SUBJECT: Management of Traumatic Brain Injury

SUPERSEDES: 12/15/17

RECOMMENDATION(S): Kyle Kalkwarf, MD

CONCURRENCE(S): Dr. J.D. Day/Trauma Faculty

Last Revised: 05/17/19

Purpose: To provide recommendations for the treatment and management of patients with severe traumatic brain injury.

Definitions:
Severe TBI - Glasgow Coma Scale (GCS) of 3 to 8 without systemic sedation and after resuscitation, with positive brain imaging.

Principles of Care:

- Elevate HOB ≥30 degrees (unless contraindicated by spine or pelvic fractures)
  - if elevating the HOB is contraindicated, place the patient in reverse Trendelenburg
  - If ICP being monitored, patients needing operative interventions should undergo a “lay flat” trial to ensure ICP stays within parameters before being cleared for the OR
- Avoid tight cervical collars and endotracheal tube ties. Maintain the head and neck in a neutral position (remove collar when possible according to established C-spine guidelines)
- Repeat head CT evaluation will occur 4 hours after the initial abnormal head CT
- Ensure adequate pain control.
- Propofol should be the first choice for sedation in the acute phase, unless the patient is hypotensive.
  - Other sedatives may be used as second line agents as dictated by hemodynamics.
- Avoid hypothermia and hyperthermia.
  - Consider cooling measures (e.g. acetaminophen, cooling blanket) for temp >100°F.
- Maintain the patient in a euvoletic state
- Maintain serum sodium 145-165
- There are no indications for systemic steroids in the treatment of severe TBI
- If patient requiring intensive management of ICP:
  - Obtain q6 BMP and serum osmolality; consider adding ABG, CBC, and/or ROTEM if clinically indicated
  - Place a central venous catheter for hemodynamic monitoring and medication administration
  - Place an arterial line for blood pressure measurement and frequent labs
  - If GCS ≤ 8T, consider 24 hour cEEG or MRI if radiographic imaging findings do not explain the clinical condition 72 hours after admission
  - Refer to Goals of Care for parameter targets

Intracranial Pressure Monitoring:

- ICP monitoring is performed based upon admission GCS. Admission GCS is determined post-resuscitation and after paralytics and sedation wear off.
- Admission GCS and ICP monitor placement should occur within 6 hours of arrival to the ED. ICP monitor will not routinely be placed before CT imaging has been obtained.
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- Indications for ICP monitoring:
  - GCS 3-8 and CT findings consistent with intracranial hemorrhage or indicative of elevated ICP or
  - an abnormal CT Head in whom a neurologic exam will be unable to be obtained for any extended period (e.g. prolonged general anesthesia or neuromuscular blockade) or
  - 2 or more of the following features in a patient with GCS 3-8 and a normal CT head:
    - Age > 40 years
    - Unilateral or bilateral motor posturing
    - SBP < 90 mmHg

*If a patient has an above listed indication for ICP monitoring but does not receive an ICP monitor, please contact the Neurosurgery service (know if a contraindication exists).*

**Goals of Care:**

<table>
<thead>
<tr>
<th>Metabolism</th>
<th></th>
<th>Endo</th>
<th>Glucose</th>
<th>80-150 mg/dL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Renal</td>
<td>Serum Osmolality</td>
<td>&lt;340</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Serum Na</td>
<td>145-165</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nutrition</td>
<td>Early enteral feeding; initiated by 24 hours and to goal by at least day 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GI</td>
<td>Stress ulcer prophylaxis, Famotidine</td>
</tr>
</tbody>
</table>

| ICP | <22 mmHg<sup>iii</sup> |
| CPP | >60 mmHg<sup>iv,v</sup> |
| Seizure prophylaxis | 7 days duration of anti-epileptic<sup>vi</sup> (Keppra 1g q12h) |
| Head of bed | >30 degrees |
| CV | SBP | ≥100 for 50-69y/o, ≥110 for 15-49 or ≥70y/o |
| | CVP | >5 mmHg |
| Pulm | SpO2 | >92%<sup>ix</sup> |
| | PaO2 | > 60 mmHg |
| | PaCO2 | 35-42 mmHg<sup>xii</sup> |
| Coag | CT | IN = 122-208 / EX = 43-82 |
| | A10 | 40-60 |
| | Alpha | 63-83 |
| | CFT | 34-159 |
| | ML | < 3% |
| | Hgb | ≥7 g/dL |
| | DVT prophylaxis | TED/SCDs; LMWH 24 hours after stable CT Head; LMWH 48 hours after craniotomy; heparin q8 hr if Cr Cl <30 |
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For Sustained (>15 minutes) ICP Elevations ≥ 22 mmHg.

- Always consider an expanding mass lesion with ICP elevations refractory to therapy and obtain a CT head.

  - First Tier Therapies:
    - Ensure head of bed > 30 degrees
    - Maintain normothermia (36.5-38.0 C/97.7-100.4 F, cooling blankets)
    - Ensure no external compression of neck from cervical collar and that the neck is in a midline, neutral position
    - Initiate CSF drainage via ventriculostomy; if ventriculostomy is present, ensure that it is patent and functioning (level and frequency to be determined by neurosurgery)
    - Ensure adequate sedation and analgesia
    - Initiate hyperosmolar therapy: (goal serum Na 145-165, goal serum osmolality 290-340).
      - Hold hypertonic saline (HTS) if serum Na >165 and/or serum osmolality >340
      - Hypertonic saline:
        - Maintenance fluid: 3% NaCl as a continuous infusion at a rate of 30 ml/hr
        - Bolus therapy: 500cc of 3% NaCl infused over 20 minutes up to q4h prn (OR)
        - Bolus therapy: 60cc of 23.4% NaCl infused over 30 minutes up to q4h prn
        - Mannitol 0.25-1 g/kg over 20 minutes followed by 0.25 g/kg q6 hours.iii
        - Do not give without approval by the attending
        - Hold mannitol if serum osmolality is >340
        - Avoid in patients with known kidney dysfunction
        - May cause or worsen hypotension.

  - Second Tier Therapies (notify NSGY team):
    - Paralysis: rocuronium 50 mg IV x once (or vecuronium 10 mg IV) and evaluate for response. If paralysis improves ICP, start continuous drip with Train of 4 monitoring, continue for 24hrs of controlled ICP prior to wean
    - Hypothermia; goal 34-35°C

  - Third Tier Therapies (notify NSGY team):
    - Craniectomy, in consultation with Neurosurgery.
    - Temporary hyperventilation (60 minutes) to PaCO2 30-35 mmHg
    - Barbiturate coma with continuous EEG monitoring.iii
For sustained (> 10 min) Cerebral Perfusion Pressure <60 mmHg
1) Ensure euvolemia:
   - Urine output ≥ 0.5ml/kg/hour
   - CVP > 5mmHg
   - IVC collapse with inspiration <50%
   - Pulse Pressure/Stroke Volume Variation <12%
   - Consider placing a pulmonary artery catheter if volume status is unclear utilizing arterial line and CVC
2) Ensure ICP <22 mmHg
   - Consider CSF drainage via EVD
   - Consider HTS if ICP>22 and CPP<60 (or on pressors)
   - Consider mannitol if ICP>22 and CPP>60
3) Begin pressors if euvolemia and CPP remains <60:
   - Norepinephrine gtt
     - consider phenylephrine gtt if HR>100
   - Add vasopressin with escalating doses of pressors (0.04 U/min, do not titrate)

For Acute Clinical Deterioration – acute mental status change, evidence of cerebral herniation, new focal neurologic symptoms, progressive (2 bolus of hyperosmolar therapy in 24 hours) and refractory ICP elevation (ICP > 22 mmHg for ≥15 min despite initial intervention):
   1) ABC’s: Verify patent airway, oxygenation, and ventilation
   2) Re-dose osmotic agent (if appropriate),
   3) Call Neurosurgery and SICU attending immediately
   4) Obtain EMERGENT CT Head

Removal of Intracranial Monitors ➔ All intracranial monitors will stay in place for a minimum of 72 hours
   - If persistently elevated ICP, the monitor will stay in place for further treatment guidance
   - If the patients neurologic exam has improved and the monitor has served its purpose, the monitor will be
     removed after Attending ICU and Attending Neurosurgeon discussion
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