Current Head Injury Guidelines

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Guideline Evidence & Recommendations

- **Grades of Evidence**
  - **Class I** - Good quality randomized controlled trial (RCT)
  - **Class II** - Moderate quality RCT, good quality cohort, good quality, or case-control
  - **Class III** - Poor quality RCT; moderate or poor quality cohort; moderate or poor case-control; case series, databases or registries
- **Levels of Recommendation**
- Levels of recommendation are Level I, II, and III, derived from Class I, II, and III evidence, respectively.
  - **Level I** - recommendations are based on the strongest evidence for effectiveness, and 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.

Severe Head Injury Standards

- The use of steroids is not recommended for improving outcome or reducing intracranial pressure (ICP). In patients with moderate or severe traumatic brain injury (TBI), high-dose methylprednisolone is associated with increased mortality and is contraindicated.
  - **THIS IS THE ONLY LEVEL I RECOMMENDATION**
- In the absence of increased ICP, chronic prolonged hyperventilation ($pCO_2 < 25$) should be avoided after severe TBI.
- Prophylactic use of Dilantin, Tegretol, or Phenobarbital is not recommended for preventing ***late*** post-traumatic seizures.

Thank you! Thank you very much!

Report to Congress: 2006

- From 1980 through 1994, the TBI-associated death rate in the United States decreased 20 percent, from 24.7 per 100,000 population to 19.8 per 100,000 population (Figure 1). Most of the decrease resulted from a 38 percent decline in transportation-related deaths, from 11.1 per 100,000 population in 1980 to 6.9 per 100,000 in 1994. Rates of TBI-associated death due to falls and other causes also decreased during this period. However, firearm-related TBI deaths increased 11 percent during this period, from 7.6 per 100,000 in 1980 to 8.4 per 100,000 in 1994. Because of this increase, firearms-use surpassed transportation crashes as the leading cause of death from TBI in 1990.

Pre-Hospital Guidelines (All are Class III – Weak strength)

- All regions should have an organized trauma care system.
- Protocols are recommended to direct Emergency Medical Service (EMS) personnel regarding destination decisions for patients with severe traumatic brain injury (TBI).
- Patients with severe TBI should be transported directly to a facility with immediately available computed tomography (CT) scanning, prompt neurosurgical care, and the ability to monitor intracranial pressure (ICP) and treat intracranial hypertension.
- The mode of transport should be selected so as to minimize total prehospital time for the patient with TBI.

Pre-Hospital Guidelines

- Monitor for hypoxemia (<90% Sat.) or hypotension (<90 mmHg Systolic)
- GCS evaluation after ABC's completed
- Pupillary assessment in the field (trauma?)
  - After resuscitation
  - Assymetry defined as > 1 mm difference
- In ground transported patients in urban environment, the routine use of paralytics to assist endotracheal intubation in patients who are breathing spontaneously, and maintaining SpO_2>90% on supplemental O_2, is not recommended.

Pre-Hospital Guidelines

- Hypotensive patients should be treated with isotonic fluids.
- Hypertonic resuscitation is a treatment option for traumatic brain injury (TBI) patients with a Glasgow Coma Scale Score (GCS) ≤8.

Pre-Hospital Guidelines

- Mild or prophylactic hyperventilation (arterial carbon dioxide pressure [$PaCO_2$] <35 mmHg) should be avoided. Hyperventilation therapy titrated to clinical effect may be necessary for brief periods in cases of cerebral herniation or acute neurologic deterioration (Adelson et al., 2003).
- Patients should be assessed frequently for clinical signs of cerebral herniation.
- The goal of hyperventilation is end tidal carbon dioxide ($ETCO_2$) of 30 to 35 mmHg. Capnography is the preferred method for monitoring ventilation.

Initial Assessment

- In Absence of Clinical Signs of Herniation - A.T.L.S. protocols should be followed
- Glasgow Coma Score followed sequentially
- N.I.N.D.S.: CT Scan if G.C.S. < 15
- In Presence of Clinical Signs of Herniation -
  - Brief usage of hyperventilation appropriate
  - Mannitol only with adequate volume resuscitation

Severe TBI – BP & Oxygenation

- **Level I**
- There are insufficient data to support a Level I recommendation for this topic.
- **Level II**
- Blood pressure should be monitored and hypotension (systolic blood pressure <90 mm Hg) avoided.
- **Level III**
- Oxygenation should be monitored and hypoxia (PaO_2 <60 mm Hg or O_2 saturation <90%) avoided.

Severe TBI - Antibiotics

- **Level II**
- Periprocedural antibiotics for intubation should be administered to reduce the incidence of pneumonia. However, it does not change length of stay or mortality.
- Early tracheostomy should be performed to reduce mechanical ventilation days. However, it does not alter 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.

Intracranial Pressure Monitoring

- Level II: G.C.S. of 3 - 8 with abnormal CT Scan
- Level III: G.C.S. of 3 - 8 & normal CT with 2 or more of following:
  - Age > 40
  - Motor posturing, Unilateral or Bilateral
  - Systolic B.P. < 90 mmHg
- May be appropriate for G.C.S > 8 with traumatic mass lesion

ICP Pressure Variations

- "A" Wave
  - Rises steeply from normal or slightly raised to 50 mmHg or more, lasts 5-20 min., then falls
  - Indicates dangerously reduced intracranial compliance
- "B" Wave
  - Rhythmic oscillations, every 1-2 mins
  - Rises 20-30 mmHg above baseline, then falls
  - More frequent, less adverse significance

Cerebral Perfusion Pressure

- **Level II**
- Aggressive attempts to maintain cerebral perfusion pressure (CPP) above 70 mm Hg with fluids and pressors should be avoided because of the risk of adult respiratory distress syndrome (ARDS).
- **Level III**
- CPP of <50 mm Hg should be avoided.
- The CPP value to target lies within the range of 50–70 mm Hg. Patients with intact pressure autoregulation tolerate higher CPP values.
  - This would suggest a general threshold in the realm of 60 mm Hg
- Ancillary monitoring of cerebral parameters that include blood flow, oxygenation, or metabolism facilitates CPP management.

Brain Tissue Oxygen Monitoring (LICOX)

- Measures partial pressure oxygen in brain tissue
  - P_BO_2 > 20
- Low values of brain tissue oxygen tension ($P_{br}O_2$) (<0–15 mm Hg) and the extent of their duration (greater than 30 min) are associated with high rates of mortality.
- Can adjust CPP to need of each patient
  - Potentially helpful in preventing secondary injury
  - Potentially improved outcomes
  - Level III: Jugular venous saturation (<50%) or brain tissue oxygen tension (<15 mm Hg) are treatment thresholds.

Mannitol

- Does **NOT** dehydrate Brain
- Does reduce ICP by reducing blood viscosity and improving CBF
- Powerful vascular expander
  - Caution with renal patients
- Hypertonic saline an alternative, but not part of adult guideline at present (Peds -> Yes).
- Level II – III recommendations

Severe TBI - Hypothermia

- Pooled data indicate that prophylactic hypothermia is not significantly associated with decreased mortality when compared with normothermic controls. However, preliminary findings suggest that a greater decrease in mortality risk is observed when target temperatures are maintained for more than 48 hours.
- Prophylactic hypothermia is associated with significantly higher Glasgow Outcome Scale (GOS) scores when compared to scores for normothermic controls.
- Target cooling: 32-33 deg. Celsius
- **MAY** have higher chances of reducing mortality if maintained > 48 hrs.

Severe TBI – DVT Prophylaxis

- **Level III**
- Graduated compression stockings or intermittent pneumatic compression (IPC) stockings are recommended, unless lower extremity injuries prevent their use. Use should be continued until patients are ambulatory.
- Low molecular weight heparin (LMWH) or low dose unfractionated heparin should be used in combination with mechanical prophylaxis. However, there is an increased risk for expansion of intracranial hemorrhage.
- There is insufficient evidence to support recommendations regarding the preferred agent, dose, or timing of pharmacologic prophylaxis for deep vein thrombosis (DVT).
- **Summary**
- Level III evidence supports the use of graduated compression or IPC stockings placed for DVT prophylaxis for patients with severe traumatic brain injury (TBI), unless lower extremity injuries prevent their use. Level III evidence supports the use of prophylaxis with low-dose heparin or LMWH for prevention of DVT in patients with severe TBI. However, no reliable data can support a recommendation regarding when it is safe to begin pharmacological prophylaxis. Moreover, no recommendations can be made regarding medication choice or optimal dosing regimen for patients with severe TBI, based on the current evidence.

Anesthetics, analgesics, and sedatives

- **Level II**
- Prophylactic administration of barbiturates to induce burst suppression electroencephalography (EEG) is not recommended.
- High-dose barbiturate administration is recommended to control elevated intracranial pressure (ICP) refractory to maximum standard medical and surgical treatment. Hemodynamic stability is essential before and during barbiturate therapy.
- Propofol is recommended for the control of ICP, but not for improvement in mortality or 6 month outcome. High-dose propofol can produce significant morbidity.

Barbiturates & Intracranial Hypertension

- Salvage Therapy
  - 10-15% of Severe Head Injury manifest intractable elevated ICP with 84-100% mortality
- Several Mechanisms:
  - Alteration of vascular tone, metabolic suppression, inhibition of free radical mediated lipid peroxidation
- Can cause undesirable hypotension

Barbiturates & Intracranial Hypertension

- Therapeutic Regimens:
  - Loading dose: 10 mg/kg over 30 minutes, 5 mg/kg every hour x 3 doses
  - Maintenance dose: 1 mg/kg per hour, Titrate to Burst Suppression on EEG

Traumatic Brain Injury

- 4th leading cause of death in U.S.A.
  - Leading cause in ages 1 – 44
- 50% of all trauma deaths are from TBI
  - GSW to head accounts for 35% of TBI deaths
- Escalation in firearms violence has lead to increase in penetrating brain injury
- Penetrating brain injury 35 times more likely to die than nonpenetrating with similar injury

Penetrating TBI Pathophysiology

- Depends on the circumstances of the injury, including the properties of the weapon or missile, the energy of the impact, and the location and characteristics of the intracranial trajectory.
- Secondary injury frequently follows primary event
- Most meaningful predictor -> Post resuscitation GCS
- Penetrating vs Perforating

Missile Wounds

- Low velocity vs high velocity
  - $K=1/2mv^2$
- Direct crush injury produced by missile
- Cavitation produced by the centrifugal effects
- Shock waves that cause a stretch injury
  - Tissue is destroyed and is either ejected out of the entrance or exit wounds
  - Creates both a permanent cavity that is 3-4 times larger than the missile diameter and a pulsating temporary cavity that expands outward (can be 30 times larger)

Medical Management

- Initial treatment follows ATLS protocols
  - BP < 90 mmHg associated with 85% increased mortality
- Seizure prophylaxis (discontinue @ 1 week)
- Antibiotic prophylaxis
  - Prolonged treatment -> resistant organisms
- ICP monitor for all patients with GCS $\leq$ 8

Current Treatment

- Management still somewhat controversial
  - A.A.N.S. Guidelines written 2001
- No standards or guidelines – only "options"
  - Local debridement / repair
  - Craniotomy / craniectomy – need watertight closure
  - Remove accessible bone fragments / mass lesions
  - In absence of mass effect, debridement of missile tract not recommended
  - Role of Decompressive Hemicraniectomy?

Case Presentation

- 38 y.o. Caucasian Male
- Working on scaffold with 15 foot fall
- Questionable L.O.C., but altered mental status at scene per EMS and in T.R.A.
- Initial GCS 14 (E4,M6,V4)
- No significant PMH

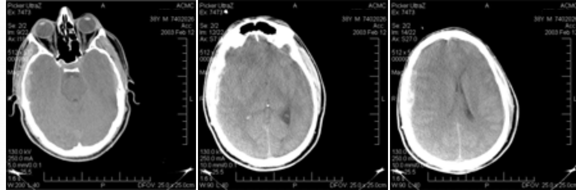
Evaluation

- GCS 14 with progressive combativeness
- Large left T-P cephalohematoma
- Pupils 4 mm RRL, No focal deficits
- Tender left clavicle
- Left paraspinal abrasion T-L junction

Initial Management

- Intubated for progressive agitation and combativeness
- Hemodynamically stable
  - BP 190/52, P 100, R 11, T 95, 96→100%
- CT Brain, C-Spine series. CT C- Spine
- CT Chest, Abdomen, Pelvis

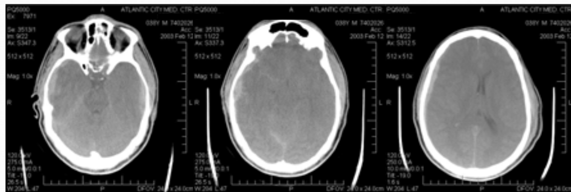
Initial CT Scan



Post-Imaging Management

- Neurosurgical Consult called
- CVP & A-Line
- Right Frontal ICP Monitor Placed
  - Initial ICP 42 mmHg
- Aggressive CPP/ICP Management
  - Two spikes after initial improvement
- Repeat CT Brain

Follow Up CT Scan



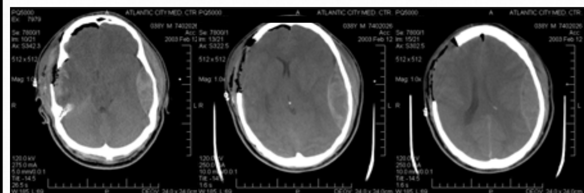
Decision Making

- Continue closed management?
- Surgery?
- Right Frontotemporoparietal Decompressive Craniectomy, Removal of Subdural Hematoma, Placement Left ICP Monitor, Implantation Bone Flap in Abdominal Wall

Post-op Management

- Initial ICP on closure 12-15 mmHg
- Rise to 30 mmHg in TICU 90 min post-op aggressively treated
- Continued rise to 50 mmHg
- Repeat CT Brain

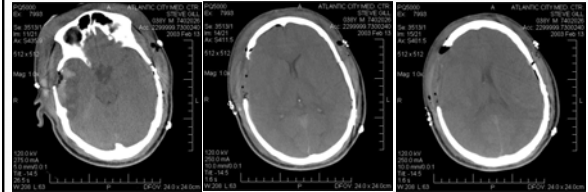
Post-Op CT Brain



Decision Making

- None → To Operating Room
- Left Temporoparietal Craniotomy and Removal of Epidural Hematoma
- Post-Op: CPP / ICP management

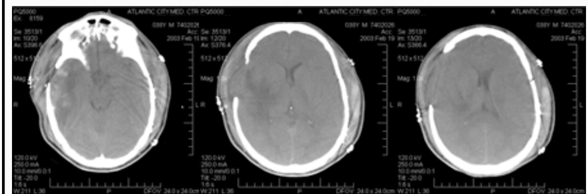
Post- Op CT Brain #2



Post-Op Course

- CPP / ICP management with fluids, Mannitol, and pressors as needed
- Considered controlled POD #7, drips and sedation weaned
- ICP monitor D/C'd POD #8
- Patient weaned and extubated POD #8

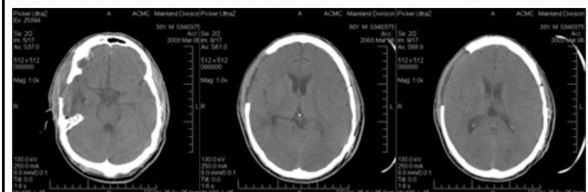
CT Scan POD #7



Post-Extubation Course

- Rapid recovery of function to GCS 13 at extubation which improved to 15
- Continued improvement in TBI rehabilitation to full independence

CT Scan POD #24



Outcome

- Elective reconstruction of skull defect on POD #30
- Continued cognitive improvement with return of driving privileges
- Discharged to RTW from NS standpoint 4 months post-injury

Resources

- AANS/CNS Section on Neurotrauma & Critical Care
  - www.neurotraumasection.org
- The Brain Trauma Foundation (professional pages)
  - www.braintrauma.org/professional-homepage/
- National Guideline Clearinghouse
  - www.guideline.gov