Post Cardiac Arrest Targeted Temperature Management (TTM)

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Note: TTM should not delay imaging studies, renal replacement therapy or re-perfusion therapy

PATIENT PRESENTATION

Cardiac arrest
- PEA
- Asystole
- Ventricular fibrillation
- Pulseless ventricular tachycardia

COOLING

Sustained ROSC > 20 consecutive minutes?

Does patient meet inclusion criteria for hypothermia?

Patient not eligible for TTM

Does patient meet exclusion criteria?

Patient not eligible for TTM

COOLING

Development of complications?

Yes

See Page 3 for TTM protocol

Initiate shivering management (see Page 4)

No

Cooling

Yes

Continued

Patient not eligible for TTM

Target temperature maintained for 24 hours?

No

Cooling

Continued

Yes

Cooling

Target temperature maintained for 24 hours?

Note:

PEA = pulseless electrical activity
ROSC = return of spontaneous circulation

1 Refer to Post-Cardiac Arrest Care - Adults algorithm and initiate order set as indicated
2 Inclusion criteria:
   - Down time < 60 minutes (< 15 minutes for asystole)
   - Intubated requiring mechanical ventilation
   - No meaningful response to verbal stimuli (Glasgow Coma Scale < 9, see Appendix A)
   - ≤ 12 hours from ROSC
3 Exclusion criteria:
   - Major traumatic injury or isolated head injury
   - Pregnancy
   - Age < 18 years
   - Uncontrolled arrhythmias
   - Uncontrolled bleeding
   - Hypoxemia – oxygen saturation < 88% on 100% FiO2 for > 30 minutes
   - Hypothermia – temperature < 30°C
   - Mean arterial pressure (MAP) < 70 mmHg despite aggressive fluid resuscitation and vasopressor support
   - Poor prognosis as discussed with primary team
4 If temperature < 36°C, no cooling required. If temperature > 36°C within 24 hours of ROSC, ICU team to initiate TTM order set.
5 See Appendix B for Complications
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**RE-WARMING**

1. **Target temperature of 37°C achieved?**
   - Yes: Continue monitoring TOF
   - No: **Continue re-warming phase** until target temperature achieved

**NORMOTHERMIA**

1. **Discontinue any paralytics**
2. **Monitor train of four (TOF) every hour until 4/4 response**

3. **TOF 4/4 achieved?**
   - Yes: **Discontinue all analgesics, sedatives, and shivering management medications (meperidine and paralytics)**
   - No: **Continue monitoring TOF**

4. **Sustained temperature of 36°C to 37°C for 72 hours?**
   - Yes: Assess neurologic prognosis
   - No: **Continue supportive care to maintain temperature 36°C to 37°C**

---

1 See Page 3 for TTM Protocol
Post Cardiac Arrest Targeted Temperature Management (TTM)

TTM Protocol (TTM should not delay imaging studies, continuous renal replacement, or re-perfusion therapy)

<table>
<thead>
<tr>
<th>Supportive Care</th>
<th>Cooling Phase</th>
<th>Maintenance Phase</th>
<th>Re-Warming Phase</th>
<th>Normothermia Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultation:</td>
<td>Cool to 36°C (goal to target temperature &lt; 4 hours)</td>
<td>Basic metabolic panel, magnesium, phosphorous, ionized calcium, CBC with differential, PT/PTT every 6 hours</td>
<td>Begin re-warming 24 hours after target temperature achieved – 0.20°C/hour for a target temperature of 37°C</td>
<td>Once temperature is 37°C:</td>
</tr>
<tr>
<td>Neuro-oncology</td>
<td>Record time of initiation of TTM and time of achieving 36°C</td>
<td>Maintain target temperature of 36°C to 37°C</td>
<td>o Discontinue any paralytics</td>
<td></td>
</tr>
<tr>
<td>Cardiology</td>
<td>Keep room as cool as possible</td>
<td>Call ICU team for temperature &gt; 37°C</td>
<td>o Monitor TOF every hour until 4/4 response</td>
<td></td>
</tr>
<tr>
<td>Baseline labs and imaging</td>
<td>Magnesium sulfate 32 mEq IV for one dose over 1 hour</td>
<td>Warm room to normal temperature</td>
<td>o Once TOF is 4/4:</td>
<td></td>
</tr>
<tr>
<td>Nursing assessment:</td>
<td>Respiratory therapy:</td>
<td>Respiratory therapy:</td>
<td>o Discontinue all sedatives, shivering management medications, and analgesics</td>
<td></td>
</tr>
<tr>
<td>o Pupil checks every 1 hour</td>
<td>o No spontaneous breathing trials</td>
<td>o No spontaneous breathing trials</td>
<td>o Notify ICU team</td>
<td></td>
</tr>
<tr>
<td>o BSAS² per TTM order set</td>
<td>Shivering management (see Page 4)</td>
<td>Notify ICU team for development of complications (see Appendix B)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o RASS³ per TTM order set</td>
<td>Notify ICU team</td>
<td>o Notify ICU team</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o Skin assessment every hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Placement of:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o Nasogastric or Orogastric tube</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Placement of cooling blanket</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Placement of Foley temperature probe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o If Foley temperature probe contraindicated, physician to place esophageal temperature probe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily 30 minute EEG</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o May convert to continuous EEG if seizures identified</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 See Appendix C Behavioral Pain Score (BPS)
2 See Appendix D Bedside Shivering Assessment Scale (BSAS)
3 See Appendix E Richmond Agitation-Sedation Scale (RASS)
4 If temperature < 36°C, no cooling required. If temperature > 36°C within 24 hours of ROSC, ICU team to initiate TTM order set.

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SHIVERING MANAGEMENT

Initiate upon commencement of TTM

Analgesia

Fentanyl 12.5 - 100 mcg/hour IV continuous infusion
- If BPS\(^1\) is > 5 and/or BSAS\(^2\) > 0, give bolus equal to twice the current infusion rate (maximum 25 mcg) every 15 minutes as needed
- If a second bolus is required within a 2 hour period, increase infusion rate by 25 mcg/hour to a maximum dose of 100 mcg/hour

Propofol 10-50 mcg/kg/minute IV continuous infusion
- If less than desired sedation, increase infusion by 10 mcg/kg/minute every 15 minutes as needed to achieve target RASS\(^4\) to a maximum of 50 mcg/kg/minute

Midazolam 1-4 mg/hour IV continuous infusion
- If less than desired sedation, give IV push bolus equal to the current infusion rate (maximum 2 mg) every 15 minutes as needed to achieve target RASS\(^4\)
- If a second bolus is required within a 2 hour period, increase infusion rate by 1 mg/hour (maximum of 4 mg/hour)

Midazolam 2 mg IV push bolus then infuse at 1 mg/hour
- If less than desired sedation, give IV push bolus equal to the current infusion rate (maximum 2 mg) every 15 minutes as needed to achieve target RASS\(^4\)

Optimize fentanyl infusion via titration orders (see Box A above)
- Meperidine 12.5 mg or 25 mg IV every 2 hours as needed
  - Reduce dose to 12.5 mg IV every 2 hours in elderly (age ≥ 65 years), liver failure (Child-Turcotte-Pugh\(^5\) score C), and renal failure\(^6\)
- Cisatracurium 0.15 mg/kg IV every 30 minutes as needed
  - Requires mechanical ventilation, analgesia and sedation to a RASS\(^4\) of -4 to -5
  - No TOF monitoring. Use BSAS\(^2\) to determine need for additional boluses.
  - Nurse to notify respiratory therapist for controlled mode of mechanical ventilation prior to administration

BSAS\(^2\) ≥ 1

BSAS\(^2\) 2-3 and patient is refractory to all other anti-shivering treatments

BSAS\(^2\) ≥ 1

Acetaminophen 650 mg per feeding tube/rectum every 4 hours for 12 doses then discontinue

Magnesium sulfate 32 mEq IV infused over 4 hours every 6 hours as needed for serum magnesium < 2.5 mg/dL (adjust dose based on renal function)

Cisatracurium 0.15 mg/kg IV every 30 minutes as needed
- Requires mechanical ventilation, analgesia and sedation to a RASS\(^4\) of -4 to -5
- No TOF monitoring. Use BSAS\(^2\) to determine need for additional boluses.
- Nurse to notify respiratory therapist for controlled mode of mechanical ventilation prior to administration

BSAS\(^2\) ≥ 1

Cisatracurium 0.15 mg/kg IV every 30 minutes as needed
- Requires mechanical ventilation, analgesia and sedation to a RASS\(^4\) of -4 to -5

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\(^1\) See Appendix C Behavioral Pain Score (BPS)
\(^2\) See Appendix D Bedside Shivering Assessment Scale (BSAS)
\(^3\) Sedation
- Propofol recommended as agent of choice due to more predictable clearance
- Use midazolam only if patient requires use of more than one vasopressor with at least one infusing at a maximum rate
- Midazolam clearance decreases by 11% for every degree drop in temperature < 36.5°C

\(^4\) See Appendix E Richmond Agitation-Sedation Scale (RASS)
\(^5\) See Appendix F Child-Turcotte-Pugh (CTP) Scale
\(^6\) Serum creatinine > 1.5 mg/dL, serum creatinine change > 0.5 mg/dL from baseline, creatinine clearance < 50 mL/minute, and/or urine output < 500 mL in previous 24 hours


dash

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APPENDIX A: Glasgow Coma Scale (GCS)\(^1\)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eye Opening Response</strong></td>
<td>Spontaneous</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>To verbal stimuli, command, speech</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>To pain only (not applied to face)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>No response</td>
<td>1</td>
</tr>
<tr>
<td><strong>Verbal Response</strong></td>
<td>Oriented</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Confused conversation, but able to answer questions</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Inappropriate words</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Incomprehensible speech</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>No response</td>
<td>1</td>
</tr>
<tr>
<td><strong>Motor Response</strong></td>
<td>Obeys commands for movement</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Localizes pain</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Withdraws in response to pain</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Flexion in response to pain</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Extension in response to pain</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>No response</td>
<td>1</td>
</tr>
</tbody>
</table>

\(^1\) GCS is obtained by adding the total score for each parameter

- Score < 9 = coma (no eye opening, no ability to follow commands, no word verbalizations)
APPENDIX B: Complications

- MAP < 70 mmHg despite aggressive fluid resuscitation and vasopressor support
- Uncontrolled arrhythmias
- Hypoxemia – oxygen saturation < 88% on 100% FiO2 for > 30 minutes
- Uncontrolled bleeding

APPENDIX C: Behavioral Pain Score (BPS)¹

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Facial Expression</strong></td>
<td>Relaxed</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Partially tightened (e.g. brow lowering)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Fully tightened (e.g. eyelid closing)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Grimacing</td>
<td>4</td>
</tr>
<tr>
<td><strong>Upper Limbs</strong></td>
<td>No movement</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Partially bent</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Fully bent with finger flexion</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Permanently retracted</td>
<td>4</td>
</tr>
<tr>
<td><strong>Compliance with Ventilation</strong></td>
<td>Tolerating movement</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Coughing but tolerating ventilator most of time</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Fighting ventilator</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Unable to control ventilator</td>
<td>4</td>
</tr>
</tbody>
</table>

¹BPS is obtained by adding the total score for each parameter
- Target: BPS ≤ 5
- Score ≤ 3 = no pain
- Score of 12 = maximum pain
- Document BPS per TTM order set
APPENDIX D: Bedside Shivering Assessment Scale (BSAS)\(^1\)

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None: No shivering noted on palpation of the masseter, neck or chest wall</td>
</tr>
<tr>
<td>1</td>
<td>Mild: Shivering localized to the neck and/or thorax only</td>
</tr>
<tr>
<td>2</td>
<td>Moderate: Shivering involves gross movement of the upper extremities (in addition to the neck and thorax)</td>
</tr>
<tr>
<td>3</td>
<td>Severe: Shivering involves gross movements of the trunk and upper and lower extremities</td>
</tr>
</tbody>
</table>

\(^1\) BSAS:
- Target: BSAS = 0
- Document BSAS every 1 hour during TTM

APPENDIX E: Richmond Agitation-Sedation Scale (RASS)\(^2\)

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Combative: Overtly combative, violent, danger to staff</td>
</tr>
<tr>
<td>3</td>
<td>Very agitated: Pulls/removes tube(s) or catheter(s); aggressive</td>
</tr>
<tr>
<td>2</td>
<td>Agitated: Frequent non-purposeful movement, fights ventilator</td>
</tr>
<tr>
<td>1</td>
<td>Restless: Anxious but movements not aggressive or vigorous</td>
</tr>
<tr>
<td>0</td>
<td>Alert and calm</td>
</tr>
<tr>
<td>-1</td>
<td>Drowsy: Awakens to voice with eye contact for more than 10 seconds</td>
</tr>
<tr>
<td>-2</td>
<td>Light Sedation: Awakens to voice with eye contact for less than 10 seconds</td>
</tr>
<tr>
<td>-3</td>
<td>Moderate Sedation: Any movement (no eye contact to voice)</td>
</tr>
<tr>
<td>-4</td>
<td>Deep Sedation: No response to voice, or any movement to physical stimulation</td>
</tr>
<tr>
<td>-5</td>
<td>Unarousable: No response to voice or physical stimulation</td>
</tr>
</tbody>
</table>

\(^2\) RASS:
- Target: RASS -4 to -5
- Document RASS per TTM order set
APPENDIX F: Child-Turcotte-Pugh (CTP) Scoring System

<table>
<thead>
<tr>
<th>Chemical and Biochemical Parameters</th>
<th>Scores (Points) for Increasing Abnormality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Hepatic encephalopathy</td>
<td>None</td>
</tr>
<tr>
<td>Ascites</td>
<td>None</td>
</tr>
<tr>
<td>Serum albumin</td>
<td>&gt; 3.5 g/dL</td>
</tr>
<tr>
<td>Total bilirubin</td>
<td>&lt; 2 mg/dL</td>
</tr>
<tr>
<td>For primary biliary cirrhosis</td>
<td>&lt; 4 mg/dL</td>
</tr>
<tr>
<td>Prothrombin time prolonged or international normalized ratio</td>
<td>&lt; 4 seconds</td>
</tr>
<tr>
<td></td>
<td>&lt; 1.7</td>
</tr>
</tbody>
</table>

1 CTP score is obtained by adding the score for each parameter

CTP class:
- Class A = 5 to 6 points
- Class B = 7 to 9 points
- Class C = 10 to 15 points
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SUGGESTED READINGS


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DEVELOPMENT CREDITS

This practice consensus statement is based on majority opinion of the TTM experts at the University of Texas MD Anderson Cancer Center for the patient population. These experts included:

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