Guidelines for the Management of Pediatric Traumatic Brain Injury

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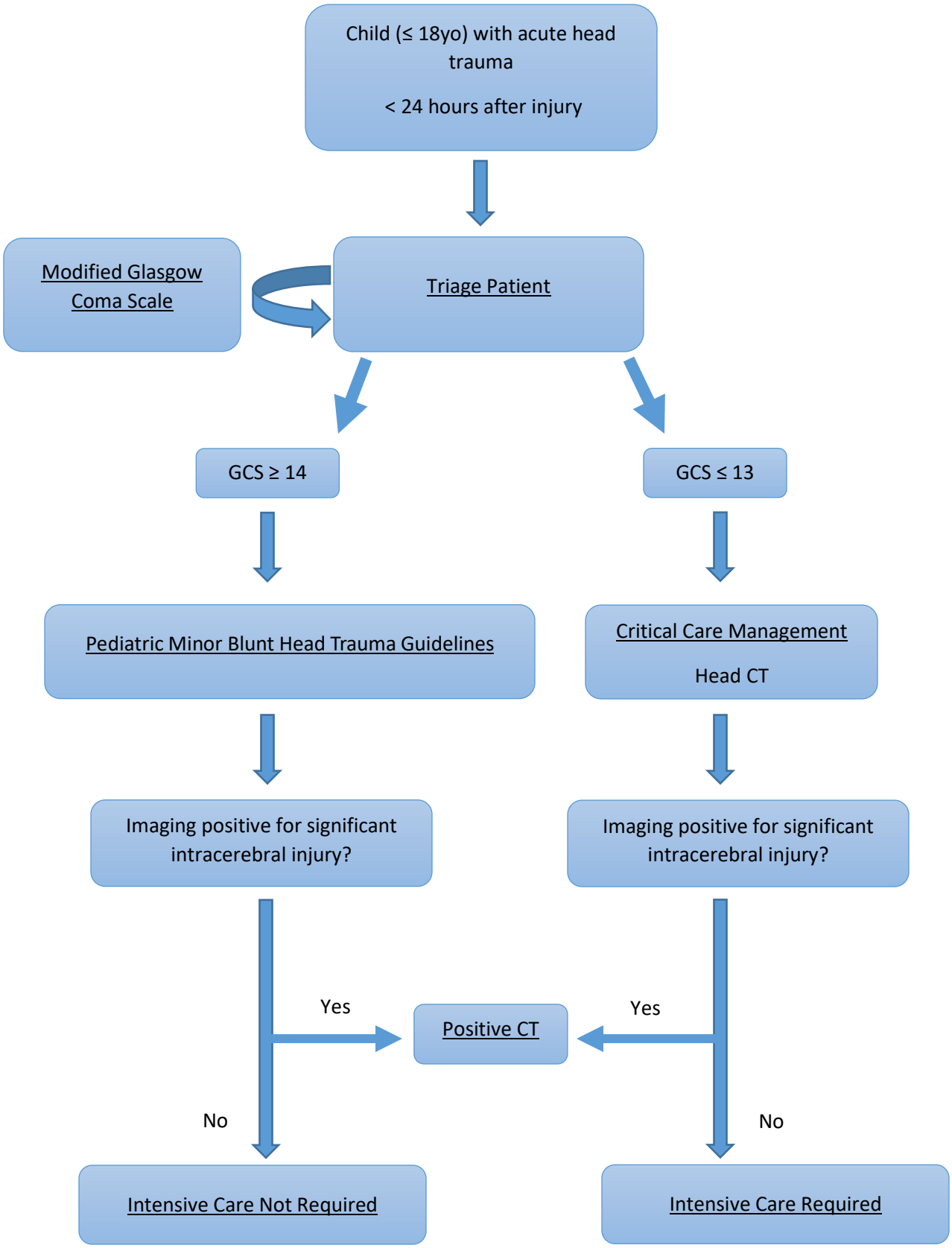
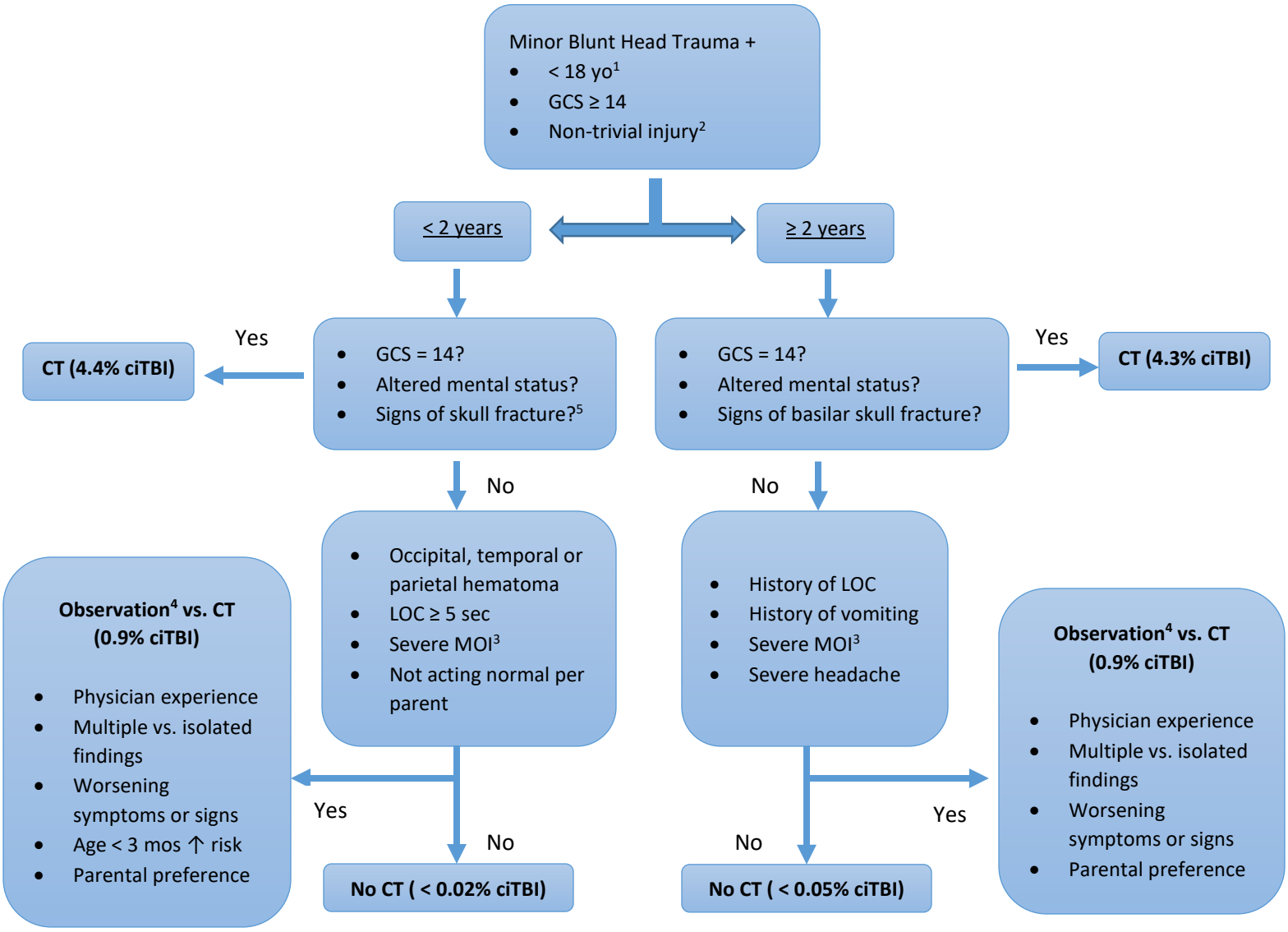
Please note, guidelines do not substitute for clinical judgement. They are for guidance only.

Emergency Room Management of Children with Traumatic Brain Injury



Pediatric Minor Blunt Head Trauma Guidelines



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

PECARN Algorithm

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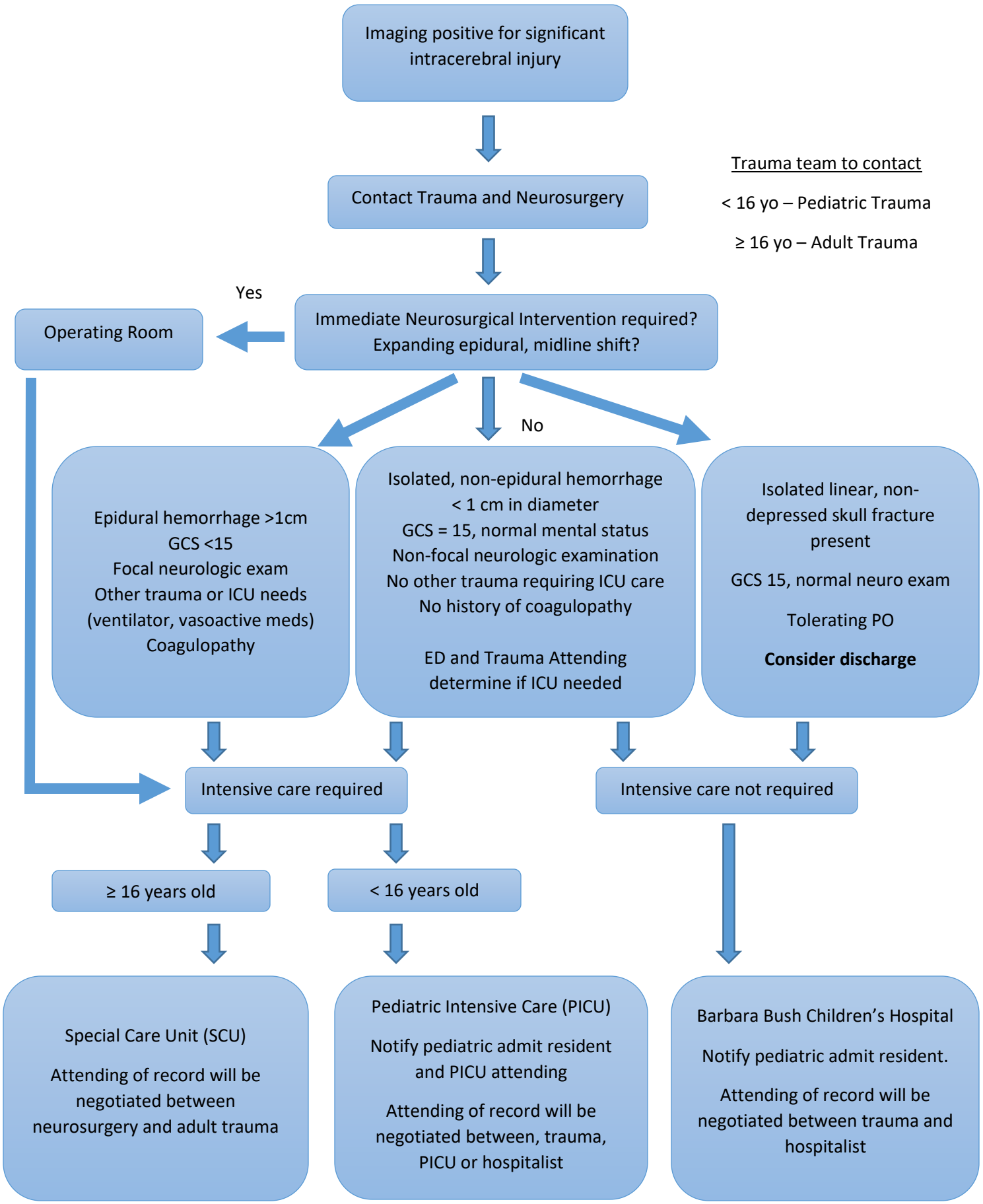
Imaging positive for significant intracerebral injury
Contact Trauma and Neurosurgery
Trauma team to contact
< 16 yo – Pediatric Trauma
≥ 16 yo – Adult Trauma
Immediate Neurosurgical Intervention required? Expanding epidural, midline shift?
Yes
Operating Room
No
Epidural hemorrhage >1cm
GCS <15
Focal neurologic exam
Other trauma or ICU needs (ventilator, vasoactive meds)
Coagulopathy
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
Isolated linear, non-depressed skull fracture present
GCS 15, normal neuro exam
Tolerating PO
Consider discharge
Intensive care required
Intensive care not required
≥ 16 years old
< 16 years old
Special Care Unit (SCU)
Attending of record will be negotiated between neurosurgery and adult trauma
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

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 $PaCO_2$ 35-40 / $EtCO_2$ 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 $PbtO_2$ to be monitored
- Targets: ICP < 20, $PbtO_2$ > 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 Arctic 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 - 5mL/kg per bolus (up to 250mL).
- Hypertonic 3% saline infusion may be run at 0.1-1mL/kg/hr.
- 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 $PaCO_2$ 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

Triage

1 Critical	2 Acute	3 Urgent	4 Urgent	5 Non-Urgent
Mental Status Changes GCS < 14 Combative Hard to arouse Inconsolable Bulging fontanelle Other Neurologic Symptoms Ataxia Inability to walk Laceration with uncontrolled bleeding See Critical Criteria	Head trauma with any of the following: Age < 3 months LOC / amnesia Post-traumatic seizures Persistent vomiting (> 2 episodes of vomiting, or any vomiting in the ED) Significant or severe headache GCS = 14 PE Irritable / change in behavior Periorbital bruising Bruising over mastoid Fluid or blood from the ear History of coagulopathy Cervical spine tenderness Parathesias Weakness Any suspicion for non-accidental trauma	Normal mental status: Any age Large non-frontal hematoma < 12 months Any large hematoma < 2 years Non-frontal hematoma	Age >3 months – 2 yrs With normal PE, or Small frontal hematoma	>2 yrs with minor mechanism, well- appearing, with small hematoma or abrasion Trauma history > 12 hours ago with normal PE

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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>
<tr><th>Assessment</th><th>Intervention(s)</th></tr>
<tr><td>Airway & Breathing</td><td>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:
○ SpO_2 > 92% and ≤ 98%
○ $EtCO_2$: 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.</td></tr>
<tr><td>Neurologic</td><td>Signs of elevated ICP in the absence of an ICP monitor:
○ Focal neurological exam deficit (e.g. unilateral dilated pupil)
AND/OR
○ 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)</td></tr>
<tr><td>Circulation</td><td>Maintain euvolemia
AVOID hypotension
If a vasopressor is needed, consider norepinephrine (phenylephrine is good too but may cause bradycardia)</td></tr>
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https://www.chop.edu/clinical-pathway/brain-injury-severe-traumatic-picu-clinical-pathway

Modified Glasgow Coma Scale for Infants and Children

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

*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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https://www.chop.edu/clinical-pathway/acute-head-trauma-clinical-pathway-modified-glasgow-coma-scale-infants-and-children

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: 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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https://www.chop.edu/clinical-pathway/acute-head-trauma-clinical-pathway-head-trauma-decision-rules-children-2-years-old

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: GCS < 15 Agitation Somnolence Slow responses Repetitive questioning
No LOC	
No Vomiting	
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 **> 5 feet** Head struck by a high-impact object
No Signs of Basilar Skull Fracture	
No Severe Headache	

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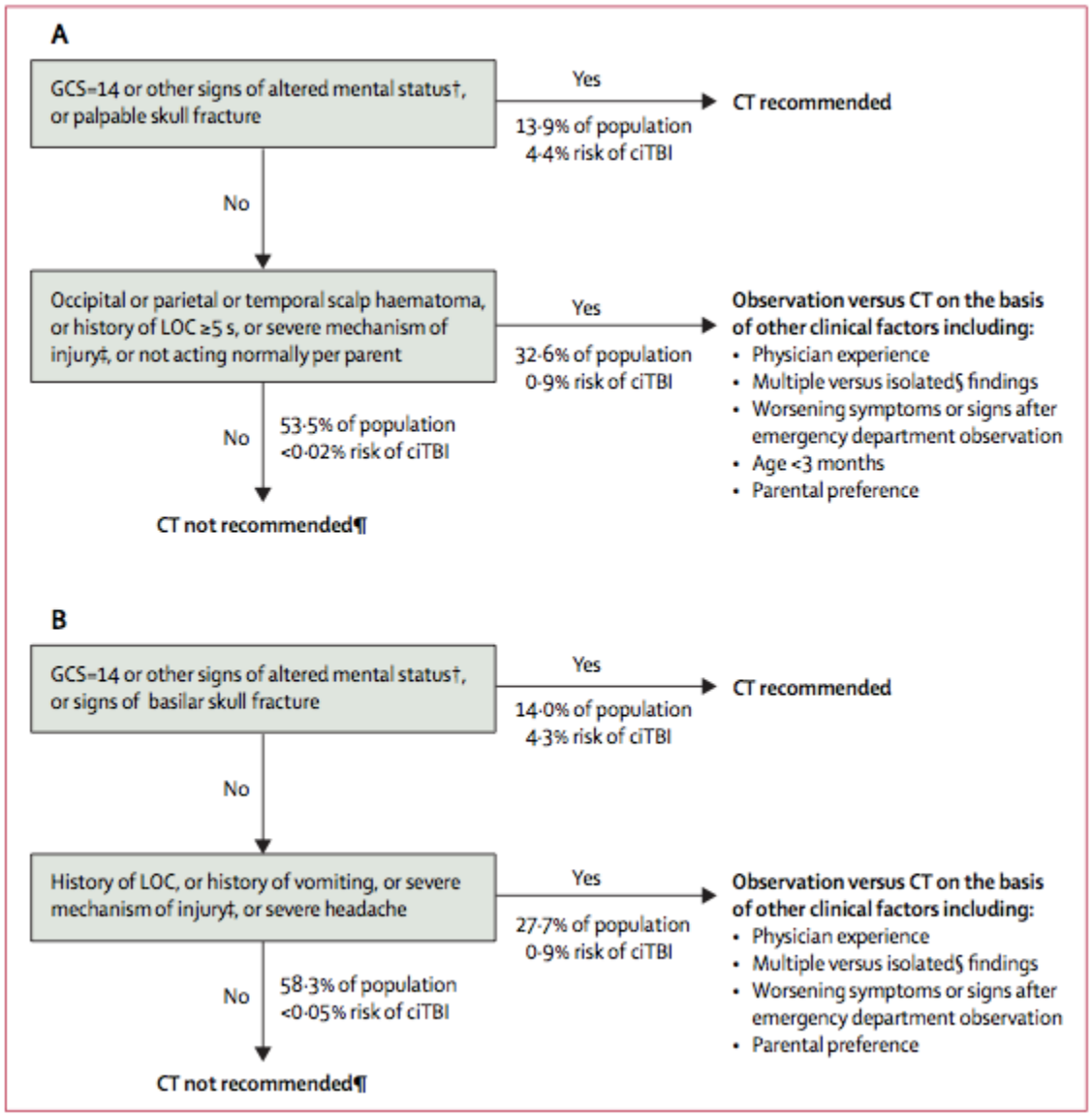
PECARN Algorithm



Kuppermann N, Holmes JF, Dayan PS et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. *Lancet*. 2009 Oct 3.

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