

3. CRANIOFACIAL, NECK & SPINE GUIDELINES
D. Severe Traumatic Brain Injury

OBJECTIVE: Traumatic Brain Injury (TBI) - The Brain Trauma Foundation, Neurocritical Care Society, and the American College of Surgeons provide Guidelines or Consensus Statements informing best care for patients with TBI. However, care should be individualized as Guidelines do not reflect best care for every patient.

GUIDELINE: TBI is defined as a patient sustaining an alteration in brain function or other evidence of brain pathology caused by an external force and severe TBI is determined when the post-resuscitation Glasgow Coma Score is less than 9.

Management and Neurosurgery consultation of the patient with TBI is based on Brain Injury Guideline (BIG) Criteria (see Table 1).

Table 1 – BIG Criteria

BRAIN INJURY GUIDELINE			
Variables	BIG 1	BIG 2	BIG 3
Abnormal Neurologic exam *	No	No	Yes
Intoxication	No	No/Yes	No/Yes
CAP/DOAC	No	No	Yes
Skull Fracture	No	Non-displaced	Displaced
SDH	≤ 4 mm	5 - 7 mm	≥ 8 mm
EDH	≤ 4 mm	5 - 7 mm	≥ 8 mm
IPH	≤ 4 mm, 1 location	5 - 7 mm, 2 locations	≥ 8 mm, multiple locations
SAH	Trace	Localized	Scattered
IVH	No	No	Yes
Midline Shift	None or < 2 mm	None or < 2 mm	≥ 2 mm
Coagulopathy present	No	No	Yes
THERAPEUTIC PLAN			
Hospitalization	No Observation (6 hrs)	Yes	Yes
Repeat Head CT	No	No	Yes
Neurosurgery Consult	No	No	Yes
Admit to ICU	No	No	Yes

BIG: brain injury guidelines; CAP: Coumadin, Aspirin, Plavix; DOAC: Direct Oral Anticoagulants, Eliquis, Pradaxa, Xarelto; EDH: epidural hemorrhage; IVH: intra-ventricular hemorrhage; IPH: intra- parenchymal hemorrhage; LOC: loss of consciousness; NSC: neurosurgical consultation; RHCT: repeat head computed tomography; SAH: subarachnoid hemorrhage; SDH: subdural hemorrhage.
* GCS ≤ 13 is considered abnormal

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A. Criteria for Neurosurgical Response <30 minutes:

- Penetrating intracranial injury with GCS greater than 5 and less than 13
- Acute Subdural Hematoma greater than 10 mm, midline shift > 5 mm, and GCS < 9
- Acute Epidural Hematoma greater than 18 mm, midline shift > 4 mm (lesions > 30 cm³), and GCS < 9
- Posterior Fossa (cerebellar) ICH with hydrocephalus and GCS < 9

A. INTRACRANIAL Pressure (ICP) Monitoring:

- Patients with GCS ≤ 8 and abnormal CT scan.
- Routine sampling of CSF is not supported due to the increased risk of infection (Neurocritical Care Society EVD Consensus Statement). CSF should only be sampled when meningitis/ventriculitis is suspected - fever alone is not reason to open a CSF line.
- All ICP monitors should be checked for function by verifying the presence of a waveform once per shift so long as ICP is not elevated and it is otherwise safe to do so. (abnormal response may consider displacement of the monitor)
- All patients requiring ICP monitoring require placement of an arterial line and central venous access. Central Line placement in the jugular veins should be avoided.

C. Anti-Epileptic Treatment

Should be administered to all patients with TBI for no longer than 7 days. A longer course may be considered for patients exhibiting seizure activity, penetrating brain trauma, or other high-risk findings.

High-risk criteria for development of post traumatic seizures:

1. acute subdural, epidural, or intracerebral hematoma (SDH, EDH, or ICH)
2. open-depressed skull fracture with parenchymal injury
3. seizure within the first 24 hours after injury
4. GCS < 10
5. Penetrating Brain Injury
6. History of significant alcohol use
7. Cortical (hemorrhagic) Contusion on CT

Keppra 1000 mg load followed by 500 mg IV/PO BID

- In select cases, Fosphenytoin may be used as an alternative (requires level check; levels in the high therapeutic range (15-20) are most beneficial).

D. Anesthetics, Analgesics, Sedation:

- Every effort should be made to preserve the clinical exam.
- Fentanyl and Propofol are the first line choices for analgesia and sedation as they are titratable and have short half-lives allowing for serial neurological examinations.
- Every patient should have a morning sedation holiday with documented neurologic exam off sedation at least every 24 hours with q1h RASS & pupillary exams.
- Benzodiazepines, such as midazolam or lorazepam, are Tier 3 use for refractory ICPs
- Barbiturate prophylactic use should be avoided.

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- May be used only to manage refractory ICP (only after consultation with neurosurgery regarding initiating use in lieu of decompressive craniotomy or subsequent to decompressive craniectomy)
 - The discontinuation of barbiturates should be considered if ineffective at controlling ICP after 24 hours.
- E. Deep Venous Thrombosis (DVT) Prophylaxis:
- Mechanical prophylaxis should be employed early after admission.
- F. Chemical VTE prophylaxis will be initiated per the chemical VTE prophylaxis guidelines
- Nutrition:
- Tube feedings initiated within 24 hours unless contraindicated.
 - If the patient is intubated and has GCS < 9, then feedings should be started as soon as logistically feasible.
 - 140% of patient's metabolic needs should be replaced if they are not paralyzed and 100% if they are paralyzed.
 - 15% of calories replaced should be provided as protein.
- E. Blood pressure/ Cerebral Perfusion Pressure (CPP):
- If ICP is being monitored, target pressures for vasoactive medications should be based on CPP. In severe TBI, the standard starting CPP target range is 60-70 mmHg.
 - As a general rule, systolic blood pressure less than 200 mmHg should not be iatrogenically reduced after TBI because this increased risk of cerebral ischemia.
 - CPP target goals will be based on patient's auto regulatory status. Autoregulating patients usually require higher CPP and may benefit from CPP greater than 70 mmHg, those not auto regulating usually benefit from lower CPP.
 - Autoregulation may be best identified with Pressure Reactivity Index (PRx)
 - CPP direct therapy is associated with a reduction in 2-week mortality (4th Ed BTF Guidelines).
- F. Hyperosmolar Therapy/ Hypertonic Saline Administration:
- Every patient receiving hypertonic/ hyperosmolar therapy needs serum sodium and osmolality order q6h.
 - In the absence of ICP elevation, normal serum sodium (135-145 mEq/mL) should be maintained.
 - Continuous infusion of 3% HTS is the preferred approach to correct hyponatremia in hypovolemic or euvolemic patients.
 - Bolus of 23.4% saline must be administered via central line. Continuous cardiac monitoring must be in place during the infusion, and care providers must watch closely for physiologic changes that might prompt a cessation or slowing of the infusion.
 - 3% saline infusions that exceed a rate of 50 mL/hr must be administered via a central line. Bolus dosing of 3% hypertonic saline can be performed concurrent with a continuous infusion and must be administered via central line.
 - Hyperosmolar therapy should not be administered prophylactically (in the absence



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of intracranial pressure elevation or neurological decline).

- Hypotonic IV fluids along with D5 containing fluids are absolutely contraindicated except in rare instances.
- Mannitol, cutoff for administration is Na > 155 mEq/mL and serum osmoles > 320 Osm/kg
- Hypertonic Saline, cutoff for administration is Na > 160 and serum osmoles > 360 Osm/kg
- Mannitol (0.25 - 1 g/kg) may be considered for use in patients without ICP monitoring who exhibit clinical decline but requires Attending approval.
- If mannitol is used, hypovolemia must be avoided, and if it occurs, use of mannitol should be avoided. Therefore, Hypertonic Saline remains the first line of treatment.

I. Glucose:

- Hyperglycemia is associated with exacerbation of hypoxic ischemic brain injury and may lead to worse overall outcome
- Goal serum glucose 100-180 mg/dl
 - Initiate insulin drip if two serum glucose measurements > 250 mg/dl or a single measurement > 300 mg/dl; aim to keep glucose < 180 mg/dl
 - Priority in glycemic management is avoiding hypoglycemia (serum glucose < 100 mg/dl)

J. Temperature:

- Goal temperature < 38.0 °C
- Tylenol for T > 38.3 °C, Cultures for T > 38.5 °C
 - consider Arctic Sun for sustained temperature > 38.5 °C not relieved with Tylenol and less invasive cooling measures.
- Warming Blanket for Temperature < 35.5 °C
- Prophylactic hypothermia not recommended

K. Infection Prophylaxis:

- There is no evidence to recommend routine antibiotic prophylaxis for intracranial monitors, and routine exchange of ventricular catheters is not recommended.
- Level II recommendations are to pursue early tracheostomy (< 7 days) to reduce days of mechanical ventilation, but this does not affect mortality or risk of pneumonia.

L. Hematocrit/Hemoglobin:

- Although blood transfusion should be avoided in general, it is recognized that increasing hemoglobin levels is the most efficient means for increasing oxygen delivery if that is a target or goal. CPP control is a means for ensuring oxygen delivery.
- Every attempt should be made to achieve a platelet count > 100,000 prior to neurosurgical procedure. INR should generally be kept < 1.5

M. Mechanical Ventilation:

- All patients should have continuous ETCO₂ monitoring. The goal in Severe TBI with elevated ICP is ETCO₂ 30-35 and 35-45 if no signs of elevated ICP.



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- PaCO₂ goal of 35-40 mmHg unless otherwise instructed. In patients requiring ICP monitoring consider an end-tidal CO₂ monitor. PaO₂ goal of > 70 to 90 mmHg (hyperoxia PaO₂ > 100 can be detrimental and should be avoided).
- Do not hyperventilate patient without signs of herniation.
- Low PaCO₂ values are harmful especially in the first 24 hours of injury and when sustained. Initial target should be pCO₂ 35-40.
- Lower levels of PCO₂ can be effective in lowering the ICP but should only be targeted if there is concurrent PbtO₂ or JVO₂ sat monitoring. It is also known that hyperventilation effects are only temporary and should only be used if patient is to undergo emergent decompressive craniectomy and there is threat of impending herniation.
- ABG results outside of target range must have corrective action within an hour of an abnormal result evidenced by ventilator changes and new ABG order.

N. Intracranial Pressure:

1. Patients should not be treated with therapies to lower ICP prophylactically (e.g., cooling, sedation, paralysis, or hyperosmolar therapy)
2. ICP treatment threshold is 22 mmHg (4th Ed BTF Guidelines)
3. Sustained ICP elevation > 22 mmHg requires evaluation and intervention:
 1. Patient positioning
 - a. Head of bed > 30°
 - b. C-Collar adjustment/ loosen
 2. Evaluate sedation and analgesia (see Anesthetics, Analgesics, Sedation above)
 3. PaCO₂/ EtCO₂ evaluation (goal 35- 40)
 4. Osmotic therapy (see Serum Electrolytes/osmolality above)
 5. If above medical management fails to lower ICP- STAT Neurosurgery notification
6. If ICP cannot be controlled, every effort should be made to maintain an acceptable CPP
7. Auto regulatory principles can be exploited as an adjunctive approach to normalize ICP

O. Early Tracheostomy and Percutaneous Endoscopic Gastrostomy:

- Should be considered in patients with GCS ≤ 8 (sustained for greater than 24 hours) with CT scan demonstrating TBI.
- < 7 days after ICU admission.

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