ph.D., R.N., Sung C. Choi, Ph.D., Harvey S. Levin, Ph.D., Stephen McCauley, Ph.D., Kenneth R. Smith, Jr., M.D., J. Paul Muizelaar, M.D., Ph.D., Franklin C. Wagner, Jr., M.D., Donald W. Marion, M.D., Thomas G. Luerssen, M.D., Randall M. Chesnut, M.D., and Michael Schwartz, M.D.
N Engl J Med 2001; 344:556-563 Februrary 22, 2001

TH in traumatic brain injury

- Studies not as positive as those with cardiac arrest
- Why?
  - Time course of neuronal death is different
  - Peak levels of neuron-specific enolase (serum biomarker of neuronal death) occurs days after cardiac arrest, whereas they peak hours after traumatic brain injury

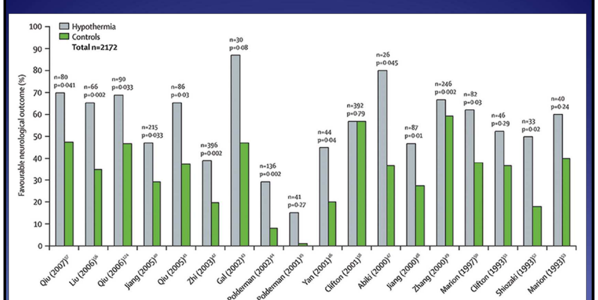
Berger RP, et al. Serum biomarkers after traumatic and hypoxemic brain injuries: insight into the biochemical response of the pediatric brain to inflicted brain injury. Dev Neurosci 2006;28:327-335.

NABIS:Hypothermia IIR

- The primary hypothesis of NABIS:H IIR is as follows: Induction of hypothermia after severe traumatic brain injury to reach 33.0°C within 4h of injury and maintained for 48h in patients aged 16–45 years will result in an increased number of patients with good outcomes at 6 months after injury compared to patients randomized to management at normothermia.
- This trial did not confirm the utility of hypothermia as a primary neuroprotective strategy in patients with severe traumatic brain injury.

Clifton GL, et al "Very early hypothermia induction in patients with severe brain injury (the National Acute Brain Injury Study: Hypothermia II): a randomised trial" *Lancet Neurol* 2010; DOI:10.1016/S1474-4422(10)70300-8.

Clinical trials assessing the effects of hypothermia on neurological outcome in patients with traumatic brain injury and intracranial hypertension.



The Lancet, Vol 371, Polderman KH, Induced hypothermia and fever control for prevention and treatment of neurological injuries, pages 1955-1969, 2008

Fever control in brain injury

Neuro ICU Fever Is Common:

Fever Above >38 C:

Subarachnoid Hemorrhage:	**73%**
Intracerebral Hemorrhage:	**91%**
Traumatic Brain Injury:	**68%**
Ischemic Stroke:	**61%**

Fever Is Harmful

- Temperature elevations after brain ischemia worsen the resulting degree of injury
- Fever associated with increased mortality and worse outcome
- 1 degree increase raises risk of poor outcome by 2.2 times
- Mortality rate of stroke patients studied at 3 months was 1% in normothermic versus 16% in hyperthermic group

Fever's Role in LOS in the Neuro ICU

Fever powerful contributor to excessive length of stay in the hospital and in the Neuro ICU.

Fever Level	Increased # days in ICU
High (>39.6°C)	10 days
Medium (38.5-39.5C)	5.5 days
Low (to 38.5C)	1.7 days

Diringer M, et al. Crit Care Med 2004 Vol.32, No7

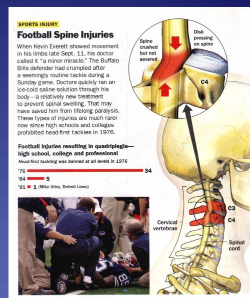
IVTM for fever in ICU


Treatment of fever in the neurologic intensive care unit with a catheter-based heat exchange system

Michael N. Diringer, MD; for the Neurocritical Care Fever Reduction Trial Group

- Prospective, randomized, controlled study of 296 Neuro ICU patients(TBI, SAH, CI, ICH)
- Compared intravascular cooling to existing best fever management methods
- **Result: 64% reduction in the incidence of fever with IVTM**
- **25% reduction in use of antipyretics**
- No safety issue!

Hypothermia in Acute Spinal Cord Injury



Hypothermia in multisystem trauma

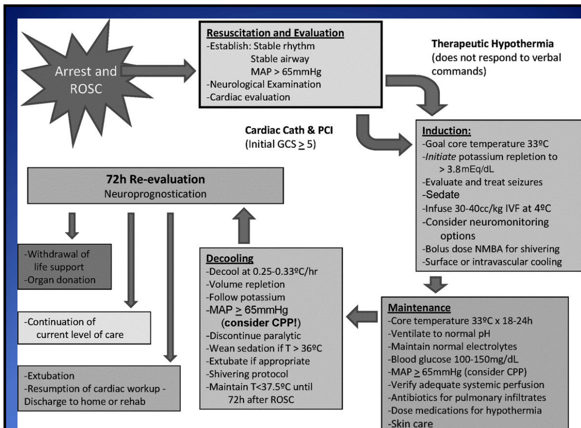
- 30%-50% of trauma mortality occurs before hospital
- Of those who die after arriving at the hospital, 70%-80% die within 24-48 hours
- Exsanguination is the most common cause of death in the first 48 hours after admission
- Once controlled, usually significant ischemic insult
- Some clinical trials underway, but by extrapolation, would hope this would improve outcomes

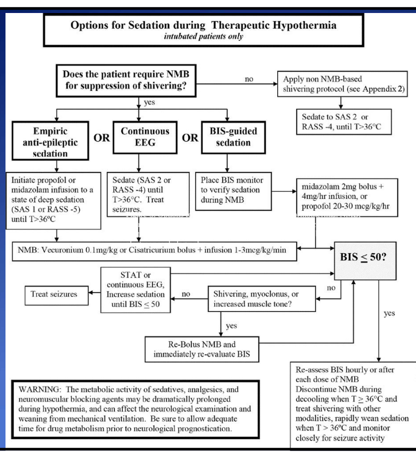
Clinical Applications Where Intravascular Temperature Management Has Been Used for Cooling

- Therapeutic hypothermia after cardiac arrest
- Fever control in Neuro/Surgical ICU
- ICP (intracranial pressure) management
- Therapeutic hypothermia for brain trauma and stroke
- Acute liver failure
- Adjunct with interventional procedure
- Malignant hyperthermia
- Heat stroke
- Spinal cord injury
- Spinal surgery
- Adjunct with hemicraniectomy
- Status epilepticus

Clinical Applications Where Intravascular Temperature Management Has Been Used for Warming

- Trauma victims
- Accidental hypothermia
- Burn surgery and intensive care
- Cardiac surgery
  - OPCAB (off-pump coronary artery bypass)
  - Post-bypass pump (prevention of after-drop)
  - LVAD (left ventricular assist device)
  - Transplant
- Thoracic aneurysm surgery
- Maintain viable donor organs for transplantation





Options for sedation during therapeutic normothermia. NMB, neuromuscular blockade; SAS, Sedation and Agitation Scale (137); RASS, Richmond Agitation and Sedation Scale (138); T, temperature; BIS, bispectral index; EEG, electroencephalography.

Therapeutic Temperature Management: State of the Art Critical Care. Crit Care Med July 2009 Vol. 37(Suppl.)

Table 1. Common physiologic effects of hypothermia

Body System	Physiologic Effect	Nursing Actions
Systemic	Decreased metabolic demands	
	Decreased CO_2 production	
	Decreased O_2 consumption	Monitor pulse oximetry and P_aO_2
Neurologic	Decreased cerebral metabolic demands	
	Decreased intracranial pressure	
	Decreased level of consciousness	
Cardiovascular	Tachycardia (observed during induction)	
	Bradycardia	None, unless symptomatic
	Hypertension	Wean vasopressors, administer analgesics and sedation if appropriate
	Hypotension	Consider fluid administration and vasopressors
	Prolonged PR, QRS, and QT intervals	
	Dysrhythmias (observed ≤32°C)	Prevent overcooling
	Decreased cardiac output	None, unless hypotensive or symptomatic
	Increased central venous pressure	
	Increased mixed venous oxygenation values	
Gastrointestinal	Decreased motility	Feeding may be delayed until the rewarming phase
Genitourinary	Diuresis	Monitor urine output; replace fluids as needed
Endocrine	Insulin resistance	Administer insulin to maintain glucose within a prescribed range
Immune	Suppression of white blood cells	Institute ventilator-associated pneumonia bundles, elevated head of bed, take measures to prevent infection