Emergency Room Management of Children with Traumatic Brain Injury

Child (≤ 18yo) with acute head trauma
< 24 hours after injury

Triage Patient

Modified Glasgow Coma Scale

GCS ≥ 14

Pediatric Minor Blunt Head Trauma Guidelines

Imaging positive for significant intracerebral injury?

Yes

Positive CT

Intensive Care Not Required

No

GCS ≤ 13

Critical Care Management

Head CT

Imaging positive for significant intracerebral injury?

Yes

Intensive Care Required

No
Pediatric Minor Blunt Head Trauma Guidelines

Minor Blunt Head Trauma +
- < 18 yo
- GCS ≥ 14
- Non-trivial injury

< 2 years   ≥ 2 years

CT (4.4% ciTBI)

Yes

CT (4.3% ciTBI)

No

Observation vs. CT (0.9% ciTBI)
- Physician experience
- Multiple vs. isolated findings
- Worsening symptoms or signs
- Age < 3 mos ↑ risk
- Parental preference

GCS = 14?
- Altered mental status?
- Signs of skull fracture?

Occipital, temporal or parietal hematoma
- LOC ≥ 5 sec
- Severe MOI
- Not acting normal per parent

History of LOC
- History of vomiting
- Severe MOI
- Severe headache

Yes

No CT (< 0.02% ciTBI)

No CT (< 0.05% ciTBI)

Yes

No

No

No

Observation vs. CT (0.9% ciTBI)
- Physician experience
- Multiple vs. isolated findings
- Worsening symptoms or signs
- Parental preference

1. < 18 yo without ventricular shunt or bleeding disorder
2. Trivial injury: ground-level fall, walking or running into stationary object, or no signs/symptoms other than scalp abrasion or laceration
3. Severe MOI: MVC with patient ejected, death of passenger, rollover, unhelmeted pedestrian or bicyclist struck by MV, falls > 1.5m (5ft) for > 2 yo or >0.9m (3ft) for < 2yo, head struck by high-impact object
4. Observation: Short period of observation (4-6 hrs from injury) provides 3.9% absolute and 11% relative reduction in CT utilization; Estimated lifetime cancer mortality risk for head CT is 1:1500 for 1 yo and 1:5000 for 10 yo; lifetime risk of ANY cancer death 20%, additional risk from single CT is ~0.05%.
5. Signs of skull fracture: Increased risk for < 1 yo, location (temporal/parietal > occipital > frontal), larger size, and palpation (boggy > barely palpable)
6. ciTBI: death, neurosurgery, intubation > 24 hrs, hospital admission > 2 nights

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Imaging positive for significant intracerebral injury

Contact Trauma and Neurosurgery

Immediate Neurosurgical Intervention required? Expanding epidural, midline shift?

Operating Room

Epidural hemorrhage >1cm
GCS <15
Focal neurologic exam
Other trauma or ICU needs (ventilator, vasoactive meds)
Coagulopathy

Intensive care required

≥ 16 years old
Special Care Unit (SCU) / Pediatric Intensive Care Unit (PICU)
Attending of record will be negotiated between neurosurgery and adult trauma

< 16 years old

Intensive care not required

Isolated, non-epidural hemorrhage < 1 cm in diameter
GCS = 15, normal mental status
Non-focal neurologic examination
No other trauma requiring ICU care
No history of coagulopathy

ED and Trauma Attending determine if ICU needed

Pediatric Intensive Care (PICU)
Notify pediatric admit resident and PICU attending
Attending of record will be negotiated between trauma, PICU or hospitalist

Barbara Bush Children’s Hospital
Notify pediatric admit resident.
Attending of record will be negotiated between trauma and hospitalist

Isolated linear, non-depressed skull fracture present
GCS 15, normal neuro exam
Tolerating PO
Consider discharge

Trauma team to contact
< 16 yo – Pediatric Trauma
≥ 16 yo – Adult Trauma
## PICU Management of Children with Severe TBI: GCS < 8

### Access
- All patients should be **intubated** and have **central line** access, an **arterial line** and a **foley catheter**.

### Respiratory
- Ventilator settings should aim for PaCO2 35-40 / EtCO2 30-35
- Hypoxia and hyperoxia should both be avoided: goal sats 92-98%

### Circulation
- Avoid hypotension
- Cerebral Perfusion Pressure (CPP) = Mean arterial pressure (MAP) - Intracranial pressure (ICP)
- Target CPP: 40-50 (Consider lower in babies, higher in teens)
- Norepinephrine may be needed to increase MAP in the setting of elevated ICP

### Neurologic Monitoring
- **ICP monitor must be placed** by neurosurgery
  - Simple ICP monitor "Bolt"
  - EVD: allows CSF drainage and ICP monitoring
  - Licox: Allows ICP and PbtO2 to be monitored
  - Targets: ICP < 20, PbtO2 > 10

### Sedation
- Goal SBS -3
- Sedate with Fentanyl 0.5-3mcg/kg/min
- Alternatives include ketamine, midazolam and dexmedetomidine.
- If paralysis required, ensure EEG in place

### Seizures
- **vEEG should be placed** for min 48 hrs
  - Prophylaxis is now recommended in pediatrics.
  - Load with fosphenytoin or Keppra at 20mg/kg. Continue Rx for 7 day.

### Temperature Control
- Controlled normothermia is the standard
- Scheduled acetaminophen
- **Cooling blankets or Artic Sun should be placed**
- Shivering should be avoided; heavy sedation or even paralysis may be necessary

### Hyperosmolar therapy
- See separate for managing elevated ICP
- Hypertonic saline (3%) can be run at 0.1-1 mL/kg/hr

### Positioning
- HOB 30 degrees.
- Ensure C-collar not too tight.
Managing elevated ICP in the ER / Pediatric Intensive Care Unit

If all the temperature, sedation, seizure and ventilator parameters above have been met and ICP is still >20 for >5 minutes

Hyperosmolar Therapy

- Hypertonic 3% saline bolus - 2mL-5mL/kg per bolus (up to 250mL).
- Hypertonic 3% saline infusion may be run at 0.1-1mL/kg/hr.
- Hypertonic 23.4% saline bolus - 0.5mL/kg per bolus (up to 30mL)
- A target Osm or Na is no longer recommended.
- Less preferred: Mannitol 0.5-1g/kg per bolus. Will cause significant diuresis and potential hypotension.

CSF Drainage

- If EVD in place, consider lowering the height of the drain with neurosurgical approval

Hypothermia

- Moderate hypothermia 32-34 can be considered but has been shown in different studies to both help and hinder survival in TBI.

Pentobarbital Coma

- Consider pentobarbital coma per EPIC order set
- Risk of pneumonia is high
- Hypotension likely, so will almost always need vasoactive agents

Re-image

- Discuss with neurosurgery and consider a stat head CT to ensure no further expansion

Surgery

- If all the above fails, may need to consider decompressive surgery
- Note that data is weak on whether this improves survival or not in pediatrics.
### Daily Patient Needs in the ICU

#### Lab Schedule
- **ABG Q12H**: Target PaCO2 35-40
- **BMP or CMP Q8H**: Target 'normal' (However Na, Cl and osm likely to be high). While hyperglycemia is bad, insulin therapy has not been shown to improve outcome.
- **CBC Q24H**: Watch for ongoing bleeding. Target 'normal'. Hb>7
- **Coags**: at admission and ongoing if abnormal or significant liver injury. Target 'normal'.

#### IV Fluids
- **Normosol** (no dextrose needed unless a neonate)
- Aiming for a total fluid limit of 'maintenance'. Consider all infusions; sedation, 3% etc and subtract from normal maintenance fluids.

#### Nutrition
- If stable at 24 hours and not on escalating vasoactive agents, consider placement of NG/OG (beware basal skull fracture) and starting feeds within 72hrs.
- TPN is not usually indicated for < 1 week NPO.

#### DVT Prophylaxis
- TBI has a high thrombotic risk.
- Minimum SCDs for all post-pubertal patients
- Consider heparin therapy if appropriate given trauma

#### Lines, Access and Restraints
- Assess the necessity of lines and foley daily
- May need a daily order for restraints
<table>
<thead>
<tr>
<th>1 Critical</th>
<th>2 Acute</th>
<th>3 Urgent</th>
<th>4 Urgent</th>
<th>5 Non-Urgent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Status Changes</td>
<td>Head trauma with any of the following:</td>
<td>Normal mental status:</td>
<td>Age &gt;3 months – 2 yrs</td>
<td>&gt;2 yrs with minor mechanism, well-appearing, with small hematoma or abrasion</td>
</tr>
<tr>
<td>GCS &lt; 14</td>
<td>Age &lt; 3 months</td>
<td>With normal PE, or Small frontal hematoma</td>
<td>With normal PE, or Small frontal hematoma</td>
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<tr>
<td>Combative</td>
<td>LOC / amnesia</td>
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<tr>
<td>Hard to arouse</td>
<td>Post-traumatic seizures</td>
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<tr>
<td>Inconsolable</td>
<td>Persistent vomiting (&gt; 2 episodes of vomiting, or any vomiting in the ED)</td>
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<tr>
<td>Bulging fontanelle</td>
<td>Significant or severe headache</td>
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</tr>
<tr>
<td>Other Neurologic Symptoms</td>
<td>GCS = 14 PE</td>
<td></td>
<td></td>
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<tr>
<td>Ataxia</td>
<td>Irritable / change in behavior</td>
<td></td>
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<tr>
<td>Inability to walk</td>
<td>Periorbital bruising</td>
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<td></td>
<td></td>
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<tr>
<td>Laceration with uncontrolled bleeding</td>
<td>Bruising over mastoid</td>
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</tr>
<tr>
<td>See Critical Criteria</td>
<td>Fluid or blood from the ear</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>History of coagulopathy</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>Cervical spine tenderness</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Parathesias</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Weakness</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Any suspicion for non-accidental trauma</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

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Borrowed and modified from the Children’s Hospital of Philadelphia clinical pathways.
https://www.chop.edu/clinical-pathway/head-trauma-acute-clinical-pathway
**ED Management**

**Goals**
- Airway management (GCS ≤ 8, GCS declining ≥2 despite treatment, imminent surgical needs)
- Avoid hypotension
- Avoid hypoxemia
- Evaluate and treat elevated ICP
- Expedite time for definitive care

**Assessments and Interventions**

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Intervention(s)</th>
</tr>
</thead>
</table>
| Airway & Breathing    | **Rapid Sequence Intubation (RSI) Recommendations:**
|                       | **RSI Option**
|                       | - Etomidate 0.3 mg/kg IV
|                       | - Rocuronium 1 mg/kg IV OR
|                       | - Ketamine 1-2 mg/kg IV
|                       | - Rocuronium 1 mg/kg IV
|                       | **Goals:**
|                       | - SpO₂ > 92% and ≤ 98%
|                       | - EtCO₂: 30-35 mmHg
|                       | **Comments**
|                       | - Etomidate lasts for approximately 8 minutes – consider that patients may need additional sedation but avoid hypotension
|                       | - Succinylcholine can be used as an alternate 2 mg/kg (< 2yo) OR 1.5 mg/kg (≥ 2yo) – beware of risks including hyperkalemia.

| Neurologic            | Signs of elevated ICP in the absence of an ICP monitor:
|                       | - Focal neurological exam deficit (e.g. unilateral dilated pupil)
|                       | - Cushing’s triad: Hypertension, bradycardia, abnormal breathing
|                       | Consider the following interventions if concern for elevated ICP:
|                       | - **Hyperosmolar therapy:**
|                       |  - Hypertonic 3% saline bolus (2-5 mL/kg IV bolus); may repeat PRN
|                       |  - Mannitol bolus (0.5-1 g/kg IV bolus); be aware of significant diuresis
|                       | - **Secondary sedation post-RSI:**
|                       |  - Consider Fentanyl, Ketamine and/or Midazolam based on the patient’s clinical status.
|                       |  - **Propofol is not permitted** for non-procedural sedation in pediatric patients at MMC.
|                       |  - Dexmedetomidine can be used but can cause bradycardia.
|                       |  - Administer the minimal amount needed to avoid hypotension.
|                       | - Load anti-epileptic medications (Fosphenytoin and/or Levetiracetam both 20mg/kg load)

| Circulation           | Maintain euvolemia
|                       | AVOID hypotension
|                       | If a vasopressor is needed, consider norepinephrine (phenylephrine is good too but may cause bradycardia)

Borrowed and modified from the Children’s Hospital of Philadelphia clinical pathways.
# Modified Glasgow Coma Scale for Infants and Children

<table>
<thead>
<tr>
<th>AREA ASSESSED</th>
<th>INFANTS</th>
<th>CHILDREN</th>
<th>SCORE*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EYE OPENING</strong></td>
<td>Open spontaneously</td>
<td>Open spontaneously</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Open in response to verbal stimuli</td>
<td>Open in response to verbal stimuli</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Open in response to pain only</td>
<td>Open in response to pain only</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>No response</td>
<td>No response</td>
<td>1</td>
</tr>
<tr>
<td><strong>VERBAL RESPONSE</strong></td>
<td>Coos and babbles</td>
<td>Oriented, appropriate</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Irritable cries</td>
<td>Confused</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Cries in response to pain</td>
<td>Inappropriate words</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Moans in response to pain</td>
<td>Incomprehensible words or nonspecific sounds</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>No response</td>
<td>No response</td>
<td>1</td>
</tr>
<tr>
<td><strong>MOTOR RESPONSE</strong></td>
<td>Moves spontaneously and purposefully</td>
<td>Obeys commands</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Withdraws to touch</td>
<td>Localizes painful stimulus</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Withdraws in response to pain</td>
<td>Withdraws in response to pain</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Responds to pain with decorticate posturing (abnormal flexion)</td>
<td>Responds to pain with flexion</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Responds to pain with decerebrate posturing (abnormal extension)</td>
<td>Responds to pain with extension</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>No response</td>
<td>No response</td>
<td>1</td>
</tr>
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</table>

*Score:
12 suggests a severe head injury
8 suggests need for intubation and ventilation
6 suggests need for intracranial pressure monitoring

**If the patient is intubated, unconscious, or preverbal, the most important part of this scale is motor response. This section should be carefully evaluated.

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# Head Trauma Decision Rules for Children < 2 Years Old

VERY LOW RISK OF INTRACRANIAL INJURY IF ALL OF THE FOLLOWING ARE PRESENT:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description</th>
</tr>
</thead>
</table>
| Normal Mental Status | Altered mental status is defined as:  
  - GCS < 15  
  - Agitation  
  - Somnolence  
  - Slow responses when developmentally appropriate  
  - Repetitive questioning |
| No Hematoma or Isolated Frontal Hematoma |  |
| No LOC or LOC < 5 Seconds |  |
| Non-Severe Injury Mechanism | Severe defined as any of the following:  
  - Motor vehicle crash with:  
    - Patient ejection  
    - Death of another passenger  
    - Rollover  
    - Pedestrian or bicyclist without helmet struck by a motorized vehicle  
  - Falls of > 3 feet  
  - Head struck by a high-impact object |
| No Palpable Skull Fracture |  |
| Acting Normally According to the Parents |  |

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## Head Trauma Decision Rules for Children ≥ 2 Years Old

**VERY LOW RISK OF INTRACRANIAL INJURY IF ALL OF THE FOLLOWING ARE PRESENT:**

| Normal Mental Status | Altered mental status is defined as:  
<table>
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<tbody>
<tr>
<td></td>
<td>GCS &lt; 15</td>
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<tr>
<td></td>
<td>Agitation</td>
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<td>Somnolence</td>
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<tr>
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<td>Slow responses</td>
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<tr>
<td></td>
<td>Repetitive questioning</td>
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<table>
<thead>
<tr>
<th>No LOC</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>No Vomiting</th>
<th></th>
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</table>

| Non-Severe Injury Mechanism | Severe defined as any of the following:  
<table>
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<tr>
<th></th>
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<tr>
<td></td>
<td>Motor vehicle crash with:</td>
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<tr>
<td></td>
<td>Patient ejection</td>
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<td>Death of another passenger</td>
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<td>Rollover</td>
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<td>Pedestrian or bicyclist without helmet struck by a motorized vehicle</td>
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<td>Falls of &gt; 5 feet</td>
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<td>Head struck by a high-impact object</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>No Signs of Basilar Skull Fracture</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>No Severe Headache</th>
<th></th>
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</thead>
</table>

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References


