UCH-SEVERE TRAUMATIC BRAIN INJURY MANAGEMENT GUIDELINE

SUMMARY
Traumatic brain injury (TBI) is the leading cause of death for all age groups in the United States, contributing to over 50% of trauma deaths. Protocolized management of severe TBI [defined as a post-resuscitation Glasgow Coma Score (GCS) < 8] improves patient outcome. Primary endpoints in the management of severe TBI include minimizing cerebral edema and intracranial pressure (ICP) while simultaneously optimizing cerebral perfusion pressure (CPP) and tissue oxygenation to reduce secondary ischemic injury.

TRAUMATIC BRAIN INJURY – TIERS OF THERAPY

TIER ZERO

The following interventions should be strongly considered in all patients with TBI:

- ☐ Maintain mean arterial pressure (MAP) > 80 mmHg if GCS < 8 and no ICP monitor; otherwise target MAP > 70 mmHg
- ☐ Administer supplemental oxygen to maintain SpO2 > 92%
- ☐ Elevate head of bed to 30 degrees
- ☐ Maintain head in neutral position to avoid jugular vein constriction
- ☐ Correct hyponatremia (serum Na+ < 140 mEq/L) with isotonic intravenous fluids (no dextrose)
- ☐ Correct coagulopathy with the appropriate reversal agent in life-threatening bleeds
    - See Anticoagulation Reversal Pathway
- ☐ Transfuse platelets in patients with known history of antiplatelet agent use and for platelet count < 75
- ☐ Avoid hyperthermia (temperature > 38°Celsius)
    - Acetaminophen 650 mg PO/PT q 4 hrs
- ☐ Avoid hyperglycemia (serum glucose > 180 mg/dL)
- ☐ Avoid hypoglycemia (serum glucose < 90)
- ☐ Ensure early appropriate nutritional support
- ☐ Prevent deep venous thrombosis (DVT)
- ☐ Prevent gastrointestinal stress ulceration
- ☐ Prevent skin breakdown / decubitus ulcer formation through appropriate bed surface

TIER ONE

The following interventions should be strongly considered in all patients with Glasgow Coma Score (GCS) < 8:

- ☐ Ensure all physiologic goals from Tier Zero are met
- ☐ **Airway / Breathing**
    - Intubate patient if GCS < 8 and as needed to protect the airway
    - Maintain PaCO2 35-40 mmHg
    - Maintain PaO2 80-120 mmHg
- ☐ **Systemic and Cerebral Perfusion**
    - Consider arterial line (leveled at the phlebostatic axis)
    - Consider central venous catheter for central venous pressure (CVP) monitoring
    - Maintain euvolemia (fluid balance positive by 500-1000 mL in first 24 hrs, CVP > 8 mmHg)
    - Maintain MAP > 80 mmHg if ICP is unavailable
    - Maintain cerebral perfusion pressure (CPP=MAP-ICP) > 60 mmHg if ICP is available
    - If CPP < 60 mmHg, notify intensivist and:
        - ➢ If CVP < 8 mmHg, give normal saline 500-1000 mL bolus
        - ➢ If CVP > 8 mmHg, start norepinephrine 0-0.5 mcg/kg/min IV infusion to maintain CPP
    - Consider ICP monitoring
        - ➢ Indications
            - Salvageable patients with severe TBI (GCS 3-8 after resuscitation) and an abnormal CT scan (hemorrhage, contusions, swelling, herniation or compressed basal cisterns)

- Patients with severe TBI and normal CT scan if two of the following are noted at admission: age >40 yrs, unilateral or bilateral posturing, systolic BP < 90 mmHg
- Patients with TBI who will not be examinable for a prolonged period of time

➢ Management
- Maintain ICP < 20 mmHg
- Consider Osmolar Therapy (see below)
- Consider short-term hyperventilation (PaCO2 30-34 mmHg) to acutely reduce ICP (avoid continued hyperventilation after ICP has been controlled)
- Verify correct ICP waveform on extraventricular drain (EVD); notify neurosurgery if ICP waveform is incorrect or there is no CSF drainage
- Level EVD at the external auditory meatus
- Close EVD and level at 0 mmHg upon insertion to monitor ICP
- If ICP > 20 mmHg for 10 minutes, open EVD at 0 mmHg for 15 minutes
  - If EVD is opened more than 3 times within 90 minutes, leave EVD open at 0 mmHg continuously and notify neurosurgery

☐ **Osmolar Therapy**
- First line therapy

☐ 3% normal saline IV bolus 100-250 mL q 2 hrs prn for ICP > 20 mmHg for > 10 minutes or 23.4% hypertonic saline 30 mL IVP for ICP >20mmHg after two rounds of 3% normal saline
- Alternate therapy
  - ➢ Mannitol 0.25-1.0 gm/kg IV q 6 hrs prn ICP > 20 mmHg
- Measure serum osmolality and electrolytes q 6 hrs
- Notify intensivist if serum Na changes by > 3 mEq/L from previous measurement
- Hold hypertonic saline therapy for serum Na > 160 mEq/L
- Hold mannitol therapy for serum sodium > 160 mEq/L and/or serum osmolality > 320 mOsm

☐ **Protect the Brain**
- Initiate continuous EEG monitoring to rule out non-convulsive status epilepticus on comatose patients for the first 12-24 hours, consider further monitoring in patients at high risk for seizure
- Provide judicious analgesia and sedation to control pain and agitation
  - ➢ Fentanyl 25-150 mcg/hr IV infusion
  - ➢ Propofol 10-50 mcg/kg/hr IV infusion for Richmond Agitation Sedation Score (RASS) > -2
- Exclude seizure activity
  - ➢ Keppra 500 mg IV BID for first 7 days (discontinue after 7 days if no seizure activity)
- Avoid:
  - ➢ Hypotension (MAP < 70 mmHg)
  - ➢ Hypoxemia (SpO2 < 92%)
  - ➢ Hypercarbia (PaCO2 > 45 mmHg)
  - ➢ Hyponatremia (serum Na+ < 140 mEq/L)
  - ➢ Hyperglycemia (glucose > 180 mg/dL)
  - ➢ Hypoglycemia (glucose < 90)
  - ➢ Hypovolemia
  - ➢ Fever (maintain temperature at 36-38°Celsius)
  - ➢ Anemia

TIER TWO

The following interventions should be considered if ICP is persistently > 20 mmHg for more than 60 minutes after discussion with neurosurgery and intensivist attendings:

☐ Ensure all physiologic goals from Tier One are met

☐ Consider head CT scan to rule out space-occupying lesion

☐ Consider continuous EEG monitoring to rule non-convulsive status epilepticus

☐ **Paralysis**
- Start rocuronium (50 mg IVP loading dose, then 8 mcg/kg/hr); adjust dose according to Train of Four

- ☐ **Avoid Hyperthermia**
  - Induce normothermia in febrile patients with goal temperature to 36 - 38° Celsius using the Arctic Sun™ cooling pads
- ☐ **Mild Hyperventilation**
  - Begin mild hyperventilation with goal PaCO2 30-34 mmHg, with restoration of normocarbia after ICP goal reached

TIER THREE

The following interventions should be considered if ICP remains > 20 mmHg despite all Tier Two goals being met:

- ☐ Ensure that medical therapy with hypertonic saline is maximized
- ☐ Consider revised ICP threshold of 25 mmHg with strict adherence to CPP goals
- ☐ Initiate continuous EEG (if not already present)
- ☐ 3% normal saline IV bolus 100-250 mL q 2 hrs prn for ICP > 20 mmHg for > 10 minutes or 23.4% hypertonic saline 30 mL IVP for ICP >20mmHg after two rounds of 3% normal saline OR Mannitol bolus as above, depending on volume status and prior response
- ☐ **Surgical Decompression**
  - ➢ Consider decompressive craniectomy in consultation with neurosurgery team
- ☐ **Avoid Hyperthermia**
  - ➢ Induce normothermia in febrile patients with goal temperature to 36 - 38° Celsius using external cooling devices
- ☐ **Barbiturate Coma**
  - ➢ If not a surgical candidate, and refractory to all above interventions, consider pentobarbital coma
    - Pentobarbital 10 mg/kg IV over 10 minutes, then 5 mg/kg IV q 1 hr x 3, then 1 mg/kg/hr IV infusion
    - Titrate pentobarbital to the minimal dose required to achieve EEG burst suppression
    - Discontinue all other sedative agents and paralytics
    - Strongly consider invasive hemodynamic monitoring (such as pulmonary artery catheter) due to the negative inotropic effects of pentobarbital
    - Once ICP < 20 mmHg for 48 hrs, taper pentobarbital dose over the next 48-72 hrs