



Severe Traumatic Brain Injury Protocol

PROTOCOL

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Patient Management: Evidence and Rationale

a. Anti-seizure Prophylaxis



Abbreviations

AMS = Altered Mental Status
BID = Twice a Day
BMP = Basic Metabolic Panel
CPAP = Continuous Positive Airway Pressure
CPK = Creatinine Phosphokinase
CPP = Cerebral Perfusion Pressure
CrCl = Creatinine Clearance
CT = Computed Tomography
DVT = Deep Vein Thrombosis
EEG = Electroencephalogram
EtOH = Ethanol (Alcohol)
EVD = Extraventricular Drain
GCS = Glasgow Coma Score
GI = Gastrointestinal
Hct = Hematocrit
Hgb = Hemoglobin
HOB = Head of Bed
IV = Intravenous
ICP = Intracranial Pressure
MAP = Mean Arterial Pressure
Mg²⁺ = Magnesium
NCSE = Non-convulsive Status Epilepticus
OT = Occupational Therapy
PbtO₂ = Partial Pressure of Oxygen in Brain Tissue
PEG = Percutaneous Endoscopic Gastrostomy
PFA = Platelet Function Assay
pCO₂ = Partial Pressure of Carbon Dioxide in Serum
PO₄⁻ = Phosphorus
PTD = Post-Trauma Day
PPI = Proton Pump Inhibitor
PPx = Prophylaxis
PT = Physical Therapy
QD = Daily
SBP = Systolic Blood Pressure
SBT = Spontaneous Breathing Trial
SubQ = Subcutaneous
TBI = Traumatic Brain Injury
TID = Three Times a Day



Protocol

I. Background/Objective

To delineate an inpatient workflow and set of guidelines that is based on best evidence to date in regards to the management of severe TBI in adults – all in an effort to improve clinical outcomes and minimize adverse events. This protocol is based, largely, on data and recommendations from the 2016 (4th Edition) Guidelines put forth by the Brain Trauma Foundation.

II. Definition of Severe TBI

This protocol is intended for patients who meet the following criteria:

1. Age \geq 18 years
2. GCS \leq 8 – **MUST** have Motor Score $<$ 6 (not following commands)
3. Clinical History/Radiographic Evidence/Mechanism of Injury concerning for TBI
4. Normoglycemic and Normotensive
5. Not actively having seizures (excluding non-convulsive status epilepticus)
6. Not meet criteria for Clinical Brain Death (see UHS Brain Death Protocol)

III. Patient Care: Parameters

IF ANY OF THESE PARAMETERS ARE NOT MET, PLEASE NOTIFY PHYSICIAN ON CALL

- ✓ Maintain head at neutral alignment with HOB at 30° elevation
- ✓ Clear C-spine and remove cervical collar based on CT C-spine alone
- ✓ Maintain normothermia: 36.5°C – 38.0°C (97.7°F – 100.4°F)
- ✓ Maintain normocapnia: pCO₂ 35 – 45 mmHg
- ✓ Maintain normotension with MAP \geq 65 mmHg
 - Maintain SBP at \geq 100 mm Hg for patients 50 to 69 years old
 - Maintain SBP \geq 110 mm Hg or above for patients 15 to 49 or over 70 years old
- ✓ ICP: $<$ 22 mmHg and CPP: $>$ 60 mmHg
- ✓ PbtO₂: $>$ 20 mmHg
- ✓ EVD open at 10 cm H₂O (leveled at midbrain) unless otherwise specified, close every 1 hour and record ICP reading following 5 minutes of equilibration
- ✓ Neurochecks, pupillometry & vital signs hourly
- ✓ Sedation holiday for 1 hour at 5am and 5pm daily (see NSICU Analgesia & Sedation Protocol)
- ✓ If intubated and ventilated, perform CPAP/SBT for at least 30 minutes every morning (30 minutes after holding sedation as tolerated) unless not appropriate based on MD recommendation
- ✓ If patient begins to follow commands order PT/OT/Rehab evaluations



IV. Patient Care: Management Timeline (First 7 days of TBI)

Post-Trauma Day (PTD) #0

- Placement of indwelling intracranial monitors by Neurosurgery
- Load with Levetiracetam 20 mg/kg IV once, then start weight-based dosing at 10 mg/kg BID unless not deemed appropriate by MD recommendation (adjust for renal impairment)
- Start GI PPx (H2-antagonist or PPI)
 - Famotidine 20 mg IV BID*
 - Ranitidine 150 mg enteral BID*
 - Pantoprazole 40 mg IV daily
 - Pantoprazole 40 mg enteral daily
- * Adjustment to daily dosing for renal CrCl < 50 ml/min
- Start Fentanyl +/- Propofol Drips if sedation/analgesia is needed (see NSICU Analgesia & Sedation Protocol)
- Obtain the following in addition to Rainbow Labs:
 - Urine Drug Screen and EtOH
 - For patients on antiplatelet medications (aspirin, clopidogrel, prasugrel, etc.) or if medication history is unobtainable:
 - Order PFA-100
 - Order VerifyNow Aspirin assay
 - Order VerifyNow Plavix assay
 - Serum Triglycerides and CPK
 - If started on Hypertonic Therapy: q6h BMP, Mg²⁺, PO₄⁻
 - If female: Pregnancy Test

PTD#1

- Typical morning labs (CBC, BMP) with ABG
- Clear c-collar based on CT c-spine if present and not done already
- Obtain morning CT Head (-) @ 4:00am
 - If stable, start Unfractionated Heparin SubQ for DVT PPx
 - < 50 kg or age > 75 years: 5000 Units BID
 - ≥ 50 kg: 5000 Units TID
 - If unstable, Neurosurgery will comment on DVT PPx
- Sedation Holiday @ 5:00 am
- CPAP/SBT @ 5:30 am



- Perform Neurological Exam during Sedation Holiday -- if patient remains GCS < 8 and not following commands:
 - Rule out metabolic and other reversible causes for AMS
 - Order continuous 24-hour EEG
 - Order TCD
 - Begin nutritional support if no contraindications

PTD#2

- Typical morning labs (CBC, BMP) with ABG
- Repeat sedation holiday with CPAP/SBT and Neuro Exam -- if patient remains GCS < 8 and not following commands
 - Order TCD

PTD#3

- Typical morning labs with ABG
- Obtain CT Head (-) and CTA @ 4:00am, unless clinical contraindication.
- If head CT stable, and CrCl \geq 30 ml/min, ok to switch to enoxaparin 30 mg BID for DVT prophylaxis (If BMI > 40, enoxaparin 40 mg BID)
- Repeat sedation holiday with CPAP/SBT and Neuro Exam
- Neurocritical Care/Ethics team screening

PTD#4

- Repeat sedation holiday with CPAP/SBT and Neuro Exam -- if patient remains GCS < 8 and not following commands:
 - Arrange for inter-disciplinary Family Meeting
 - Consider Social Work, Case Management, and Palliative Medicine
 - Order TCD if CTA showed vasospasm

PTD#5

- Obtain repeat CT Head (-) @ 4:00am
 - If stable, Neurosurgery will remove Codman ICP monitor and Licox
 - EVD remains at 10cmH₂O above midbrain
- Repeat sedation holiday with CPAP/SBT and Neuro Exam – if patient remains GCS < 8 and not following commands:
 - Consider Trach/PEG

PTD#6

- If no ICP issues, raise EVD to 15cmH₂O above midbrain
- Repeat sedation holiday with CPAP/SBT and Neuro Exam



PTD#7

- If no ICP issues, raise EVD to 20cmH2O
- Repeat sedation holiday with CPAP/SBT and Neuro Exam -- if patient remains GCS < 8 and not following commands:
 - Consider Trach/PEG or Goals of Care Discussion

V. Nursing Care: Communication Orders

Please notify Neurosurgery Resident On-call for any of the following:

- MAPs < 65 or Maintain SBP at ≥ 100 mm Hg for patients 50 to 69 years old and Maintain SBP ≥ 110 mm Hg or above for patients 15 to 49 or over 70 years *
- ICPs ≥ 22 mmHg *
- CPPs < 60 mmHg *
- Serum Na ≤ 135 or ≥ 155 mEq/L
- PbtO₂ < 20 mmHg

*only if values persist for more than 5 minutes after initial troubleshooting:

Please record values for the following parameters every hour when available:

- Neurochecks (especially pupillary size and response)
- Pupillometry
- Vital Signs
- ICP, MAP, CPP
- PbtO₂ (Licox)

VI. Neurosurgery Care

- Intracranial Monitoring
 - If OR for craniotomy/hemicraniectomy and GCS remains < 8 post operatively:
 - Intra-op Codman ICP monitor placement
 - Post-op contralateral EVD placement
 - Post-op contralateral Licox placement
 - If no OR:
 - Placement of Codman ICP monitor, EVD, Licox
- No MRI Brain / Cervical Spine in the acute post-trauma period!!
- No administration of mannitol / hypertonic saline without ICP to support administration (see Hypertonic Saline Guidelines for Use in Adults)



APPENDIX

Patient Parameters: Evidence and Rationale

A. Positioning

- Head in neutral alignment with HOB at 30° elevation allows for optimization of venous return

B. C-spine Clearance

- Meta-analysis of 14,327 patients with blunt trauma (Panczykowski et al, 2011)
 - Sensitivity and specificity of modern CT C-spine for diagnosis of a cervical spine injury following blunt trauma is > 99.9%
 - Negative likelihood of an unstable cervical spine injury in the setting of a negative CT C-spine is < 0.001%
 - Negative predictive value of normal CT C-spine is 100%

C. Temperature

- TBI Guidelines (Brain Trauma Foundation, 2007)
 - Level I: None
 - Level II: None
 - Level III: Prophylactic hypothermia is not significantly associated with decreased mortality when compared with normothermic controls. Preliminary findings suggest a greater decrease in mortality risk when target temps are maintained for > 48 hrs

D. Ventilation (pCO₂)

- TBI Guidelines (Brain Trauma Foundation, 2007)
 - Level I: None
 - Level II: Prophylactic hyperventilation (PaCO₂ of 25 mmHg or less) is not recommended.
 - Level III: Hyperventilation is recommended as a temporizing measure for the reduction of elevated ICP.
 - Level III: Hyperventilation should be avoided during the first 24 hrs after injury when CBF is often critically reduced.
 - Level III: If hyperventilation is used, jugular venous oxygen saturation (SjO₂) or brain tissues oxygen tension (PbtO₂) measurements are recommended to monitor oxygen delivery.



E. Blood Pressure and Oxygenation (PbtO₂)

- TBI Guidelines (Brain Trauma Foundation, 2007)
 - Level I: None
 - Level II: BP should be monitored and Hypotension (SBP < 90 mmHg) avoided.
 - Level III: Oxygenation should be monitored and Hypoxia (PaO₂ < 60 mmHg or O₂ sat < 90%) avoided.

F. ICP Management

- TBI Guidelines (Brain Trauma Foundation, 2007)
 - Level I: None
 - Level II: Treatment should be initiated when ICP is above 20 mmHg.
 - Level III: A combination of ICP values, clinical exam, and CT findings should be used to determine the need for treatment.

G. CPP Management

- TBI Guidelines (Brain Trauma Foundation, 2007)
 - Level I: None
 - Level II: Aggressive attempts to maintain CPP above 70 mmHg with fluids and pressors should be avoided because of the risk of ARDS.
 - Level III: CPP < 50 mmHg should be avoided
 - Level III: Ancillary monitoring including blood flow, oxygenation, or metabolism facilitates CPP management.

H. Brain Tissue Oxygenation

- PbtO₂ monitors have been shown to provide unique clinical data independent of ICP or CPP.
 - Several authors have noted that cerebral ischemia may occur despite adequate CPP values.
 - As such, PbtO₂ represents an adjunctive means of evaluating the perfusion status of local cerebral tissue.
- TBI Guidelines (Brain Trauma Foundation, 2007)
 - Level I: None
 - Level II: None
 - Level III: Jugular venous saturation < 50% or brain tissue oxygenation (PbtO₂) < 15 mmHg are treatment thresholds



Patient Management: Evidence and Rationale

- Anti-seizure Prophylaxis
 - Keppra (Levetiracetam) has been shown to be just as effective as Dilantin (Phenytoin) for preventing early post-traumatic seizures; but with a milder side-effect profile and no need to monitor serum drug levels.
 - TBI Guidelines (Brain Trauma Foundation, 2007)
 - Level I: None
 - Level II: Prophylactic use of phenytoin or valproate is not recommended for preventing late post-traumatic seizures (PTS).
 - Level II: Anticonvulsants are indicated to decrease the incidence of early PTS (within 7 days of injury). However, early PTS is not associated with worse outcomes.

References

Carney N, et al. Guidelines for the Management of Severe Traumatic Brain Injury 4th Edition.

Brain Tissue Oxygen Monitoring in Traumatic Brain Injury (BOOST 2) Trial

Manley G, et al. Hypotension, Hypoxia and Head Injury. *Arch Surg* 2001;136:1118-1123.

Marmarou A, et al. Impact of ICP instability and hypotension on outcome in patients with severe head trauma. *J Neurosurg* 1991;75(1):S59-S66.

Panczykowski DM, Tomycz ND and Okonkwo DO. Comparative effectiveness of using computed tomography alone to exclude cervical spine injuries in obtunded or intubated patients: meta-analysis of 14,327 patients with blunt trauma. *J Neurosurg* 2011;115(3):541-9.

Picetti E, et al. Intra-hospital transport of brain-injured patients: a prospective, observational study. *Neurocrit Care* 2013;18(3):298-304.

Stiefel MF, et al. Reduced mortality rate in patients with severe traumatic brain injury treated with brain tissue oxygen monitoring. *J Neurosurg* 2005;103(5):805-11.