Severe Traumatic Brain Injury: Guideline for Management of ICH in PICU

Tier 1

Admit: To PICU with safe hand off

Reassess: History, Pt status

- Validate Neurosurgery consult
- Optimal Positioning: Elevate HOB 30° head midline
- Labs: PT / INR, PTT, Fibrinogen, CBC, Na
- Maintain end tidal CO_2: $paCO_2$ 35-45 mmHg
- Foley catheter, cervical collar
- Rectal probe: Maintain core temp 36-37° C
- Seizure prophylaxis** Keppra 20 mg/kg/ dose Q 12 hrs (max 1000 mg)
- Avoid hypotension

Care Team discussion on prognosis

Is injury survivable?
- No → Provide supportive care
- Yes →
  - Insert A-line, Central line
  - Consults within 24 hours: Rehab, *Neurology, Nutrition
  - HTS therapy may be used during resuscitative phase for suspected ICH before ICP monitor placed
  - ICP monitor should be considered if 6 hours post injury the GCS is <9. If NSGY feels the risk of placement outweighs the benefit or ICP is not indicated, a note needs to be documented as to why.

ICP indicated
- No → Continue to monitor, target normotension and treat appropriately
- Yes → Coags within goal range?
  - No → Correct blood coagulation → Decision by NSU on type of ICP monitor
  - Yes → Decision by NSU on type of ICP monitor

Coags Goal:
INR ≤ 1.4
Platelets>100,000

Decision by NSU on type of ICP monitor → Insertion of ICP monitor → *Continuous EEG monitoring

CPP Goal:
40 – 60 mmHg

ICP sustained ≥ 20 x 5 min
- No → Continue treatment, reassess previous actions
- Yes → Is CPP below target?
  - Yes → Vasoactive agents to optimize CPP → (reassess box)
  - No →
    - Reassess patient: Pupil exam, HOB 30°, optimal positioning, temperature control, CO_2 target of 35 – 45 mm HG
    - Sedation and analgesia
    - Consider repeat CT scan

ICP sustained ≥ 20 for 5 min and / or CPP goal below target
- No → Continue to monitor and treat
- Yes → **Tier 2**

Inclusion / Exclusion Criteria

Inclusion:
- Abnormal CT scan with hematomas, swelling, herniation, compressed basal cistern, or diffuse axonal injury AND either #1 or #2 below
  1. Traumatic brain injury (TBI) with GCS ≤ 8 (field, transport, or ED);
  2. TBI patient admitted with GCS > 8, with deterioration to GCS ≤ 8

NOTE: a NORMAL head CT scan does not preclude the use of this guideline.

Exclusion:
- Hypoxic ischemic injuries
- Patient that is deemed non-salvageable after discussion / agreement by clinical care team
- Infants with open fontanelles

Acute and Sustained Rise in ICP: Concern for Impending Herniation

Indicators:
- Acute rise in ICP
- Pupil changes
- Bradycardia and hypertension

Actions:
- Contact **Intensivist, Neurosurgeon and Trauma Surgeon**
- Hyperventilation (brief) to CO_2 level between 30-35 mmHg
- Add sedation / paralysis to treatment
- Give 3% HTS bolus at 4 mL/kg (max 500 ml) or Mannitol 0.25 gm-1 gm/kg
- Obtain I-Stat with electrolytes to assess sodium and CO_2

**Seizure Treatment
For actively seizing and/or concern for status epilepticus:
Keppra 60 mg/kg IV every 12 hours (max 4500 mg)

*Consider 48 hours of cEEG after admission

Additional Goals:
- Pulse Ox ≥ 92-99%
- SBP (normotension for age)
- Hemoglobin ≥ 7 g/dl
- Serum Osmolality < 360
- Glucose 80–180 mg/dl

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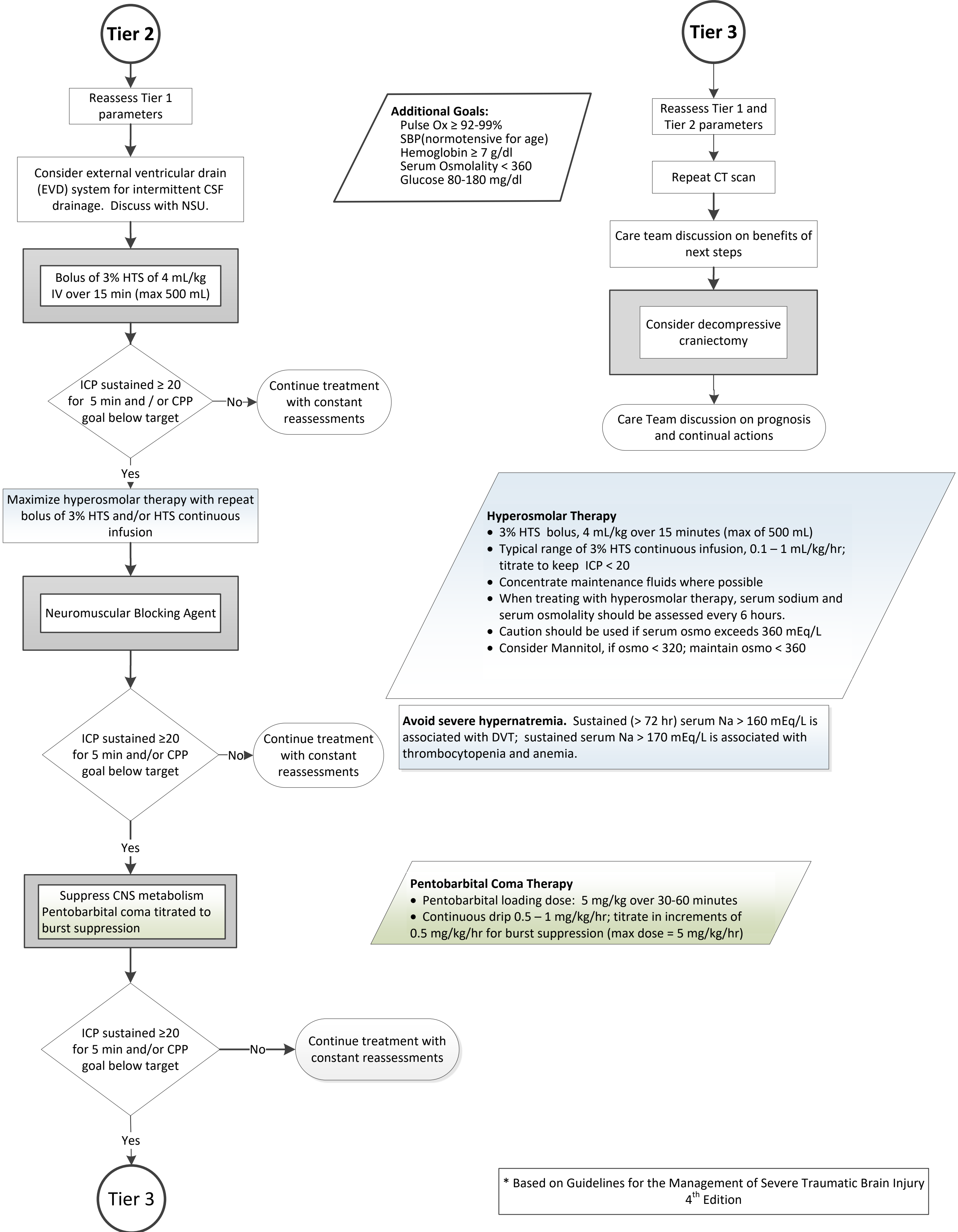

Tier 2: ICP Non Responsive to Tier 1 Therapy
Tier 3: ICP Non Responsive to Tier 2 Therapy
Tier 2
Reassess Tier 1 parameters
Consider external ventricular drain (EVD) system for intermittent CSF drainage. Discuss with NSU.
Bolus of 3% HTS of 4 mL/kg IV over 15 min (max 500 mL)
ICP sustained ≥ 20 for 5 min and / or CPP goal below target
No
Continue treatment with constant reassessments
Yes
Maximize hyperosmolar therapy with repeat bolus of 3% HTS and/or HTS continuous infusion
Neuromuscular Blocking Agent
ICP sustained ≥20 for 5 min and/or CPP goal below target
No
Continue treatment with constant reassessments
Yes
Suppress CNS metabolism Pentobarbital coma titrated to burst suppression
ICP sustained ≥20 for 5 min and/or CPP goal below target
No
Continue treatment with constant reassessments
Yes
Tier 3
Additional Goals:
Pulse Ox ≥ 92-99%
SBP(normotensive for age)
Hemoglobin ≥ 7 g/dl
Serum Osmolality < 360
Glucose 80-180 mg/dl
Tier 3
Reassess Tier 1 and Tier 2 parameters
Repeat CT scan
Care team discussion on benefits of next steps
Consider decompressive craniectomy
Care Team discussion on prognosis and continual actions
Hyperosmolar Therapy
• 3% HTS bolus, 4 mL/kg over 15 minutes (max of 500 mL)
• Typical range of 3% HTS continuous infusion, 0.1 – 1 mL/kg/hr; titrate to keep ICP < 20
• Concentrate maintenance fluids where possible
• When treating with hyperosmolar therapy, serum sodium and serum osmolality should be assessed every 6 hours.
• Caution should be used if serum osmo exceeds 360 mEq/L
• Consider Mannitol, if osmo < 320; maintain osmo < 360
Avoid severe hypernatremia. Sustained (> 72 hr) serum Na > 160 mEq/L is associated with DVT; sustained serum Na > 170 mEq/L is associated with thrombocytopenia and anemia.
Pentobarbital Coma Therapy
• Pentobarbital loading dose: 5 mg/kg over 30-60 minutes
• Continuous drip 0.5 – 1 mg/kg/hr; titrate in increments of 0.5 mg/kg/hr for burst suppression (max dose = 5 mg/kg/hr)
* Based on Guidelines for the Management of Severe Traumatic Brain Injury 4th Edition