

Moderate/Severe Traumatic Brain Injury (TBI) Care Guideline



Pre-arrival (Care at Outside Hospital OR transfer via Critical Care Transport Team)

Inclusion Criteria: Moderate traumatic brain injury (GCS 9-12) **or** severe traumatic brain injury (GCS 3-8)
Exclusion Criteria: Neonates < 30 days, patients with congenital heart disease

Management Priorities

- Airway management
- Neuroprotective measures

Neurocritical Care Considerations

- If concerned for increased intracranial pressure (i.e., decreased pupillary reactivity, Cushing's triad (*Figure 1*)) treat cerebral edema PRN – per MD guidance:
 - Administer 3% hypertonic saline bolus: dose: 5 mL/kg over 20 minutes
- Seizure management per MD guidance:
 - Consider anticonvulsant loading dose:
 - 1st line: Levetiracetam 60 mg/kg/dose IV for < 75 kg; max 4500 mg UNDILUTED
 - If 1st line unavailable: Phenobarbital 20 mg/kg/dose IV; max 1000 mg/dose
 - Seizure rescue medication:
 - Diazepam 0.2 mg/kg/dose bolus IV; may repeat dose x1 after 10 minutes; max 10 mg/dose
 - Lorazepam 0.1 mg/kg/dose bolus IV; may repeat dose x1 after 5 minutes; max 4 mg/dose
 - Midazolam 0.2 mg/kg/dose IM; may repeat dose after 5 minutes; max 10 mg/dose

Consider emergent intubation within 5 minutes if: GCS $\leq$ 8 or combative

Considerations for non or delayed intubation:

- Hemorrhagic Shock – discuss with ED or Trauma team and consider intubation after and/or during active hematologic resuscitation.
- Concern for difficult airway or tracheal injury – Consider consulting ENT and/or Anesthesia services at OSH or consider transporting with native airway while team mobilizes difficult airway team at accepting hospital.

Airway Management

Recommended sedation for intubated patients:

- ❖ Propofol: start 25 mCg/kg/min IV, adjust by 10 mCg/kg/min to achieve desired sedation goal; titration range 25-100 mCg/kg/min
- ❖ Fentanyl 1 mCg/kg/dose IV PRN; max 50 mCg/dose; may re-dose q1 hour

Pain control:

- ❖ Fentanyl 1 mCg/kg/dose IV PRN; max 50 mCg/dose
- ❖ Morphine 0.05 mg/kg/dose IV; max 2 mg/dose - may repeat dose in 5 minutes

Pain & Sedation

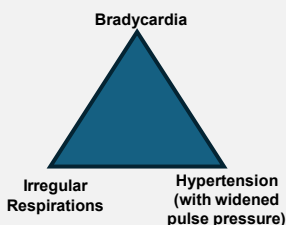
Acute Intervention

- Maintain or establish 2 large-bore peripheral IVs; consider Intraosseous (IO) access early
- Administer O₂ via non-rebreather or OxyMask at 15 L/min
- Fluid resuscitation with Isotonic fluids (Normal Saline 0.9% or Lactated Ringers) for tachycardia or hypotension
- FULL spine precautions, including hard cervical collar & log-roll
- Maintain age-related MAPs (see *Table 1*)

Assessment & Monitoring

- Neurologic exam including GCS (*Table 2*), motor function, sensation, and reflexes
- Monitor for signs of increased intracranial pressure (ICP): worsening GCS, focal neuro deficit, pupillary changes.
- Monitor for Cushing's triad (*Figure 1*)

**Figure 1:
Cushing's Triad
(Increased Intracranial Pressure)**



**Table 1
MAP (mean arterial pressure) Age-related Norms**

Age	Goal CPP (in mmHg)	Normal BP range (in mmHg)	MAP (in mmHg)
0-3 months	40-50	65-85 / 35-55	45-65
3-12 months	40-50	75-95 / 40-60	50-75
1-5 years	50-60	85-100 / 40-60	55-75
6-8 years	50-60	95-115 / 55-70	60-80
> 8 years	50-70	112-128 / 70-80	60-80

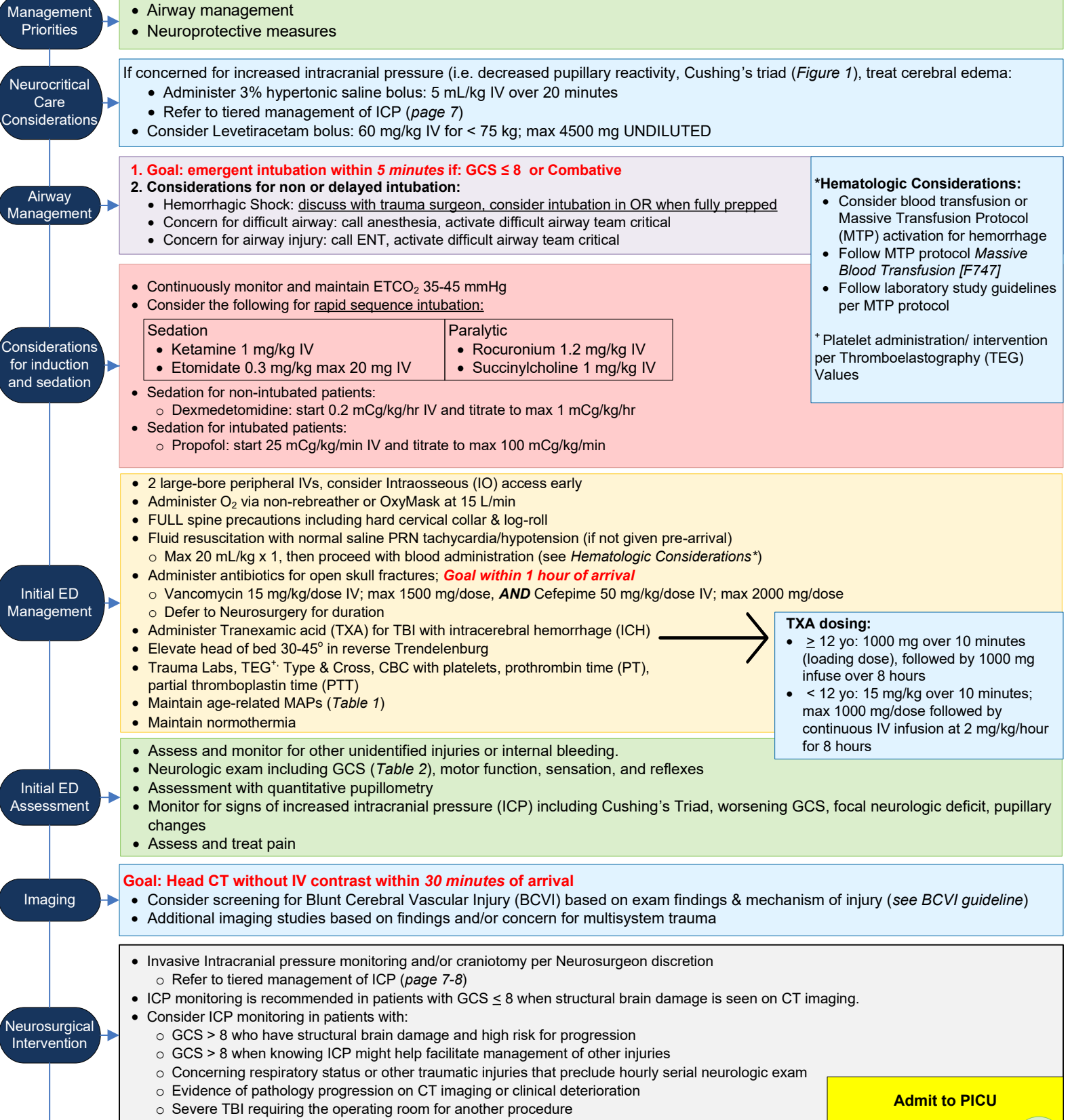
	Table 2 - Pediatric Glasgow Coma Scale (GCS)	
Best Eye Response	No eye opening	1
	Eye opening to pain	2
	Eye opening to speech	3
	Eye opening spontaneously	4
Best Verbal Response	No verbal response	1
	Inconsolable / agitated	2
	Cries but consolable, inappropriate interactions	3
	Smiles, oriented to sounds, follows objects, interacts	4
Best Motor Response	No motor response	1
	Extension to pain (decerebrate)	2
	Abnormal flexion to pain (decorticate)	3
	Flexion-Withdrawal	4
	Localizes pain	5
	Spontaneous	6

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Emergency Department Resuscitation Within 30 minutes of arrival

- Evaluation should follow the standard ATLS protocol, including a thorough primary and secondary survey, with assessment and management of traumatic injuries conducted by the Emergency Medicine physician and Trauma Team.
- The following guidelines represent best practices for the management of traumatic brain injury (TBI) and should include the recommended components as able, while maintaining careful consideration of potential multisystem injuries.



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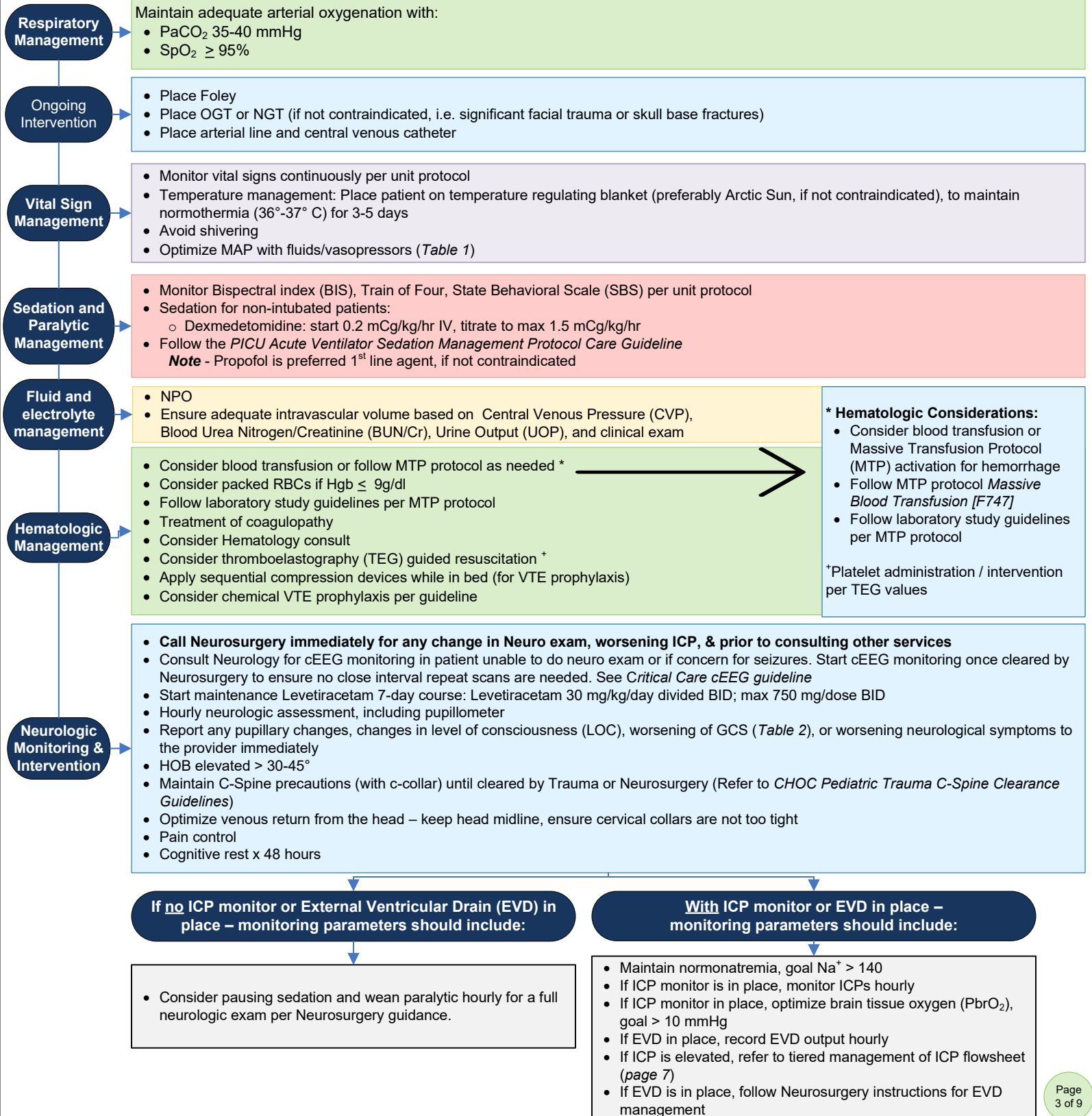
Inpatient Management

PICU Stabilization Phase – “Getting in the Zone”

Inclusion Criteria: Moderate traumatic brain injury (GCS 9-12) **or** severe traumatic brain injury (GCS 3-8)
Exclusion Criteria: Neonates < 30 days, patients with congenital heart disease

Within 1-2 hours of PICU admission

- The following guidelines represent best practices for the management of traumatic brain injury (TBI) and should include the recommended components as able, while maintaining careful consideration of potential multisystem injuries.



Moderate/Severe Traumatic Brain Injury (TBI) Care Guideline



Inpatient Management

PICU Stabilization Phase – “Staying in the Zone”

Inclusion Criteria: Moderate traumatic brain injury (GCS 9-12) **or** severe traumatic brain injury (GCS 3-8)
Exclusion Criteria: Neonates < 30 days, patients with congenital heart disease

The following guidelines represent best practices for the management of traumatic brain injury (TBI) and should include the recommended components as able, while maintaining careful consideration of potential multisystem injuries.

Respiratory Management

- Maintain adequate arterial oxygenation with:
 - PaCO₂ 35-40 mmHg
 - SpO₂ ≥ 95%
- Consider Chest Physiotherapy (CPT) and airway clearance if not contraindicated

Ongoing Intervention

- Maintain Foley and remove as soon as possible
- Maintain oral/nasal gastric tube to low continuous suction until GI function returns or cleared for diet (see fluid and electrolyte management)
- Maintain arterial line and central venous catheter

Vital Sign Management

- Monitor vital signs continuously per unit protocol
- Temperature management: Place patient on temperature regulating blanket (preferably Arctic sun if not contraindicated), to maintain normothermia (36-37° C) for 3-5 days
- Avoid shivering
- Optimize MAP (*Table 1*) with fluids/vasopressors

Sedation and Paralytic Management

- Monitor Bispectral index (BIS), Train of Four, State Behavioral Scale (SBS) per unit protocol
- Sedation for non-intubated patients:
 - Dexmedetomidine: start 0.2 mcg/kg/hr IV and titrate to max 1.5 mcg/kg/hr
- Follow the *PICU Acute Ventilator Sedation Management Protocol Care Guideline*
Note - Propofol is preferred 1st line agent, if not contraindicated

Fluid and Electrolyte Management

- Ensure adequate intravascular volume based on CVP, BUN/Cr, UOP, and clinical exam
- Establish nutrition via appropriate route as soon as possible per *PICU Enteral Feeding Guidelines* and guidance of dietitian, goal to start nutrition within 48 hours post-injury given no contraindications and cleared by Trauma Surgery
- Start bowel regimen
- Histamine-2 receptor antagonist (H2) blocker or Proton Pump Inhibitor (PPI) for gastric ulcer prevention

Hematologic Management

- Treatment of coagulopathy
- Continue sequential compression devices while in bed (for VTE prophylaxis)
- Collaborate on VTE prophylaxis within 24 hours; start chemical VTE prophylaxis per *VTE prophylaxis clinical care guideline*

Neurologic Monitoring & Intervention

- **Call Neurosurgery immediately for any change in neurologic exam, worsening ICP, before consulting other services, and before ordering additional imaging studies.**
- The frequency and context of neurologic exams and pupillometer should be reassessed daily
- Report any pupillary changes, changes in LOC, worsening of GCS (*Table 2*), or worsening neurological symptoms to the provider immediately
- HOB elevated > 30-45°
- Maintain C-Spine precautions (with c-collar) until cleared by Trauma or Neurosurgery (*Trauma C-Spine Clearance Guidelines*)
- Optimize venous return from the head – keep head midline, ensure cervical collars are not too tight
- Continue pain control
- Continue Levetiracetam prophylaxis x 7-day course for prophylaxis without seizure. If clinical or electrographic seizure, defer to Neurology for management
- Delirium prevention – after 48 hours - lights on, windows open 8am-6pm
- No dilated eye exam should be performed until cleared by Neurosurgery

**If no ICP monitor or EVD in place –
monitoring parameters should include:**

- Consider pausing sedation and wean paralytic hourly for a full neurologic exam per Neurosurgery guidance
- Na⁺ goal 150-155 mEq/L for 24 hours

**With ICP monitor or EVD in place –
monitoring parameters should include:**

- Maintain normonatremia, goal Na⁺ > 140 mEq/L
- If ICP monitor is in place, monitor ICPs hourly
- If ICP monitor in place, optimize PbrO₂, goal > 10mmHg
- If EVD in place, record EVD output hourly
- If ICP is elevated, refer to tiered management of ICP flowsheet (*page 7*)
- If EVD is in place, follow Neurosurgery instructions for EVD management

Moderate/Severe Traumatic Brain Injury (TBI) Care Guideline



Inpatient Management PICU Weaning Phase

Inclusion Criteria: Moderate traumatic brain injury (GCS 9-12) **or** Severe traumatic brain injury (GCS 3-8)
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The following guidelines represent best practices for the management of traumatic brain injury (TBI) and should include the recommended components as able, while maintaining careful consideration of potential multisystem injuries.

Respiratory Management

- Consider extubation when cleared by Neurosurgery, no evolving lesions documented on last CT scan, patient able to control upper airway reflexes and cough.
- Extubate per daily Extubation Readiness Test (ERT) (*CHOC policy F807*)
- Tracheostomy considerations: Consider tracheostomy within 10-14 days of injury if unable to extubate within this time

Ongoing Intervention

- Remove Foley
- Continue current nutrition
- With extubation consider removal of arterial line and central venous catheter

Vital Sign Management

- Normalize temperature management
- Normalize Cerebral Perfusion Pressure / Central Venous Pressure (CPP/CVP)

Sedation

- Discontinue paralytics
- Decrease and wean sedation/analgesia
- If needed, start methadone. Consult Palliative care for methadone wean

Fluid and Electrolyte Management

- Continue nutrition; goal to reach full nutritional supplementation by 7 days post-injury
- Continue bowel regimen
- Stop H2 blocker or PPI when tolerating diet

Hematologic Management

- Continue sequential compression devices while in bed (for VTE prophylaxis)
- Continue chemical VTE prophylaxis per VTE prophylaxis guideline

Neurologic Monitoring & Intervention

- Space neurologic monitoring
- Discontinue VTM per Neurology recommendations
- Discontinue EVD and/or ICP monitor
- HOB elevated > 30°
- Maintain C-Spine precautions (with c-collar) until cleared by Trauma or Neurosurgery (Refer to Trauma C-Spine Clearance Guidelines)
- Continue pain control
- Continue Levetiracetam prophylaxis x 7 day maximum for prophylaxis with seizure. If clinical or electrographic seizure, defer to Neurology for management
- Delirium prevention: Lights on and windows open 8am-6pm

Rehabilitation

- Consider Physiatry (Physical Medicine and Rehabilitation (PM&R) consult by day 3 of hospital admission
- Consult PT/OT/Speech therapies
- Bedside swallow evaluation after extubating
- Assess for pre-existing physical, cognitive, emotional and sleep pattern symptoms to identify risk factors for prolonged recovery
- Before mobilizing patient, assess the patient's fall risk and assist with mobility to ensure safety

Downgrade/Transfer Criteria:

- Cleared by Neurosurgery for floor status
- Arterial line removed
- ICP monitor/EVD removed
- Paralytics and sedatives discontinued
- All patients should be transferred to the floor to the Trauma Service as primary

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Inpatient Management Post-ICU Care Phase

Inclusion Criteria: Moderate traumatic brain injury (GCS 9-12) **or** severe traumatic brain injury (GCS 3-8)
Exclusion Criteria: Neonates < 30 days, patients with congenital heart disease

The following guidelines represent best practices for the management of traumatic brain injury (TBI) and should include the recommended components as able, while maintaining careful consideration of potential multisystem injuries.

Respiratory Management

- Room Air
- Incentive Spirometry

Ongoing Intervention

- Remove Foley
- Consider long-term feeding (i.e. Gastroenterology consult for PEG tube if unable to tolerate oral intake)

Vital Sign Management

- Routine vital sign monitoring per unit protocol

Sedation

- Wean methadone and opioids; consult Palliative care for wean management

Fluid and Electrolyte Management

- Continue nutrition
- Consider Nutrition consult
- Continue bowel regimen
- Stop H2 blocker or PPI when tolerating diet

Hematologic Management

- Continue sequential compression devices while in bed (for VTE prophylaxis)
- Continue chemical VTE prophylaxis per VTE prophylaxis guideline

Neurologic Monitoring & Intervention

- Routine neurologic monitoring
- HOB elevated > 30°
- Maintain C-Spine precautions (with c-collar) until cleared by Trauma or Neurosurgery (Refer to *Trauma C-Spine Clearance Guidelines*)
- Continue pain control
- Continue Levetiracetam prophylaxis x 7 day maximum for prophylaxis with seizure. If clinical or electrographic seizure, defer to Neurology for management

Rehabilitation

- Consult Psychiatry (PM&R) after day 3 of hospital admission
- Consult PT/OT/Speech therapies
- **GOAL: Mobilize to full capacity, to goal of walking three times/day x 20 minutes**
- Consider swallow evaluation
- Assess for pre-existing physical, cognitive, emotional and sleep pattern symptoms to identify risk factors for prolonged recovery
- Before mobilizing the patient, assess the patient's fall risk and assist with mobility to ensure safety
- Consider acute inpatient rehabilitation

Psych/Social

- PTSD screen when the patient is cognitively able
- Consider Psychology consult as needed
- Social work involvement as needed

Discharge Criteria:

- Tolerating a regular diet, or a long-term nutrition plan in place
- Ambulating without difficulty and/or appropriate supportive equipment ordered
- Pain controlled with oral pain medications
- Ensure rehab therapies have cleared the patient before discharge

Provide patient education:

- Provide family with head injury handout
- Provide family with intracranial hemorrhage handout (if applicable)

Moderate/Severe Traumatic Brain Injury (TBI) Care Guideline



Tiered Management of Increased Intracranial Pressure First Tier Therapies

ICP monitor inserted

Figure 1:

Baseline care including sedation/analgesia, adequate oxygenation, normothermia, insuring appropriate CVP, maintaining appropriate Hgb levels and treating coagulopathy, elevating HOB, cEEG and seizure prophylaxis – all as described in the above guideline.

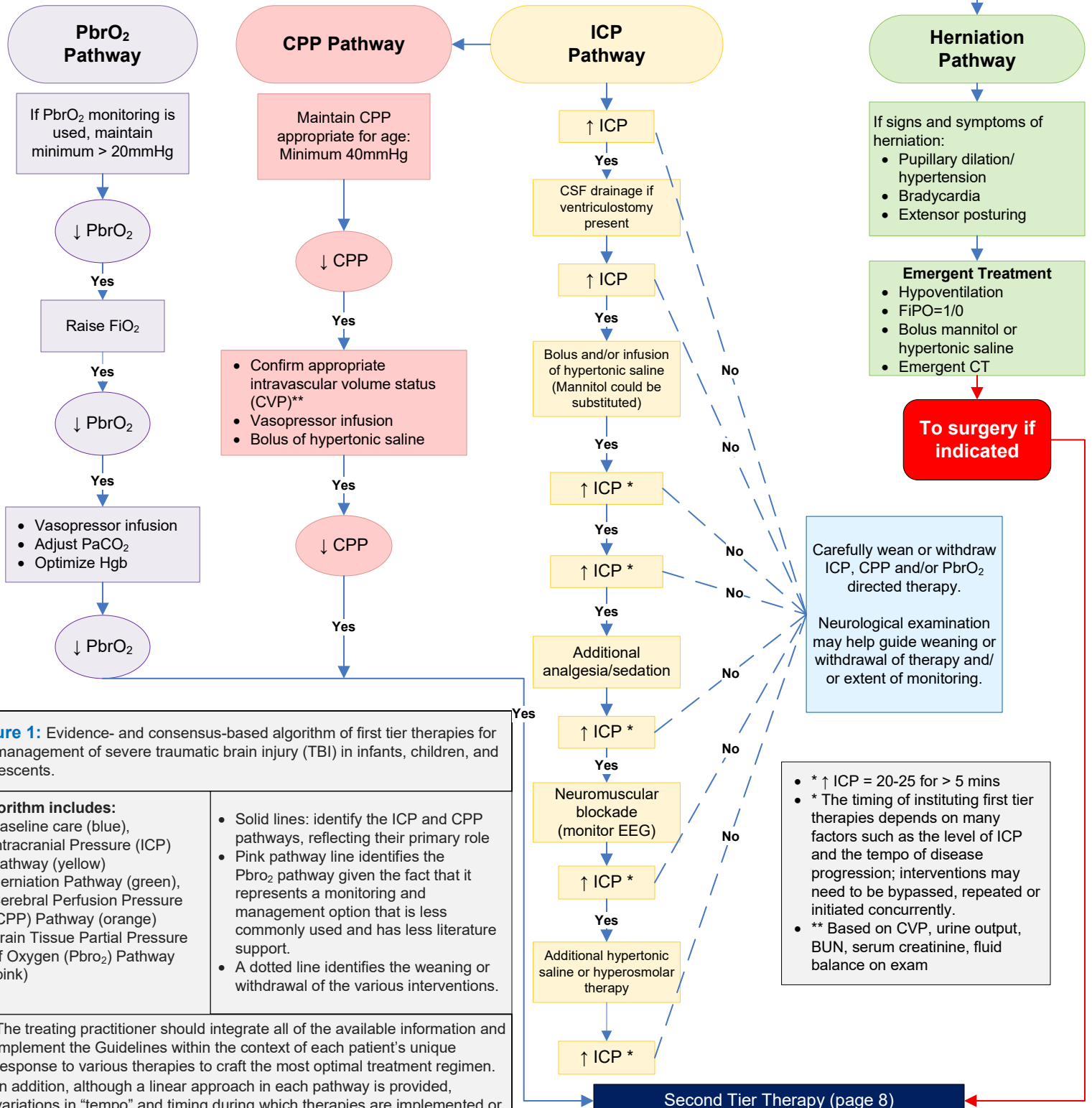


Figure 1: Evidence- and consensus-based algorithm of first tier therapies for the management of severe traumatic brain injury (TBI) in infants, children, and adolescents.

Algorithm includes:

- Baseline care (blue),
- Intracranial Pressure (ICP) Pathway (yellow)
- Herniation Pathway (green),
- Cerebral Perfusion Pressure (CPP) Pathway (orange)
- Brain Tissue Partial Pressure of Oxygen (PbrO₂) Pathway (pink)

- Solid lines: identify the ICP and CPP pathways, reflecting their primary role
- Pink pathway line identifies the PbrO₂ pathway given the fact that it represents a monitoring and management option that is less commonly used and has less literature support.
- A dotted line identifies the weaning or withdrawal of the various interventions.

- The treating practitioner should integrate all of the available information and implement the Guidelines within the context of each patient's unique response to various therapies to craft the most optimal treatment regimen.
- In addition, although a linear approach in each pathway is provided, variations in "tempo" and timing during which therapies are implemented or weaned/withdrawn will depend on each given clinical context.
- If baseline care is insufficient to control intracranial pressure, then progression down the ICP and CPP pathways is indicated (solid black line).

- * ↑ ICP = 20-25 for > 5 mins
- * The timing of instituting first tier therapies depends on many factors such as the level of ICP and the tempo of disease progression; interventions may need to be bypassed, repeated or initiated concurrently.
- ** Based on CVP, urine output, BUN, serum creatinine, fluid balance on exam

Moderate/Severe Traumatic Brain Injury (TBI) Care Guideline



Tiered Management of Increased Intracranial Pressure Second Tier Therapies

Figure 2:

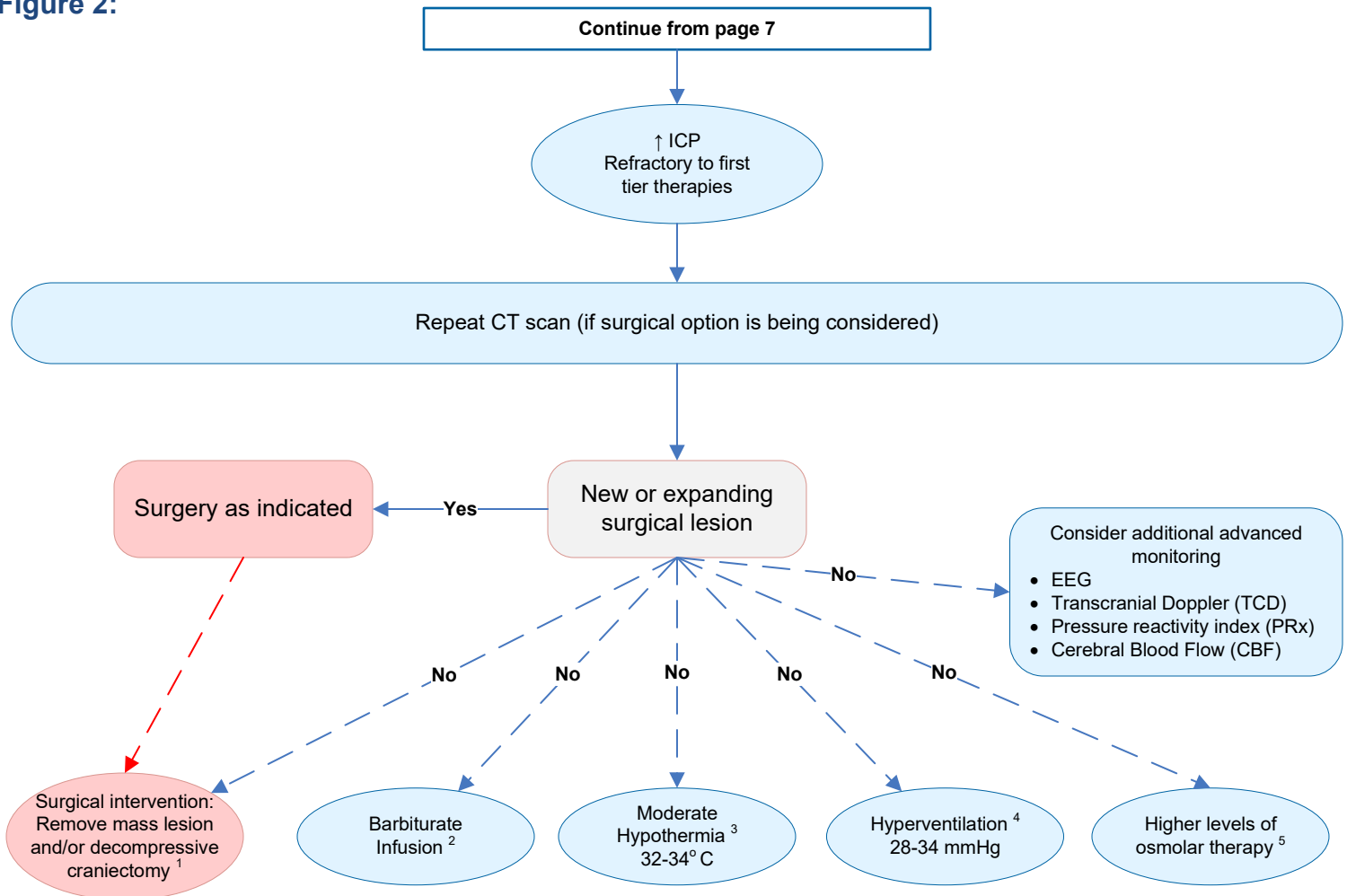


Figure 2: Evidence- and consensus-based algorithm of second tier therapies for the management of severe traumatic brain injury in infants, children, and adolescents.

- ¹ Salvageable patient and evidence of mass, lesion or swelling on CT
- ² Active EEG and no medical contradictions
- ³ No contradictions
- ⁴ Strongly consider advanced neuro-monitoring for ischemia
- ⁵ Advance dose of 3% saline or mannitol, or use bolus 23.4% saline. If possible, avoid serum sodium concentration of > 160 mEq/L and serum osmolarity of > 360 mOsm/L

- The algorithm is linked to the first tier therapy algorithm. (Figure 1) and represents the treatment options for refractory intracranial hypertension where tier 1 approaches are inadequate.
- These therapies may be applied singly, serially, or in combinations.
- In addition, as shown, the management of refractory intercranial hypertension in the second-tier phase may be aided by the use of advanced monitoring.

Adapted from:

Kochanek, P. M., Tasker, R. C., Bell, M. J., Adelson, P. D., Carney, N., Vavilala, M. S., Selden, N. R., Bratton, S. L., Grant, G. A., Kissoon, N., Reuter-Rice, K. E., & Wainwright, M. S. (2019). Management of Pediatric Severe Traumatic Brain Injury: 2019 Consensus and Guidelines-Based Algorithm for First and Second Tier Therapies. *Pediatric Critical Care Medicine: A Journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies*, 20(3), 269–279. <https://doi.org/10.1097/PCC.0000000000001737> (Level II)

References

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- Kochanek, P. M., Tasker, R. C., Bell, M. J., Adelson, P. D., Carney, N., Vavilala, M. S., Selden, N. R., Bratton, S. L., Grant, G. A., Kisson, N., Reuter-Rice, K. E., & Wainwright, M. S. (2019). *Guidelines for the management of pediatric severe traumatic brain injury* (3rd ed.). Society of Critical Care Medicine & World Federation of Pediatric Intensive and Critical Care Societies. (Level I)
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- Musick, S., & Alberico, A. (2021). Neurologic assessment of the neurocritical care patient. *Frontiers in Neurology*, 12, 588989. <https://doi.org/10.3389/fneur.2021.588989> (Level V)

This Moderate/Severe Traumatic Brain Injury (TBI) Guideline has been developed by the:

- Trauma Program
- Department of Neurosurgery
- Department of Critical Care Medicine
- Department of Emergency Medicine
- Department of Neurology

*** This guideline is a tool to aid clinical decision making. It is not a standard of care. The physician should deviate from the guideline when clinical judgment so indicates. ***