Severe Head Injury - Management and Recent Advances
KEY

• Epidemiology
• Resuscitation
• Primary survey
• Secondary survey
• Neurological evaluation
• Brain trauma foundation guidelines
• Neuropharmacology
• Robotics and TBI Rehabilitation
• Future of TBI Technology
Epidemiology

- Incidence 56-430/100,000
- Male: female = 3:2
- 60% occur in 20-40 yr age
- High mortality and morbidity
- Majority of deaths occur in the first 72 hrs
- Commonest cause is road traffic accidents
- Annual medical and rehabilitation costs $5000 billion USD
Resuscitation

• Goal- Halt ongoing injury and prevent onset of additional injury.

• Secondary cerebral insults
  – Hemorrhage – intra-axial, subdural, epidural
  – Cerebral edema
  – Increased intracranial pressure
  – Ischemia- hypotension, hypoxia
Primary survey

• Airway
• Breathing – trachea, auscultation, pulse oximetry
  – PaO2 >60 mmHg
  – Endotracheal intubation when GCS is < 9, 9-13 with multiple injuries, persistent hypoxia or patient unable to maintain airway.
  – Rapid sequence induction- thiopentone + succinylcholine
• Circulation-
  – SBP >90 mmHg, MAP >90 mmHg and CPP >70 mmHg.
• Disability – Neurological evaluation AVPU/GCS
• Exposure
Secondary survey

- Head to toe examination
  - AMPLE history
  - External injuries - fractures, lacerations, contusions
  - Eyes - pupils, motility, hemorrhage
  - CSF Leak
  - Neck - trachea, carotid pulsation, jugular venous distension, posterior cervical pain/spinous process step off
  - Log roll
Glasgow coma score

- **Eye opening**
  - Spontaneous 4
  - To speech 3
  - To pain 2
  - No eye opening 1

- **Best verbal response**
  - Oriented 5
  - Confused 4
  - Inappropriate words 3
  - Incomprehensible sounds 2
  - No verbal response 1
Glasgow coma score

- **Best motor response**
  - Obeys commands: 6
  - Localizes pain: 5
  - Withdraws from stimulation: 4
  - Abnormal flexion: 3
  - Extension: 2
  - No motor response: 1

- Mild Head injury: GCS 13-15
- Moderate head injury: GCS 9-12
- Severe head injury: GCS <8
Brain Trauma Foundation

- EBM Guidelines established in 1996
- Endorsed by AANS and WHO
- 50% reduction in mortality
- 262 million USD cost savings annually.
Grades of Evidence

• **Class I** - Good quality randomized controlled trial (RCT)

• **Class II** - Moderate quality RCT, good quality cohort, or good quality case-control

• **Class III** - Poor quality RCT; moderate or poor quality cohort; moderate or poor case-control; or case series, databases, or registries
Levels of Recommendation

- **Level I** - Recommendations are based on the strongest evidence, represent principles of patient management that reflect a high degree of clinical certainty.
- **Level II** - Recommendations reflect a moderate degree of clinical certainty.
- **Level III** - Recommendations for which the degree of clinical certainty is not established.
Hyperosmolar therapy

- **Level II**
- Mannitol is effective for control of raised intracranial pressure (ICP) at doses of 0.25 g/kg to 1 g/kg body weight in rapid neurologic decline and presumed herniation.
- Arterial hypotension (systolic blood pressure <90 mm Hg) should be avoided.
- Serum osmolarity maintained below 310 mOsm.
- Intermittent boluses preferred over constant infusions.

Mannitol

• Schwartz et al 1984 (Class I)  N=59
  – Mannitol group had lower outcome mortality in DAI.
    • 41% vs. 77%
  – Better CPP in Mannitol group.

• Fortune et al 1995 (Class II)  N=22
  – Studied effect of Mannitol and hyperventilation on $S_{jv}O_2$.
  – 196 interventions on 22 patients.
  – $S_{jv}O_2$ increased with Mannitol and decreased with hyperventilation.
Hyperosmolar therapy

Potential Benefits
• Rapid reduction in intracranial pressure
• Reduced morbidity and mortality

Potential Harms
• Reduce perfusion to the brain.
• Arterial hypotension, sepsis, nephrotoxic drugs, or pre-existing renal disease place patients at increased risk for renal failure with hyperosmotic therapy.
• A rebound phenomenon.
Hyperventilation

• Temporizing measure for the reduction of elevated ICP. (Level 3)
• Avoided during the first 24 hours because of risk of ischemia.
• If used, jugular venous oxygen saturation (SjO$_2$) or brain tissue oxygen tension (PbrO$_2$) measurements to monitor oxygen delivery.

Anaesthetics and sedatives

• **Level II**

• High-dose barbiturate to control elevated intracranial pressure (ICP) refractory to maximum standard medical and surgical treatment.

• Prophylactic barbiturates is not recommended.

• Propofol no improvement in mortality or 6 month outcome.

Kelly PF et al,. Propofol in treatment of SHI. J Neurosurg 1999;90:1042-57
Current practice

- Short acting narcotics + benzodiazepine

- Propofol infusion – 1-2mg/Kg/hr

- Patient agitated, hypertonic or resisting the ventilator- neuromuscular blockade - vecuronium
DVT/PE prophylaxis

- Intermittent pneumatic compression stockings (Level III).

- LMWH or low dose UFH should be used in combination, but there is increased risk for expansion of ICH.

Current practice

• Pneumatic compression stockings in all patients until ambulatory.
• Full anticoagulation in acute head injury only after at least 10-14 days, ideal timing unclear.
• Contraindicated in abnormal coagulation studies and unstable hemorrhagic lesions.
• Proximal DVT with Wells ratio > 6 – inferior vena caval filter placement.

Steroids

• Level I

• The use of steroids is not recommended for improving outcome or reducing intracranial pressure (ICP).

• High-dose methylprednisolone is associated with increased mortality in moderate or severe traumatic brain injury (TBI) and is contraindicated.
CRASH TRIAL

- Head injury with GCS ≤ 14
- Primary outcome
  - Death at 2 weeks
  - Disability at 6 months (not yet reported)
- 10,008 subjects
- Multicentre RCT Randomization groups
  - Placebo
  - Methylprednisolone
    - Load 2 gms
    - Maintenance 0.4 gm/hr for 47 hours
- Mortality
  - Placebo 18%
  - Steroids 21%

Lancet 2004; 364: 1321-38
Seizure Prophylaxis

- Level II evidence that DPH/phenobarbital NOT necessary beyond one week.

- They prevent EPTS but not LPTS.
Current practice

• Phenytoin during the first week to maintain serum therapeutic level of 15-20ug/L.

• Second line – valproate/phenobarbitone.


• Late post traumatic seizures- 17% after SHI. Higher risk with brain contusion with SDH, skull fractures, loss of consciousness/amnesia >1 d, age >65 yrs.

Infection prophylaxis

Level II

• Periprocedural antibiotics for intubation reduce the incidence of pneumonia. No change in length of stay or mortality.
• Early tracheostomy reduce mechanical ventilation days. No change in mortality or the rate of nosocomial pneumonia.

Level III

• Routine ventricular catheter exchange or prophylactic antibiotic use for ventricular catheter placement is not recommended to reduce infection.
• Early extubation in qualified patients can be done without increased risk of pneumonia.
Prophylactic hypothermia

- Level III
- No decrease in mortality.
- Prophylactic hypothermia is associated with favourable neurological outcomes (GOS 4 or 5) when compared to scores for normothermic controls.
- Confounding and effect modifying factors not accounted for.
Brain oxygen monitoring

- **Level III**
- Jugular venous saturation or brain tissue oxygen monitoring measures cerebral oxygenation.
- Jugular venous saturation (<50%) or brain tissue oxygen tension (<15 mm Hg) are treatment thresholds.
  - episodes of desaturation ($SjO_2 < 50–55 \%$)
  - low values of brain tissue oxygen tension ($P_{br}O_2$) $< 15$ mm Hg for $> 30$ min are associated with high rates of mortality.
ICP Monitoring

- GCS score is < 9.
- CT shows either space-occupying lesions or edema that compresses the basal cisterns.
- Normal CT if two of three findings present:
  - age > 40 years,
  - persistent SBP < 90 mm Hg, or the
  - presence of motor posturing.
- Maintain ICP < 20mmHg.
Does ICP Monitoring Improve Outcome

• No randomized controlled trial
  
  – Lane et al 2000 (Class II)
    • Retrospective study of trauma database
    • 5507 head injured patients
    • Used AIS scores to define injury
    • Results
      – multivariate analyses controlling for AIS head, ISS and injury mechanism indicated that ICP monitoring was associated with significantly improved survival (p < 0.015)
  
**Elevated ICP Management**

- CPP be maintained above 70 mmHg.
- Ventricular drainage
- Repeat CT scans when indicated.
  - Head elevation 30 deg
  - Hyperventilation to a pCO2 of 30-35 mmHg
  - Sedation
  - Ventricular drainage
  - Mannitol up to 1 g/kg
  - Propofol/phenobarbital coma
Surgical guidelines

• Intracranial hematomas complicate 25-45% severe TBI.
• Effective and timely surgical management essential.
• Evacuate EDH if > 30 cm$^3$, 15 mm thick or >5mm shift.
• Evacuate SDH if > 10 mm thick or 5 mm shift or if in coma, GCS drops >2, or ICP > 20 mmHg.
Surgical guidelines

• Progressive neurological deterioration, medically refractive intracranial hypertension.
• GCS 6-8 with frontal/temporal >20 and any lesion >50cm$^3$.
• Posterior fossa lesion with mass effect or neurological dysfunction referable to lesion.
• Decompressive craniectomy, evacuation of mass lesion and temporal lobectomy are treatment options.
Neuropharmacology

- Improve survival and outcome
  - Progesterone
- Increase arousal, attention and performance.
- Amantadine – behavioural & mood change.
  

- Methylphenidate – arousal and consciousness level in the sub-acute phase, Improve processing speed and attention.
  

- Donepezil
  - Centrally acting reversible acetylcholinesterase inhibitor
  - Main therapeutic use is in the treatment of Alzheimer's disease
  - Improved cognition and behaviour
Robotics and TBI Rehab

- Benefit of robotics in UE and LE motor scores and: Lkj
- Safe and affordable.
- Relies on novel human-robot interaction.
- Use of robotics to improve wakefulness and arousal in vegetative States.
- Control of repetitive movements may reduce development of abnormal brain response and compensatory movement patterns.

Future of TBI Technology

• The activation of hand area neurons is accompanied by a circumscribed ER over the hand area.

• Depending on the type of motor imagery different EEG patterns can be obtained.
Brain Computer Interface

- External device communicate directly to the brain through neuron silicon interfaces.
- Transmit / receive signals to and from the brain which can be used to restore function / movement to sensory organs /limbs.
- Successful in restoring sight, movement and hearing.

Neurobotics

“The integration of mechanically engineered human-like hardware (limbs, joints, tendons) with our own body's software – the nervous system.” -Yoky Matsuoka

• Rehabilitate/assist human movement capabilities.

• Strokes, spinal cord injuries, traumatic brain injuries, Parkinson’s, Cerebral Palsy, amputees, and other injuries and disorders that inhibit daily activities.

• Sports medicine, military, and entertainment applications.
### Overall outcome in patients with head injury

<table>
<thead>
<tr>
<th>Glasgow Outcome Score</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Death</td>
<td>454 / 2062 (22%)</td>
</tr>
<tr>
<td>2 Vegetative</td>
<td>156/782(19%)</td>
</tr>
<tr>
<td>3 Severe disabled</td>
<td>103/782 (13%)</td>
</tr>
<tr>
<td>4 Mod. disabled</td>
<td>139/782 (17%)</td>
</tr>
<tr>
<td>5 Good recovery</td>
<td>226/782 (28%)</td>
</tr>
</tbody>
</table>

45% favourable outcome

<table>
<thead>
<tr>
<th>GCS score</th>
<th>Mode of Treatment</th>
<th>Survived</th>
<th>Died</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-8</td>
<td>Surgery</td>
<td>617</td>
<td>192</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>Conservative</td>
<td>78</td>
<td>203</td>
<td></td>
</tr>
<tr>
<td>9-12</td>
<td>Surgery</td>
<td>109</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conservative</td>
<td>226</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>13-15</td>
<td>Surgery</td>
<td>23</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conservative</td>
<td>561</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>
AIIMS Results

- Kagan RJ 1994: 26.7% (Overall), 41.4% (Severe)
- Fakhry SM 2004: 28.8% (Overall), 0% (Severe)
- Udekwu P 2004: 21% (Overall), 31.5% (Severe)
- Present study: 22% (Overall), 36% (Severe)

Outcome in Head Injured Patients: Experience at a Level 1 Trauma Centre

*Indian Journal of Neurotrauma (IJNT) 2009, Vol. 6, No. 2, pp. 119-122*
THANK YOU

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