Objectives

• Define Therapeutic Hypothermia (TH)
• Describe current evidence
• Discuss rationale for TH
• Describe clinical inclusion criteria
• Describe timelines for cooling, maintenance & re-warming
• Discuss mechanisms of heat loss
• Describe methods of cooling
Objectives

- Equipment needed
- Describe order set
- Drugs
- Monitoring – cooling phase
  - Troubleshooting
- Monitoring – maintenance phase
- Monitoring - re-warming phase
  - Troubleshooting

Therapeutic Hypothermia (TH)

- Defined as: an induced, rapid achievement of cooling, to attain a core body temperature of 32-34°C.
Why?

- People recovered from cardiac arrest but later died or had poor neurological recovery

Why?

- Persistence of unfavourable outcomes, (despite advances in CPR) led the AHA to recognize brain injury after cardiac arrest as an important area for clinical research

Laver et al, 2004
Why?

• Post Cardiac Arrest Syndrome
  – Hypoxic brain injury
  – Myocardial dysfunction
  – Systemic ischemia/inflammation response
  – Persistent precipitating pathology

History

• Hypothermia has been studied since the 1950s
• Shown to reduce cerebral oxygen consumption in head injuries
• In the 1980s, canine studies demonstrated improved neurological status & survival outcomes
History

  — Found 49% of patients in the hypothermia arm went home or to a rehab facility, compared to 26% of patient in the normothermia arm.
• 2002 in NEJM, Hypothermia after Cardiac Arrest Group (HACA)
  — Found 55% patients treated with hypothermia had favourable neurological outcomes compared to 39% of those in the normothermia group

• 2003, International Liaison Committee on Resuscitation (ILCOR)
  — Recommended that all unconscious adult patients with ROSC following out-of-hospital arrest due to VF should be cooled to 32-34°C for 12-24 hours.
  — Also stated patients post-cardiac arrest caused by other rhythms & those in-hospital arrests may also benefit from this therapy.
• 2005, American Heart Association (AHA) included these recommendations in their post-resuscitation support guidelines.
History

• The Cochrane Database’s systematic review in 2009 found an NNT (Number needed to treat) of 5 to 7.
  – Hence, there is a good likelihood that TH improves the outcome in about 1 in 5 patients
  – Aspirin (NNT = 40) & thrombolysis NNT = 100) for MI pale in comparison.

• 2010 AHA Guidelines introduced induced hypothermia into post-arrest care algorithm
After the CPR stops...

Post-cardiac arrest syndrome consists of four main clinical considerations.

1. Brain Injury
   • Disruption on both a micro- & macro- circulatory levels may result in either ischemia or hyperemia.

2. Myocardial dysfunction
   • Although the heart initially becomes hyperkinetic, likely due to circulating catecholamines, global hypokinesis often follows.

3. Systemic Ischemia/Reperfusion Response
   • The response of the body is similar to septic shock with activation of the immune system, release of inflammatory cytokines & a wide range of cellular responses.

4. Persistent precipitating pathology
   • The cause of the arrest may continue to impact physiological parameters.
After the CPR stops...

- Post cardiac arrest brain injury related to:
  - Hypoxia during the arrest
  - Inflammation associated with reperfusion after the arrest
    
    "Reperfusion Injury"

Postcardiac Arrest Brain Injury

- Brain is aerobic – when bloodflow ceases, oxygen stores are quickly depleted
  - ATP production stops → cell membrane damage
- Reperfusion → inflammation
  - ↑ intracranial pressure (ICP), which leads to cell injury /death
  - ↑ ICP → ↓ perfusion → disruption of the blood-brain barrier
- Ca++ shifts, release of free radicals, nitric oxide, catecholamines, cytokines
Why Cool?

• Even moderate dips in temperature strengthen the cellular membrane, helping to minimize disruption to the cellular environment
  o Helps stabilize blood-brain barrier
  o ↓ cerebral metabolism
  • For every one degree Celsius drop in body temperature, cerebral metabolism (demand) slows by 5-7%

Why Cool?

• Hypothermia moderates inflammation & reduces free radical production
  o ↓ ATP usage & glucose consumption
  o ↓ inflammation & cerebral edema → ↓ ICP
Recommended Inclusion Criteria
(All of the following)
1. Non-traumatic cardiac arrest with ROSC
2. Persistent coma with lack of response to verbal commands

Recommended Exclusion Criteria
(Any of the following)
1. Improving neurological status
2. Severe active bleeding or ICH
3. Coma due to non-cardiac causes
4. Refractory hypoxia or shock (despite vasopressors)

Timeline: Cooling
• ASAP
• Goal: achieve 32-34°C within 6 hours of ROSC
• Goal: achieve 32-34°C within 3 hours of starting to cool
Timeline: Maintenance

- Goal: maintain 32-34°C for 24 hours (from start of cooling)

Timeline: Re-warming

- Goal: passive re-warming
- Usually about 8-12 hours
Body Temperature

- Primarily regulated through a balance of heat production & heat loss
- Thermoregulation centre in hypothalamus
- Thermo receptors for heat/cold on skin
- When our skin is stimulated, thermo receptors send signals to the hypothalamus to either increase or decrease body temperature

Mechanisms of Heat Loss

- Conduction
- Convection
- Respiration
- Radiation
- Evaporation
Conduction

- The transfer of heat from a warmer object to a cooler object when the two objects are in direct contact with each other.
- Major source of heat loss is wet clothing, due to water’s excellent conductive properties.

Convection

- Occurs in response to movement of a fluid or gas.
- Occurs when warm air next to the body and in clothing is displaced by cool air from the outside environment.
- The biggest factor contributing to convective heat loss, of course, is wind.
Respiration

- Combines the processes of evaporation (of moisture in the lungs) and convection (displacement of warm air in the lungs by cold air from the outside environment).

Radiation & Evaporation

- Radiation occurs primarily due to infrared emission.
- When the normal heat source (the sun) is unavailable and the ambient temperature drops.
- Evaporation occurs when a liquid (sweat) changes to a vapor (sweat vapor).
- Body heat drives this
- Can occur in one of two ways:
  - Sensible (active)
  - Insensible (passive)
Methods of Cooling

Orders/Protocols
Getting started

- PIV (2) insertion
- Ventilate without warming
- Esophageal probe inserted
- Arterial line placement
- Foley catheter insertion

Equipment

4°C NS
- Rapid infusion of 2L of 4°C NS
  - PIV preferred route
  - Facilitates rapid decline in temperature
**Equipment**

**Ice Bags**
- Grab 8!
  - 2 for the groin (bilaterally)
  - 2 for the axilla (bilaterally)
  - 2 for the back of neck (bilaterally)
  - 2 for the top of the head
- Change q1h

**Wet sheets**
- Change q1h

**Equipment**

**Cooling Blanket**
- Placed under or wrapped around patient
- Place a cotton sheet between patient & blanket

**Cooling machine**
- Automatic setting preferred
  - Has ability to monitor patient temperature & adjust blanket water temperature accordingly
Opioids, Sedatives & NMBAs

- Fentanyl (Sublimaze) infusion
- Midazolam (Versed) infusion
- Pancuronium (Pavulon) prn [IVP/infusion]

Monitoring – Cooling Phase

- Hyperoxia is bad
  - Minimize FiO2
  - Goal: SpO2 ≥ 94%
Monitoring – Cooling Phase

• Hypocarbia is **bad**
  – Causes cerebral vasoconstriction

• Ventilate to:
  – EtCO₂ of 35-40 mmHg
  – PaCO₂ levels of 40-45 mmHg

Monitoring – Cooling Phase

• Hypotension is **bad**
  – MAP goal specified in pre-printed order set
  – Usually > 65mmHg
  – Orders may include fluid bolus or vasopressors

*I believe we got your blood pressure back up to normal.*
Monitoring – Cooling Phase

• Hypothermia is associated with:
  • High blood glucose, greater glucose variability & higher insulin requirements
  • Hypokalemia (exacerbated with insulin administration)
  • Hypomagnesaemia
  • Hypophosphatemia

Monitoring – Cooling Phase

• Monitor temperature continuously
• Often hypertensive during cooling phase d/t vasoconstriction
• May autodiurese during cooling
• Wrap hands/feet
Monitoring – Cooling Phase

• Shivering is bad
  – occurs at a core temp of approximately 35.5°C
  – creates heat
  – causes an increase in metabolic rate & oxygen demand
• Sedatives & NMBAs used to control
• Watch for ‘sub-clinical’ shivering

Troubleshooting

- Check temperature monitor
  – Probe placed/functioning properly? Change?
- Check cooling technique
  – More ice? Blanket function?
- Treat shivering & encourage vasodilation
  – Sub-clinical? Sedation? NMBAs? Mg++?
- Consider further bolus of 4°C NS

Repeat checklist in 1 hour if needed
Monitoring: Maintenance Phase

Guidelines for Maintenance of Hypothermia

<table>
<thead>
<tr>
<th>Below 32°C</th>
<th>Target of 32-34°C</th>
<th>Above 34°C</th>
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<tbody>
<tr>
<td>• Discontinue ice packs (if being used)</td>
<td>• Discontinue ice packs, refrigerated fluids and wet sheets Continue cooling blanket set at 33°C</td>
<td>• Continue ice packs and replace q1h • Continue wet sheets and replace q1h • Continue cooling blanket If cooling delayed or challenging (less than 0.8°C per hour): Treat shivering aggressively Consider repeat cold saline bolus Consider Magnesium Sulphate for vasodilation</td>
</tr>
<tr>
<td>• Discontinue use of refrigerated fluids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If temperature continues to be less than 32°C • Remove wet sheets • Discontinue cooling blanket</td>
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Monitoring: Maintenance Phase

- Watch for dysrhythmias – bradycardia most common
- Watch for bleeding
- Monitor skin carefully for evidence of frostbite
- Protect vulnerable areas (bony prominences)
- Hypothermia can compromise the immune system, watch for S&S infection/sepsis
Monitoring: Maintenance Phase

- ECG changes can include prolongation of the PR, QRS and QT intervals, as well as Osborne waves (J-waves)
- Drug metabolism is generally slowed, leading to increased half-life and possible drug accumulation

Monitoring – Re-warming Phase

- Stop all cooling & cover with dry sheets
- Takes around 8-12 hours to passively rewarm
- If on NMBAs – keep them running until temp >36°C
- Keep analgesia & sedation running until temperature >36°C or until 2 hours after NMBAs stopped
Monitoring – Re-warming Phase

- Vasodilation may result in hypotension
- Hyperkalemia
- If on Insulin (from cooling period) watch BS closely

Troubleshooting

- Ideally warming 0.2-0.5°C per hour
- Treat hyperthermia (>38°C) aggressively
  - Reinstitute cooling blanket
  - Administer cold NS
  - Consider administration of Mg++
Future

- PACT
- TH initiated by EMS
- High Tech
- Controlled re-warming

Bibliography

Thank you!

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