

Hasbro Children's Hospital Pediatric Trauma Program Pediatric Traumatic Brain Injury Clinical Pathway

Patient definition

- Age birth to 18 years
- With severe accidental or abusive traumatic brain injury with Glasgow Coma Scale ≤ 8

Objectives

Minimize secondary brain injury by targeting an intracranial environment conducive to prevention of further neurocyte injury as well as promotion of healing.

Clinical Goals

- Promote oxygen delivery and nutrients necessary to support cellular respiration
- Reduce exposure to neurotoxic agents
- Support neurovasculature during disruption of autoregulation
- Decrease:
 - Duration and number of occurrences of elevated ICP
 - Length of time to initial CT scan/OR/PICU admission
 - Length of time to placement of invasive ICP monitor
 - Length of time from recognition to medical treatment of increased ICP
 - Length of time from medically refractory treatment of increased ICP to decompressive craniotomy
 - Number of ventilator days
 - Number of central venous line days
 - PICU length of stay
 - Mortality

Quality Metrics

- Time from initial ED evaluation to initial disposition (CT, PICU, or OR) 30 minutes or less
- Time to placement of ICP monitor
- Mortality
- Time with ICP >20 mmHg

Literature/resources

“Guidelines for the Management of Pediatric Severe Traumatic Brain Injury, Third Edition: Update of the Brain Trauma Foundation Guidelines.” *Pediatric Critical Care Medicine*, May 2019.

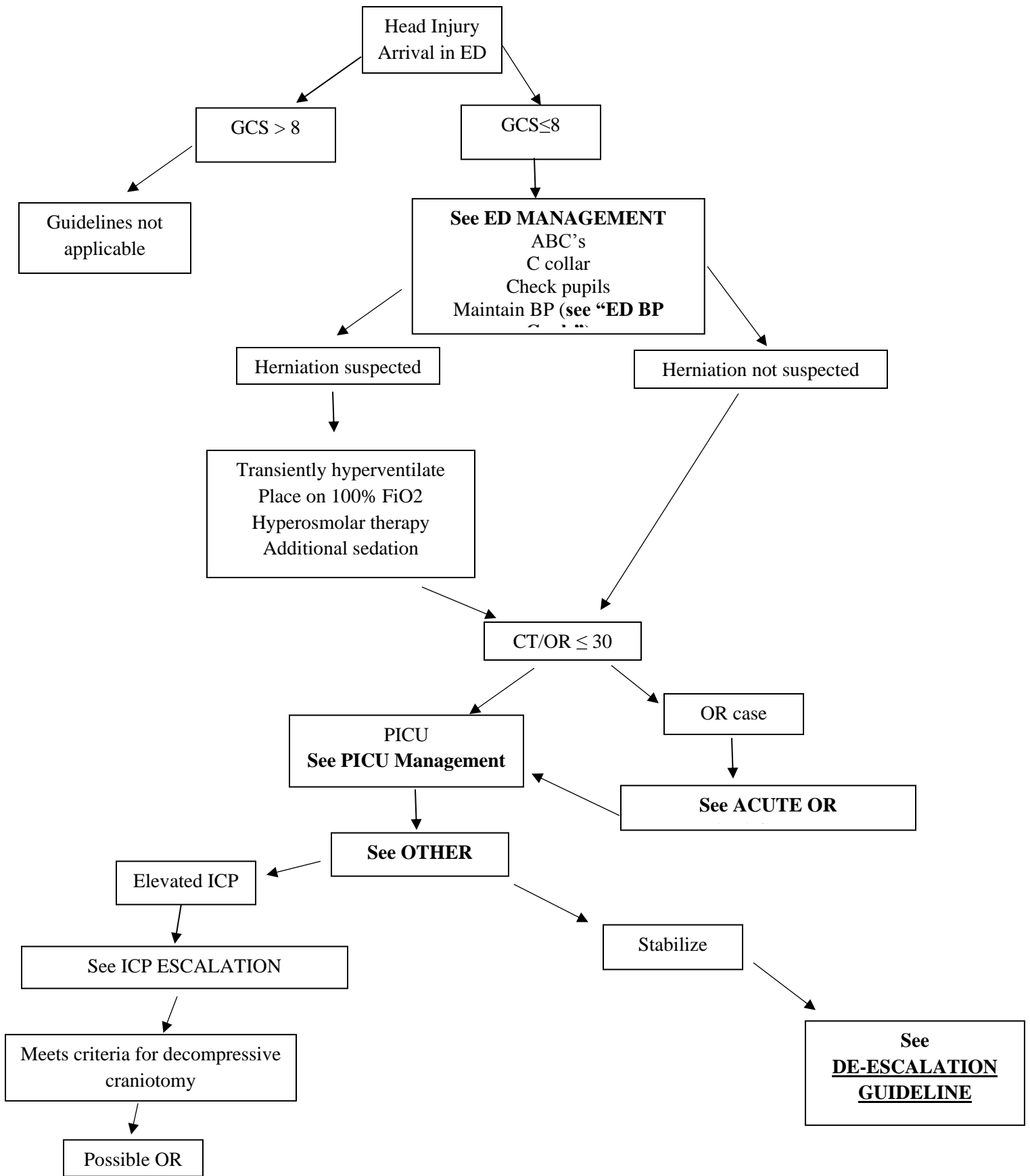
https://journals.lww.com/pccmjournal/Fulltext/2019/03000/Management_of_Pediatric_Severe_Traumatic_Brain.8.aspx;

<https://www.braintrauma.org/guidelines/pediatric#/>

“Guidelines for the Management of Severe Traumatic Brain Injury 4th Edition,” Brain Trauma Foundation.

https://braintrauma.org/uploads/03/12/Guidelines_for_Management_of_Severe_TBI_4th_Edition.pdf

“Guidelines for the Acute Medical Management of Severe Traumatic Brain Injury in Infants, Children, and Adolescents, Second Edition,” Brain Trauma Foundation. https://braintrauma.org/uploads/03/15/guidelines_pediatric2_2.pdf



Please note: this diagram is to be used as a guide to direct the clinician to the appropriate area in the protocol which will contain detail regarding patient care

ED MANAGEMENT

Acute ED Management (30 minutes or less)

- Pediatric Trauma Surgery presence at bedside as outlined in trauma guidelines
- Immediate Neurosurgery consult
 - Neurosurgery resident at bedside to obtain exam
- Alert PICU to pending admission
- Airway management
 - Obtain definitive airway if not achieved in the field
 - RSI recommendations: (ketamine 1-2 mg/kg IV and rocuronium 1 mg/kg IV) OR (etomidate 0.3 mg/kg IV and rocuronium 1 mg/kg IV)
 - Goal SpO₂: 94-98%
 - avoid hypoxemia, avoid over-oxygenating
 - Goal EtCO₂: 30-34 mmHg
- IV access established and Trauma labs sent
- Place C-Collar if indicated and not already completed in the field; Miami-J preferred
- Pupillary exams per protocol and document exam
- Manage clinical signs of elevated ICP
 - Avoid hypotension (See ED BP Goals)
 - Ensure C-collar has adequate space to allow venous drainage
 - Reverse Trendelenburg positioning if feasible; if no thoracic/lumbar/sacral spinal injury suspected, elevate HOB to 30 degrees
 - If signs of herniation*, **treat immediately:**
 - 1) Hyperventilate to transiently lower EtCO₂ to reversal of unilateral pupillary dilation,
 - re-evaluate frequently (every 2-4 minutes)
 - attempt additional medical treatments to limit periods of hyperventilation
 - 2) Increase FiO₂ to 100%
 - 3) Provide hyperosmolar therapy
 - hypertonic 3% saline bolus push (5 ml/kg IV up to 250 mL, may repeat PRN) first line, mannitol second line (0.5 g/kg IV push via 0.22 μ filter)
 - 4) Sedation post-RSI: consider additional ketamine or fentanyl, administer minimal amount needed and avoid hypotension
- Maintain euolemia and avoid hypotension
- STAT non contrast head CT
- Expedite time to definitive care (**30 minutes or less to CT scanner, PICU, or OR**)
 - Patient transport led by Trauma Surgery
- STAT non-contrast head CT

ED BP Goals (assuming no ICU monitor) MINIMUM MEAN ARTERIAL PRESSURE (MAP) GOALS:

- 0-30 days: >40 mmHg
- 31 days – 1 year: >45 mmHg
- 1 year – 6 years: >50 mmHg
- 6 years – 13 years: >60 mmHg
- >13 years: >65 mmHg

***SIGNS OF HERNIATION:** focal neurologic exam deficit such as a unilateral dilated pupil, hypertension/bradycardia, or extensor posturing

ACUTE OR MANAGEMENT

- For poly-trauma: may require additional imaging but **do not delay** definitive neurosurgical operative care for imaging; alternatives such as fluoroscopy and ultrasound are available in the OR
- Indication for immediate neurosurgical operative care: Epidural hematoma or mass lesion with midline shift
- Prioritize ICP monitor placement in OR for poly-trauma cases (ICP monitor = EVD or bolt)
- Transport to OR or PICU by Trauma Surgery

PICU MANAGEMENT

Prior to arrival:

- Prepare room for critically ill patient, including ventilator, IV poles, central line and arterial line supplies including transducers and set-ups
- Place cooling blanket on the bed

Within 15 minutes of arrival:

- Glucose and sodium check via iSTAT
- Room environment: normal temperature, establish minimal stimulation environment
- Cooling blanket in place and Blanketrol set up for controlled normothermia, esophageal temperature monitoring probe placed
- Foley placed
- Patient position: Reverse Trendelenburg, or if spinal precautions are lifted, HOB elevated to 30 degrees with neutral midline head positioning
- C collar with adequate space to allow venous drainage
- CXR to confirm ETT placement, sump, esophageal probe
- Resuscitative measures as needed
- Maintenance fluids initiated (D5NS <36 months, NS >36 months)
- If ICP monitor not already placed in OR, preparation for placement by Neurosurgery resident at bedside

Within 1 hour of arrival:

- Central line and arterial line placement if indicated
- Initial labs drawn: CBC with differential, CMP/M/P, PT/INR, PTT, fibrinogen, serum tox, serum osmolality, arterial blood gas with lactate, TEG
- Controlled normothermia to target <38 C, acetaminophen IV scheduled unless severe liver injury
- Ventilation established to normocarbica: goal ETCO₂ (30-35) and PaCO₂ (35-40), lung protective strategies with any polytrauma
- Oxygenation to target sats 94-98%, PaO₂ 90-100 mm Hg
- **CPP target <6 years 45-55, >6 yrs 50-60, ICP <20**
- **CVP 5-10**, target clinical euvolemia with goal UOP >1 mL/kg/hr, with vigilance for inappropriate UOP of >4 mL/kg/hr
- Sedation:
 - Use the smallest dose or rate of infusion to achieve effect
 - Until ICP monitor is place, be aware of need for best assessment of neurologic status by exam
 - Avoid repeated bolus doses of sedation to avoid hypotension
 - Fentanyl/morphine and benzodiazepines are reasonable first-line therapies
 - Be wary of risk of delirium in benzodiazepines
 - Propofol has risk of hypotension, and prolonged propofol is contra-indicated in pediatric patients
- Reach the following laboratory targets:
 - Hgb >7
 - Sodium 140-160, utilizing 3% drip if need be to attain normonatremia
 - Osm >320, less than 360
- Seizure prophylaxis initiated with levetiracetam or fosphenytoin
- Consult to Pediatric Neurology and continuous EEG placed
 - Patients with severe traumatic brain injury should be monitored with continuous EEG monitoring in order to identify seizures

Lab	Goal	Lab Frequency
ABG with lactate	PaO ₂ 90-100; PaCo ₂ 35-40; normalization of metabolic acidosis and lactate	q 4 hours
Serum Na	140 – 160 meq	q 4 hours via iSTAT sodium or BMP
Glucose	100-180 g/dL	q 4 hours
BMP/Mag/Phos	Normal for age	q 8 hours
Serum osmolality	320 – 360	q 8 hours
CBC with differential	Hgb ≥ 7 g/dL	q 8 hours
PT/INR, PTT, fibrinogen	Titrate treatment of coagulopathy to presence of active bleeding or to TEG	q 8 hours
Type and screen		q 72 hours
TEG		BID

*Evaluate for patient stability and reduce frequency of lab draws whenever reasonable

ICP ESCALATION GUIDELINE

Treating Elevated ICP and Escalation of Therapy

- Minimize noxious stimuli, and cluster care
- For elevated ICP ≥ 20 , take the following actions:
 - Ensure HOB elevated to 30 degrees and head is in midline position
 - Loosen C-collar to promote venous drainage but maintain C-spine stability
 - If EVD is in place, ensure that it is open and draining at 0
 - **Alert PICU Resident and Attending**
 - Provide adequate sedation and analgesia while avoiding hypotension
- If no resolution after 5 minutes
 - Provide hyperosmolar therapy (first line: 3% hypertonic saline solution, 5 ml/kg IV push bolus, max to 250 ml, repeat once prn)
 - May start 3% infusion (start at 0.1 ml/kg/hr and titrate to minimum effective dose to keep ICP < 20 ; up to 1 ml/kg/hr)
 - STAT page to Neurosurgery first call and Trauma first call (if on trauma service)
 - Mannitol can be considered if failing to have response after two push boluses of hypertonic saline; high risk for hypotension (dose 0.5 gm/kg IV); can also consider therapies listed below
- If no resolution after an additional 5 minutes
 - Provide additional sedation and neuromuscular blockade (NMB), consider starting NMB infusion such as vecuronium (consider cisatracurium if significant renal injury)
 - Ensure continuous EEG in place if initiating neuromuscular blockade but do not delay therapy
- If no resolution after an additional 5 minutes
 - Hyperventilate patient transiently to ETCO₂ of 30, with re-evaluation every 2-4 minutes
 - Neurosurgery to bedside to evaluate EVD and flush if needed
 - Provide additional hyperosmolar therapy
 - PICU Attending to discuss directly with Neurosurgery Attending and Trauma Attending (if on trauma service)
 - Consider STAT non-contrast head CT
 - Consider pentobarbital
 - Goal of burst suppression on EEG
 - Bolus dose of 3-5 mg/kg (monitor for hypotension)
 - Can start continuous infusion: start at 1 mg/kg/hr and can titrate up to 4 mg/kg/hr; however, may only require repeat bolus doses due to lengthy half-life of pentobarbital
 - Order vasoactive infusion so that it is available to counteract hypotension (first line norepinephrine)
 - Pentobarbital levels will be required to assess for toxicity (during treatment) and duration of effect (when discontinuing)
 - Consider operative treatment

DECOMPRESSIVE CRANIOTOMY CRITERIA

- Indication for immediate neurosurgical operative care: Epidural hematoma or mass lesion with midline shift
- Additional indications include persistent $ICO \geq 20$ or $CPP \leq 40$ that fails to respond to escalation of therapies
- Must be a multi-disciplinary discussion among Trauma Attending, Neurosurgery Attending, and PICU Attending as involved

SUPPORTIVE CARE

- Nutrition
 - Be vigilant for hypo- or hyperglycemia
 - Treat hyperglycemia with minimization of dextrose-containing fluids (consider changing drug diluents to NS) or insulin
 - Plan for Nutrition is a multi-disciplinary discussion with PICU, Trauma, and Neurosurgery
 - Discuss ability to place NG/OG feeding tube (facial fractures or basilar skull fracture may be contraindications)
 - Discuss ability initiate enteral feeds daily; goal is to initiate enteral nutrition within 72 hours
 - If unable to initiate enteral feeds by day 3 of admission, initiate parenteral nutrition
 - Establish a total fluid limit that accounts for parenteral nutrition, IV fluids, infusions and carriers
- Physical/Occupational Therapy
 - Consult on admission
- Skin Care
 - Turn patients every 2 hours at minimum, maintaining any precautions from Trauma/Neurosurgery/Orthopedics
 - Patients may need sedation pre-medication prior to turning or cares

DE-ESCALATION GUIDELINE

- Removal of invasive monitoring and therapies can likely begin after 24-48 hours of normal ICP
- Requires discussion among Trauma, PICU, and Neurosurgery
- Wean and discontinue infusion/intervention (if present) per patient condition as tolerated and per clinical team:
 - 1st Pentobarbital infusion
 - 2nd Neuromuscular blockade infusion
 - 3rd 3% hypertonic saline infusion
 - 4th Sedative infusions
- Remove:
 - 1st ICP monitor (per Neurosurgery)
 - 2nd Foley catheter
 - 3rd Endotracheal tube (per PICU and Trauma)
 - 4th Arterial line
 - 5th CVL
 - 6th C-spine (c-collar) if cleared by Trauma

HCH TRAUMATIC BRAIN INJURY CLINICAL PATHWAY - EMERGENCY DEPARTMENT MANAGEMENT

Patients 18 years of age or younger with severe traumatic brain injury and GCS \leq 8

**30
minutes
or less**

Emergent ED Management

Airway: obtain definitive airway with C collar in place

Breathing: Ventilate to ET CO_2 30-34

Circulation: Obtain IV/IO access, resuscitate as needed, **AVOID HYPOTENSION**

Frequent pupil checks

Signs of herniation: unilateral dilated pupil, extensor posturing, hypertension/bradycardia

Treatment of Impending Herniation

Transiently hyperventilate to reversal of unilateral dilated pupil
FiO $_2$ to 100%

Hyperosmolar therapy: 3% saline 5 mL/kg push max 250 mL
or mannitol 0.5 g/kg push

Additional sedation

Avoid hypotension

STAT non-contrast head CT (or directly to OR)

Emergency Department MINIMUM MEAN ARTERIAL PRESSURE (MAP) GOALS:

- 0-30 days: >40 mmHg
- 31 days – 1 year: >45 mmHg
- 1 year – 6 years: >50 mmHg
- 6 years – 13 years: >60 mmHg
- >13 years: >65 mmHg