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

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

2 Exclusion criteria:
- Major traumatic injury or isolated head injury
- Major operative procedure within 72 hours
- Hypoxemia – oxygen saturation < 88% on 100% FiO2 for > 30 minutes
- Mean arterial pressure (MAP) < 70 mmHg despite aggressive fluid resuscitation and vasopressor support
- Poor prognosis as discussed with primary team

3 If temperature < 36°C, no cooling required. If temperature > 36°C within 24 hours of ROSC, ICU team to initiate TTM order set.

3 See Appendix B for Complications

**COOLING**

- Initiate Post Cardiac Arrest TTM order set with target temperature of 36°C
- See Page 3 for TTM protocol
- Initiate shivering management (see Page 4)

See Page 2 for re-warming phase

Development of complications?

- Patient not eligible for TTM
- Continue TTM
- Continue shivering management (see Page 4)

Target temperature maintained for 24 hours?

No

Yes

Does patient meet exclusion criteria?

No

Yes

Does patient meet inclusion criteria for hypothermia?

No

Yes

Sustained ROSC > 20 consecutive minutes?

No

Yes

Patient not eligible for TTM

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Department of Clinical Effectiveness V6

Approved by the Executive Committee of the Medical Staff on 11/15/2022
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**RE-WARMING**

- Re-warming phase
  - Target temperature of 37°C achieved?
    - Yes
      - TOF 4/4 achieved?
        - Yes
          - No
          - Continue monitoring TOF
          - Continue re-warming phase until target temperature achieved
        - No
          - Continue re-warming phase until target temperature achieved
    - No
      - Continue re-warming phase until target temperature achieved

**NORMOTHERMIA**

- Sustained temperature of 36°C to 37°C for 72 hours?
  - Yes
    - Assess neurologic prognosis
  - No
    - Discontinue all analgesics, sedatives, and shivering management medications (meperidine and paralytics)
    - Notify ICU team
    - Discontinue any paralytics
    - Monitor train of four (TOF) every hour until 4/4 response
    - Continue monitoring TOF
    - 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 4</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>Maintain temperature of 37°C</td>
<td>Discontinue any paralytics</td>
</tr>
<tr>
<td>- Cardiology</td>
<td>Keep room as cool as possible</td>
<td>Warm room to normal temperature</td>
<td>Call ICU team for temperature &gt; 37°C</td>
<td>Monitor TOF every hour until 4/4 response</td>
</tr>
<tr>
<td>Nursing assessment:</td>
<td>Magnesium sulfate 32 mEq IV for one dose over 1 hour</td>
<td>Respiratory therapy:</td>
<td>Respiratory therapy:</td>
<td>Once TOF is 4/4:</td>
</tr>
<tr>
<td>- Pupil checks every 1 hour</td>
<td>No spontaneous breathing trials</td>
<td>- Shivering management (see Page 4)</td>
<td>- Shivering management</td>
<td>Discontinue all sedatives, shivering management medications, and analgesics</td>
</tr>
<tr>
<td>- BSAS² per TTM order set</td>
<td>Notify ICU team for development of complications (see Appendix B)</td>
<td>Notify ICU team</td>
<td>Notify ICU team</td>
<td>Notify ICU team</td>
</tr>
<tr>
<td>- RASS³ per TTM order set</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>- Nasogastric or Orogastric tube</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Place 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>- If foley temperature probe contraindicated, physician to place esophageal temperature probe</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>Daily 30 minute EEG</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 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
- Sedation
- More than one vasopressor
- Hemodynamically stable or minimal vasopressor support

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 dose (maximum 25 mcg) every 15 minutes as needed
- If a second bolus is required within a 2 hour period, increase infusion dose by 12.5-25 mcg/hour to a maximum dose of 100 mcg/hour

Propofol 10-50 mcg/kg/minute IV continuous infusion
- Titrate up or down by 5-10 mcg/kg/minute every 5-20 minutes as needed to achieve and maintain target RASS\(^3\). Maximum dose is 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 dose (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 dose by 1 mg/hour (maximum dose of 4 mg/hour)

BSAS\(^2\) ≥ 1

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

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

- 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\(^6\)

- 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)

\(^1\) 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

Department of Clinical Effectiveness V6
Approved by the Executive Committee of the Medical Staff on 11/15/2022
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>Facial Expression</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>Upper Limbs</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>Compliance with Ventilation</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 Combative:</td>
<td>Overtly combative, violent, danger to staff</td>
</tr>
<tr>
<td>3 Very agitated:</td>
<td>Pulls/removes tube(s) or catheter(s); aggressive</td>
</tr>
<tr>
<td>2 Agitated:</td>
<td>Frequent non-purposeful movement, fights ventilator</td>
</tr>
<tr>
<td>1 Restless:</td>
<td>Anxious but movements not aggressive or vigorous</td>
</tr>
<tr>
<td>0 Alert and calm</td>
<td></td>
</tr>
<tr>
<td>-1 Drowsy:</td>
<td>Awakens to voice with eye contact for more than 10 seconds</td>
</tr>
<tr>
<td>-2 Light Sedation:</td>
<td>Awakens to voice with eye contact for less than 10 seconds</td>
</tr>
<tr>
<td>-3 Moderate Sedation:</td>
<td>Any movement (no eye contact to voice)</td>
</tr>
<tr>
<td>-4 Deep Sedation:</td>
<td>No response to voice, or any movement to physical stimulation</td>
</tr>
<tr>
<td>-5 Unarousable:</td>
<td>No response to voice or physical stimulation</td>
</tr>
</tbody>
</table>

² RASS:
- Target: RASS -4 to -5
- Document RASS per TTM order set

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### APPENDIX F: Child-Turcotte-Pugh (CTP) Scoring System

#### Chemical and Biochemical Parameters

<table>
<thead>
<tr>
<th>Parameter</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</td>
<td>&lt; 4 seconds</td>
</tr>
<tr>
<td>international normalized ratio</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


**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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