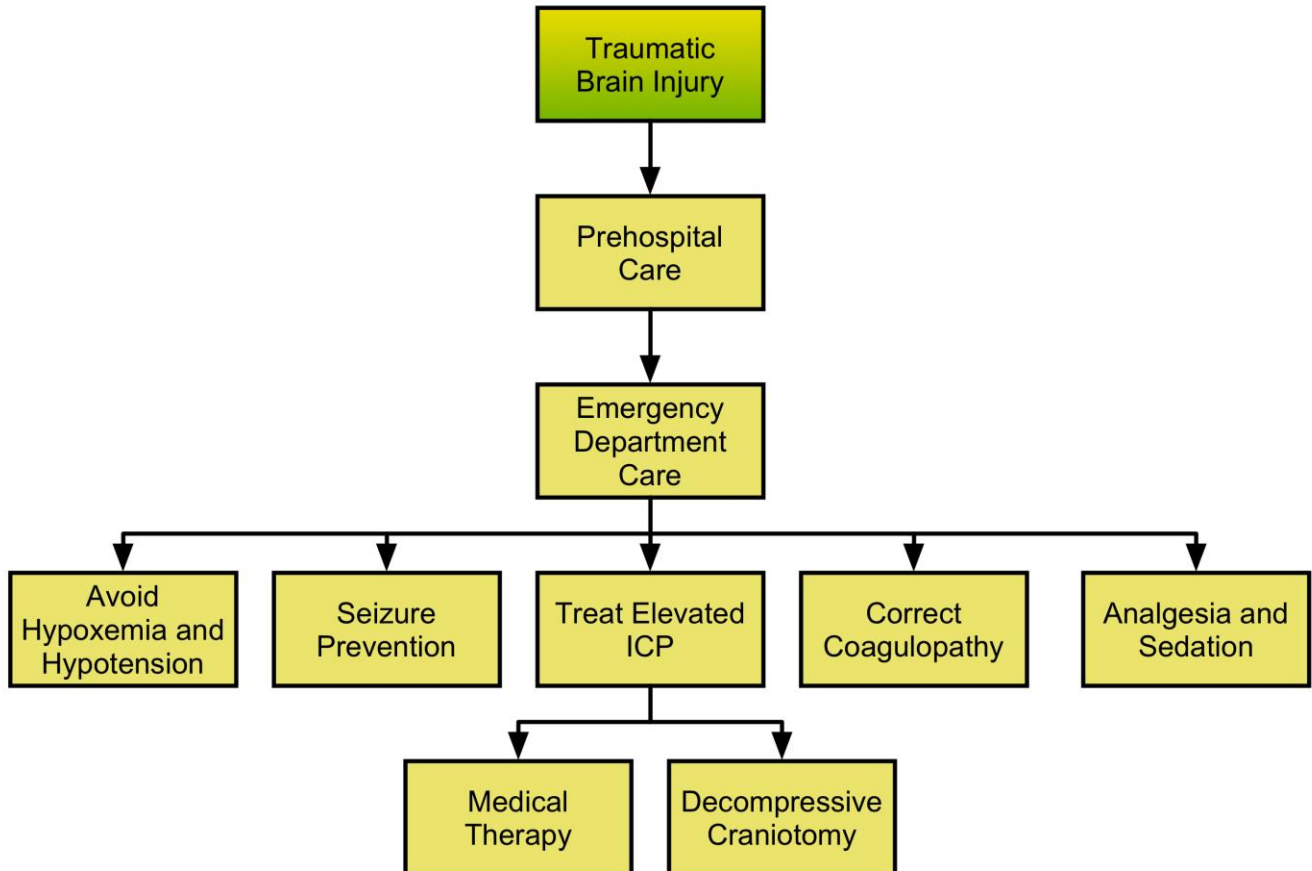


Emergency Neurological Life Support

Traumatic Brain Injury

Version: 2.0

Last Updated: 19-Mar-2016



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Checklist

- Secure Airway
- SBP > 90 mmHg and O₂ saturation > 90%
- C-spine precautions
- Head CT
- Treat herniation
- Neurologic examination

Communication

- Patient age and mechanism of injury
- Pre-injury health, including home medications
- Head CT findings
- Post resuscitation GCS with detailed neurologic exam
- Completed interventions
- Focal motor findings
- Coagulation status and other pertinent laboratory findings
- Other injuries
- State of cervical spine - cleared, not cleared, injury
- Current vital signs



Analgesia and Sedation

Patients with severe TBI typically require tracheal intubation for airway protection. Depending on the level of consciousness and agitation, sedation is often required. Concomitant skull and body injuries also require analgesia (rib fractures for example). See the ENLS protocol [Airway, Ventilation and Sedation](#) for a discussion on medications and methodology.

For extubated patients care must be given to prevent oversedation with respiratory depressant medications (opiates and IV benzodiazepines).



Avoid Hypoxia and Hypotension

Keep SBP > 90 mmHg, O₂Sat > 90%

Hypotension (SBP < 90 mmHg in adults; < 70 mmHg + age X 2 for children) in the setting of TBI is harmful. At any point in the initial encounter, treat with IV fluid bolus (500 ml – 1 L of crystalloid in adults; 20 ml/kg for children). Avoid use of D5W.

Oxygenation should be maintained with supplemental oxygen as needed to keep O₂ Sat > 90%. Avoid hyperoxia.



Coagulopathy

Recognition and treatment

Indicated if known or suspected coagulopathy:

- recent elevated PT/INR/PTT
- low platelets
- history or physical examination consistent with end-stage hepatic or renal disease
- on anticoagulant therapy
- on antiplatelet therapy

Consider the following:

- Plasma or PCC and vitamin K - for patients on warfarin
- Consider FFP for patients with liver dysfunction with coagulopathy
- Platelets - for patients with conditions with low or malfunctioning platelets
- DDAVP - for patients with end-stage renal disease or on certain anti-platelet agents

See ENLS reference [Pharmacotherapy](#) for detailed antidotes and dosing.

Sidebar common pitfalls

- In most cases, reversal can begin immediately according to empiric guidelines and does not require laboratory values or confirmation.
- Reversal of anticoagulation is a complex subject, and in some cases, such as in patients with hemophilia and other bleeding dyscrasias, it may be necessary to obtain specialist consultation from a hematologist.
- Reversal of antiplatelet agents such as ASA, clopidogrel and ticlopidine is controversial. Evidence for platelet transfusion in this cohort is equivocal. Some authors recommend the use of DDAVP despite lack of conclusive benefit.



Diagnosis

What constitutes TBI?

Traumatic Brain Injury (TBI):

- Severe TBI: Mechanism consistent with TBI and/or physical signs of trauma in unconscious patient, with a Glasgow Coma Scale (GCS) < 9.
- It is important to consider other treatable causes of decreased level of consciousness. Every attempt should be made to identify and reverse vascular, metabolic, infectious, environmental, toxicological and other non-traumatic causes. These causes may co-exist with TBI.
- The GCS should be obtained through interaction with the patient (e.g. by giving verbal commands or if those unable to respond by applying a painful stimulus)
- The GCS should be assessed after appropriate resuscitation and before the administration of sedative or neuromuscular blocking agents

Diagnosis of TBI - recognition of TBI depends on consideration of:

- Physiology (e.g. GCS)
- Anatomy (scalp laceration, depressed skull fracture)
- Mechanism of injury (e.g. fall > 20 feet, MVA > 30 mph)

Concussion

- Concussion is recognized as a clinical syndrome of biomechanically induced alteration of brain function, typically affecting memory and orientation, which may involve loss of consciousness (LOC).
- This protocol will not address concussion further

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Hemicraniectomy

And other surgical interventions

Surgical removal of hematoma (subdural, epidural, intracerebral) depend on the patient's clinical status and the judgment of treating physicians. Some general guidelines include

- Epidural hematoma or subdural hematomas > 1 cm thick and midline shift > 5 mm
- Intracerebral hemorrhage > 50 cc in volume or > 3 cm in diameter
- Penetrating skull injury
- Depressed skull fracture
- Refractory ICP

Decompressive hemicraniectomy, either unilateral or bilateral, in select patients can markedly lower ICP and likely improve outcomes; proper patient selection is still being elucidated.

Initial Hospital Management

If not done prehospital

- Spinal precautions to be maintained at all times
- Advanced airway management to ensure: a) airway protection to maintain oxygen saturation > 90%, b) control of ventilation (if inadequate or inappropriate). See ENLS protocol [Airway, Ventilation and Sedation](#).
- Obtain CXR
- Continuous monitoring of oxygenation, blood pressure, cardiac rhythm and PCO₂
- Obtain parenteral access (IV or IO)
- Diagnose hypoglycemia: if hypoglycemic give D_{50%} 50 ml IV
- Obtain CT Head without contrast
- Consider spine imaging; see ENLS protocol [Traumatic Spine Injury](#).

Neurosurgical consultation may be necessary depending on the severity of the injury and the patient's clinical status. Findings that should prompt neurosurgical consultation include:

- GCS < 13
- The patient has seizures
- Lateralizing findings on neurological examination, including unequal pupils or focal weakness
- Abnormal head CT scan
- Head CT is not consistent with clinical signs
- CSF leak, or signs of basal skull fracture
- Penetrating skull injury
- Cerebrovascular injury
- Suspected cervical spine injury

Sidebar common pitfalls

- Although a Glasgow Coma Scale of 8 or less during the initial evaluation is an indication for endotracheal intubation; severe extracranial injuries or a rapidly declining mental status may also be indications.
- Patient can be ventilated with 100% O₂ until ABG values are available. Any adjustments should maintain S_aO₂ > 90%.



Medical Therapy

Initial treatment may include:

- Positioning: ensuring head midline and at 30 degrees HOB elevation if able
- Analgesic - Fentanyl preferred, ketamine is an option
- Sedation - Propofol or precedex, depending on patient's vital signs (benzodiazepines are not recommended in TBI patients). Both agents likely drop MAP which will decrease CPP (MAP-ICP)
- Transfuse RBCs if active bleeding or hemoglobin < 7 gm/dl
- Use pressors if needed to maintain Goal CPP of $\geq 50-70$ mmHg
- Neuromuscular blockers only if shivering or difficulty ventilating patient
- Control body temperature; avoid fever. Consider [temperature management protocol](#)
- Mannitol or hypertonic saline: Administer 20% mannitol 0.5-1 g/kg IV as a rapid (5 minutes) IV infusion; If BP (systolic) < 90 mmHg in adults, hypertonic saline rather than mannitol should be used - administer 3% NaCl 250ml IV over minutes
- Maintain normocarbica or mild hypocarbica. $PbTO_2$ or $SjvO_2$ monitoring may be beneficial in avoidance of injury due to hyperventilatory ischemia. If needed for ICP control, hyperventilate to target a PCO_2 of 28-35 mmHg (20 breaths a minute in adult) until other urgent, definitive strategies can be employed (typically surgical)
- Vasopressors may be needed to maintain cerebral perfusion during the process of volume resuscitation

If ICP is refractory to medical therapy, hemicraniectomy or lesion removal should be considered.

Sidebar common pitfalls

- Hypotension (systolic BP < 90 mmHg) should prompt rapid discontinuation of mannitol.
- To administer hypertonic saline, serum sodium should be < 160 mEq/L

Prehospital

Evaluation and management in the field

- Spinal precautions to be maintained at all time
- Basic and advanced airway management as indicated to maintain oxygen saturation greater than 90%. See ENLS protocol [Airway, Ventilation and Sedation](#).
- Normal breathing should be maintained (EtCO₂ 35-40 mmHg) and hyperventilation avoided (EtCO₂ < 35 mmHg) unless there are signs of herniation (see below). When hyperventilation is indicated, 20 breaths per minute in the adult can be used as temporary measure until signs of herniation resolve
- Continuous monitoring of oxygenation (pulse oximetry) and blood pressure
- In the adult, systolic BP should be > 90 mmHg
- Hypotensive patients should be treated with isotonic or hypertonic fluids
- Obtain IV access
- Diagnose hypoglycemia: if hypoglycemic give D_{50%} 50 ml IV
- Assess Glasgow Coma Score and pupils

Common pitfalls

- The use of neuromuscular blocking medications to facilitate intubation (rapid sequence intubation) in the field worsened outcomes in one large study. If it is performed for other indications, monitoring of oxygenation, blood pressure and end-tidal CO₂ should take place.
- Hypo- and hyperventilation should both be avoided. If EtCO₂ measurement is available, this should be in the range of 35 to 40 mmHg.
- Hyperventilation to decrease PCO₂ to between 28-35 mm Hg is only indicated for patients with signs of herniation (rapidly decreasing LOC, particularly with changes in pupil reactivity)
- Intravenous fluid boluses (500cc to 1L of crystalloid or smaller volumes of hypertonic saline solutions) may be given in adult trauma victims with systolic BP < 90 mmHg or with signs of hypoperfusion (e.g. poor capillary refill)
- Pupils should be measured after resuscitation and evidence of orbital trauma noted
- Pupil asymmetry is defined as > 1mm difference in diameter
- A fixed pupil is defined as < 1 mm decrease in size in response to bright light
- Signs of herniation include: dilated and nonreactive pupils, asymmetric pupils, motor exam that demonstrates extensor posturing or no response or progressive decline in neurologic condition (decrease in GCS > 2 points)



Seizures

Control and prevention

If seizure activity was witnessed, or the patient has a depressed level of consciousness, or the head CT is abnormal, it is recommended to treat with anti-epileptic drugs unless there is a known allergy.

- Phenytoin 20 mg/kg IV no faster than 50 mg/minute
- Levetiracetam 20 mg/kg is also an option

For patients who develop status epilepticus, refer to the ENLS protocol [Status Epilepticus](#).

Treat Elevated ICP

Indicated if signs of herniation develop in the unconscious patient. These include:

- dilated and nonreactive pupils
- asymmetric pupils
- motor exam that demonstrates extensor posturing or no response
- progressive decline in neurologic condition (decrease in GCS > 2 points) that are not associated with non-TBI causes
- Cushing's response (increased BP, decreased pulse and irregular respirations)

If signs of herniation are present, the patient should be treated presumptively for high ICP while simultaneously facilitating the placement of an ICP monitor. Treatments include medical (principally hyperosmolar) therapies and surgical therapies.

ICP Monitoring- Indications and treatment algorithm

Placement of an ICP monitor is guided by Brain Trauma Foundation guidelines and should be considered in the following clinical scenarios:

- GCS 3-8 and abnormal CT scan
- GCS 3 - 8 with normal CT and 2 or more of the following: a) age > 40 years, b) motor posturing, and c) SBP < 90 mmHg
- GCS 9-15 and CT scan showing mass lesion (extra-axial blood > 1 cm thick, temporal contusion, or ICH > 3 cm), effaced cisterns, or brain shift > 5 mm
- Following craniotomy
- Neurological examination cannot be followed e.g. requires another surgical procedure or deep sedation

Elevated ICP treatment (ICP > 20 mmHg for more than 2 min):

- Elevate HOB 30 degrees (as tolerated by MAP, ICP, $P_{bt}O_2$)
- Drain CSF (if available)

Open drainage until:

- ICP drops below 20 mmHg, or
- 5-15 ml CSF drains, or
- Drainage stops
- Repeat as needed; do not actively withdraw CSF
- Other option: leave EVD open to drain at 10-15cmH₂O. Some studies have shown that this method is better for ICP control