Chapter 52
Approach to Head Injury in the ICU

52.1 Introduction

Traumatic brain injury (TBI) is a life-threatening condition that demands immediate, structured, and evidence-based management to prevent secondary injuries and optimize neurological outcomes. The primary objectives in the ICU setting include maintaining adequate cerebral perfusion and oxygenation, stabilizing intracranial pressure (ICP), and preventing complications such as hypoxia, hypotension, cerebral edema, and seizures [1, 2]. [Ref: Algorithm 52.1].

52.2 Primary Goals

- Prevent Secondary Brain Injury: Secondary brain injury can result from hypoxia, hypotension, elevated ICP, seizures, and hyperthermia. Vigilant monitoring and immediate intervention are crucial to mitigate these risks.
- Maintain Oxygenation and Cerebral Perfusion: Ensure optimal oxygenation ($SpO_2 > 98\%$) and maintain cerebral perfusion pressure (CPP) between 60 and 70 mm Hg to preserve brain function. Blood pressure control is vital to sustain adequate cerebral perfusion without exacerbating intracranial hypertension.

52.3 Team Dynamics

- Effective Communication: Implement clear communication protocols within the trauma team to ensure timely and coordinated care.
- Role Distribution: Assign specific roles to team members to streamline interventions and reduce delays during acute management.

S. B. Mishra et al., *Mastering ICU Care*,
https://doi.org/10.1007/978-981-95-0179-3_52

52.4 Initial Assessment and Resuscitation (ABCDE Approach)

Airway (A)

- Airway Protection: Patients with a Glasgow Coma Scale (GCS) ≤8 or compromised airway reflexes require early intubation to prevent aspiration and ensure adequate oxygenation.
- Cervical Spine Precautions: Assume a cervical spine injury in all trauma patients until ruled out. Use the jaw-thrust maneuver to open the airway without moving the cervical spine.
- High-Flow Oxygen: Initiate 100% oxygen delivery to manage hypoxia and optimize oxygenation.

Breathing (B)

- Ventilation Management: Adjust ventilation to maintain $PaCO_2$ of approximately 35 mm Hg. Avoid hypercapnia (>45 mm Hg) and hypocapnia (<30 mm Hg), as both can adversely affect cerebral blood flow and ICP. A brief period of hyperventilation ($PaCO_2$ 25–30 mm Hg) may be used to manage immediate neurological deterioration, to buy time for other anti-ICP measures to be initiated.
- Oxygenation: Continuously monitor SpO_2 to maintain levels >98%.

Circulation (C)

- Blood Pressure Control: Maintain systolic blood pressure ≥ 100 mm Hg (for patients aged 50–69, aim for SBP ≥110 mm Hg or above for patients 15–49 or over 70 years) to ensure adequate CPP.
- Volume Resuscitation: Use isotonic fluids judiciously to correct hypotension while avoiding fluid overload that could increase ICP.
- Avoid Hypotension: Hypotension (SBP <100 mm Hg) can exacerbate secondary brain injury by reducing cerebral perfusion.

Disability (D)

- Neurological Assessment: Perform frequent GCS scoring and pupillary examinations to detect any neurological decline. Exclude confounding factors such as drugs, alcohol, other intoxicants, and injuries. Ensure normotension during neurological assessment. The best motor response elicited is a more accurate prognostic indicator than the worst response. The GCS score and pupillary examination must be completed before initiation of sedation or neuromuscular blockade.
- Monitor for Signs of Elevated ICP: Watch for changes in consciousness, pupil size/reactivity, and motor responses.

Exposure/Environmental Control (E)

- Temperature Management: Maintain normothermia (36–38 °C). Treat hyperthermia promptly, as fever can worsen neurological outcomes.
- Full-Body Examination: Expose the patient adequately to assess for other injuries while preventing hypothermia.

52.5 Imaging and Neurosurgical Consultation

- Head CT Scan: Obtain a non-contrast CT scan promptly once the patient is hemodynamically stable. This is critical for patients with a GCS ≤8 or focal neurological deficits.
- Neurosurgical Evaluation: Immediate consultation is necessary for any intracranial lesions requiring surgical intervention or if advanced monitoring is considered.
- Transfer Protocols: If neurosurgical services are not available, initiate transfer to an appropriate facility while stabilizing the patient.

52.6 ICP and CPP Management

ICP Monitoring

- Indications: Place an ICP monitor in patients with severe TBI (GCS ≤8) and an abnormal CT scan, or those with normal CT scans but with risk factors (age > 40, SBP <90 mm Hg, motor posturing).
- ICP Targets: Maintain ICP ≤20 mm Hg to reduce the risk of cerebral herniation.
- Advanced Cerebral Monitoring: Utilize tools like external ventricular drains (EVD) for both monitoring and therapeutic CSF drainage. Bedside transcranial doppler can also be done as an indirect method.

CPP Management

- CPP Targets: Maintain CPP between 60 and 70 mm Hg. Avoid CPP <60 mm Hg to prevent ischemia and CPP >70 mm Hg to reduce the risk of acute respiratory distress syndrome (ARDS).
- Blood Pressure Management: Use vasopressors if necessary to maintain adequate MAP while monitoring for potential increases in ICP. Maintain euvolemia.

52.7 Medical Management

52.7.1 Hyperosmolar Therapy

Mannitol

- Indications: Use for acute ICP spikes or sustained elevated ICP.
- Dosage: Administer 0.25–1 g/kg IV bolus. 1 g/kg over 5 min if a patient under observation develops a dilated pupil, has hemiparesis, or loses consciousness.
- Monitoring: Watch for hypotension, dehydration, and renal function.
- Contraindications: Active intracranial bleed, extradural hemorrhage, severe dehydration, severe pulmonary edema, severe renal disease and anuria.

Hypertonic Saline
- Indications: Alternative or adjunct to mannitol, especially in hypotensive patients.
- Dosage: 3% NaCl solution 250 mL over 30 min or continuous infusion.
- Monitoring: Check serum sodium levels to avoid hypernatremia and central pontine myelinolysis.

52.7.2 Controlled Hyperventilation

- Temporary Measure: A brief period of hyperventilation ($PaCO_2$ 35–40 mm Hg) may be used to manage immediate neurological deterioration, to buy time for other anti ICP measures to be initiated.
- Risks: Prolonged hyperventilation can cause cerebral vasoconstriction and ischemia. It should not be part of routine ICP management.

52.7.3 Sedation and Analgesia

- Medications: Use sedatives (e.g., propofol) and analgesics (e.g., fentanyl) to reduce metabolic demand and control ICP. High-dose barbiturates may be used to treat refractory raised ICP. Hypotension and delay in determining brain death are the factors that go against its regular use.
- Neuromuscular Blockade: Consider in patients with refractory ICP elevations.

52.7.4 Seizure Control

- Early Prevention: Administer anticonvulsants (e.g., phenytoin, levetiracetam) during the first week post-injury to prevent early post-traumatic seizures. It must be kept in mind that early anticonvulsant use does not change long-term traumatic seizure outcome. Prophylactic use of phenytoin or valproate is not recommended for preventing late post-traumatic seizures.
- Monitoring: Observe for side effects and therapeutic drug levels.

52.7.5 Temperature Management

- Normothermia: Actively prevent and treat fever using antipyretics and cooling devices.
- Hypothermia Therapy: Not routinely recommended but may be considered in refractory ICP cases, weighing potential systemic effects.

52.8 Monitoring and Maintenance

Neurological Monitoring
- Frequent Assessments: Regularly evaluate GCS, pupillary responses, and motor function to detect changes.
- Advanced Monitoring: Utilize cerebral oxygenation monitors or jugular venous oximetry when available.

Vital Signs and Laboratory Parameters
- Hemoglobin: Maintain ≥7 g/dL to ensure adequate oxygen delivery. Recent studies show that there is benefit in targeting.
- INR ≤ 1.4
- Blood Glucose: Keep levels between 80 and 180 mg/dL to avoid hypo- or hyperglycemia.
- Serum Sodium: Maintain between 135 and 145 mEq/L; monitor during hyperosmolar therapy.
- $PaCO_2$: Keep within 35–40 mm Hg to regulate cerebral blood flow.
- PaO_2: Ensure ≥100 mm Hg to prevent hypoxia.
- Pulse Oximetry: Maintain SpO_2 ≥98%.

  pH 7.35–7.45.
  Platelets ≥$75 \times 10^3/mm^3$.

Infection Control
- Antibiotic Prophylaxis: Consider around neurosurgical procedures or in patients with CSF leaks.
- Aseptic Techniques: Strict adherence to prevent ventilator-associated pneumonia and line infections.

DVT Prophylaxis
- Mechanical Prophylaxis: Initiate with compression devices upon admission.
- Pharmacological Prophylaxis: Start low-dose anticoagulants once bleeding risks are controlled.

52.9 Surgical Intervention

52.9.1 Decompressive Craniectomy

Indications:

- Late Refractory ICP Elevation: Secondary decompressive craniectomy (DC) is recommended for patients with sustained ICP elevation (>25 mm Hg for 1–12 hours) refractory to maximal medical therapy, occurring within 10 days of injury.

- Early Refractory ICP Elevation: Routine use of DC for early refractory ICP elevation (>20 mm Hg for 15 min within a 1-hour period, within the first 72 hours) is not recommended to improve mortality and favorable outcomes.

Surgical Technique:

- Size of Craniectomy: A large frontotemporoparietal DC (not less than 12 × 15 cm or 15 cm in diameter) is recommended over smaller decompressions to reduce mortality and improve neurological outcomes.
- Procedure Selection: Choice between unilateral (hemicraniectomy) and bilateral (bifrontal craniectomy) decompression should be based on individual patient pathology and neurosurgical judgment.

Considerations:

- Outcome Expectations: While DC can reduce ICP and decrease the duration of intensive care, the relationship between these effects and long-term favorable outcomes is uncertain.
- Functional Prognosis: Discuss potential long-term functional outcomes and quality of life implications with the patient's family or surrogate decision-makers prior to surgery.

Complications: Be aware of risks such as surgical site infections, subdural hygromas, and syndrome of the trephined (neurological deterioration due to absence of bone flap).

Evidence Basis:

RESCUEicp Trial:

- Demonstrated that DC for late refractory ICP elevation improves mortality and increases favorable outcomes at 12 months.
- Patients who underwent DC had lower ICP and reduced ICU stays but experienced higher rates of some complications.

DECRA Trial:

- Showed that DC for early refractory ICP elevation did not improve mortality or favorable outcomes at 6 and 12 months.
- Patients had lower ICP and shorter ICU stays but worse functional outcomes compared to medical management.

Clinical Application:

- Individualized Decision-Making: Consider DC for patients with late refractory ICP elevation after exhaustive medical management.
- Avoid Routine Early DC: Do not use DC as an early intervention for ICP management without clear indications of refractory ICP unresponsive to initial therapies.
- Multidisciplinary Discussion: Engage neurosurgeons, intensivists, and ethical consultants when contemplating DC to ensure comprehensive patient-centered care [3].

52.9.2 Craniotomy

- Mass Lesions: Evacuate epidural or subdural hematomas causing mass effect or neurological deterioration promptly to prevent secondary injury.

52.9.3 Penetrating Injuries

- Object Removal: Do not remove impaled objects without imaging and surgical planning.
- Vascular Assessment: Evaluate for vascular injury before intervention.

52.10 Secondary Survey and Serial Assessments

- Comprehensive Evaluation: Perform a thorough secondary survey to identify other injuries that may contribute to hypoxia or hypotension.
- Serial Neurological Exams: Continue regular assessments to guide treatment adjustments.

52.11 Long-Term Care and Prognosis Considerations

52.11.1 Rehabilitation Planning

- Multidisciplinary Approach: Engage physical therapists, occupational therapists, speech therapists, and neuropsychologists early.
- Family Involvement: Include family members in care discussions and rehabilitation goals.

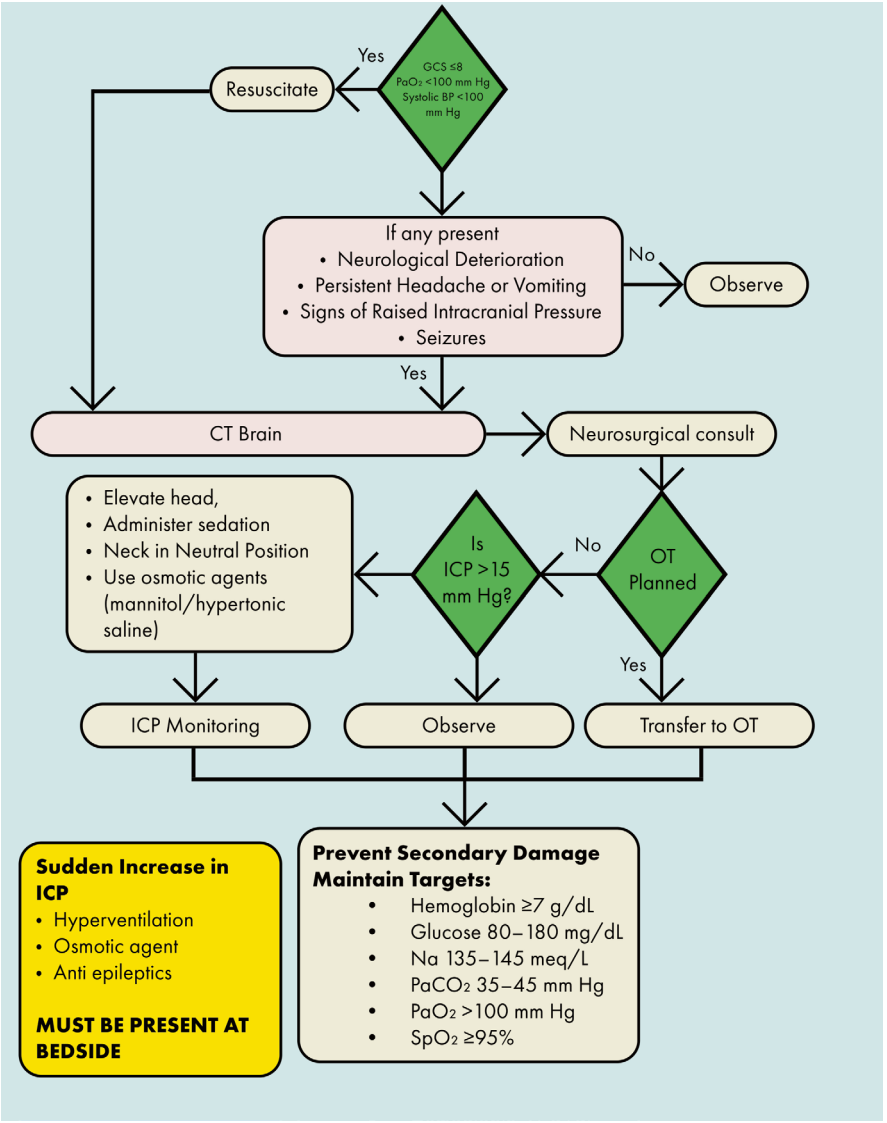
52.11.2 Complication Management

- Coagulopathy: Monitor coagulation profiles and correct abnormalities.
- Infections: Early detection and treatment of pneumonia, meningitis, or wound infections.
- Seizure Control: Adjust anticonvulsant therapy based on ongoing risk.

52.12 Conclusion

Effective ICU management of severe traumatic brain injury requires a systematic approach that incorporates early airway protection, meticulous monitoring of ICP and CPP, judicious use of medical therapies, and timely surgical interventions. Adhering to established guidelines and integrating multidisciplinary care can significantly improve patient outcomes. Preventing secondary injuries through vigilant monitoring, maintaining physiological homeostasis, and initiating early rehabilitation are essential steps in the recovery journey of patients with severe TBI.

Algorithm 52.1: Approach to head injury in the ICU



Bibliography

1. American College of Surgeons. Advanced trauma life support (ATLS): student course manual. 10th ed. Chicago: American College of Surgeons; 2018.
2. Brain Trauma Foundation. Guidelines for the management of severe traumatic brain injury. 4th ed. New York: Brain Trauma Foundation; 2016.
3. Hawryluk GWJ, Rubiano AM, Totten AM, O'Reilly C, Ullman JS, Bratton SL, et al. Guidelines for the management of severe traumatic brain injury: 2020 update of the decompressive craniectomy recommendations. Neurosurgery. 2020;87(3):427–34.