- **Patient Definition**
  - Birth to <18 years
  - With severe accidental or abusive blunt traumatic brain injury with Glasgow Coma Scale ≤ 8

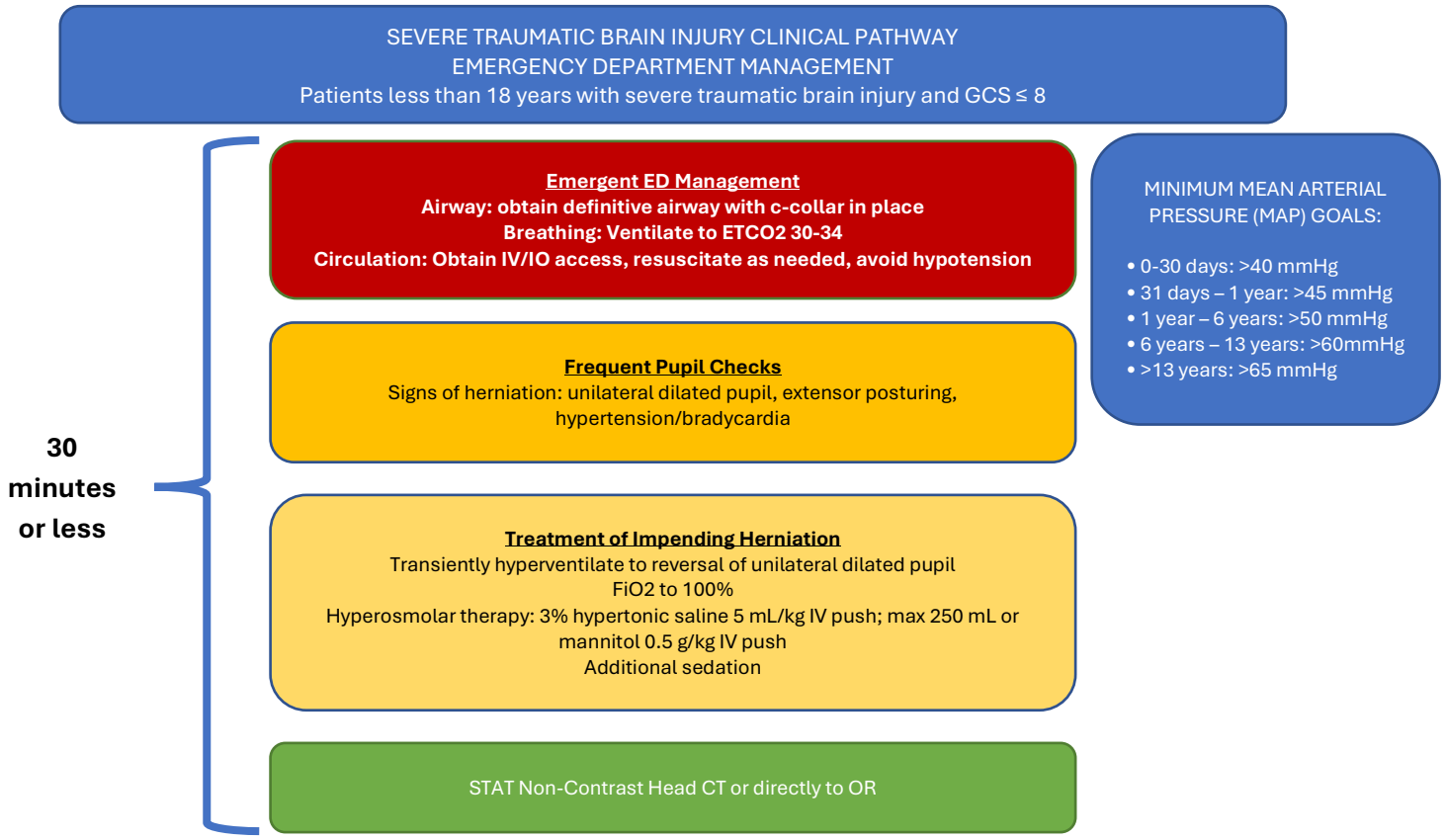
- **Objectives**
  - Minimize secondary brain injury by targeting an intracranial environment conducive to prevention of further neurocyte injury as well as promotion of healing.

- **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

- **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/coma/guidelines/guidelines-for-the-management-of-severe-tbi-4th-ed
  - "Guidelines for Management of Pediatric Severe Traumatic Brain Injury. Third Edition" Brain Trauma Foundation. https://braintrauma.org/coma/guidelines/pediatric

Hasbro Children's
Pediatric Severe Traumatic Brain Injury Clinical Pathway



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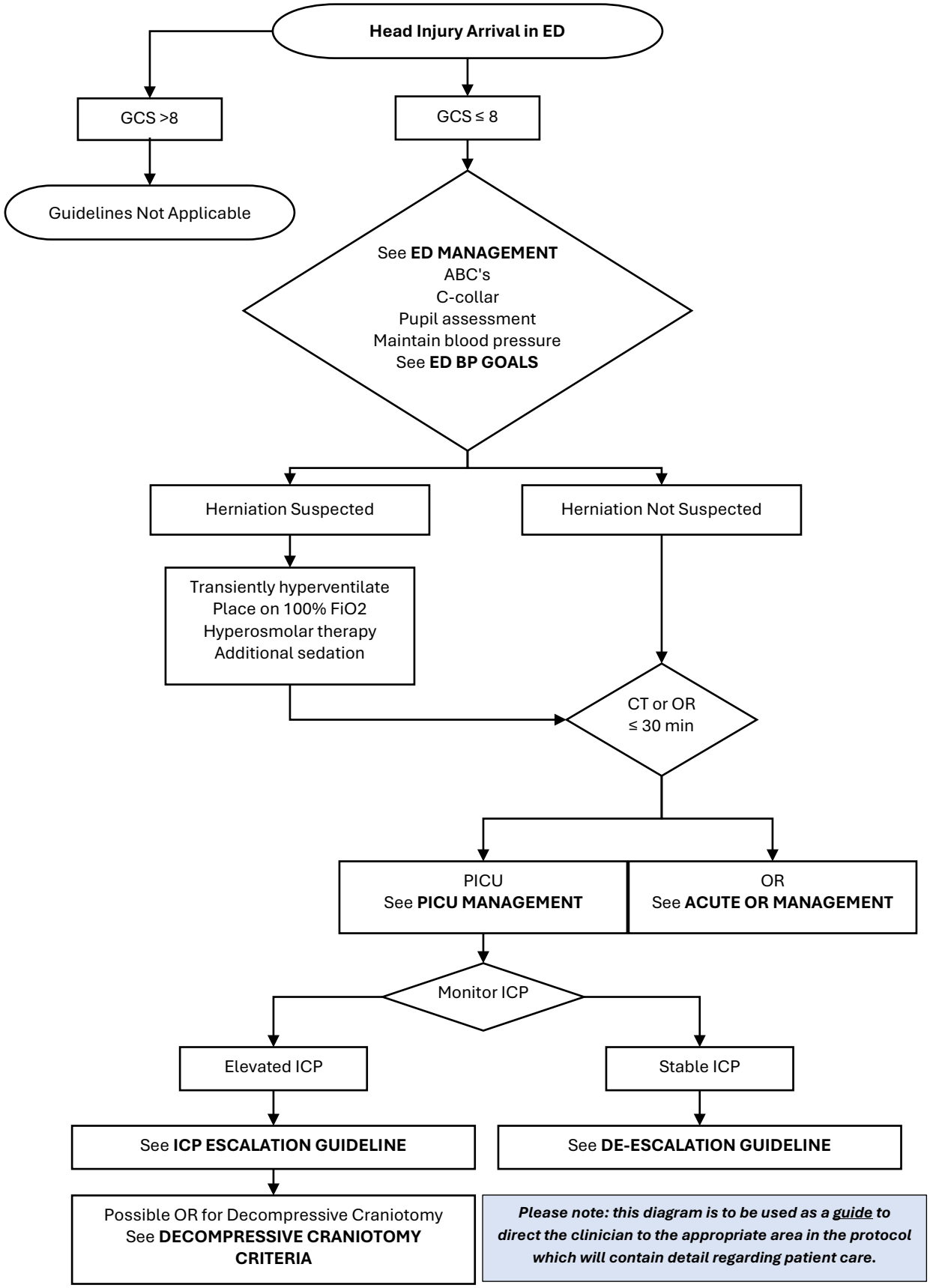
Pediatric Severe Traumatic Brain Injury Clinical Pathway



Pediatric Trauma Committee Initial Draft 10/2019
Revision 12/2025

- **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:
      - Hyperventilate to transiently lower EtCO2 until reversal of unilateral pupillary dilation
        - Re-evaluate frequently (every 2-4 minutes)
        - Attempt additional medical treatments to limit periods of hyperventilation
      - Increase FiO2 to 100%
      - 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)
      - Sedation post-RSI: consider additional ketamine or fentanyl, administer minimal amount needed and avoid hypotension
  - Maintain euvolemia and avoid hypotension
  - 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 US are available in the OR.
  - All Level A traumas should have CXR, PXR, and FAST in trauma room
  - 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
    - Controlled normothermia
      - Target <38 C, acetaminophen IV scheduled unless severe liver injury
    - Ventilation established to normocarbia
      - Goal ETCO2 (30-34) 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
      - 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
        - Prolonged propofol is contraindicated in pediatric patients
    - 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 to identify seizures

Lab Draws	Goal	Frequency
ABG with lactate	PaO2 90-100 PaCO2 35-40 pH and lactate WNL	Q4 hours
Serum Na	140-160 meq	Q4 hours
Glucose	100-180 g/dL	Q4 hours
BMP/ Mag/ Phos	Age-appropriate WNL	Q8 hours
Serum osmolality	320-360	Q8 hours
CBC with differential	Hgb ≥7 g/dL	Q8 hours
PT/ INR, PTT, fibrinogen	Titrate coagulopathy treatment based on presence of active bleeding or TEG	Q8 hours
TEG		BID
Type and screen		Initial
Serum tox		Initial
**Evaluate patient stability and reduce frequency of lab draws as able*		

- **ICP ESCALATION GUIDELINE**
  - Treating Elevated ICP and Escalation of Therapy
    - Minimize noxious stimuli, and cluster care
    - For elevated ICP ≥20:
      - 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)
    - If no resolution after an additional 5 minutes
      - Provide additional sedation and neuromuscular blockade
        - Consider starting 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
            - 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)
        - Monitor pentobarbital levels to assess for toxicity during treatment and duration of effect during discontinuation
    - Consider operative treatment

- **DECOMPRESSIVE CRANIOTOMY CRITERIA**
    - <u>Indication For Immediate Neurosurgical Operative Care</u>
        - Epidural hematoma or mass lesion with midline shift
        - Persistent ICP≥20 or CPP≤40 that fails to respond to escalation of therapies
    - Must be a multi-disciplinary discussion among Trauma Attending, Neurosurgery Attending, and PICU Attending

- **SUPPORTIVE CARE**
    - Nutrition
        - Nutrition is a multi-disciplinary discussion with PICU, Trauma, and Neurosurgery
        - Assess for hypo/hyperglycemia
        - Treat hyperglycemia with minimization of dextrose-containing fluids or insulin
            - Consider changing drug diluents to NS
        - Discuss ability to place NG/OG feeding tube
            - Facial fractures or basilar skull fracture may be contraindications
            - Discuss initiation of daily enteral feeds
                - Goal to initiate enteral nutrition within 24-48 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 Therapy/ Occupational Therapy
        - Consult on admission
    - Skin Care
        - Turn Q2 hours at minimum
        - Maintain precautions from Trauma, Neurosurgery, and Orthopedics
        - Consider pre-medication prior to turning or cares

- **DE-ESCALATION GUIDELINE**
    - Requires discussion among Trauma, PICU, and Neurosurgery
    - Removal of invasive monitoring and therapies can likely begin within 24-48 hours of normal ICP
    - Wean and discontinue infusion/intervention per patient condition as tolerated and per clinical team:
        - Infusions:
            - Pentobarbital infusion
            - Neuromuscular blockade infusion
            - 3% hypertonic saline infusion
            - Sedative infusions

- Interventions:
    - ICP monitor per Neurosurgery
    - Foley catheter
    - Endotracheal tube per PICU and Trauma
    - Arterial line
    - CVL
    - C-collar removed if cleared by Trauma- needs to be removed by Trauma or Spine (NSG or Ortho).