# Trauma Center Practice Management Guideline

*Iowa Methodist Medical Center — Des Moines*

## *Management of Patients with Severe Traumatic Brain Injury (GCS < 9)*

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| **ADULT**<br>**Practice Management Guideline** | **Effective: 03/2014** |
| **Contact: Trauma Medical Director** | **Last Reviewed: 04/2024** |

## Treatment of Elevated Intracranial Pressure

**Goals**
- ICP < 22 mmHg
- Systolic BP > 100
- CPP > 60
- $SpO_2 \geq 95$ %
- $PaO_2 \geq 100$ mmHg
- Avoid aggressive attempt to maintain CPP > 70 mmHg with fluid and vasopressor

**ACUTE CLINICAL DETERIORATION**
- Verify oxygenation and ventilation
- Temporary hyperventilation to $pCO_2$ 30-35 mmHg
- Re-dose osmotic agent (3% saline, mannitol)

Is ICP > 22 or CPP<60?

NO

YES

**Ensure euvolemia**

**Consider CT Head to exclude mass lesion**

**Ensure HOB elevated at least 30°**

**Ensure adequate analgesia and sedation**
- Fentanyl, 50 mcg IV, intermittent bolus, consider IV infusion titrated to effect
- Propofol, if needed for sedation, 5-80 mcg/kg/min

NO

Is ICP > 22 or CPP<60?

NO

YES

**Initiate hyperosmolar therapy: 3% Saline**
- 250 ml bolus over 10-15 minutes, then
- Infusion at 50 ml/hour
- Monitor serum Na level
  - If Na < 150, re-bolus 150 ml over 1 hour
  - If Na 150-154, increase infusion by 10 ml/hour
  - If Na 155-160, maintain infusion at current rate
  - If Na > 160, hold infusion for one hour, re-check and resume infusion reduced by 10 ml/hour

Is ICP > 22 or CPP<60?

NO

YES

***Alternative is Mannitol, avoid use in hypovolemic patients***
- *0.25 – 1.0 gm/kg bolus over 20 minutes, then*
- *0.25 gm/kg IV every 4 hours*
- *Hold mannitol for serum osmolality is >320*

***Consider* vasopressor use for euvolemic patient with CPP < 50 mmHg**

**Neurosurgery to consider decompressive craniectomy**

Continue to Monitor

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**Purpose**

Standardize comprehensive care of the patient with severe traumatic brain injury

**Procedure Statements**

**Phase of Care: Emergency Department**

1. Primary Survey & Resuscitation according to ATLS
2. Neurologic Examination – Document:
    a. GCS, including best motor response
    b. Focal neurologic deficits
    c. Pupillary size and response
3. Secure airway with endotracheal intubation
    a. Drug-assisted intubation (etomidate + succinylcholine or rocuronium)
    b. Hi-Lo ETT
4. Prevent hypoxia, maintain $SaO_2 \geq$ 95% and PaO2 $\geq$100 mmHg
5. Maintain normocarbia, $pCO_2$ 35-45 mmHg
6. Prevent hypotension, maintain SBP > 100 mmHg
7. Reverse any anticoagulants via protocol
8. Analgesia and sedation
    a. Fentanyl, 50 mcg IV, intermittent bolus
    b. Propofol, if needed for sedation
    c. Avoid long-acting paralytic
    d. If paralytic is required use rocuronium 1 mg/kg IV
9. Standard laboratory evaluation, including ROTEM
10. Emergent empiric treatment of intracranial hypertension
    a. 3% saline bolus 100-250 ml over 10 minutes
    b. *Alternative is mannitol 1.0 gm/kg over 20 minutes, avoid use in hypovolemic patients*
    c. Temporary hyperventilation to $pCO_2$ 30-35 mmHg
11. Emergent CT head
12. Neurosurgical consultation, emergent craniotomy for surgical lesions
13. TXA
    a. For patients with moderate traumatic brain injury (Glasgow Coma Scale greater than 8 and less than 13) presenting within three hours of injury
    b. May also be reasonable in severe TBI and reactive pupils
    c. 1 g (or 10 to 15 mg/kg) once; administer at a rate not to exceed over 10 to 20 minutes

**Phase of Care: Intensive Care Unit**

1. Neurosurgical consultation, emergent craniotomy for surgical lesions
2. General measures
    a. Head midline, avoid tight cervical collar or circumferential ETT tie
    b. Elevate HOB 30°, reverse Trendelenburg if spine is not cleared
    c. Prevent hypoxia, maintain $SaO_2 \geq 95\%$ and PaO2 $\geq$100 mmHg
    d. Maintain normocarbia, $pCO_2$ 35-45 mmHg
    e. Prevent hypotension, maintain SBP > 100 mmHg
    f. Do not administer steroids
    g. Document serial neurologic examinations: GCS, pupil size and reactivity, focal neurologic deficits
    h. Repeat CT head within 24 hours of admission and as required for clinical deterioration
    i. Serial laboratory monitoring during the acute phase, including electrolytes, ABG, and coagulation studies
3. Establish access & monitoring
    a. Standard ICU monitors
    b. Arterial line, BP monitoring
    c. Central venous catheter, CVP monitoring
    d. Patients in whom neurological status cannot be monitored clinically, ICP monitoring (ICP bolt, ventriculostomy):
        - salvageable patient with GCS 3-8 and abnormal CT scan (hematoma, contusion, edema, herniation, compressed basal cisterns)
        - salvageable patient with GCS 3-8 and normal CT scan if 2 or more of the following present on admission: age >40, unilateral or bilateral motor posturing, SBP < 90.
4. Maintain euvolemia, CVP 5-10
    a. Resuscitate to euvolemia with isotonic fluid (normal saline or lactated ringers)
    b. Maintain euvolemia with $D_5$ normal saline or $D_5$ lactate ringers
5. Avoid fever, goal temperature < 37.2° C
    a. Acetaminophen 1000 mg PO/PR Q 6 hours prn
    b. Cooling blanket, avoid shivering
    c. Consider ibuprofen, 600 mg NG/OG Q 6 hours prn
6. Maintain normoglycemia
    a. > 80 and <150 mg/dL
    b. Insulin infusion, if needed
7. Analgesia, sedation
    a. Fentanyl, 50 mcg IV, intermittent bolus, consider IV infusion titrated to effect
    b. Propofol, if needed for sedation, 5-80 mcg/kg/min
    c. Consider daily “wake up,” per sedation protocol, with neurosurgical approval
    d. Avoid paralytics
8. Ulcer prophylaxis for all patients
9. Intracranial pressure management
    a. Definitions
        - ICP = Intracranial pressure
        - MAP = Mean arterial pressure
        - CPP = Cerebral perfusion pressure: MAP – ICP = CPP
    b. Goals:
        - ICP < 22 mmHg
        - Systolic BP > 100
        - CPP > 60 mmHg
        - Avoid aggressive attempt to maintain CPP > 70 mmHg with fluid and vasopressor
    c. Treatment of ICP >22 mmHg
        - Ensure adequate analgesia and sedation
        - Ensure HOB elevated at least 30°
        - CSF drainage, if ventriculostomy present
        - Initiate hyperosmolar therapy (goal = euvolemic, hyperosmolar state)

1. 3% saline
    a. Goal Na 150-160
    b. 250 ml bolus over 10-15 minutes, then
    c. Infusion at 50 ml/hour
    d. Monitor serum Na level
        i. If Na < 150, re-bolus 150 ml over 1 hour
        ii. If Na 150-154, increase infusion by 10 ml/hour
        iii. If Na 155-160, maintain infusion at current rate
        iv. If Na > 160, hold infusion for one hour, re-check and resume infusion reduced by 10 ml/hour
2. *Alternative is Mannitol, avoid use in hypovolemic patients*
    a. *0.25 – 1.0 gm/kg bolus over 20 minutes, then*
    b. *0.25 gm/kg IV every 4 hours*
    c. *Hold mannitol for serum osmolality is >320*

- Serial monitoring of laboratory values including ABG, Electrolytes, serum osmolality

d. Treatment of CPP < 60 mmHg
- Ensure euvolemia
- Treat ICP, as above
- Have associated injuries been excluded?
- Check intra-abdominal pressure; *consider* decompressive laparotomy if intra-abdominal pressure is >20-25
- *Consider* vasopressor use for euvolemic patient with CPP < 50 mmHg
- Neurosurgery to consider decompressive craniectomy

e. Consider repeat CT head to exclude development of surgical mass lesion
f. Acute clinical deterioration
- Obtain ABG to verify oxygenation and ventilation
- Temporary hyperventilation to $pCO_2$ 30-35 mmHg
- Re-dose osmotic agent (3% saline, mannitol)
- Emergent CT head
- Contact neurosurgery

10. Seizure prophylaxis and treatment
    a. Anti-epileptic medication should be used for prophylaxis of early post traumatic seizures in patient with significant intracranial hemorrhage (subdural hematoma > 10 mm, significant lobar hemorrhages), and penetrating brain injury
    b. Seizure activity after injury should be treated with anti-epileptic medication
    c. The decision regarding anti-epileptic medication should be made in consultation with neurosurgery
    d. Levetiracetam (KEPPRA) is the preferred medication, 1 gm load followed by 500 mg every 12 hours.
    e. Fosphenytoin (CEREBRYX) is an alternative medication, 1 gm load followed by 300mg daily. Monitor serum level.
    f. Seizure prophylaxis should be discontinued after 7 days if there is no penetrating brain injury and no development of seizures
    g. Treat acute seizure
        - Lorazepam (ATIVAN) 1-2 mg IV *or* midazolam (VERSED) 5-10 mg IV, followed by
        - Fosphenytoin (CEREBRYX)
11. DVT/PE prophylaxis
    a. Below knee sequential compression device (SCD) for all patients, unless otherwise contraindicated
    b. Chemical prophylaxis (enoxaparin, heparin) should be considered within the first 72 hours of TBI , in consultation with neurosurgery
12. Nutritional support
    a. Enteral nutrition should be initiated as soon as it is safe to do so
    b. Avoid agitation and intracranial hypertension with placement of feeding tube
    c. Nutrition should begin early, as soon as the patient is hemodynamically stable, and ideally within

24-48 hours of injury.

d. Full nutritional supplementation should be achieved within 7 days of injury.

13. Consider adjunctive measures based on patient clinical condition
    a. EEG monitoring for seizure activity
14. Adjunctive Pharmacotherapy
    a. Nimodiopine: The use of nimodipine does not have a significant beneficial effect in patients with TBI
    b. Magnesium sulfate: Maintain magnesium levels > 2. Low magnesium level is a predictor for poor outcome. Avoid using oral magnesium as it could cause diarrhea and worsening hypomagnesemia.
    c. Amantadine: Amantadine appears to be effective in accelerating the pace of recovery during acute rehabilitation phase in patients with severe TBI and prolonged posttraumatic disturbances in consciousness.
        - 100 mg twice daily at 8 AM and 12 PM.
        - Initiate therapy between day 4 and 7 after trauma
        - Duration of treatment is 6 to 12 weeks
        - Discontinue if agitation
        - Discuss with the pharmacist for potential of drug interactions, particularly, with antipsychotics

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**TABLE 1. Updated Treatment Recommendations**[a,b]

| Topic | Recommendations |
|---|---|
| Decompressive craniectomy | Level IIA |
| | • **Bifrontal DC is not recommended to improve outcomes as measured by the GOS-E score at 6 mo post-injury in severe TBI patients with diffuse injury (without mass lesions), and with ICP elevation to values >20 mm Hg for more than 15 min within a 1-h period that are refractory to first-tier therapies. However, this procedure has been demonstrated to reduce ICP and to minimize days in the ICU.** |
| | • **A large frontotemporoparietal DC (not less than 12 x 15 cm or 15 cm diameter) is recommended over a small frontotemporoparietal DC for reduced mortality and improved neurologic outcomes in patients with severe TBI.** |
| | *The committee is aware that the results of the RESCUEicp trial[2] were released soon after the completion of these Guidelines. The results of this trial may affect these recommendations and may need to be considered by treating physicians and other users of these Guidelines. We intend to update these recommendations if needed. Updates will be available at https://braintrauma.org/coma/guidelines. |
| Prophylactic hypothermia | Level IIB |
| | • **Early (within 2.5 h), short-term (48 h post-injury), prophylactic hypothermia is not recommended to improve outcomes in patients with diffuse injury.** |
| Hyperosmolar therapy | Recommendations from the prior (Third) Edition not supported by evidence meeting current standards. |
| | Mannitol is effective for control of raised ICP at doses of 0.25 to 1 g/kg body weight. Arterial hypotension (systolic blood pressure <90 mm Hg) should be avoided. |
| | Restrict mannitol use prior to ICP monitoring to patients with signs of transtentorial herniation or progressive neurologic deterioration not attributable to extracranial causes. |
| Cerebrospinal fluid drainage | Level III |
| | • **An EVD system zeroed at the midbrain with continuous drainage of CSF may be considered to lower ICP burden more effectively than intermittent use.** |
| | • **Use of CSF drainage to lower ICP in patients with an initial GCS <6 during the first 12 h after injury may be considered.** |
| Ventilation therapies | Level IIB |
| | • Prolonged prophylactic hyperventilation with $PaCO_2$ of ≤25 mm Hg is not recommended. |
| | Recommendations from the prior (Third) Edition not supported by evidence meeting current standards. |
| | Hyperventilation is recommended as a temporizing measure for the reduction of elevated ICP. |
| | Hyperventilation should be avoided during the first 24 h after injury when CBF often is reduced critically. |
| | If hyperventilation is used, $SjO_2$ or $BtpO_2$ measurements are recommended to monitor oxygen delivery. |
| Anesthetics, analgesics, and sedatives | Level IIB |
| | • Administration of barbiturates to induce burst suppression measured by EEG as prophylaxis against the development of intracranial hypertension is not recommended. |
| | • High-dose barbiturate administration is recommended to control elevated ICP refractory to maximum standard medical and surgical treatment. Hemodynamic stability is essential before and during barbiturate therapy. |
| | • Although propofol is recommended for the control of ICP, it is not recommended for improvement in mortality or 6-month outcomes. Caution is required as high-dose propofol can produce significant morbidity.[3] |
| Steroids | Level I |
| | • The use of steroids is not recommended for improving outcome or reducing ICP. In patients with severe TBI, high-dose methylprednisolone was associated with increased mortality and is contraindicated. |
| Nutrition | Level IIA |
| | • **Feeding patients to attain basal caloric replacement at least by the fifth day and at most by the seventh day post-injury is recommended to decrease mortality.** |
| | Level IIB |
| | • **Transgastric jejunal feeding is recommended to reduce the incidence of ventilator-associated pneumonia.** |
| Infection prophylaxis | Level IIA |
| | • Early tracheostomy is recommended to reduce mechanical ventilation days when the overall benefit is thought to outweigh the complications associated with such a procedure. However, there is no evidence that early tracheostomy reduces mortality or the rate of nosocomial pneumonia. |
| | • **The use of PI oral care is not recommended to reduce ventilator-associated pneumonia and may cause an increased risk of acute respiratory distress syndrome.** |

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|---|---|
| | Level III |
| | • **Antimicrobial-impregnated catheters may be considered to prevent catheter-related infections during external ventricular drainage.** |
| )eep vein thrombosis Prophylaxis | Level III |
| | • LMWH or low-dose unfractioned heparin may be used in combination with mechanical prophylaxis. However, there is an increased risk for expansion of intracranial hemorrhage. |
| | • In addition to compression stockings, pharmacologic prophylaxis may be considered if the brain injury is stable and the benefit is considered to outweigh the risk of increased intracranial hemorrhage. |
| | • There is insufficient evidence to support recommendations regarding the preferred agent, dose, or timing of pharmacologic prophylaxis for deep vein thrombosis. |
| ·eizure prophylaxis | Level IIA |
| | • Prophylactic use of phenytoin or valproate is not recommended for preventing late PTS. |
| | • Phenytoin is recommended to decrease the incidence of early PTS (within 7 d of injury), when the overall benefit is thought to outweigh the complications associated with such treatment. However, early PTS have not been associated with worse outcomes. |
| | • **At the present time there is insufficient evidence to recommend levetiracetam compared with phenytoin regarding efficacy in preventing early post-traumatic seizures and toxicity.** |

**TABLE 2. Updated Monitoring Recommendations[a,b]**

| Topic | Recommendations |
|---|---|
| Intracranial pressure monitoring | Level IIB |
| | • **Management of severe TBI patients using information from ICP monitoring is recommended to reduce in-hospital and 2-week post-injury mortality.** |
| | Recommendations from the prior (Third) Edition not supported by evidence meeting current standards. |
| | ICP should be monitored in all salvageable patients with a TBI (GCS 3-8 after resuscitation) and an abnormal CT scan. An abnormal CT scan of the head is one that reveals hematomas, contusions, swelling, herniation, or compressed basal cisterns. |
| | ICP monitoring is indicated in patients with severe TBI with a normal CT scan if ≥2 of the following features are noted at admission: age >40 years, unilateral or bilateral motor posturing, or SBP <90 mm Hg. |
| Cerebral perfusion pressure monitoring | Level IIB |
| | • **Management of severe TBI patients using guidelines-based recommendations for CPP monitoring is recommended to decrease 2-wk mortality.** |
| Advanced cerebral monitoring | Level III |
| | • Jugular bulb monitoring of $AVDO_2$, as a source of information for management decisions, may be considered to reduce mortality and improve outcomes at 3 and 6 mo post-injury. |

**TABLE 3. Updated Recommendations: Thresholds[a,b]**

| Topic | Recommendations |
|---|---|
| Blood pressure thresholds | Level III |
| | • **Maintaining SBP at ≥100 mm Hg for patients 50 to 69 years old or at ≥110 mm Hg or above for patients 15 to 49 or >70 years old may be considered to decrease mortality and improve outcomes.** |
| Intracranial pressure thresholds | Level IIB |
| | • **Treating ICP >22 mm Hg is recommended because values above this level are associated with increased mortality.** |
| | Level III |
| | • A combination of ICP values and clinical and brain CT findings may be used to make management decisions. |
| | *The committee is aware that the results of the RESCUEicp trial[2] were released after the completion of these Guidelines. The results of this trial may affect these recommendations and may need to be considered by treating physicians and other users of these Guidelines. We intend to update these recommendations if needed. Updates will be available at https://braintrauma.org/coma/guidelines. |
| Cerebral perfusion pressure thresholds | Level IIB |
| | • **The recommended target CPP value for survival and favorable outcomes is between 60 and 70 mm Hg. Whether 60 or 70 mm Hg is the minimum optimal CPP threshold is unclear and may depend upon the autoregulatory status of the patient.** |
| | Level III |
| | • Avoiding aggressive attempts to maintain CPP >70 mm Hg with fluids and pressors may be considered because of the risk of adult respiratory failure. |
| Advanced cerebral monitoring thresholds | Level III |
| | • Jugular venous saturation of <50% may be a threshold to avoid in order to reduce mortality and improve outcomes. |