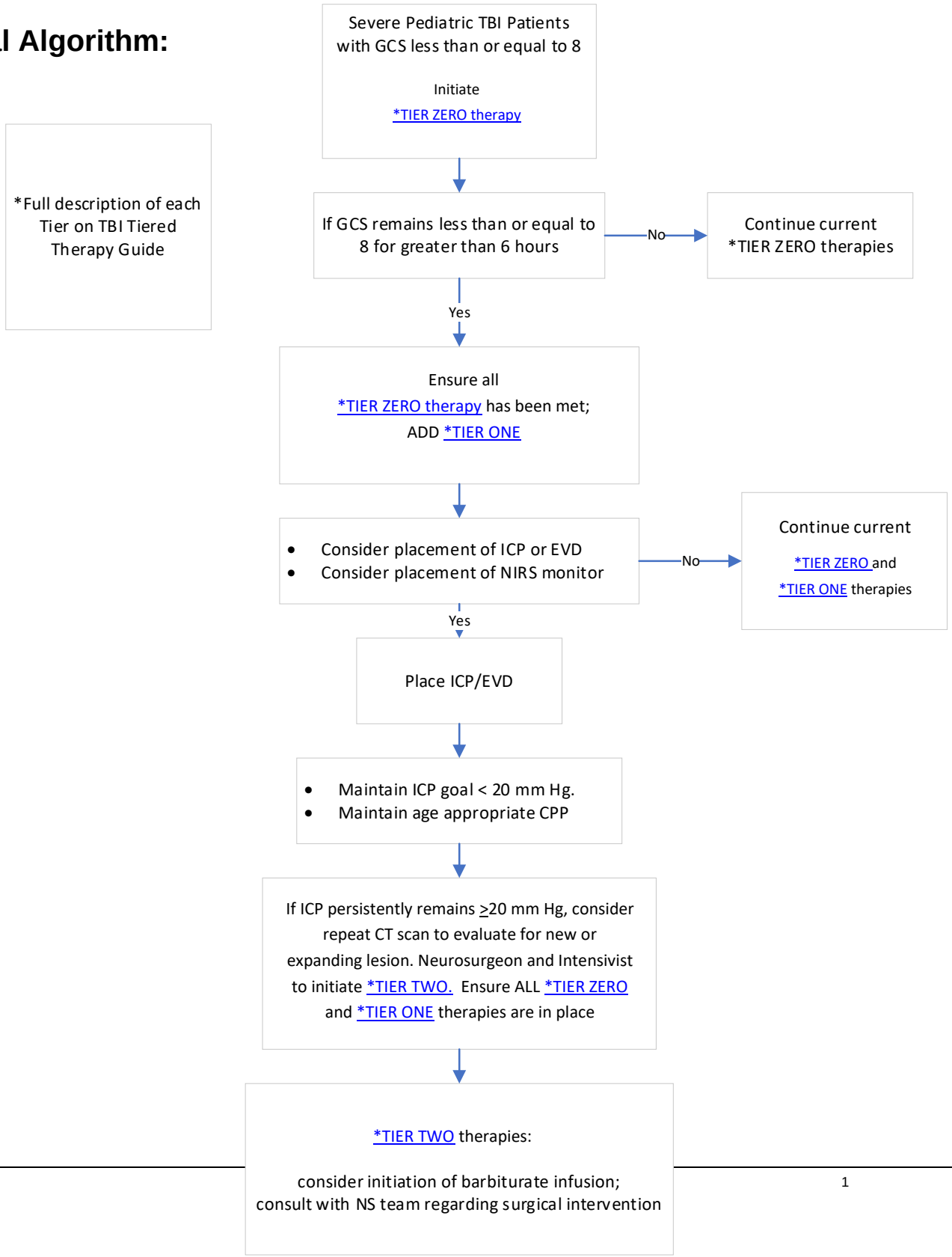
Severe Traumautic Brain Injury, Pediatric, Inpatient

Updated: December 15, 2023

Clinical Algorithm:



Clinical Pathway Summary

CLINICAL PATHWAY NAME: Severe Traumatic Brain Injury, Pediatric, Inpatient

PATIENT POPULATION AND DIAGNOSIS: Pediatric patients in the PICU. Treatment may begin prior to the PICU admission (as soon as TBI is identified).

APPLICABLE TO: Helen DeVos Children's Hospital

BRIEF DESCRIPTION: The Pediatric Severe Traumatic Brain Injury (TBI) Algorithm and Tiered Therapy Guide were developed through a collaboration of the pediatric experts in Pediatric Trauma, Surgical Critical Care, Neuro Critical Care, Neurology, and Neurosurgery. Evidence-based guidelines for severe TBI management have been used to guide this work along with consensus from experts when no published evidence is available.

IMPLEMENTATION DATE: 12/6/2023

LAST REVISED: 12/15/2023

Clinical Pathway: Tiered Approach For Severe TBI Management

A. TIER ZERO: Baseline Care (ALL TBI patients with GCS ≤ 8)

a. Elevate HOB to 30° (no further than 45°), with neutral head positioning
b. Maintain C- spine precautions (see policy for Cervical Spine Immobilization and Clearance). Ensure c-collar is not too tight and obstructing venous return. C-collar may be removed to facilitate venous drainage while maintaining c-spine precautions ONLY if patient is sedated and immobile. Nursing communication order must be in place for this.
c. Controlled mechanical ventilation:
    i. Titrate PEEP, FiO2 to achieve target SpO_2 > 92-99%, target paO_2 90-100 mm Hg
    ii. Adjust minute ventilation to achieve target $PaCO_2$ 35-40 mm Hg
d. Maintain normothermic core temperature (goal temp 36-37.5° C). Schedule acetaminophen to prevent fevers if needed. Treat fevers promptly; avoid and treat shivering as clinically indicated (see bedside temperature management algorithm).
e. Maintain euvolemia. Initiate normal saline (NS) IV fluids to run at least 75% of maintenance rate
f. Maintain minimum hemoglobin level of 7.0 g/dL
g. Correct coagulopathy as clinically indicated
h. Initiate levetiracetam (Keppra) prophylaxis for at least 7 days after injury (10 mg/kg/dose IV q12, max dose 2g/day). Consider initiation of continuous EEG to evaluate for non-convulsive seizures in consultation with neurocritical care service
i. Initiate stress ulcer prophylaxis
j. Ensure early nutritional support and bowel regimen, ideally within 72 hours of admission, unless clinically contraindicated. Enteral route is preferred over parenteral, unless there are clinical contraindications.
k. If known rhinorrhea or anterior skull base fractures, avoid any nasal tubes, suctioning, or other manipulation
l. Initiate VTE screening for all patients; initiate VTE prophylaxis as clinically indicated
m. Screen all patients for potential cerebrovascular injury using McGovern score (see Pediatric Cerebrovascular Injury pathway). Consider need for CTA head/neck imaging in consultation with Pediatric Neurosurgical and Trauma teams

n. Hourly neurologic assessments. Consider less frequent neurologic assessments ONLY in patients with ICP monitor who have high risk of developing intracranial hypertension. For such patients, maintain low stimulation environment; place “Low Stimulation” sign at bedside for awareness of staff and visitors

B. TIER ONE: Ensure ALL TIER ZERO criteria are met

a. ICP monitor or EVD should be placed for GCS ≤ 8 if GCS does not improve within 6 hours from the time of admission, *providing low GCS is not due to medication effect.*

i. Elevated ICP cannot be excluded based on reassuring initial CT scan in a comatose patient. Neurologic exam should thus be closely monitored to help determine need for ICP monitor placement

ii. Initial CT scan and follow-up CT is often done within the first 24 hours of admission. However routinely obtaining serial CT scans greater than 24 hours after admission is not warranted for decisions about neurosurgical intervention, unless there is evidence of neurologic deterioration or increased ICP

b. Consider placement of NIRS monitor (Foresight setup) HDVCH NIRS Guideline.pdf

c. Maintain ICP goal < 20 mm Hg. If ICP remains ≥ 20 mm Hg for ≥ 5 minutes:

i. Optimize adequate sedation/analgesia

ii. Ensure hypercarbia, hypoxia, and hyperthemia have been corrected

iii. Monitor for and treat seizures if clinically indicated

iv. CSF diversion if EVD in place

v. Consider hyperosmolar therapy

1. 3% sodium chloride bolus (2-5 mL/kg over 10-20 min, max 250 mL) or continuous infusion (0.1-1 mL/kg/hr). If fluid overload is a concern, may use 23.4% sodium chloride (0.5 mL/kg, max 30 mL, central line access required)
2. Mannitol bolus (0.25-1 g/kg IV over 20-30 min)
3. Check serum sodium q 6 hrs if hypertonic saline is initiated; avoid serum sodium persistently > 160 mEq/L
4. Monitor serum osmolar gap and renal function if mannitol is frequently administered. Avoid osmolar gap > 20 to prevent kidney injury

vi. Consider neuromuscular blockade (NMB)- (consider trial dose of NMB even if patient appears well-sedated). Initiate continuous EEG monitoring if NMB infusion is started; monitor level of NMB q12 using train-of-fours monitoring (Peripheral Nerve Stimulation (PNS) Testing v.6 (navexone.com))

d. Maintain age-dependent CPP goals by ensuring adequate volume status, adequate Hgb level, and use of vasoactive infusions as clinically indicated:

i. Maintain CPP 40-50 for infants to age ≤ 5 years old

ii. Maintain CPP 50-60 for ages 6 to 17 years old

C. TIER TWO: Ensure ALL TIER ONE and TIER TWO criteria are met. If ICP persistently remains ≥ 20 mm Hg despite Tier One and Tier Two measures:

a. Consider repeat CT scan to evaluate for a new or expanding surgical lesion. Consult with Neurosurgical team regarding removal of an expanding lesion with refractory ICP

b. Maximize hyperosmolar therapies (avoiding serum sodium > 160 mEq/L), if not already done

c. Consider initiation of barbiturate infusion

i. Pentobarbital loading dose (2-5 mg/kg over 20-30 min); maintenance infusion: 1-5 mg/kg/hr)

ii. Initiate continuous EEG monitoring if pentobarbital infusion is started

iii. Monitor serum osmolality, serum lactate levels, and LFT’s if pentobarbital infusion is started

iv. Titrate pentobarbital dose to goal ICP or burst suppression, in consultation with Neurocritical care service

v. Increasing pentobarbital dosing is generally not indicated if EEG shows < 1 burst per 10 second screen (averaged over several screens), and may lead to toxicity/adverse complications
vi. Optimize bowel regimen, monitor for development of ileus if patient is being enterally fed, due to high risk of compromised gastrointestinal motility from pentobarbital infusion

- Consult with Neurosurgical team regarding surgical decompression for the following:
  - Evacuation of a mass lesion or for focal swelling
  - Diffuse swelling when ICP remains refractory despite the above measures. This should be considered at any point (early or late) in the clinical course
- Patients who have undergone decompressive craniectomy for refractory intracranial hypertension should still have ICP monitor in place after decompression, for continued management of ICP, CPP
- Consider mild hyperventilation ($paCO_2$ 30-34 mm Hg) for late and refractory intracranial hypertension
- Consider mild to moderate hypothermia (34-35 °C) for late and refractory intracranial hypertension

** It is recognized that the progression of intracranial disease may warrant a non-linear approach, and complex scenarios may require a cross-tiered approach to clinical management.

D. Weaning of Therapies

a. Consider careful withdrawal of therapies when ICP and CPP have remained stable for at least 24 hours

b. In general, interventions are withdrawn in the reverse order of their application

Pathway Information

OWNER(S): Dr. Elora Hussain

CONTRIBUTOR(S): Lindsey Jelsma, DNP, Casey Madura, MD, Ankit Shukla, PharmD, Jim DeCou, MD, John Winters, MD

EXPERT IMPROVEMENT TEAM (EIT): N/A

CLINICAL PRACTICE COUNCIL (CPC): Children's CPC

CPC APPROVAL DATE: 11/28/2023

OTHER TEAM(S) IMPACTED: N/A

References

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

Hawryluk, G.W.J., Rubiano A.M., Totten A.M., O'Reilly C., Ullman J.S., Bratton S.L., Chesnut R., Harris O.A., Kissoon N., Shutter L., Tasker R.C., Vavilala M.S., Wilberger J., Wright D.W., Lumba-Brown A., Ghajar J. Guidelines for the Management of Severe Traumatic Brain Injury: 2020 Update of the Decompressive Craniectomy Recommendations. Neurosurgery. 2020 Sept 1:87(3): 427-434.

Cook, A.M., Morgan Jones, G., Hawryluk, G.W.J., et al. Guidelines for the Acute Treatment of Cerebral Edema in Neurocritical Care Patients. *Neurocritical Care*. 2020 (32)3: 647-666.

Woods KS, Horvat CM, Kantawala S., et al. Intracranial and Cerebral Perfusion Pressure Thresholds Associated with In-Hospital Mortality Across Pediatric Neurocritical Care. *Pediatric Crit Care Med*. 2021; 22(2): 135-146

Allen BB, Chiu Ya-lin, Gerber LM., et al. Age-Specific Cerebral Perfusion Pressure Thresholds and Survival in Children and Adolescents with Severe Traumatic Brain Injury. *Pediatr Crit Care Med*. 2014; 15(1): 62-70