

Head trauma is considered severe in a child with a [Glasgow Coma Scale \(GCS\) score of  \$\leq 8\$](#) . These children often have intracranial injury identified on neuroimaging and all have suffered traumatic brain injury (TBI). Injury is the leading cause of death in children  $>1$  year of age, and TBI is the most significant cause of death and disability across all ages.<sup>1</sup>

### Pediatric Considerations

- » Children have larger head-to-body size ratios (higher incidence of head trauma), thinner cranial bones (increased risk of skull fractures), and unfused sutures (better initial tolerance of increased intracranial pressure).
- » Pediatric brains have increased water content and decreased myelination making children more susceptible to shear injuries (e.g., diffuse axonal injury) and cerebral swelling.
- » Consider abusive head trauma in infants and young children (see [TREKK Recommendations for Suspected Child Abuse](#)).

### Assessment Principles

- » Stabilize children with severe head trauma as per Advanced Trauma Life Support (ATLS) principles.
- » Consider unique differences in childhood anatomy/physiology (see [TREKK Recommendations for Multisystem Trauma](#)).
- » Apply spinal motion restriction when indicated.
- » Once need for advanced trauma care is identified, refer and organize transport early after stabilization to optimize outcomes.
- » Use the [modified GCS for Infants and Children](#) to assess and document neurological status in preverbal children. Alternatively, use the AVPU Scale (Alert, Voice, Pain, Unresponsive). A child who is responsive only to pain/unresponsive has a GCS of  $\leq 8$ .
- » Assume multisystem injury in all children presenting with significant head trauma due to mechanism of injury and smaller size/unique anatomy.
- » Manage airway of children with severe TBI prior to transport.
- » Recognize intracranial hypertension and cerebral herniation by:
  1. Progressive obtundation
  2. Unilateral pupillary dilatation
  3. Cushing's triad (hypertension, bradycardia, abnormal respiration)
- » Do not proceed with CT imaging prior to transport to Pediatric Trauma Centre unless recommended by transport/accepting physician. CT imaging is not required for diagnosis and should **NOT** delay transport.

### Treatment

- » The main goal of treatment of TBI is to prevent secondary brain injury by maintaining cerebral perfusion while minimizing increased intracranial pressure.

$$\text{Cerebral Perfusion Pressure (CPP)} = \text{Mean Arterial Pressure (MAP)} - \text{Intracranial Pressure (ICP)}$$

- » Neuroprotective measures with expedient transfer are critical to optimizing outcome.
- » **Avoid hypoxia and hypotension** with effective airway and hemodynamic support. These 2 factors contribute most to secondary brain injury.
- » Aim for euthermia and normocapnia (**ETCO<sub>2</sub> 35-40**). Hyperventilation is reserved for herniation. Inadvertent hyperventilation with ETCO<sub>2</sub>  $< 30$  contributes to cerebral ischemia.

**“Non-value added time” in pediatric TBI has been shown to worsen outcomes.**

**Streamline resuscitation as much as possible and transfer early for definitive care.**

### Management of Cerebral Herniation

- » This includes EMERGENT reduction of intracranial pressure:
  1. Hyperventilation to pupillary response, reversal of Cushing's Triad, and/or ETCO<sub>2</sub> of 30-35.
  2. Raise head of bed to 30° and loosen cervical collar or provide manual in-line stabilization.
  3. Hyperosmolar agents (**3% NaCl** and/or **mannitol**, see dosing table below).
  4. Airway protection with Drug Assisted Intubation while spinal motion restriction is maintained.
  5. Neurosurgical intervention for hematoma evacuation or decompressive craniectomy.



# BOTTOM LINE RECOMMENDATIONS

# Severe Head Trauma

## Medications for Use in Severe Head Trauma

Indication	Drug	Usual Dose	Comments
Pain	Fentanyl	1 mcg/kg/dose (MAX 50 mcg) IV/IO q30-60 min PRN Infusion 1 mcg/kg/hr IV/IO	Infusion preferred after initial dose.
Sedation	Midazolam	0.1 mg/kg/dose (MAX 5 mg) IV/IO. May repeat PRN. Infusion: 50 mcg/kg/hr IV/IO	If hemodynamically stable. Intubation required for safe administration of infusion.
Drug Assisted Intubation *Pre-induction*	Atropine	0.02 mg/kg/dose (MAX 0.5 mg) IV/IO	For bradycardia or potential bradycardia (e.g., infant < 12 months or repeat doses of succinylcholine).
	Fentanyl	<b>Hemodynamically stable:</b> 3 mcg/kg/dose (MAX 200 mcg) IV/IO <b>Hemodynamically unstable:</b> 1 mcg/kg/dose (MAX 50 mcg) IV/IO <b>Peri-arrest:</b> Do not administer.	<b>Optional</b> to theoretically prevent intubation-associated ICP ↑. <b>Most often used for additional sedation and to blunt tachycardia.</b> If used, give in rapid succession with induction agent below to avoid apnea prior to induction.
Drug Assisted Intubation *Induction*	Ketamine	<b>Hemodynamically stable:</b> 2 mg/kg/dose (MAX 100 mg) IV/IO <b>Hemodynamically unstable:</b> 0.5 - 1 mg/kg/dose (MAX 50 mg) IV/IO <b>Peri-arrest:</b> Do not administer.	Usual induction agent.
	Etomidate	<b>Hemodynamically stable:</b> 0.3 mg/kg/dose (MAX 20 mg) IV/IO <b>Hemodynamically unstable:</b> 0.1 – 0.15 mg/kg/dose (MAX 10 mg) IV/IO <b>Peri-arrest:</b> Do not administer.	Alternate induction agent.
	Propofol	<b>Hemodynamically stable:</b> 1 – 3 mg/kg/dose (MAX 200 mg) IV/IO <i>Usually 1-2 mg/kg/dose, repeat PRN.</i> <b>Hemodynamically unstable/Peri-arrest:</b> Do not administer.	Alternate induction agent.
Drug Assisted Intubation *Neuromuscular Blocker*	Rocuronium	1 mg/kg/dose (MAX 100 mg) IV/IO	
	Succinylcholine	Infants: 2 mg/kg/dose IV/IO Children: 1 - 2 mg/kg/dose IV/IO Adolescents: 1 - 1.5 mg/kg/dose IV/IO	
Intracranial Hypertension +/- Cerebral Herniation	3% NaCl	5 mL/kg/dose (MAX 250 mL) IV/IO	Infuse over 10 minutes. Preferred over mannitol. <sup>2</sup>
	Mannitol	1 g/kg/dose (MAX 100 g) IV/IO	Use 20% (0.2 g/mL). Infuse over 15 minutes through a less than 5 micron filter. Use if 3% NaCl not available or in addition to 3% NaCl.
Seizure Treatment	See <a href="#">TREKK Status Epilepticus Algorithm</a> . Treat seizures aggressively. Consult Pediatric Trauma Centre for consideration of seizure prophylaxis.		

## Securing the Airway in TBI

- » Use a standardized streamlined approach with agents delivered in rapid succession.
- » Ensure volume resuscitation, when indicated, is initiated prior to induction to prevent hypotension.

## For a full list of references and development team members, please see the following page.

The purpose of this document is to provide healthcare professionals with key facts and recommendations for the diagnosis and treatment of severe head trauma in children in the emergency department. This summary uses the best available knowledge at the time of publication. However, healthcare professionals should continue to use their own judgment and take into consideration context, resources and other relevant factors. The TREKK Network is not liable for any damages, claims, liabilities, costs or obligations arising from the use of this document including loss or damages arising from any claims made by a third party. The TREKK Network also assumes no responsibility or liability for changes made to this document without its consent.

# BOTTOM LINE RECOMMENDATIONS

# Severe Head Trauma

## Bottom Line Recommendations

Bottom Line Recommendations are short summaries for healthcare providers of the latest knowledge related to the diagnosis and management of pediatric emergency conditions. This resource is not intended to be used as a step-by-step guide. It is ideal for educational purposes and to summarize existing evidence on severe head trauma in pediatric emergency care. Development of this resource involved a rigorous and iterative process, bringing together experts from a variety of specialties (nursing, simulation, emergency medicine, intensive care, and pharmacy). To learn more about the development, see the References & Development Team section below.

## References

1. Ajdari A, Boyle LN, Kannan N et al. [Examining Emergency Department Treatment Processes in Severe Pediatric Traumatic Brain Injury](#). J Health Qual. 2017 Nov/Dec;39(6):334-344.
2. Kochanek, P, Tasker, RC, Carney, N, et al. [Guidelines for the Management of Pediatric Severe Traumatic Brain Injury, Third Edition: Update of the Brain Trauma Foundation Guidelines](#). Pediatr Crit Care Med. 2019 Mar;20(3S):S1-S82.
3. Lumba-Brown A, Totten A, Kochanek PM. [Emergency Department Implementation of the Brain Trauma Foundation's Pediatric Severe Brain Injury Guideline Recommendations](#). Pediatr Emerg Care. 2020 Apr;36(4):e239-e241.

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