Traumatic Brain Injury

Tallahassee Memorial Healthcare
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Neurosurgery
Terms

- Head injury
- Closed head injury
- Traumatic brain injury (TBI)
- Concussion
- Chronic traumatic encephalopathy (CTE)
Concussion

The formal medical definition of concussion is a clinical syndrome characterized by immediate and transient alteration in brain function, including alteration of mental status and level of consciousness, resulting from mechanical force or trauma.
TBI Prevalence (CDC data, 2010)

• TBI was diagnosed in 2.2 million US Emergency Dept (ED) visits
• TBI was diagnosed in 280,000 hospitalizations
• TBI was responsible for 50,000 deaths
• An estimated 248,418 children (<19 yo) treated in US EDs for concussion or TBI related to sports

References:


Causes of TBI (CDC data, 2006-10)

• #1: falls (40%)
• #2: unintentional blunt trauma (15%)
• #3: motor vehicle accidents (14%)
  MVC is the second leading cause of death from TBI (26%)
• #4: assault (10%)
Leading cause of TBI deaths

Leading cause differs depending on age:

- 65+ yo  ----- falls
- 5 – 24 yo -- motor vehicle trauma
- 0 – 4 yo  ---- assault
Hemorrhagic injuries to brain

- Traumatic subarachnoid hemorrhage
- Acute subdural hematoma
- Acute epidural hematoma
- Cerebral contusion
- Intraventricular hemorrhage
- Intraparenchymal hemorrhage
- Duret shear hemorrhage of brainstem
Traumatic Subarachnoid
Acute Subdural Hematoma
Acute Epidural Hematoma
Cerebral Contusion
Intraventricular Hemorrhage
Intraparenchymal Hemorrhage
Duret Brainstem Hemorrhage
Duret hemorrhage at autopsy
Bony injuries in TBI

- Facial fractures
- Associated cervical fracture(s)
- Occipital condyle fracture
- Skull fracture
  - Basal
  - Convexity
Diagnostic evaluation

- Emergency Center admission
- A B C (Airway, Breathing, Circulation)
- noncontrast head CT (computerized tomography, “CAT scan”)
- Clinical examination
  - Brainstem function
  - Glasgow coma score/scale
Brainstem Reflexes

- Pupillary light response
- Corneal response
- Cough
- Gag
- Motor response to pain (sternal rub, pinch)
- Oculocephalic reflex ("doll’s eye")
- Cold caloric response
- Respiration with elevated serum pCO₂
Glasgow Coma Scale

- Published in 1974 by Drs. Graham Teasdale and Bryan J Jennett, both neurosurgeons

- University of Glasgow’s Institute of Neurological Sciences at Glasgow Southern General Hospital, Scotland

### Glasgow Coma Scale

<table>
<thead>
<tr>
<th>Eye(s) Opening</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spontaneous</td>
<td>4</td>
</tr>
<tr>
<td>To speech</td>
<td>3</td>
</tr>
<tr>
<td>To pain</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Verbal Response</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oriented to time, place, person</td>
<td>5</td>
</tr>
<tr>
<td>Confused/disorientated</td>
<td>4</td>
</tr>
<tr>
<td>Inappropriate words</td>
<td>3</td>
</tr>
<tr>
<td>Incomprehensible sounds</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Best Motor Response</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obeys commands</td>
<td>6</td>
</tr>
<tr>
<td>Moves to localised pain</td>
<td>5</td>
</tr>
<tr>
<td>Flexion withdraws from pain</td>
<td>4</td>
</tr>
<tr>
<td>Abnormal flexion</td>
<td>3</td>
</tr>
<tr>
<td>Abnormal extension</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
</tr>
</tbody>
</table>

**Best response**

- 15

**Comatose patient**

- 8 or less

**Totally unresponsive**

- 3
Brain Tissue Injury Cascade

- Impact -> delivery of force
- Mechanical deformation of brain tissue
- Micro vascular injury
- Alteration of blood-brain barrier function
- Increased capillary permeability
- Inflammatory mediator release
- Glial cell swelling
- Loss of autoregulation
- Disruption of oxygen/nutrient delivery
- Glutamate release (Excitatory neurotransmitter)
- Cell toxicity and death
Cerebral Autoregulation

CBF = cerebral blood flow
MAP = mean arterial pressure
Autoregulation Impairment
Hospital care of TBI

- Medical Intensive Care support
- Surgery
- Monitoring
- Cerebral perfusion pressure (CPP) optimization
Intensive Care

- Normothermia
- Ventilatory support
- Intravenous hydration/volume support
- Normoglycemia
- Correction of coagulopathy
- Seizure prophylaxis
- ICU monitoring and Neuro checks
- Intracranial pressure (ICP) monitoring
- Management of intracranial pressure
- Deep venous thrombosis (DVT) prophylaxis
Surgery

- ICP monitor placement
- Decompressive hemicraniectomy
- Evacuation of mass effect hematomas
Medical Management

- ICP monitoring for CPP
- Mannitol
- Hypertonic (3%) saline
- Minimization of free water administration
- Blood volume resuscitation
- Seizure prophylaxis
Intracranial pressure ICP Monitors
Intracranial Pressure (ICP) Monitoring

- Ventricular drain
  - Permits drainage of some cerebrospinal fluid
  - More difficult to implant
  - Pressure readings can be inaccurate
  - Potentially higher infection risk
- Fiber optic transducer
  - Fast implantation
  - Continuous and instantaneous reading
  - Interfaces with ICU monitors
Fiber Optic ICP monitor
Cerebral Perfusion Pressure

Cerebral Perfusion Pressure (CPP)
Mean Arterial Pressure (MAP)
Intracranial Pressure (ICP)

CPP = MAP – ICP

(Ideal CPP = 50 – 70 mm Hg)
Mannitol and Hypertonic Saline

- Diuretic effect (mannitol)
- Decrease fluid in brain tissue
- Reduce cerebral edema
- Reduce brain volume
- Decrease ICP
- Maintain target CPP
Caveats of hyperosmolar therapy

- Watch serum Osm (<320)
- Watch serum Na (<155)
- Gently and slowly correct Na abnormalities
- Preserve renal function
- Maintain organ perfusion to rest of body
Mannitol vs. Hypertonic Saline

“While ... both mannitol and hypertonic saline were effective in reducing ICP, there was heterogeneity with regard to which agent was most efficacious.”

Seizure Prophylaxis

• Primarily two anticonvulsants used:
  • Dilantin (phenytoin)
  • Keppra (levetiracetam)

• Both agents are considered effective in reducing seizure risk for 7 days after trauma

Surgical management

- Craniotomy for evacuation of hematoma
- Decompressive hemicraniectomy
Decompressive Hemicraniectomy

- Craniectomy, not craniotomy
- Removal of a portion of skull without replacement
- Opening of the dura
- Often done with evacuation of subdural hematoma
- Bone flap placed in abdomen or discarded
- Later reconstruction of skull with cranioplasty surgery
Hemicraniectomy
Hemicraniectomy defect
Postoperative defect
Bone flap
After reconstruction
Decompressive Hemicraniectomy

Decompressive hemicraniectomy for traumatic brain injury: A systematic review.

- Review of literature from 2011-2015
- Only 12 of 5,528 publications met criteria for review
- 3 were prospective clinical trials
“CONCLUSIONS: Our study underscores the importance of continued international prospective data collection for assessing types of surgical interventions in addition to DC and their timing in patients who have severe TBI. In addition, in geographic areas with limited access to advanced medical treatment for severe TBI, DC is of benefit when performed <5 hours after injury in younger patients with Glasgow Coma Scale >5.”
Next Generation Treatment of TBI?

PROGESTERONE?
How might progesterone work?

- Reduce cerebral edema
- Re-establish the compromised BBB
- Improve vascular tone
- Down-regulate expression of inflammatory factors
- Reduce excitotoxic damage (glutamate)
- Prevent post-traumatic seizures
ProTECT Trial

Progesterone for Traumatic Brain Injury, Experimental Clinical Treatment

- Double blind, placebo controlled trial of 100 Pts
- Moderate to severe TBI (GCS 4-12)
- Continuous i.v. drip progesterone for first 11 hr
- Additional i.v. progesterone 10 hrs/day for 3 d
- No adverse effects
- If started within 6-8 hr of injury in severe TBI, mortality was reduced 50% vs. controls

ProTECT III

- National multicenter Phase 3 trial
- 1,000+ patients with moderately to severe TBI
- Treatment initiated within 4 hr of injury
- Given over 72 hr with a 24 hr taper
- Placebo controls
Protect III failure

• Study was halted after enrollment of 882 of the planned 1,140 patients
• Failed to achieve primary outcome of increase of 10% in the proportion of patients with favorable outcomes
• Increased complication rates of phlebitis and thrombophlebitis

SYNAPSE Study

the Study of a Neuroprotective Agent, Progesterone, in Severe Traumatic Brain Injury

- A second multicenter prospective Phase 3 trial
- 1195 patients enrolled
- Progesterone administered within 8 hr of injury
- Continued for 120 hr after injury
SYNAPSE Study failure

- 50.4% favorable outcome - Progesterone
- 50.5% favorable outcome - Placebo
- No statistical difference in mortality between two study groups

TBI Guidelines

Prevention of TBI

- Reduction of fall risks
- Rigorous seatbelt use
- Avoidance of intoxicated driving
- Diligent helmet use
“I liked recess a lot better before the safety helmets.”
References


