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
  - updated in 2007.
- 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.

Muizelaar JP et al. Effect of mannitol on ICP & CBF and correlation with pressure autoregulation in severe head injured patients. J Neurosurg. 1984;61:700-706.

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.

Oertel M, et al. Efficacy of hyperventilation in controlling ICP after head injury. J Neurosurg 2002;97:1045-53

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.

Gerlach R et al, Risk of postoperative hemorrhage following intracranial surgery after early Nadoparin administration – prospective sstudy: Neurosurgery 2003;53:1028-34.

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.

Wells PS, Ginsberg JS, Anderson DR, et al "Use of a clinical model for safe management of patients with suspected pulmonary embolism". *Ann Intern Med* ***129*** *(12): 997–1005.*

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.

Ma CY, Xue YJ, Li M, Zhang Y, Li G Z. Sodium valproate for prevention of early posttraumatic seizures. Chin J Traumatol. 2010 Oct 1;13(5):293-6

- 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.

Temkin NR, Dikmen SS, Anderson GD et al. V**alproate therapy for prevention of posttraumatic seizures: a randomized trial.** J Neurosurg. 1999 Oct;91(4):593-600

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 ($p < 0.015$)
  - Fakhry, Trask, Waller et al. Management of brain injured patients by EBM protocol. J Trauma 2004;56:492-500

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.

brain Meythaler JM, Brunner RC, Johnson A. Amantadine to improve neurorecovery in traumatic injury-associated diffuse axonal injury: a pilot double-blind randomized trial. J Head Trauma Rehabil. 2002 Aug;17(4):300-13

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

Hossein A. Khalili, Kamyar Keramatian . Effect of Methylphenidate in Patients with Acute Traumatic Brain Injury; a Randomized Clinical TrialProgress in Neurotherapeutics and Neuropsychopharmacology (2008), 3:1:189-197

- 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.

Matarić M, Tapus A, Winstein C, Eriksson J. Socially assistive robotics for stroke and mild TBI rehabilitation. Stud Health Technol Inform. 2009;145:249-62

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.

H.I. Krebs, J.J. Palazzolo, L. Dipietro,et al R**ehabilitation Robotics: Performance-Based Progressive Robot-Assisted Therapy.** Autonomous Robots.Volume 15; Number 1: 7-20.

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.

AIIMS Results

Overall outcome in patients with head injury

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

45% favourable outcome

GCS score	Mode of Treatment	Survived	Died	P value
3-8	Surgery	617	192	<0.05
	Conservative	78	203	
9-12	Surgery	109	18	
	Conservative	226	27	
13-15	Surgery	23	2	
	Conservative	561	12	

AIIMS Results

	Overall	Severe
• Kagan RJ 1994	26.7%	41.4%
• Fakhry SM 2004	28.8%	0
• Udekwu P 2004	21%	31.5%
• Present study	22%	36%

Out come in Head Injured patients :Experience at a level 1 Trauma Centre

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THANK YOU

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