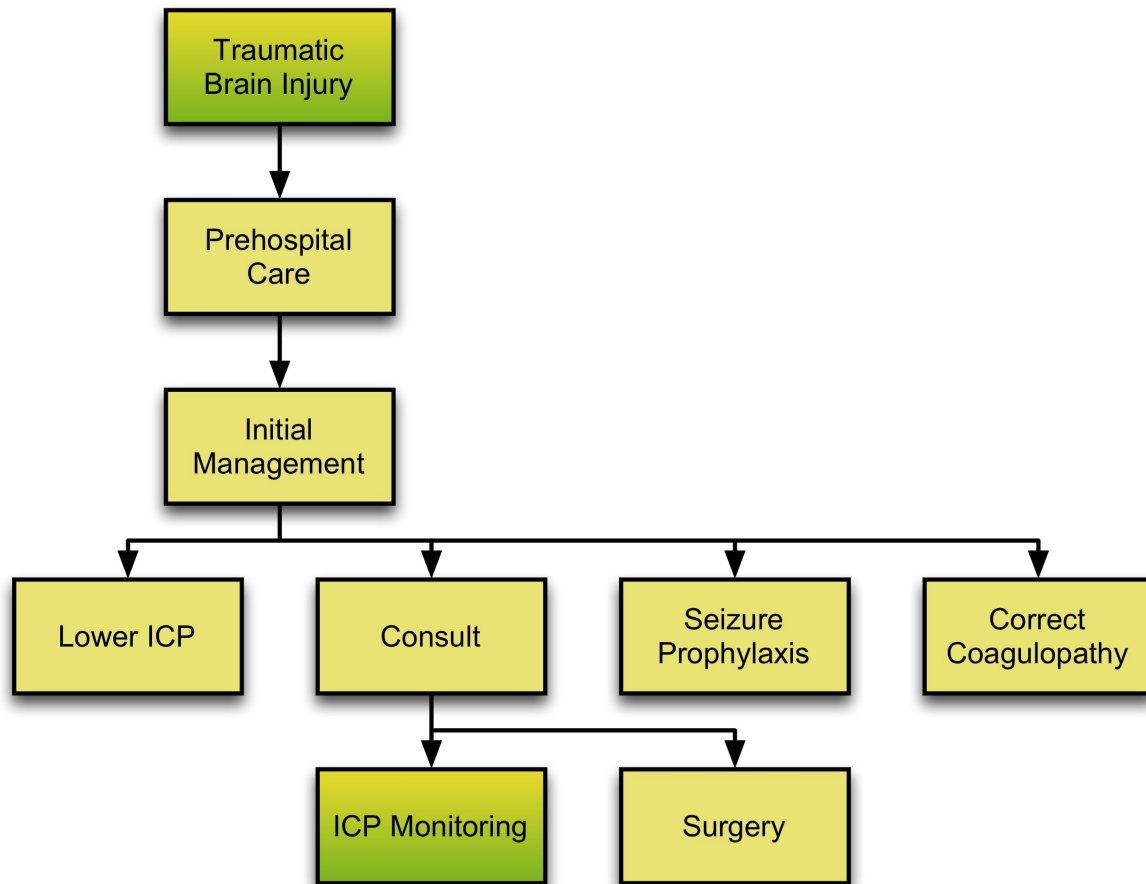


## Traumatic Brain Injury

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[Checklist & Communication](#)



## Checklist

- ☐ Airway
- ☐ SBP > 90 mmHg
- ☐ C-spine precautions
- ☐ Head CT
- ☐ Reverse herniation

## Communication

- ☐ Patient age
- ☐ Pre-injury health, if the information is available
- ☐ Mechanism of Injury
- ☐ Post resuscitation GCS
- ☐ Pupil size, reaction, and symmetry
- ☐ Focal motor findings
- ☐ Coagulation status
- ☐ Other injuries
- ☐ State of cervical spine - cleared, not cleared, injury
- ☐ CT scan findings



## 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 and vitamin K - for patients on warfarin or with end-stage liver disease
- Platelets - for patients with conditions with low or malfunctioning platelets
- DDAVP - for patients with end-stage renal disease or on certain anti-platelet agents

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, with some authors recommending the use of DDAVP.



## Consults

### Neurosurgery

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
- Lateralizing findings on neurological examination, including unequal pupils or focal weakness
- Abnormal head CT scan
- CSF leak, or signs of basal skull fracture
- Penetrating skull injury



## 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 < 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 nontraumatic 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)

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## ICP Management

### Strategies to lower 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 (see next section). Initial treatment may include:

- Mannitol or hypertonic saline: Administer 20% mannitol 0.25-1 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
- Hyperventilation: Target a PCO<sub>2</sub> of 28-35 mmHg (20 breaths a minute in adult)
- Goal CPP (MAP-ICP) is ≥ 60 mmHg
- Additional crystalloid if ICP allows
- If lactate not elevated, norepinephrine 10-100 mcg/min once adequate volume is achieved, and add other pressors as needed
- Transfuse RBCs if active bleeding or Hgb < 7 gm/dl

Sidebar common pitfalls

- Hypotension (systolic BP < 90 mmHg) should prompt rapid discontinuation of mannitol.
- To administer hypertonic saline (5% NaCl), serum Na should be < 160 mEq/L

## ICP Monitoring

### Indications and treatment algorithm

Placement of an ICP monitor is indicated in the following clinical scenarios:

- GCS 3-8 and abnormal CT scan
- GCS 3 - 8 with normal CT & 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 ml CSF drains, or
- Drainage stops
- Repeat as needed; do not actively withdraw CSF

Meds: Continuous

- Analgesic - Fentanyl or Morphine
- Sedation - Propofol for 24 to 48 hours, then lorazepam
- Neuromuscular blockers only if shivering or bucking ventilator
- Control body temperature; avoid fever. Consider normothermia protocol
- Osmotherapy - in sequence - mannitol boluses, then 5% hypertonic saline boluses, then 3% NaCl infusion titrated according to Na level
- Hyperventilate to decrease  $P_aCO_2$  as tolerated by  $P_{bt}O_2$  &  $S_{jv}O_2$  If ICP remains elevated despite these measures
- Additional propofol to EEG burst suppression
- Decompressive craniectomy
- Pentobarbital bolus then continuous infusion



## 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)
- Continuous monitoring of oxygenation, blood pressure, cardiac rhythm and PCO<sub>2</sub>
- Obtain parenteral access (IV or IO)
- Diagnose hypoglycemia: if hypoglycemic give D<sub>50%</sub> 50 ml IV
- Obtain CT Head without contrast

### 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% O<sub>2</sub> until ABG values are available. Any adjustments should maintain S<sub>a</sub>O<sub>2</sub> > 90%.



## 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%
- Normal breathing should be maintained ( $E_T\text{CO}_2$  35-40 mmHg) and hyperventilation avoided ( $E_T\text{CO}_2 < 35$  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 fluids
- Hypertonic resuscitation is an option
- Obtain IV access
- Diagnose hypoglycemia: if hypoglycemic give D<sub>50%</sub> 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. In the spontaneously breathing individual who maintains an  $S_a\text{O}_2 > 90\%$  on supplemental oxygen, endotracheal intubation is not indicated. If it is performed for other indications, monitoring of oxygenation, blood pressure and end-tidal  $\text{CO}_2$ ) should take place.
- Hypo- and hyperventilation should both be avoided. If  $E_T\text{CO}_2$  measurement is available, this should be in the range of 35 to 40 mmHg.
- Hyperventilation to decrease  $\text{PCO}_2$  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  $> 1$ mm difference in diameter
- A fixed pupil is defined as  $< 1$  mm 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 IV phenytoin unless there is a known allergy.

- Phenytoin 18 mg/kg IV no faster than 50 mg/minute



## **Surgery**

### **Indications for operative intervention**

General indications for surgical intervention after trauma

- Extra-axial mass lesion > 1 cm thick
- Midline shift > 5 mm
- ICH > 3 cm
- Midline shift < 5mm but ICP > 20 mmHg
- Penetrating injury
- Compound depressed skull fracture
- Intracranial hypertension refractory to medical management