Learning Objectives: After the lecture, the trauma physician should be better able to:
1. Recognize patients with head trauma.
2. Identify which patient might need surgical intervention.
3. Determine when surgical intervention is warranted for increasing intracranial pressure.

TBI EPIDEMIOLOGY: UNITED STATES

TBI in the United States and developed countries has declined in recent years.

Mortality rates from severe TBI declining from 80% in the 1950s to about 20% in the past 5 years.

Attributed most likely to the combined effects of prevention, evidence-based guidelines that promote early intervention, and improved neurocritical care.
Head injury causes about 75,000 deaths in the United States each year. Thus, it has a great impact on public health, and continuous improvements in prevention and care are needed.

TRAUMA COMA DATA BANK

Death can be expected in approximately 30% to 36% of patients with severe TBI (GCS ≤8)

Good outcome in only 25%.

Gunshot wounds to the head tend to have a worse prognosis:
- prehospital mortality rates approaching 90%
- mortality rate of at least 60% for those who are alive upon arrival at a hospital.

TRAUMA COMA DATA BANK

The incidence of TBI is:

- Increasing within the elderly population
  Elderly population: increase in falls complicated by anticoagulant use.

- Decreasing for those younger than 45 years.
  < 45 year: increase motor vehicle safety (texting, mobile phones???)
A CT scan ideally should be obtained in all head injury patients except those who are completely asymptomatic.

Patients with Glasgow Coma Score (GCS) 14 or GCS 15 (mild head injury) with documented:
1. loss of consciousness,
2. amnesia,
3. focal neurological deficit,
4. seizures
5. signs of skull fractures

GLASGOW COMA SCALE

<table>
<thead>
<tr>
<th>Score</th>
<th>Best motor response</th>
<th>Best verbal response</th>
<th>Best eye-opening response</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Obeys</td>
<td>—</td>
<td>Spontaneously open</td>
</tr>
<tr>
<td>5</td>
<td>Localizes</td>
<td>—</td>
<td>Open to voice</td>
</tr>
<tr>
<td>4</td>
<td>Watches</td>
<td>Words/phrases</td>
<td>Open to pain</td>
</tr>
<tr>
<td>3</td>
<td>Flaps (Decorticate)</td>
<td>Incomprehensible sounds</td>
<td>Remain closed</td>
</tr>
<tr>
<td>2</td>
<td>Extends (Decerebrate)</td>
<td>Spontaneously open</td>
<td>Remain closed</td>
</tr>
<tr>
<td>1</td>
<td>No response</td>
<td>None</td>
<td>Remain closed</td>
</tr>
</tbody>
</table>

Severity of injury

- Minor (GCS = 15)
- Mild head injury (GCS = 13-14)
- Moderate head injury (GCS = 9-12)
- Severe head injury (GCS ≤8)

• 25% to 45% of severe TBI cases (GCS ≤8)
• 3% to 12% of moderate TBI cases (GCS = 9–12)
• Approximately 1 in 500 mild TBI cases (GCS 13-14)

The general principle is prompt evacuation of mass lesions that are causing mass effect, neurologic deficits, and poor or worsening Glasgow Coma Scale (GCS) score, in an attempt to LIMIT OR PREVENT THE PROGRESSION OF SECONDARY INJURY.
Main focus is identification and management of hypoxia and hypotension by reversing conditions that may jeopardize brain oxygenation.

The basic field principles of airway, breathing, and circulation remain critical to the management of patients with cerebral trauma.

**Hypoxemia** is a strong predictor of poor outcome and should be addressed immediately with oxygen supplementation.

*Because of conflicting results from recent studies demonstrating worse outcomes for patients intubated in the field, endotracheal intubation should be reserved for patients who are unable to adequately oxygenate, ventilate, or protect their airway or in those whose clinical course suggests that the benefits of intubation outweigh the risks.* (Contemporary Neurosurgery: Volume 34; Number 25; Dec 15, 2012)

Oxygen saturation kept greater than 90% with normal breathing rates and end-tidal CO2 levels between 35 and 40 mm Hg.

Hyperventilation with end-tidal CO2 levels below 35 mm Hg should be avoided unless there is evidence of cerebral herniation.

Routine use of paralytic agents to assist endotracheal intubation in spontaneously breathing patients should be avoided.

Use of induction agents has not been demonstrated to improve outcomes although evidence is inconclusive.

The effects of hypoxemia seem to be amplified when combined with hypotension, resulting in worse outcomes than those associated with hypoxemia alone.
TBI BASIC MEDICAL GUIDELINES

Hypotension, which is systolic blood pressure less than 90 mm Hg, has been determined to be one of the 5 factors to have at least 70% positive predictive value for mortality.

Intravascular volume repletion is essential for restoring blood pressure and thereby cerebral perfusion and oxygen delivery.

Hypotensive patients should be resuscitated with isotonic fluids.

INITIAL MEDICAL MANAGEMENT OF SEVERE TBI (GCS ≤8)

1. Head of bed elevation - 30 degrees or higher
2. Keep neck straight/ avoid tight trach tape
3. Avoid hypotension < 90 mm Hg/ control hypertension
4. Avoid hypoxemia PaO₂ <60 mm Hg or O₂ sat < 90%
5. Ventilate to normocarbia (PaCO₂ 35-40 mm Hg)
6. Sedation- Morphine 2-4 mg/1hr /Propofol drip or Paralysis (Vecuronium 8-10 mg IV)

MEDICAL MANAGEMENT

7. Routine Steroids is not recommended for treatment of head injury
8. Head CT without contrast
9. Mannitol 0.25-1 gm/kg q6h (serum osmol <320). Hold If hypotensive (SBP<90 mmHg) or hypovolemia
10. Seizure prophylaxis Yes or No??? Grey Zone.
11. Cerebrospinal fluid (CSF) drainage- Ventriculostomy (ICP)
12. Do not hyperventilate unless ongoing brain herniation or indicated PaCO₂ = 25-30 mmHg, <25 mmHg mm Hg Avoid at all times
BP Guidelines
- Hypertension should be treated only if mean arterial pressure is > 130 mm Hg or systolic BP is > 165 mm Hg.
- Nicardipine (Cardene)
  - 2.5 mg/h IV is given initially; dose is increased by 2.5 mg/h q 5 min to a maximum of 15 mg/h as needed to decrease systolic BP by 10 to 15%.

HIGH-RISK CRITERIA FOR POST-TRAUMATIC SEIZURES*
- Acute SDH, EDH, or ICH
- Open–depressed skull fracture with brain injury
- Seizure within 24 hours of injury
- Glasgow Coma Scale score 10
- Penetrating brain injury
- Significant ethanol abuse history
- +/- Cortical contusion on head CT

EARLY POST-TRAUMATIC SEIZURES
In patients at high risk for seizure activity especially comatose and neurologic examinations are unreliable:
- EEG monitoring is recommended
- Administration of phenytoin within 24 hours of injury and continuing for 7 days to prevent the occurrence of early seizures.

Phenytoin should be loaded at 20 mg/kg followed by a maintenance dose to ensure high therapeutic levels between 10 and 20 mcg/mL.

***Continuation beyond 7 days is not recommended unless:
- penetrating injury
- undergone craniotomy
- history of seizures
- experiences repeated seizures
The main objective of surgical and neurocritical care is to anticipate the evolution of secondary brain injury and prevent its deleterious effects.

**SURGICAL AND NEUROCRITICAL CARE**

**SURGICAL CARE: PREVENTING SECONDARY BRAIN INJURY**

Need for Ventriculostomy or placing an intraparenchymal monitor in patients with GCS score of 8 or less to measure ICP.

The goal has been to maintain ICP below and CPP above specific thresholds to ensure adequate cerebral perfusion and oxygenation. Although there is consensus for treating persistently elevated ICP higher than 20 mm Hg, CPP management has been less straightforward.

Some studies have demonstrated improved outcomes with CPP higher than 70 mm Hg, whereas others have not and have revealed high rates of pulmonary complications such as acute respiratory distress syndrome.
According to Current Brain Trauma Foundation guidelines, the critical threshold below which CPP should not fall below is 50 mm Hg, but artificially driving CPP (MAP-ICP) higher than 70 mm Hg has fallen out of favor.

*Avoid aggressive use of fluids and pressors to maintain CPP > 70 mmHg (risk of adult respiratory distress syndrome [ARDS]).

**NEUROCRITICAL CARE**

**CURRENT TRENDS**


Hypertonic Saline: May reduce ICP in patients refractory to mannitol, although no improvement in outcome over mannitol has been demonstrated. J Trauma 44 (1): 50-58, 1998

**WHEN IS SURGICAL INTERVENTION WARRANTED??**
Guidelines can be useful, but they may be a simplification of a complicated and, sometimes, unpredictable clinical situation. The most critical factors in deciding whether to operate on a traumatic intracranial hematoma are:

1. Patient’s neurological status (GCS)
2. Imaging findings (Head CT: mass effect, midline shift)
3. Presence and severity of extracranial lesions.

NON-OPERATIVE MANAGEMENT

In a patient with a small hematoma causing **less than 5 mm shift who is neurologically intact**, a conservative approach is justified. However, the patient may deteriorate rapidly, so very close observation is vital.

There is general agreement that an urgent operative course is indicated in a rapidly deteriorating patient with an expanding intracranial hematoma that is causing significant mass effect.

Significant mass effect may be arbitrarily defined as displacement of midline structures more than 5 mm or effacement of basal cisterns on CT scan (or both).
In general, surgical intervention is decided more readily for intracranial hemorrhages located:

- Temporal lobe
- Posterior fossa lesions

In these locations small lesion may lead to compression and irreversible brain stem damage within a shorter period of time.

TRAUMATIC INTRACRANIAL HEMORRHAGE CLASSIFICATION

- Epidural Hematoma (EDH)
- Subdural Hematoma (SDH)
- Traumatic Brain Injury
  - Cerebral Contusion/Hemorrhagic Contusion
  - Traumatic SAH
  - Skull fracture
  - Penetrating injury- GSW
  - Diffuse Axonal Injury- rotational deceleration/acceleration injury-nonsurgical

ANATOMY OF SDH VS EDH
EDH

EPIDURAL HEMATOMA (EDH)

- 84% cases have Classic appearance
  - High density biconvex shape
  - Textbook presentation < 10-27%
  - Brief posttraumatic LOC
  - Followed by “lucid interval” for several hours
  - Then, obtundation, contralateral hemiparesis, ipsilateral pupillary dilation
  - Untreated: Decerebrate posturing, HTN, respiratory failure and death

ACUTE EDH

Acute Epidural Hematoma

- Surgical evacuation should occur as soon as possible if GCS score ≤ 8, GCS 9-12, midline shift > 5 mm and the patient has anisocoria.

- If the thickness is < 15 mm with < 5 mm midline shift in a patient with GCS score higher than 8 without focal deficit, the acute epidural hematoma may also be managed non-operatively.
50% of cases there will be a slight transient increase in size between days 5-16 and some patients required emergency craniotomy.

- Close Neuro observation if nonsurgical.
- Serial Head CT’S

**EDH MANAGEMENT**

**EDH**

- Nonsurgical
  - Small < 1 cm max thickness
  - Subacute or Chronic
  - Minimal neurologic signs/symptoms
    - HA, lethargy
    - No mass effect, no herniation

**SDH**

<table>
<thead>
<tr>
<th>Category</th>
<th>Time frame</th>
<th>Density on CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute</td>
<td>1 to 3 days</td>
<td>Hypodense</td>
</tr>
<tr>
<td>Subacute</td>
<td>4 days to 2 or 3 wks</td>
<td>Isodense</td>
</tr>
<tr>
<td>Chronic</td>
<td>&gt; 3 weeks and &lt; 34 mins</td>
<td>Hypodense (approaching density of CSF)</td>
</tr>
<tr>
<td>Chronic</td>
<td>&lt; 1-2 months</td>
<td>May become lenticular shaped with density &gt; CSF, &lt; fresh blood</td>
</tr>
</tbody>
</table>

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SUBDURAL HEMATOMA (SDH)

- Acute/Chronic
- Midline shift > 5 mm midline shift
- Effacement of 3rd and posterior horn of right lateral ventricle

NONSURGICAL SDH

- Subdural often do not need surgical intervention **
- If asymptomatic or mild headache
  - Maintain BP < 165/90
  - Stop all NSAIDS, Anticoagulants
  - Medical Management
ACUTE SDH SURGICAL INDICATION

Surgical evacuation should occur when the hematoma thickness is greater than 10 mm or there is a midline shift more than 5 mm regardless of GCS score. Symptomatic-lethargy, hemiparesis etc

Patients with a GCS score higher than 9 or above does not meet the earlier criteria should undergo surgical evacuation if:

• GCS score declines by 2 or more points
• Patient develops anisocoria (unequal pupils)
• And/or ICP exceeds 20 mm Hg

CEREBRAL (HEMORRHAGIC) CONTUSION

• High density area on CT
• Most commonly occur in areas where sudden deceleration of the head causes the brain to impact a bony prominences
  • Coup or Contrecoup (Counter Blow) injury
    • Temporal
    • Frontal
    • Occipital
• Majority nonsurgical
CONTUSION OR ICH

The decision to remove an intracerebral hematoma or cerebral contusion should be based on several key factors, including (but not limited to):

- Blood Volume of the lesion > 20 cm³
- Depth and location of the lesion in relation to eloquent brain areas
- Patient's neurological status
- ICP > 20 mmHg with medical management
- Most are nonsurgical

TRAUMATIC ICH

- Elderly with history of fall on anticoagulants
- Delayed ICH incidence is 10%
- Most occur within 72 hrs of trauma
- “Talk and deteriorate” only 12%
- Poor outcome: mortality ranging from 50-75%
- Common with coagulopathy
  - Flecainide platelets
  - Coumadin-FFP and Vit. K
TRAUMATIC SAH
- Low risk for vasospasm
- Need to be observed in ICU
- Delayed Hydrocephalus
- ICP monitor-Intraventricular
- Nonsurgical
- MRA or CT angiogram/Cerebral Angiogram Gold standard-R/O Vascular malformation

SKULL FRACTURES
- Depressed Skull fracture
- Criteria for surgery
  - > thickness of skull or >8-10mm
  - Deficit related to underlying brain
  - CSF leak
  - Open depressed fx
  - More conservative treatment is recommended if overlying major dural sinus

SKULL FRACTURE TREATMENT
- Prophylactic antibiotics
  - Controversial
  - Most physicians recommend a broad spectrum antibiotic
    - Ciprofloxin for 7-days
    - Ancef 1 g IV
    - Rocephin 1 g IV once
SKULL FRACTURE WITH UNDERLYING HEMATOMA (VENOUS VS ARTERIAL)

- Surgical emergency
- If > 3 cm needs emergent surgery
- Maintain SBP <185
Decompressive Craniectomy trial (DECRA), published in the New England Journal of Medicine 2011, demonstrated higher rates of unfavorable outcome compared with standard medical management.

The goal in managing a patient with cerebral trauma is to anticipate the evolution of secondary brain injury and intervene early, before its progression.