Title: PEDIATRIC TRAUMATIC BRAIN INJURY GUIDELINE

Scope/Patient Population:
1. Condition – Mild, Moderate, and Severe Traumatic Brain Injury (TBI)
2. Guideline purpose – Identify patients and provide clinicians with an evidence based framework to base clinical decision making
3. Guideline objectives –
   a. Define mild, moderate, and severe TBI
   b. Provide evidence-based recommendations to optimize care of the pediatric patient with a head injury
4. Target population – Pediatric patients (<18 yrs) who have suffered a head injury as the result of traumatic mechanism
5. Define common terms and definitions (please see p.6)

Policy Statement/Background:
Methodology:
1. The guideline developer performed a literature search through Ovid, The Cochrane Database of Systemic Reviews; The Joanna Briggs Institute, The National Guideline Clearinghouse
2. Search terms
   a. Pediatric head injury treatments
   b. Traumatic Brain Injury (TBI) treatment
   c. Pediatric TBI treatment
   d. TBI guidelines

Procedure:
1. Pre-hospital Recommendations
   a. Pediatric patients with severe TBI should be transported directly to Mary Bridge Children’s Hospital and Health Center
   b. Hypoxia must be avoided and adequate oxygenations and airway stabilization maintained
      i. There is no evidence to support airway support via endotracheal intubation over bag-valve-mask
      ii. Children with GCS<9 should have a controlled airway in order to avoid hypoxemia, hypercarbia, and aspiration
      iii. If endotracheal intubation is instituted for pediatric patients with TBI, then specialized training including the use of end-tidal CO2 detection is necessary
   c. Prophylactic hyperventilation should be avoided but may be utilized in the pre-hospital setting as an intervention in the patient with suspected cerebral herniation
      i. Hyperventilation is defined as:
         1. >20 in adults
         2. >25 BPM in children
3. >30 BPM in infants
   
   ii. Hypotension should be identified and corrected as soon as possible
   
   1. Hypotension is defined as SBP below the fifth percentile for age or by clinical indication of shock
   2. Lower limit of SBP may be estimated by 70 + (2 X age in years)

2. Hospital Management

<table>
<thead>
<tr>
<th>TBI Classification</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blunt traumatic acceleration/deceleration mechanism with:</td>
<td></td>
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</tr>
<tr>
<td>Post-resuscitative GCS</td>
<td>13-15</td>
<td>9-12</td>
<td>3-8</td>
</tr>
<tr>
<td>Loss of consciousness at time of incident</td>
<td>May be present but &lt;30 minutes</td>
<td>&gt;30 minutes</td>
<td>&gt;30 minutes</td>
</tr>
<tr>
<td>Impaired or amnesic memory of event</td>
<td>Present &lt;24 hrs</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>Neurological impairment</td>
<td>Possibly disoriented, confused or dazed at time of incident. Focal impairment may include H/A, Sz, N/V, dizziness, blurred vision, fatigue, sleep disturbances, behavioral changes, difficulty concentrating, or memory impairment</td>
<td>Global</td>
<td></td>
</tr>
<tr>
<td>Neuroimaging results</td>
<td>See Algorithm</td>
<td>May be present</td>
<td>Evidence of hematomas, contusions, cerebral edema, or compressed basal cisterns</td>
</tr>
</tbody>
</table>

Treatment Recommendations
<table>
<thead>
<tr>
<th>TBI Classification</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
</table>
| Airway support     | Prevent hypoxia | Oxygenation by appropriate means to prevent hypoxia | Obtain controlled airway and prevent hypoxia  
Mild hyperventilation (PaCO2 30-35) may be considered for longer periods of ICHTN unresponsive to sedation analgesia, neuromuscular blockade, CSF drainage, and hyperosmolar tx. |
| Neuroimaging       | Refer to Mild Traumatic Brain Injury Guideline algorithm | Head CT | Head CT |
| Disposition        | Refer to Mild Traumatic Brain Injury Guideline algorithm | Admission | Admission w/ appropriate specialty consults |
| Surgical intervention | Rarely | As indicated | As indicated for mass lesions  
- For GCS less than 8, refer to airway management and recommend ICP monitoring  
- Consider decompressive craniectomy as adjunct; most viable candidates include patients with some or all of the following: Diffuse cerebral swelling, intervention within 48 hours of injury, no episodes of ICP>40 mm Hg prior to surgery, GCS>3 at some time subsequent to injury, secondary deterioration, evolving }
<table>
<thead>
<tr>
<th>Cerebral Herniation</th>
<th>Analgesia, sedation or neuromuscular blockade</th>
<th>Analgesia per discretion</th>
<th>Analgesia per discretion</th>
<th>Analgesia per discretion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Analgesia per discretion</td>
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<td>Analgesia per discretion</td>
<td>Analgesia per discretion</td>
</tr>
</tbody>
</table>

*Little evidence available regarding sedation and neuromuscular blockade – use MD discretion

<table>
<thead>
<tr>
<th>Temperature regulation</th>
<th>Normalize</th>
<th>Normalize</th>
<th>Normalize</th>
</tr>
</thead>
</table>

*Some adult evidence supporting mild hypothermia (32-33˚C) for refractory intracranial HTN (IC HTN)

<table>
<thead>
<tr>
<th>Intracranial HTN* control (IC HTN)</th>
<th>N/A</th>
<th>N/A</th>
</tr>
</thead>
</table>

*IC HTN defined as ICP>20 mmHg

Open fontanels do not preclude development of IC HTN
IC may be helpful w/ traumatic lesions of when serial neuro exams are compromised
IC HTN effect is r/t peak and duration of elevation; initiate tx for ICP>= 20 mmHg for >= 10 minutes or presence of plateau waves or spot elevations >30 mmHg w/ noxious stimuli
ICP interpretation includes clinical assessment and physiological monitoring in conjunction with cerebral imaging
Optimal CPP in children not known but CPP<40 is associated w/ poor outcomes
Hypertonic saline (3%) is supported for IC HTN; Maintain serum osmolarity <360 mOsm/L
Mannitol is supported for IC HTN; Maintain serum osmolarity <320mOsm/L
Monitor serum sodium levels
Small studies suggest high-dose barbiturate tx may be effective for refractory IC HTN; therapy effects warrant selective utilization and careful monitoring limited to critical care providers w/ appropriate systemic monitoring to identify and rapidly treat hemodynamic instability

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Pediatric</th>
<th>Adult</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anti-epileptics</td>
<td>N/A</td>
<td>N/A</td>
<td>Option for early prophylaxis (first 7 days)</td>
</tr>
<tr>
<td>Glucose control</td>
<td>N/A</td>
<td>N/A</td>
<td>Avoid prolonged hyperglycemia (BS&gt;220); goal 100-180</td>
</tr>
<tr>
<td>Nutritional support</td>
<td>Normalize</td>
<td>Normalize</td>
<td>Replace 130-160% of resting metabolic expenditure; enteral route preferred. Begin within 72 hours of injury with full support by day 7</td>
</tr>
<tr>
<td>Corticosteroids</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>DVT prophylaxis</td>
<td>N/A</td>
<td>N/A</td>
<td>Little evidence available regarding DVT prophylaxis in pediatric trauma – use MD discretion</td>
</tr>
<tr>
<td>Rehabilitation</td>
<td>Mild TBI follow-up</td>
<td>Early rehabilitation recommended (undefined)</td>
<td>Consult Mary Bridge Pediatric Rehabilitation Medicine for inpatient consult if possible; otherwise, outpatient consult is acceptable.</td>
</tr>
<tr>
<td>Neuropsychology</td>
<td>If admitted, consult Mary Bridge Pediatric Neuropsychology.</td>
<td>Consult Mary Bridge Pediatric Neuropsychology.</td>
<td></td>
</tr>
</tbody>
</table>

3. Definitions:
BPM - breaths per minute
CPP - cerebral perfusion pressure  
CSF - cerebrospinal fluid  
ED - emergency department  
GCS - Glasgow Coma Scale  
H/A - headache  
HCT - head computed tomography (CT)  
HTN - hypertension  
IC - intracerebral  
ICP - intracerebral pressure  
LOC - loss of consciousness  
N/V - nausea/vomiting  
O2 - oxygen  
PaCO2 - arterial partial pressure of carbon dioxide  
PO - per os (oral intake)  
Sat - saturation  
SBP - systolic blood pressure  
Sx - symptoms  
Sz - seizures  
TBI - traumatic brain injury  
Tx – treatment

**Related Policies:** Non-Accidental Trauma Screening and Management Guideline

**Related Forms:** MBCH TBI Discharge Instructions

**References:**


Coombs JB, Davis RL; Subcommittee on Management of Minor Head Injury for  
the American Academy of Pediatrics/American Academy of Family  
Physicians.  

Cushman JG, Agarwal N, Fabian TC, Garcia V, Nagy KK, Pasquale MD,  
Salotto AG; EAST Practice Management Guidelines Work Group.  

Erlichman DB, Blumfield E, Rajpathak S, Weiss A. Association between linear  
skull fractures and intracranial hemorrhage in children with minor head
trauma.

Holmes JF, et al; TBI Study Group for the Pediatric Emergency Care Applied Research Network. Do children with blunt head trauma and normal cranial computed tomography scan results require hospitalization for neurologic observation?

Kamerling SN, Lutz N, Posner JC, Vanore M.

Kay T. Mild traumatic brain injury committee of the head injury interdisciplinary SIG of the American congress of rehabilitation medicine.
J Head Trauma Rehabil 1993;8(3):86-87


Identification of children at very low risk of clinically-important brain


Point of Contact: Carolynn Morris MB Trauma Program Manager 403-4417, AMC Trauma Program Manager 545-2859
<table>
<thead>
<tr>
<th>Approval By:</th>
<th>Date of Approval:</th>
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</thead>
<tbody>
<tr>
<td>MBCH Pediatric Trauma Multidisciplinary Committee</td>
<td>09/19/2013</td>
</tr>
<tr>
<td>NEC</td>
<td>2/14</td>
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<tr>
<td>AMC Trauma Committee</td>
<td>4/14</td>
</tr>
<tr>
<td>AMC Surgery Committee</td>
<td>6/14</td>
</tr>
<tr>
<td>AMC MEC</td>
<td>7/14</td>
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| Original Date:                | 12/13           |
| Revision Dates:              | X/XX; X/XX     |
| Reviewed with no Changes Dates: | 7/14            |

Distribution: MHS Intranet
Mild Traumatic Head Injury Guidelines (GCS ≥ 13)

**Head Injury with/without other injuries**

Low Risk Mechanism#

- Yes: GCS 15
- No: High Risk Mechanism*

High Risk Mechanism*

- Yes: High Risk Order Set
- No: Meets Major or Modified Trauma Activation Criteria

Meets Major or Modified Trauma Activation Criteria

- Yes: Triage Level 1/Trauma Activation
- No: Severe mechanism of injury*

Severe mechanism of injury*

- Unstable or Abnormal Vital Signs
- Other significant Injuries

- Yes: High Risk Order Set
- No: Signs of Fracture:

  - Palpable skull fracture/suspected open or depressed skull fracture
  - Basilar Skull fracture (Hemotympanum, Raccoon eyes, Battle Sign)
  - Large Boggy Cephalohematoma

- Yes: High Risk Order Set
- No: Altered Mental Status or:

  - Agitation
  - Somnolence
  - Repetitive questioning
  - Slow response to verbal communication
  - History of LOC
  - Vomiting
  - Severe Headache

- Yes: Head CT
- No: Triage Level

  - GCS ≤ 13: Triage Level 1
  - GCS 14-15: Triage Level 2

Admission Neurosurgery +/- Trauma

* Low Risk Criteria:
- Ground Level Fall
- Walked or fall into stationary object
- Bumped heads
- Abrasions/lacerations
- No “Significant” Hematoma
- No concern for Non Accidental Trauma

* Severe mechanism of injury:
- MVC with patient ejected/rollover/death
- Pedestrian/bicyclist struck by a motorized vehicle
- Falls of more than 0.9 m (3 feet)
- Head struck by a high-impact object
- Consider increased risk if:
  - Mechanism unknown
  - Patient needs operative procedure
  - Late at night (difficult to monitor mental status)
Mild Traumatic Brain Injury Observation Pathway

Observation Period
Two hours Post Injury

Return to Baseline Neurological status
No concerning symptoms

- Deteriorating LOC
  - GCS 13 or less

- GCS 14-15
  - Severe/worsening headache
  - Persistent Vomiting

- Improving Neurological Status
  - GCS = 15
  - No concerning symptoms

Head CT

- Observe 2-4 additional hours
  - Or 4-6 hours post injury

- Provider assessment done and documented
- Discharge/Follow up management
  - PCP
  - Neuropsychology
  - Sports Medicine
- Concussion Instructions Pamphlet

- Admission
  - Consult Trauma surgery if
    - Other trauma injuries
    - Suspected NAT
  - Consult Neurosurgery for + CT finding

Observation Pathway
- Baseline Vitals/GCS/Neurologic Exam
- Vitals/GCS/Neuro Check q30” for first 2 hours
  - then Q1-2 hours (ED or floor)

Pediatric GCS Scoring

<table>
<thead>
<tr>
<th>Positive Head CT:</th>
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<tbody>
<tr>
<td>- Skull Fracture (depressed)</td>
</tr>
<tr>
<td>- Subdural/Epidural Blood</td>
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<tr>
<td>- Intraparenchymal hemorrhage</td>
</tr>
<tr>
<td>- Subarachnoid hemorrhage</td>
</tr>
<tr>
<td>- Intraventricular hemorrhage</td>
</tr>
<tr>
<td>- Evidence of cerebral edema</td>
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<tr>
<td>- Intraparenchymal contusion</td>
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</tbody>
</table>

Non-depressed skull fractures with no other injuries do not require neurosurgical consult or admission

Consider admission:
- Concern for NAT (see NAT guidelines)
- Social concerns/Lack of follow up
- Difficulty in assessment of mental status (pre-existing neurologic condition or late night assessment)
- Isolated skull fracture less than 1 year with other concerns for mechanism/cause/mental status

This guideline is endorsed by Mary Bridge Emergency Department but it is not intended as a substitute for clinical judgment. It should be used as an adjunct to sound clinical decision making which accounts for individual patient considerations.