BỆNH VIỆN ĐẠI HỌC Y DƯỢC
THÀNH PHỐ HỒ CHÍ MINH®
UNIVERSITY MEDICAL CENTER HCMC
Thấu hiểu nỗi đau - Niềm tin của bạn

Optimization of Patients with Traumatic Brain Injury Before Surgery

LE Hong Chinh. MD

University Medical Center HCMC

Introduction

The burden (USA)

- 3.3–5.3 million people affected per year
- Direct cost: $9.2 billion/year ($13.1 billion in 2013)
- $51.2 billion lost to missed work and reduced productivity
- Leading causes: falls, motor-vehicle crashes, assault; males affected ~2× more than females
- Older adults: highest rates of TBI-related hospitalization and death in those ≥75; falls cause 51% of TBI in older adults

Farrell.Current Anesthesiology Reports (2018) 8:279–289

Introduction

Severity

- Classified by the Glasgow Coma Scale (GCS); severe TBI = GCS ≤ 8
- Mortality closely tracks the initial GCS score

Primary vs. secondary injury

- **Primary injury:** Primary injury occurs at the moment of trauma due to mechanical forces applied to the skull and brain, causing direct neuronal tissue damage.
- **Secondary injury:** begins immediately after the primary injury and evolves over time through neuroinflammation, blood–brain barrier disruption, cerebral edema, increased ICP, ischemia, and cell death; this cascade may be modified to improve outcomes.

Farrell.Current Anesthesiology Reports (2018) 8:279–289

Concept of “high quality” perioperative traumatic brain injury care

Edoardo Picetti. Minerva anestesiologica 2022 May;88(5):380-9

Two scenarios the anesthesiologist will face

Isolated severe TBI

- Defined by GCS ≤ 8
- Highly lethal early: about half of severe TBI patients die within 2 hours of injury

Severe TBI within polytrauma

- Polytrauma complicates up to 70% of TBI cases
- Polytrauma = AIS ≥ 3 injuries in ≥ 2 body regions,
- Plus ≥ 1 of: SBP ≤ 90 mmHg; GCS ≤ 8; BE ≤ −6.0; INR ≥ 1.4 or PTT ≥ 40 s; age ≥ 70.
- 50–60% die within 4 hours (in-scene, ED, or OR); a substantial proportion of survivors die within 24 hours

Picetti. J. Clin. Med. 2022, 11, 18

Two scenarios the anesthesiologist will face

Polytrauma with Severe TBI

- Limited evidence guides management during emergency extracranial surgery.
- Treatment varies widely among trauma centers.
- Care must balance hemorrhage control with neuroprotection.
- Main priorities: cardiorespiratory optimization, coagulation/transfusion management, prevention of secondary brain injury, and selected use of SMS.

Picetti. J. Clin. Med. 2022, 11, 18

Hemodynamic Management

In polytrauma

- Hemorrhage control and massive transfusion are major priorities.
- Permissive hypotension may be used to reduce bleeding, but it is not appropriate when severe TBI is present.

In polytrauma with TBI

- Hypotension must be avoided to preserve cerebral perfusion and prevent secondary brain injury.
- Recommended targets:
  - SBP ≥ 100 mmHg in patients aged 50–69 years
  - SBP ≥ 110 mmHmmHgg in patients aged 15–49 years or >70 years
  - MAP ≥ 80 in severe TBI

Cannon. J. Trauma Acute Care Surg. 2017, 82, 605–617.
Carney. Neurosurgery 2017, 80, 6–15.

Hemodynamic Management

Normal saline vs. balanced fluids:

- Isotonic saline is suggested over balanced crystalloids for volume expansion in adult critically ill patients with TBI.
- More hypotonic balanced crystalloids, such as Ringer's lactate or acetate, should probably be avoided.
- Clinical implication: Normal saline is the preferred fluid in TBI to reduce mortality.
- For other acute brain injuries such as SAH or ICH, current evidence is insufficient to prefer normal saline over balanced solutions.

Regenmortel. Intensive Care Med (2025) 51:1904–1908

Hemodynamic Management

Albumin

- Isotonic saline is suggested over albumin for volume expansion in adult critically ill patients with TBI.
- Clinical implication: Albumin is not preferred for resuscitation or maintenance in brain-injured patients due to limited evidence and possible harm, especially with hypo-osmolar albumin solutions.

Glucose-containing fluids

- No recommendation.
- Clinical implication: Glucose-containing hypo-osmolar fluids are not advised for resuscitation or maintenance.

Regenmortel. Intensive Care Med (2025) 51:1904–1908

Respiratory Management

- In polytrauma without TBI, prehospital SpO_2 < 94% is associated with higher in-hospital mortality and worse disability.
- In TBI, even a single episode of SpO_2 ≤ 92% increases mortality and disability. Therefore, strict oxygenation control is essential to prevent secondary brain injury.
- However, hyperoxia has been linked to worse outcomes in TBI, possibly due to cerebral/coronary vasoconstriction and oxygen free radical toxicity.
- Current evidence is mixed, but oxygen therapy should aim to avoid both hypoxemia and severe hyperoxia.

Chu. Lancet 2018, 391, 1693–1705
Baekgaard. Crit. Care 2020, 24, 604

Respiratory Management

- $PaCO_2$ abnormalities should be avoided in the acute phase of TBI.
- Hypocapnia from hyperventilation can reduce ICP but may cause cerebral vasoconstriction, ischemia, and worse neurological outcomes.
- Hyperventilation may also increase airway pressure, reduce venous return, and worsen hypotension in bleeding trauma patients.
- Hypercapnia can increase cerebral blood volume and exacerbate intracranial hypertension.
- Recommended target in TBI: $PaCO_2$ 35–40 mmHg.Temporary hypocapnia should be reserved for suspected cerebral herniation while awaiting or during emergency neurosurgery.

Picetti. World J. Emerg. Surg. 2019, 14, 53

Airway Management in TBI

- Indication for endotracheal intubation and rapid sequence induction: GCS ≤ 8.
- Cervical spine injury occurs in about 3.5–6.2% of trauma patients and should always be suspected in TBI.
- Endotracheal intubation and patient repositioning should minimize cervical spine movement.
- Video laryngoscopy with cervical immobilization may reduce upper cervical motion compared with Macintosh laryngoscopy and allows faster intubation than flexible bronchoscopy.
- Awake flexible bronchoscopic intubation minimizes cervical movement but requires expertise and may be difficult in patients with impaired consciousness.

Carney. Neurosurgery 80:6–15, 2017
Kim. Anesth Pain Med 2023;18:104-113

Airway Management in TBI

- Avoid nasotracheal intubation when skull base fracture is suspected due to risk of intracranial tube passage.

Tracheostomy in Severe TBI

- Tracheostomy is commonly performed in ICU patients with TBI, often after the first week.
- Early tracheostomy may reduce duration of mechanical ventilation, ICU and hospital length of stay, and ventilator-associated pneumonia.
- BTF guidelines recommend early tracheostomy when expected benefits outweigh the risk of complications.

Carney. Neurosurgery 80:6–15, 2017
Kim. Anesth Pain Med 2023;18:104-113

Glycemic Control in TBI

- Trauma can cause stress-induced hyperglycemia through increased stress hormones, cytokines, insulin resistance, and altered insulin secretion.
- Stress-induced hyperglycemia is associated with higher morbidity and mortality, but may reflect injury severity rather than direct causation.
- Strict glucose control has not shown clear benefit and may increase harm, including hypoglycemia.
- Tight control to keep glucose <110 mg/dL is generally not required and may be detrimental.
- A moderate strategy aimed at avoiding both hyperglycemia and hypoglycemia appears safer

Kim. Anesth Pain Med 2023;18:104-113

Temperature Management in TBI

- Fever is common after severe TBI and may worsen neurological recovery.
- Evidence supports maintaining normothermia in patients with TBI.
- Prophylactic hypothermia has not improved 6-month neurological outcomes and is not recommended by BTF guidelines.
- Hypothermia may reduce refractory intracranial hypertension, but should not be used routinely as a neuroprotective strategy.
- Core body temperature may not accurately reflect brain temperature; direct brain temperature monitoring is more accurate but not routinely available

Kim. Anesth Pain Med 2023;18:104-113

Coagulation and Transfusion Management

- In bleeding trauma patients, RBC transfusion is generally recommended Hb is 7–9 g/dL.
- The optimal Hb threshold in polytrauma patients with TBI remains uncertain.
- Most evidence supports a restrictive transfusion strategy; trials show no clear mortality or neurological benefit with liberal transfusion.
- In hemodynamically stable patients, RBC transfusion is recommended when Hb < 7 g/dL.
- In unstable patients or those with cardiovascular disease, transfusion should be individualized.
- Coagulation management should balance hemorrhage control with prevention of secondary brain injury.

Spahn. Crit. Care 2019,23, 98.
McIntyre. Neurocrit. Care 2006, 5,4–9.

Coagulation and Transfusion Management

Transfusion Ratios in Massive Bleeding

- Massive transfusion is often required in bleeding polytrauma patients, especially when TBI is present.
- Initial transfusion protocol should use plasma:platelets:RBC = 1:1:1.
- The ratio can later be adjusted based on laboratory values and POC coagulation tests.
- Compared with 1:1:2, the 1:1:1 strategy improves hemostasis and reduces death from exsanguination within 24 hours, although overall mortality is similar.

Picetti. J. Clin. Med. 2022, 11, 18

Coagulation and Transfusion Management

- Trauma-related coagulopathy increases mortality and may worsen intracranial hematoma progression and neurological outcomes.
- In life-threatening bleeding or emergency neurosurgery:
  - Maintain platelets >50,000/mm^3
  - Target >100,000/mm^3 if ongoing bleeding, TBI, or neurosurgery/ICP probe insertion
  - Keep PT and aPTT ≤1.5 times normal
- Point-of-care tests such as TEG/ROTEM may help guide individualized coagulation therapy.
- TXA should be given within 3 hours in actively bleeding trauma patients; in TBI, may benefit mild–moderate TBI, but has no clear benefit in severe TBI.

Spahn. Crit. Care 2019,23, 98.
Picetti. J. Clin. Med. 2022, 11, 18

Perioperative Brain Protection

ICP/CPP Monitoring in Polytrauma with TBI

- Intracranial hypertension and low CPP can worsen secondary brain injury and increase mortality/disability.
- CPP = MAP − ICP; therefore, both blood pressure and ICP control are critical.
- ICP > 22 mmHg is associated with increased mortality.
- In comatose TBI patients with CT signs of intracranial hypertension, invasive ICP monitoring should be considered after life-threatening bleeding is controlled.
- ICP monitoring may help detect and treat intracranial hypertension or low CPP during emergency extracranial surgery.

Carney. Neurosurgery 80:6–15, 2017
Picetti. J. Clin. Med. 2022, 11, 18

Perioperative Brain Protection

Perioperative ICP/CPP Management

- Perioperative management in severe TBI focuses on controlling ICP and maintaining adequate CPP.
- Key targets include CPP 60 -70 mmHg and early treatment of intracranial hypertension.
- In suspected cerebral herniation, osmotherapy and temporary hypocapnia may be used while awaiting or during emergency neurosurgery.
- A stepwise approach is recommended: escalate therapy gradually and reserve aggressive interventions for refractory intracranial hypertension.
- Advanced neuromonitoring, such as brain tissue oxygenation, may help personalize therapy in complex cases, but may not be available early and can increase information burden

Carney. Neurosurgery 80:6–15, 2017
Picetti. J. Clin. Med. 2022, 11, 18

Perioperative Brain Protection

Maintaining CPP by *Reducing ICP*

- Lower ICP to maintain CPP using CSF drainage, if feasible.
- Optimize cerebral venous drainage: head elevation 30° and neutral neck position.
- Prolonged prophylactic hyperventilation with PaCO2 of 25 mmHg or less is not recommended.
- Use hyperosmolar therapy such as mannitol or hypertonic saline to reduce cerebral edema.
- In stable patients, mannitol 0.25–1 g/kg may be given slowly over 15 minutes to avoid hypovolemia and hypotension.

Carney. Neurosurgery 80:6–15, 2017
Kim. Anesth Pain Med 2023;18:104-113

Perioperative Brain Protection

Maintaining CPP by *Reducing ICP*

- Hypertonic saline may improve CPP, but evidence shows no clear superiority over mannitol in mortality or neurological outcomes.
- Monitor serum sodium closely; Na^+ >155 mmol/L may predict acute kidney injury, and rapid sodium shifts should be avoided.
- Effects of hyperosmolar agents may be altered when the blood–brain barrier is disrupted, as often occurs in TBI.

Carney. Neurosurgery 80:6–15, 2017
Kim. Anesth Pain Med 2023;18:104-113

Perioperative Brain Protection

Maintaining CPP by *Increasing Systemic Blood Pressure*

- Increasing MAP should be considered to maintain adequate CPP.
- Blood pressure must be optimized before and during anesthesia, especially in trauma patients with unstable hemodynamics.
- Correct reversible causes of hypotension first: bleeding; anesthetic-induced vasodilation.
- Vasopressors should be considered when needed to maintain MAP and CPP.
- Phenylephrine may increase MAP and CPP more effectively than norepinephrine or dopamine, but optimal vasopressor choice remains uncertain.
- Because cerebral autoregulation is often impaired after TBI, hypotension can directly reduce cerebral blood flow and should be strictly avoided.

Carney. Neurosurgery 80:6–15, 2017
Kim. Anesth Pain Med 2023;18:104-113

Perioperative Monitoring in TBI Patients

- Standard monitoring should include $ETCO_2$, SpO_2, ECG, invasive arterial blood pressure, urine output, and body temperature.
- In TBI patients undergoing damage control surgery (DCS) or interventional radiology immediately after admission, ICP/CPP monitoring should be considered if clinically indicated and feasible.
- In patients undergoing emergency neurosurgery, the same standard monitoring is required.
- In TBI patients undergoing urgent extracranial surgery after 24 hours, continue standard monitoring and maintain ICP/CPP monitoring if already in place.

Picetti. J. Clin. Med. 2022, 11, 18

Choice of Induction Agents in TBI

- Induction agents should reduce cerebral metabolism and ICP while preserving MAP and CPP.
- Propofol, thiopental, midazolam, and etomidate reduce $CMRO_2$, cerebral blood flow, and ICP.
- Propofol and thiopental may cause hypotension and reduce CPP; careful dose titration is required.
- Etomidate preserves MAP and may be preferred in hemodynamically unstable patients, but adrenal suppression remains a concern.
- Ketamine is no longer contraindicated in TBI; current evidence shows no clear harm and suggests possible neuroprotective effects.

Kim. Anesth Pain Med 2023;18:104-113

Anesthetic Maintenance in TBI

- No specific maintenance anesthetic has proven superiority in improving TBI outcomes.
- Maintenance can use inhalational or intravenous agents, but must prioritize hemodynamic stability and CPP preservation.
- TIVA with propofol and opioids is useful for cerebral hemodynamic control and neurophysiological monitoring.
- Dexmedetomidine may reduce anesthetic/opioid requirements and postoperative nausea/vomiting, but optimal dosing and comparative effects remain unclear.

Kim. Anesth Pain Med 2023;18:104-113

Anesthetic Maintenance in TBI

- Low-dose volatile agents may reduce brain metabolism, but higher concentrations can increase cerebral blood flow and ICP.
- Nitrous oxide should be avoided because it increases cerebral blood flow and ICP.
- If volatile anesthesia is used, MAC < 1 appears appropriate in TBI patients.

Kim. Anesth Pain Med 2023;18:104-113

Steroids and Seizure Prophylaxis in Severe TBI

Steroids in Severe TBI

- Steroids are not recommended to improve outcomes or reduce ICP in TBI.
- High-dose methylprednisolone is associated with increased mortality in severe TBI and is contraindicated.

Seizure Prophylaxis in Severe TBI

- Prophylactic phenytoin or valproate is not recommended to prevent late post-traumatic seizures.
- Phenytoin is recommended to reduce early post-traumatic seizures, defined as seizures within 7 days after injury, when benefits outweigh treatment-related risks.
- Early post-traumatic seizures have not been clearly associated with worse outcomes.
- Current evidence is insufficient to recommend levetiracetam over phenytoin for preventing early seizures or reducing toxicity.

Carney. Neurosurgery 80:6–15, 2017

Take-Home Messages

- **Goal before surgery:** Prevent secondary brain injury — optimize rapidly and in parallel with resuscitation.
- **Identify the scenario** — isolated severe TBI vs. TBI in polytrauma. In polytrauma with TBI, balance hemorrhage control with neuroprotection; permissive hypotension is not appropriate.
- **Perfusion & oxygenation:** Avoid hypotension (age-based SBP targets, CPP 60–70 mmHg, treat ICP > 22 mmHg); avoid hypoxia and abnormal $PaCO_2$; no prophylactic hyperventilation.

Take-Home Messages

- **Airway:** rapid sequence induction when GCS ≤ 8, with cervical-spine precautions.
- **Coagulation & transfusion:** correct coagulopathy early; massive transfusion 1:1:1; meet platelet/fibrinogen targets; use a restrictive hb threshold.
- **Don't miss the basics:**
  - Normoglycemia and normothermia;
  - Steroids contraindicated;
  - Anesthetic choice matters less than hemodynamic stability and cpp.


THANK YOU
for your attention!