Managing Severe TBI in the ICU Setting using a Three Tier Approach

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Managing Severe TBI in the ICU Setting using a Three Tier Approach

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Objectives

• 1) Assess the effects of injury to the brain in the neurologic injured patient and implement a tiered approach to manage severe TBI
• 2) Evaluate TBI patients using multimodality monitoring
• 3) Apply interventions to manage brain injury & integrate the complex multi-system issues and manage these patients using an actual case study.

Case DF: Pre-Hospital

• 75 year old male riding bike with helmet on downhill went over the handlebars
• VS: BP 166/62 HR 44 R 18 O2 sat 82% on O2
• Awake at seen: GCS 3-5-1 – deteriorating...
• Laceration over left eye / blood coming from ears

Trauma Room 1143- Tier 1 Red

• BP 80/40 HR 50s RR 18
• Intubated emergently in trauma room
• Neuro
  • GCS 1-1-1
  • Right np 3 mm / Left np 4 mm
• Crepitus over left chest with suspicion of tension pneumothorax right
  • Needle thoracostomies
  • Bilateral chest tubes
  • O2 saturation improves to 100% BP 120/80
• Heart rate drops to 30s...Patient arrests (Vfib) 10 minutes after arrival
  • CPR 5-6 minutes
  • Defibrillation
  • Epinephrine
  • Thoracostomy performed - Opened chest
  • Blood products given
  • Tx/VR

IntraOp

• Left sided Thoracotomy – cross clamped aorta
  • Obvious cardiac contusion
  • Multiple lung contusions
• Abdomen opened
  • Grade 1 splenic injury
  • Mesenteric hematoma
• Flail chest noted with bilateral hemotoraces
• Massive Transfusion
  • 6 Packed RBCs, 4 FFP, and Super pack Platelets
• Abdomen left open with wound vac placed
• To CT...
Admit SICU 300pm

- Decision to induce hypothermia at 36 degrees C x 24 hours due to V Fibrillation arrest
  - Concerns about bleeding
  - Neurosurgeon decides to hold ICP placement this evening
  - Pads placed strategically with open belly
  - Pacing wires present
  - Bilateral chest tubes to suction
- VS stable
  - MAP 80-90 HR 56 Ventilated at 10 breaths/minute

Neuro
- GCS 3-1-1
  - Right pupil: NP 1 CV 0.52 mm/sec
  - Left pupil: NP 0.5 CV 0.09 mm/sec

Severe TBI

- Sum score 3 to 8 &/or motor score < 5
- Brain injury association
  - Prolonged unconscious state or coma lasting days, weeks or months
- Primary Injury
  - Occurs at the time of the event
  - Includes EDH, SDH, SAH, Contusions, DAI etc

Secondary Brain Injury

- Secondary Head Injury
  - Extracranial causes
    - Hypotension
    - Hypocapnia and Hypercapnia
    - Hypoxia
    - Anemia
    - Hyperglycemia & Hypoglycemia
    - Hyperthermia

TBI Classification by Age Group - Mechanism

3 Factors

- CBF
  - Phases of CBF after TBI
    - Early: Low CBF and
    - Days 2-6: Higher CBF –
    - Days 7-14: Low CBF – fall in cytotoxic edema

- Pressure
  - Early to mid week: cytotoxic edema forms during this phase as well as vascular engorgement

- Oxygen
  - PaO2 is low – vasodilation
  - PaCO2 is low – vasoconstriction
  - PaCO2 is high – vasodilation

A bit of Physiology
Cerebral Blood Flow

Autoregulation

- Vasomotor control
  - Intact: Increase in CPP causes vasoconstriction and decrease in ICP
  - Vasomotor reactivity failure: Increase in CPP causes vasodilation and inc ICP

- Flow metabolism
  - ↑ metabolism ↑ CBF

- Metabolic substances
  - PaO2
  - PaCO2
  - pH i.e., acidosis = vasodilatation

Pressure: Intracranial Pressure

- Theories on Brain Compartment
  - 80% brain
  - 10% blood
  - 10% CSF

- If one increases the other two decrease
- Compensatory mechanisms

Intracranial Pressure: It is more than a number...it is all about compliance!

Cerebral Perfusion Pressure

MAP – ICP = CPP
Optimal CPP in TBI
60-80 mm Hg

Brain Tissue Oxygen (PbtO2)

- Normal: 20-40 mm Hg
- Risk of death increases
  - < 25 mm Hg for 30 minutes
  - < 20 mm Hg for 10 minutes
- PbtO2 < 5 mm Hg
  - High mortality
- PbtO2 < 2 mm Hg - neuronal death

Influence of Airway/Ventilation Issues

Day 8: Lungs Worsening
ICP is no longer an issue
Managing Severe TBI

ACS TQIP Guidelines Severe TBI

• Recommendations

  • Use GCS to assess neuro status
  • Triage & Transport
    • Patients with GCS < 13 and/or combination of GCS < 15 and moderate to severe extra-cranial anatomic injuries and AIS > 3 should be transported to highest level trauma center to allow for expedient neurosurgical assessment and intervention

  • ICP Monitoring
    • Important but does not replace neuro exam
    • Indicated in patients with
      • GCS < 8 (not indicated if no structural injury seen on CT Scan)
      • Considered in GCS > 8 with structural brain damage with high risk for progression (large contusions/coagulopathy)
      • Indicated in patients requiring urgent surgery for extracranial injuries requiring mechanical ventilation & evidence of CT progression of injury
    • Preferred method for ICP monitoring is EVD

ACS TQIP Guidelines Severe TBI

• Recommendations: ICP Management

  • Global measure
  • Additional neuromonitoring (PbtO2, SjO2, Autoregulation, and CBF) and assessment of cerebral autoregulation may help to individualize treatment
  • 3 Tiered approach to ICP Management
  • Failure to control ICP/CPP within one tier should prompt rapid progression to the next tier’s treatment options
  • Repeat CT imaging and neurological exam should be considered to rule out the development of surgical lesion and guide management

ACS TQIP Guidelines Severe TBI

• Recommendations: Advanced Neuro Monitoring

  • Cerebral Autoregulation may be helpful in identify a more individualized approach to treatment
  • Impaired cerebral oxygenation can occur in the face of normal ICP and CPP
  • Cerebrovascular pressure reactivity (PRx) and CBF monitoring can assess autoregulation status which may be helpful in determining patient specific CPP and ICP goals

ACS TQIP Guidelines Severe TBI

• Recommendations: Surgical Management

  • Large traumatic hematoma should be evacuated before neuro deterioration develops irrespective of GCS
  • Formal craniotomy is necessary to perform adequate resection
  • TBI patients in coma should be taken to the OR immediately if large hematoma is identified as cause of coma
  • Decompressive craniectomy is effective in controlling ICP but uncertainty exists in its potential to improve outcome

Three-Tiered Management of ICP

Tier 1

• Head of Bed elevated 30 degree (reverse Trendelenburg) to improve cerebral venous outflow
• Sedation and analgesia using recommended short acting agents
  • Propofol, Fentanyl, and Midazolam) in intubated patients
• Ventriculostomy drainage performed intermittently.
  • Continuous drainage is not recommended unless additional ICP monitor is placed, as when the drain is open, it does not accurately reflect the true ICP
• Repeat CT imaging and neurologic examination should be considered to rule out the development of a surgical mass lesion and guide treatment
• IF ICP remains >20-25 mm Hg, proceed to Tier 2
In patients with a parenchymal ICP monitor, an EVD should be considered to allow for intermittent CSF drainage.

Hyperosmolar therapy should be given intermittently as needed for ICP elevation and not on a routine schedule.

Mannitol should be administered in intermittent boluses (0.25–1 gm/kg body weight).

Caution with hypovolemic patient when osmotic diuresis is instituted with mannitol.

Additional doses should be held if serum osmolality exceeds 320 mOsm/l.

Mannitol should be held if evidence of hypovolemia.

Hyperosmolar therapy should be given intermittently as needed for ICP elevation and not on a routine schedule.

Hypertonic saline may be administered in intermittent boluses of 3% sodium chloride solution (250 ml over ½ hour) or other concentrations (e.g., 30 cc of 23.4%).

Serum sodium and osmolality must be assessed every 6 hours and a.

Additional doses should be held if serum sodium exceeds 160 mEq/l.

Cerebral autoregulation should be assessed.

If patient is not autoregulating, CPP should be lowered to reduce ICP.

Additional neuromonitoring (e.g., PbtO2, SjvO2, CBF) may help determine optimal CPP.

PaCO2 goal of 30-35 mm Hg should be maintained, as long as brain hypoxia is not evident.

Additional neuromonitoring (e.g., PbtO2, SjvO2, CBF) may help determine optimal PaCO2.

Repeat CT imaging and neurologic examination should be considered to rule out development of a surgical mass lesion and guide treatment.

Neuromuscular paralysis achieved with a bolus test dose of a neuromuscular blocking agent should be considered if the above measures fail to adequately lower ICP and restore CPP.

If there is a positive response, continuous infusion of a NMB should be employed (Tier 3).

If ICP remains > 20-25 mm Hg, proceed to Tier 3.

Venous Thromboembolism prophylaxis

High rates of DVT (20-30%).

VTE prophylaxis should be considered within first 72 hours following TBI in most patients.

Earlier initiation of pharmacologic prophylaxis (<72 hours) appears to be safe in patients at low risk for progression of ICH bleeding and have stable CT scan.

Prophylactic inferior vena cava filter should be considered in patients at high risk for progression of ICH hemorrhage and cannot receive pharmacologic prophylaxis.
**Goals for Treatment**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Pulse Oximetry</td>
<td>&gt; 95%</td>
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<tr>
<td>ICP</td>
<td>20-25 mm Hg</td>
</tr>
<tr>
<td>Ser. Na</td>
<td>135-145</td>
</tr>
<tr>
<td>PaO2</td>
<td>&gt; 100 mm Hg</td>
</tr>
<tr>
<td>PtbiO2</td>
<td>&gt; 15 mm Hg</td>
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<tr>
<td>INR</td>
<td>&lt; 1.4</td>
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<tr>
<td>PaCO2</td>
<td>35-45 mm Hg</td>
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<tr>
<td>CPP</td>
<td>&gt; 60 mm Hg</td>
</tr>
<tr>
<td>SBP</td>
<td>&gt; 100 mm Hg</td>
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<tr>
<td>Temp.</td>
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<tr>
<td>Hgb</td>
<td>&gt; 7 g/dL</td>
</tr>
<tr>
<td>pH</td>
<td>7.35-7.45</td>
</tr>
<tr>
<td>Glucose</td>
<td>80-180 meq/L</td>
</tr>
</tbody>
</table>

**Management of TBI**

- **Presence of Anticoagulants/Antiplatelets**
  - If patient on Anti-coagulants/Anti-platelet medications and have a CT evidence of bleeding
  - Note the type of medication
  - Stop drug
  - Reversal strategies

**TQIP Guidelines Focus Severe TBI**

- Section on Elderly Patients with TBI
  - Often present with GCS 13-15 and appear mild in nature due to brain atrophy
  - Neuro evaluation more complicated due to dementia, cognitive decline, and hearing/visual deficits
  - Determine baseline from family
  - Anti-coagulants/Anti-platelet medications exacerbate sequelae of TBI
    - Reversal is important to remember
  - Older age carries higher mortality and worse functional outcome

**Critical Care Management of Severe TBI**

- Pathological Changes
- Secondary Injury
- Dynamics of Injury Monitoring
- Technologies
- Evidence Based Practice
- Coordinated ICU Multidisciplinary Care

**Severe TBI Patient: GCS 3-8 CT+ Injury**

- **RSI**
  - Lidocaine 1mg/kg IV
  - Etomidate 0.3 mg/kg IV

- **Paralytic of Choice**
  - Fentanyl

- **Avoid hyperventilation**
  - Use Capnography to monitor ET CO2 (15)
Severe TBI Patient: GCS 3-8 CT+ Injury

Arrival: Emergency Department Trauma Bay

Assess A-B-C:
Oxygenation and Ventilation
Assess Circulation:
Assess Pulse, ECG and BP
IV fluids to maintain adequate MAP

Place Foley & OG
Maintain MAP > 80 mm Hg with IV NS:
Assess need for Blood Products and/or Vasopressors
Assess need for Central Line/Arterial Line

Assess Neuro: GCS/Pupils
If S/S Increased ICP
Non-reactive single pupil(s) &/or Posturing

Administer 3% Saline 200 ml (Preferred) or Mannitol 1gm/kg IV (if no signs hypotension or bleeding)

Severe Brain Injury Algorithm

Secondary Survey
Other Interventions as needed
Is patient on any anti-coagulants or anti-platelet medications?

Anticoagulation/Anti-platelet Reversal
PCC agents Platelets/FFP DDA VP

Radiology:
CT Scan Non-Contrast/C-Spine
Positive for Bleeding?

PACU:
Hold/Lines Placed if time
Place Central Line/Art line with Flotrac
OR:
Monitors (ICP/Pao2)/Craniotomy
ED Trauma or SICU RN assist in OR

ICU Care: Primary Interventions

Airway/Breathing
Reassess ABG/Baseline Capnography evaluation for accuracy
Maintain PaO2 > 100 mm Hg (Titrate FIO2 based on patient status)
Maintain PaCO2/ETCO2 35 -45 mm Hg. Optimize based on ICP and PbtO2
Titrate PaCO2 to balance ICP <20 mm Hg and PbtO2 ≥ 20 mm Hg
Maintain Head of Bed at 30 degrees
Rotate side to side for pulmonary management

Circulation
Arterial line to Hemodynamic Monitor
√MAP/SVV/CO/CI
Maintain CPP >60 mm Hg as initial target
1) Use fluids to maintain SVV < 10-13%
2) Vasopressors Norepinephrine or Phenylephrine
ICP Management: Goal ICP < 20 mm Hg and PbtO2 > 20 mm Hg

Tier 1 Interventions: Instituted on admission to ICU

- Provide sedation and analgesia
  - Propofol 10-50 mcg/kg/min & Fentanyl 50-200 mcg/hr
- Drain CSF if ventriculostomy in place for ICP > 20 mm Hg
- Head of Bed at 30 degrees
- Maintain PaCO2 35-45 mm Hg: consider 35 mm Hg if ICP elevated
- Keep Temperature 37 – 37.5 degrees C.
- Institute cooling measures x 7 days
- Keep room quiet/lights low

Tier 2 Intentions:

- Mannitol 0.25 - 1.0 gram or Hypertonic Saline 3% 200 ml vs 23% 30 ml over 20-30 minutes
- Consider Propofol 10-50 (up to 100 mcg/kg/hr) as needed
- Paralytic bolus x 1 – determine ICP response
- Consider repeat CT of brain

Tier 3 Interventions:

- Paralytic of choice for ventilator control or ICP control (consider other interventions first)
- Elective craniectomy per neurosurgery
- Mild Hypothermia (33-35) for refractory ICP
- Protocordial Coma for refractory increased ICP

Note: Use nurse critical thinking algorithm for individualized targeted needs

System Support:

- Monitor Labs/Coags/TEG - Maintain WNL with sodium target < 160 mg/dL (max)
- DVT Prophylaxis: compression boots thigh high and anticoagulation Day 2-4 per MD instructions
- NPO: begin early enteral nutrition Day 1-2 (post pyloric)
- Monitor Glucose: 80-180 mg/dL
- Early Mobility Protocol:
  - Cycle Ergometry Begin Day 2-3/ROM
- PT/OT/Physiatry consult

CONCLUSION

PROTOCOLIZE AND INDIVIDUALIZE

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