

***Sports-Related Severe
Traumatic Brain Injury:
Management by the
Emergency Medicine Specialist***

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FERNE

**Foundation for the
Education and Research of
Neurological Emergencies**

www.FERNE.org

***IBIA
International Brain
Injury Association***

**5th World Congress
On Brain Injury**

Stockholm, Sweden

**Overview
*Global Objectives***

- Understand disease state (TBI)
- Utilize best management strategies
- Have many options available
- Optimize patient outcome
- Maximize resource use
- Make our practice enjoyable

Overview

Session Objectives

- Consider the frequency of this event
- Look at pathophysiology TBI
- Examine how we evaluate TBI
- Look at specific therapies
- Consider prognostic findings

Overview

Session Specifics

- Present a representative case
- Address clinically relevant therapies
- Utilize the medical literature
- Review what are optimal strategies
- Summarize what we know
- Be clear on our approach

Methodology

Methodology

Literature Search

- MEDLINE, PubMed
- TBI AND Guidelines
- TBI AND Diagnosis AND E.D.
- TBI AND Therapy AND E.D.

Methodology

Internet Sources

- www.cochrane.org/
- www.update-software.com/Cochrane/default.HTM/
- www.neurosurgery.org/aans/
- www.braintrauma.org/
- www.ferne.org/
- www.google.com/

Methodology

Source Documents

- Cochrane Review abstracts
- Guidelines for Rx Severe Head Injury
– *J Neurotrauma*, Vol 15:11 November 1996
- Guidelines for Prehospital RX TBI
– Brain Trauma Foundation (BTF) 1999
- Rx and Prognosis of Severe TBI
– BTF website, Feb 2000

Methodology

Source Documents

- Emergency Medicine Reports
 - December 3, and December 17, 2001
- Guidelines for Rx of Adults with TBI
 - *J of Neurosurgical Sciences*
 - Vol 44:1 March 2000
 - Three articles
 - Initial assessment, medical, surgical Rx

TBI Overview

Epidemiology

TBI Incidence

- 1.6 million head injuries per year
- 800,000 receive ED, outpatient care
- 270,000 hospital admissions
- 52,000 deaths
- 90,000 permanent neuro disabilities

Epidemiology

TBI and Mortality

- 52% of all trauma deaths due to TBI
- CNS: more lethal than other body sites
- ASCOT: ISS with CNS weighting
- Morbidity data: key CNS role also

Pathophysiology

Damage Types

- Primary damage:
 - Surface contusions
 - Lacerations
 - Diffuse axonal injury
- Secondary Damage:
 - Hemorrhage
 - Swelling, ICP & hypoxic effects, infection

Pathophysiology

Brain Edema and ICP

- Brain edema:
 - Vasogenic, hydrostatic, osmotic effects
 - Cytotoxic effects
 - Interstitial edema
- Normal intracranial pressure
 - $CPP = MAP - ICP$
 - $80 = 90 - 10$ (mm Hg)

Pathophysiology *SBP, ICP, and Low CPP*

- $CPP = MAP - ICP$
- Increased intracranial pressure
– $60 = 80 - 20$ (mm Hg)
- Low systolic BP
– $60 = 70 - 10$ (mm Hg)
- Both elevated ICP and low SBP
– $50 = 70 - 20$ (mm Hg)

Pathophysiology *Elevated ICP*

- ICP < 15 mm Hg is normal
- Altered mental status patients:
– 40% will have increased ICP
- CBF is disturbed above 40 mm Hg
- ICP > 60 mm Hg is lethal
- Begin therapy with ICP above 20

Pathophysiology *Cytotoxic Effects*

- Secondary auto-destruction
- Delayed O₂ radical formation
- Intracellular calcium shifts
- Glutamate, NMDA effects
- Ongoing cell death

Health Care Costs *TBI Effects*

- Leading cause of death & disability
- Loss of life
- Loss of productivity
- Significant health care costs
- Annual cost: \$40 billion

A Sports-Related Severe TBI Case

The Disease State *A Sports Severe TBI Case*

- What likely diagnoses?
- What diagnostic tests in the ED?
- What acute therapies?
- What disposition?
- What expected outcome?

Sports Severe TBI Case *History*

- 21 year old male
- Snowmobiling in Colorado
- Swerves into a tree
- Headache, blood from the helmet
- Loss of consciousness for 10 minutes
- Dad has cell phone

Sports Severe TBI Case *History*

- 15 minutes wait for EMS
- Prehospital care: IV, O2, monitor
- Pt is immobilized
- 30 minute transport to nearest ED
- Pt responds only to painful stimuli

Sports Severe TBI Case *Clinical Questions*

- How is severe TBI defined?
- Is MOI related to type of CNS injury?
- What physical exam elements are key?
- What are the components of the GCS?
- What findings suggest increased ICP?
- What findings suggest herniation?

Sports Severe TBI Case *Airway Rx Questions*

- What are the indications for ET intubation?
- What is the accepted algorithm for rapid sequence induction?
- In what position should ETI be performed?
- What is the role of suspected c-spine injury in ETI with TBI?

Sports Severe TBI Case *Therapy Questions*

- What are the indications for
 - Fluids, hypertonic saline, blood?
 - Hyperventilation?
 - Mannitol?
 - Barbiturates?
 - Hypothermia?
 - Steroids?
 - Seizure prophylaxis?

Sports Severe TBI Case *ICP Therapy Questions*

- What is the accepted algorithm for the treatment of increased ICP?
- What is the role for ICP monitoring?
- When is a repeat CT indicated?
- When is surgical evacuation indicated?

Sports Severe TBI Case ***Outcome Questions***

- What resus findings predict outcome?
- What physical findings correlate?
- What CT findings predict outcome?
- What other factors predict outcome?
- How is poor outcome defined?
- How is outcome measured? When?

Sports Severe TBI Case ***Physical Exam***

- 98.8 100/60 110 12 approx 70 kg
- Gen: ? Non-purposeful mvmt on cart
- Head: Large laceration, contusion over R temporal-parietal region
- Face: Several abrasions, contusions
- Eyes: 4 mm, equal, reactive, EOM OK

Sports Severe TBI Case ***Physical Exam***

- Chest: BSBE, no crep pox 95%
- Cor: Tachycardia without murmur
- Abd: Soft, ? non-tender, no peritonitis
- Pelvis: Stable to compression
- Ext: No fracture evident, abrasions

Sports Severe TBI Case ***Neurologic Exam***

- Motor: Withdraws to painful stimuli
- Sensory: No apparent anesthesia level
- Eyes: Open to painful stimuli
- Verbal: Moans to painful stimuli
- Reflex: No posturing, pathological reflex

Sports Severe TBI Case ***Provisional Diagnosis***

- Severe TBI (GCS Score approx 8)
- R/o skull fracture
- R/o cerebral contusion
- R/o epidural hematoma

Sports Severe TBI Case ***Acute Management***

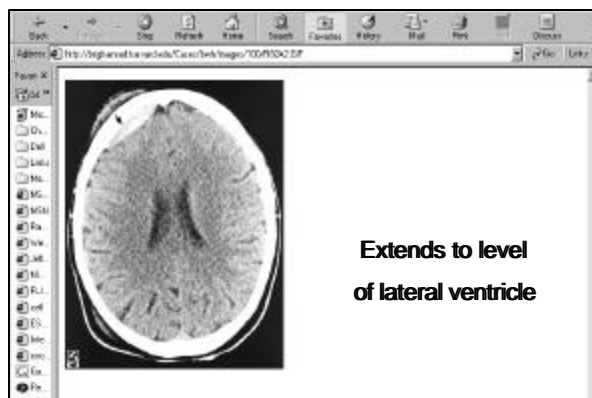
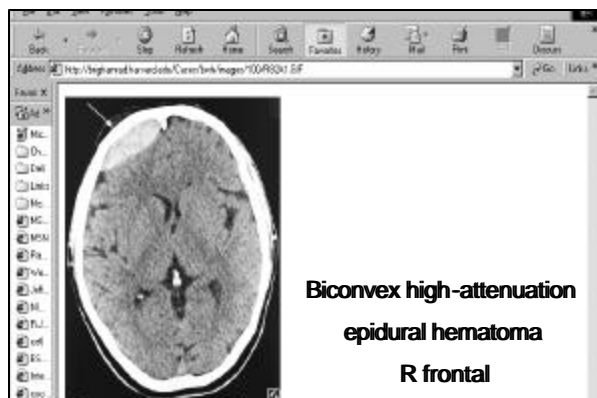
- IV NS 500 cc bolus, BVM O2 100%
- Rapid sequence induction
 - Lidocaine 100 mg IVP
 - Midazolam 4 mg IVP
 - Succinylcholine 100 mg IVP
- Endotracheal intubation
- Ventilator: 100%, TV 600, IMV 14, PEEP 5

Sports Severe TBI Case *Acute Diagnostic Tests*

- XTL C-spine, chest, pelvis x-rays
- Non-contrast CT head
- Trauma labs, type and screen
- ABG after on ventilator for 10 min
- DPL prn for persistent hypotension

Sports Severe TBI Case *Test Results*

- No fractures on x-ray
- CT head: skull fracture, epidural
- ABG: 7.30 35 280 100% BD -3
- Hb 11.4, other labs OK
- DPL not indicated



Sports Severe TBI Case *ED Diagnoses*

- Linear skull fracture, non-depressed
- Epidural hematoma
- Severe TBI, GCS 8
- Scalp laceration
- Multiple abrasions and contusions

Sports Severe TBI Case *ED, Hospital Disposition*

- Helicopter transfer
- Neurosurgery consultation
- To OR: epidural hematoma evacuation
- Admitted to ICU, intubated 8 days
- Discharged to rehab facility: day 20

Severe TBI Case

Patient Outcome

- Six month assessment
- Glasgow Outcome Scale Score
- Functions at home OK
- Just now beginning to drive
- Short work days
- Persistent headaches, amnesia

Brain Trauma Foundation TBI Guidelines

Guidelines Methods

1999, 2000 BTF Guidelines

- IOM Clinical Practice Guidelines
- Develop practice parameters

- Class I: PRCTs: standards
- Class II: Prospective: guidelines
- Class III: Retro, opinions: options

Guidelines Methods

2000 BTF Guidelines

- Standard: high degree of clinical certainty
- Guidelines: moderate degree of certainty
- Options: clinical uncertainty

Guidelines Methods

AMA Attributes for Guides

- I: By experts, with broad-based reps
- II: Describe methods, use best lit, reps
- III: Comprehensive, specific
- IV: Remain current via updates
- V: Wide dissemination

Treatment

Trauma Systems

- Standards: None
- Guides: Regionalized trauma systems
- Option: Neurosurgeons need to have a responsive system in place
- Option: In rural setting, where no neurosurgeon: know how to Rx extra-cerebral hematoma in deteriorating pt

Treatment

Initial Management

- Standards: None
- Guides: None
- Options: Directly address what we do

Treatment

Initial Management Options

- Rapid physiologic resuscitation
- No intracranial HTN Rx unless herniation or rapid neurologic deterioration
- Rapid hyperventilation
- Mannitol if adequate volume established
- Sedation as desired
- Short-acting neuromuscular blockade prn

Treatment

Resus: Blood Pressure

- Standards: None
- Guides: Achieve SBP > 90 mm Hg
- Options: MAP > 90 mm Hg
CPP > 70 mm Hg
- Use fluid infusion to achieve above

Treatment

Resuscitation: Hypoxia

- Standards: None
- Guides: PaO₂ > 60 mmHg, O₂ sat > 90%
- Options: Endotracheal intubation for
 - GCS < 9
 - Unable to maintain airway
 - Persistent hypoxia

Treatment

Hyperventilation

- Standards: Normal ICP, avoid sustained pCO₂ ≤ 25 mm Hg in severe TBI
- Guides: Avoid early prophylactic hyperventilation (pCO₂ ≤ 35 mm Hg)
 - Note: During first 24 hours, cerebral perfusion can be compromised due to low cerebral blood flow

Treatment

Hyperventilation Options

- Option: Hyperventilation useful briefly
 - Acute neurologic deterioration
 - Longer use if intracranial HTN persists despite other medical therapies (sedation, paralysis, mannitol, CSF drainage)
- Option: Test for cerebral ischemia
 - Jugular venous O₂ sat, AV O₂ sat diff
 - If sustained pCO₂ < 30 mm Hg needed

Treatment

Hyperventilation - CR

- Rapidly lowers ICP via vasoconstriction, which reduces cerebral blood flow
- One RCT
- Considerable uncertainty
- Possible beneficial effect on mortality
- No proven neurologic outcome benefit

Treatment

Mannitol

- Standards: None
- Guides: Controls increased ICP
 - Severe TBI
 - 0.25 to 1.0 gr/kg body weight

Treatment

Mannitol Options

- Options: Use in herniation, rapid decline
- Avoid hypovolemia
- Keep serum osmolarity below 320mOsm to avoid renal failure
- Achieve euvolemia, use a foley
- Use intermittent boluses, may be better

Treatment

Mannitol - CR

- May reverse brain swelling, lower ICP
- Few eligible RCTs
- Considerable uncertainty
- May be superior:
 - to pentobarbital for increased ICP
 - in setting of measured increased ICP

Treatment

High Dose Barbiturates

- Standards: None
- Guides: Controls increased ICP
 - May be useful when maximal therapies fail
 - Includes both medical and surgical Rx
 - Severe TBI, salvageable
 - Hemodynamically stable

Treatment

Barbiturates - CR

- Lower ICP via lower cerebral metabolism
- Few eligible RCTs
- No evidence of improved outcome
- Noted hypotension in 1 of 4 patients
- May offset any beneficial ICP effects

Treatment

Cerebral Perfusion Pressure

- Standards: None
- Guides: None
- Guides: Maintain CPP at 70 mm Hg

Treatment

ICP Rx Algorithm

- Insert ICP monitor, maintain CPP > 70
- Ventricular drainage
- Repeat CT
- Hyperventilate to pCO₂ 30-35 mm hg
- Mannitol 0.25 to 1.0 gr/kg
- Second tier Rx: barbituates, pCO₂ < 30

Treatment

ICP Monitoring

- Standards: None
- Guides: Useful in severe TBI (GCS < 9)
- Guides: Abnormal initial head CT
 - Hematomas, contusions
 - Edema, compressed basal cisterns
- All other recommendations are options

Treatment

ICP Monitoring: Normal CT

- Guides: ICP monitor with normal CT if two of three noted
 - Age > 40 years
 - Persistent BP < 90 mm Hg
 - Motor posturing

Treatment

ICP Monitoring Not Indicated

- Guides: Not useful with GCS > 8
- May be useful if traumatic mass lesion if evident on head CT

Treatment

ICP Monitoring Technology

- Ventricular catheter (Camino catheter)
- External strain gauge
- Accurate, low-cost, reliable
- Parenchymal monitor: drifting values
- Subarachnoid, subdural, epidural: no

Treatment *Seizure Prophylaxis*

- Standards: Proph use for late sz: NO
- Guides: None
- Guides: High risk: prevent early sz
 - Phenytoin, carbamazepine effective
 - Reduces spikes in ICP in theory
 - No difference in long-term outcome

Treatment *Seizure Prophylaxis, Rx -CR*

- Reduced secondary damage due to increased metabolism, ICP, glutamate
- Six RCTs
- RR for early sz prophylaxis: 0.34 (95% CI: .21-0.54)
- For every 100 patients treated, 10 would remain seizure-free for the first week
- No reduction in late seizures or outcome

Treatment *Steroids*

- Standards: Not recommended
 - No decrease in ICP
 - No improved outcome
- Guides: None
- Options: None

Treatment *Calcium Channel Blockers-CR*

- Prevent vasospasm, keep blood flow
- Four RCTs
- Considerable uncertainty
- Two RCTs, traumatic SAH, nimodipine
 - Pooled OR 0.59 for death (95% CI .37-.94)
 - Pooled OR 0.67 for death, disability

Outcome Prediction in TBI Patients

Outcome Prediction *Early Indicators of Prognosis*

- Uses prognostic indicators as tests
- Absence or presence related to outcome
- Outcome measure: Lived or died
- 2 x 2 table
- Class I evidence
- 70% Positive Predictive Value (PPV)

Outcome Prediction
Glasgow Coma Scale Score

- Lower GCS, stepwise higher mortality
- Standardized bedside measurement
- After pulmonary, hemodynamic Rx
- Without sedatives, paralytics
- By any trained medical personnel

Outcome Prediction
Age

- Higher age, stepwise higher mortality
- No inter-rater variability
- Consistent with other trauma data

Outcome Prediction
Pupil Exam

- Bilat absent light reflex: higher mortality
- Asymmetry: > 1 mm diameter difference
- Dilated pupil: > 4 mm size
- Fixed pupil: < 1 mm response to light
- Record duration of pupillary abnormality over time (ie abn pupil for 2 hours)

Outcome Prediction
Recording the Pupil Exam

- Fixed, dilated or both
- Asymmetry at rest or to light
- Evidence of orbital trauma
- Record after pulm, hemodynamic resus
- Any trained personnel can record data

Outcome Prediction
Hypotension, Hypoxia

- Persistent SBP < 90 mm Hg: 67% PPV
- With hypoxia: 79% PPV for bad outcome
- Measure frequently, record hypotension
- Any trained personnel can record data

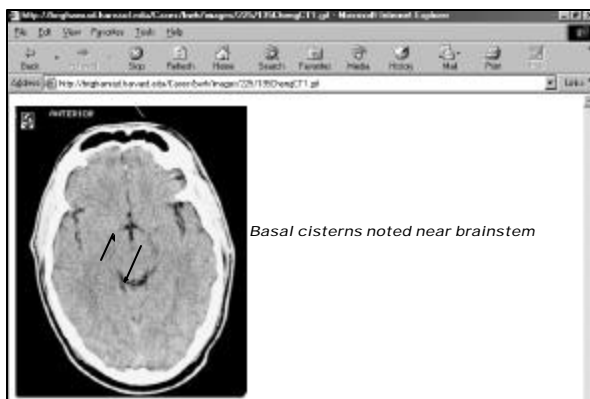
Outcome Prediction
Head CT Findings

- Four categories with prognostic value
- Basal cisterns and increased ICP signs
- Traumatic subarachnoid hemorrhage
- Midline shift
- Intracranial lesions

Head CT Prognosis

Basal Cisterns, Increased ICP

- Compressed or absent basal cisterns
- Three-fold risk of raised ICP, mortality
- Related to pupillary activity
- May be related to focal lesions, GCS, insults due to hypoxia, hypotension



Head CT Prognosis

Subarachnoid Hemorrhage

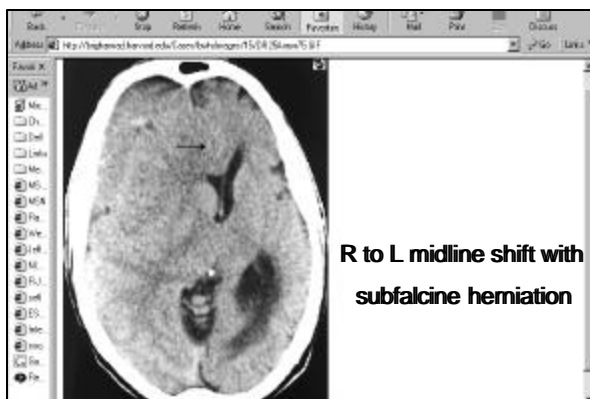
- Occurs in 26-563% of severe TBI
- Most commonly over convexity
- Mortality increased two-fold with tSAH
- Blood in basal cisterns, 70% PPV bad
- Extent of tSAH is related to outcome
- Signif independent outcome predictor

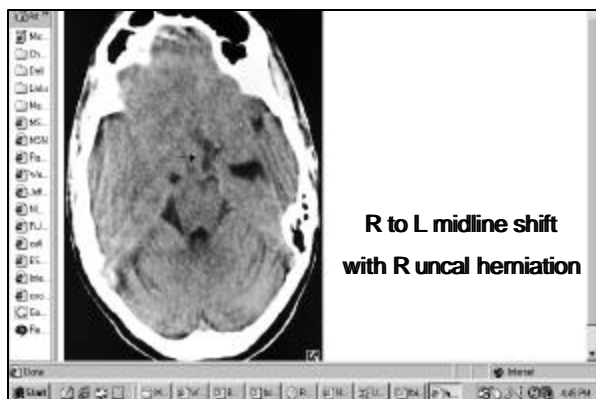


Head CT Prognosis

Midline Shift

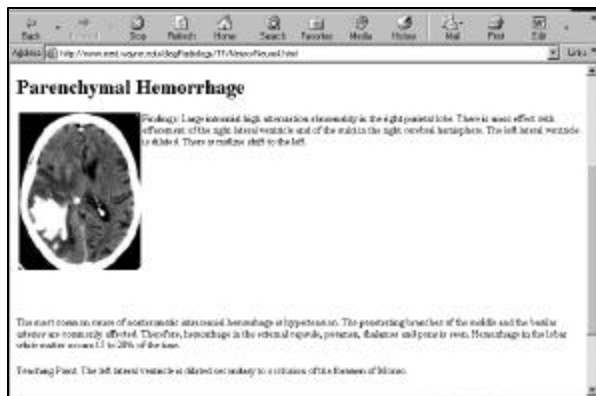
- I: Age > 45 & > 5 mm shift, 78% PPV bad
- II: Shift > 15 mm, 70% unfavorable outcome
- Shift related to increased ICP, variable amt
- Other CT parameters more imp't than shift
- Recheck CT midline shift after surgical Rx





Head CT Prognosis *Intracranial Lesions*

- Coma? Think intracranial lesions
- II: Mass lesion, 78% PPV poor outcome
- Mass, age > 45: 79% dead or vegetative
- Mortality higher in acute subdural hematoma than extradural hematoma
- Hematoma volume is related to outcome
- Worst outcome: subdural>DAI>epidural



Conclusions *Emergency Physicians & TBI*

- It is a significant public health problem
- We see it commonly in the EDs
- Mild TBI in all comprehensive EDs
- Severe TBI seen in trauma centers
- EPs manage the airway and early resus
- What happens early can influence outcome

Conclusions

TBI: The Clinical Entity

- Direct brain injury with bleeding, swelling
- Secondary effects related to ICP, CBF
- Cytotoxic cascade related to ischemia
- Early resuscitation: prevent ongoing injury
- Early diagnosis: predicts Rx and outcome

Conclusions

E.D. TBI Therapy

- Despite few standards, an algorithm exists
- Treat hypotension, hypoxia, elevated ICP
- ICP monitor and ventricular drainage
- Mild hyperventilation, bolus mannitol
- Barbiturates, other ICU interventions
- Use all aggressively with decompensation

Conclusions

TBI Outcome Prediction

- Related to four CT findings
- Compressed basal cisterns
- Subarachnoid hemorrhage
- Midline shift > 5-15 mm (age dependent)
- Mass lesion and hematoma volume
- Worst outcome: subdural>DAI>epidural

Recommendations

TBI Therapy Implications

- Optimize early diagnosis and resuscitation
- Document findings that suggest outcome
- Know the ICP management algorithm
- Know which CT findings are relevant
- Be able to predict neurosurgeon's role
- Continually review the guidelines

Sports-Related Severe TBI

Questions?

- www.google.com
- www.ferne.org
- www.cochrane.org
- www.braintrauma.org
- www.internationalbrain.org

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