


**FERNE / MEMC IV Neurological Emergencies Track:
Neuro-resuscitation: TBI
Andy Jagoda, MD, FACEP**



Neuro-resuscitation: TBI

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Disclosures

Objectives

- To review the approach to the prehospital management of agitation and airway in TBI patients
- To review the indications and techniques for RSI in TBI patients
- To provide an overview of ICP management in TBI patients with a focus on hyperventilation, hypertonic saline, and mannitol

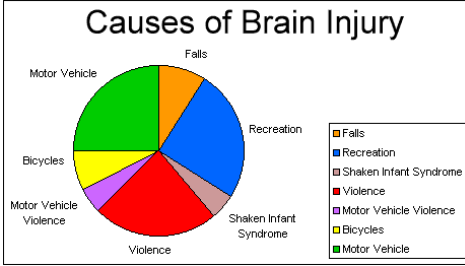
Why talk about this?



- 150,000 trauma deaths in the US each year
 - 50,000 deaths from TBI
- 250,000 TBI survivors require hospitalization and inpatient care
- Prehospital and ED care is critical to improving outcomes
- Mortality has decreased from 50% to 25% in the past 30 years
 - Impact of evidence based guidelines
 - Prevention

Epidemiology of Brain Injury

Causes of Brain Injury




<http://www.biausa.org/preventi.htm>

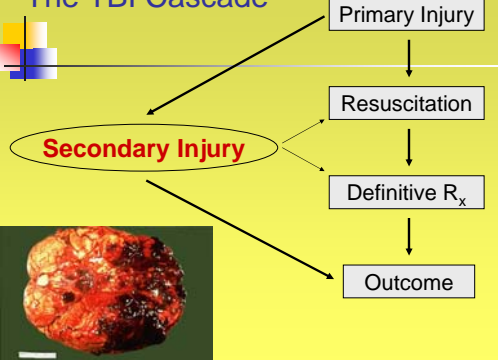
Sports/Recreation Among Leading Causes

Brain Trauma Foundation, 2007 www.braintrauma.org

- Guidelines for the prehospital management of TBI
- Guidelines for the management of severe TBI



The TBI Cascade



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    graph TD
      PI[Primary Injury] --> R[Resuscitation]
      R --> DR[Definitive Rx]
      DR --> O[Outcome]
      SI((Secondary Injury)) --> R
      SI --> DR
  
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Secondary Injury In TBI

- Prospective study of 717 patients with severe TBI at 4 centers.
- A single episode of hypotension (BP <90 mmHg) or hypoxia (PaO₂ <60 mmHg) during the initial resuscitation was associated with a significant increase in morbidity and mortality.

Chestnut RM. *J Trauma* 1993; 34:216.

Case

- 18 year-old male assaulted and beaten several times on the back of the head. Unconscious upon EMS arrival, now intermittently agitated.
- 130/80, 90, 18, BS 110, Pox 92% - 98% on face mask
- GCS score 8: Eyes open to pain (2), verbal inappropriate words (3), motor flexion abnormal (3). Pupils equal and reactive
- Gag intact; teeth clenched

???

Should the patient be intubated at the scene?

A. Yes?

B. No?

EMS Airway Management

- Winchell, Arch Surg 1997
- Case controlled study, 1092 patients with severe TBI who were hypoxic and / or not protecting their airway
- 74% survival for EMS intubation vs 50% survival for ED intubation
- For patients with severe TBI who are unresponsive and hypoxic or not protecting their airway, prehospital ETI is indicated

EMS Airway Management

- Bochicchio, J Trauma 2003
- Prospectively collected data base review of 191 adult trauma patients with TBI (GCS ≤ 8).
- Intubation – 51% field / 49% ED:
 - Field intubation mortality 23%.
 - ED intubation mortality 12%
 - Field intubation associated with longer ICU and hospital stay
- Huge limitations: selection bias, transport time

EMS Airway Management

- Davis, J Trauma 2003
- Prospective observational study of 209 patients compared to 627 matched controls:
 - Ground transport time > 10 minutes
 - Inability to intubate without RSI
 - Unclear how many patients had a gag or were able to maintain oxygenation above 90 mm Hg
 - 67 patients had either mTBI or no TBI
- Midazolam / succinylcholine
 - 15% failure rate rescued with CombiTube®

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EMS Airway Management

- Patients who underwent RSI had higher mortality rate and worse neurologic outcomes

	Mortality	Good Outcome
Field RSI group	33%	45%
ED RSI group	24%	57%

EMS Airway Management

- Dunford, Ann Emerg Med 2003
- Thirty-one (57%) desaturated during RSI; 26 (84%) of these occurred in patients with a SaO₂ >90% prior to paralysis
 - 19/31 had concomitant bradycardia
- The median duration of desaturation was 160 seconds (max 270 seconds) and the median percent decline in oxygen saturation was 22%

EMS Airway Management

- San Diego Studies
- Scene times were longer for patients intubated in the field
- Hypoxia and bradycardia associated with field intubation
- Higher rates of inadvertent hyperventilation as measured by ETCO₂
- RSI no longer used in the San Diego EMS system

**BTF: Prehospital Management of TBI – R
 Level 3 Recommendations:**

- Establish an airway in patients who have severe head injury, the inability to maintain an adequate airway, or hypoxemia not corrected by supplemental O₂
- Confirm intubation by utilization of auscultation plus at least one other technique that includes end-tidal CO₂ measurement.
- In ground transported patients in urban environments, the routine use of paralytics to assist endotracheal intubation in patients who are spontaneously breathing and maintaining an oxygen saturation above 90% on supplemental is O₂ **not** recommended
- EMS systems implementing endotracheal intubation protocols including the use of RSI protocols should monitor blood pressure, oxygenation, and ETCO₂.
- Avoid hyperventilation (unless the patient shows signs of herniation) and correct immediately when identified.

???

Should the patient be given a sedative to facilitate transport? Which one?

A. Yes?

B. No?

Case continued

- Patient was given lorazepam 2 mg in the field; arrives in the ED backboarded and collared with bag-valve-mask assisted ventilations
- BP is 90 / 60, P 110, RR 24, Pulse Ox 92%, blood glucose 100.
- GCS score 5 (nonverbal 1, eyes open to pain 2, extension posturing 2)
- Right pupil dilated and fixed

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???

Intubation technique [RSI vs other?]

A. RSI
 B. Other

???

Your rescue technique if RSI is unsuccessful?

A. Trach light?
 B. I-LMA?
 C. Combitube?
 D. Surgical?
 E. Surgical?

Rapid Sequence Intubation

7 P's FOR RSI PROCEDURE

- Preparation
- Preoxygenation
- Pretreatment
- Paralysis and sedation
- Protection and positioning
- Pass the tube
- Post intubation management

National Emergency Airway Course®

Reflex Sympathetic Response
 To Laryngoscopy (RSRL)

- Results from manipulation of the airway
- Indirect and direct pathway
- Not eliminated by paralysis
- Response:
 - Hypertension, tachycardia
 - Increased ICP
 - Increased IOP

Rapid Sequence Intubation

Pretreatment with **LOAD** drugs:

Lidocaine	1.0 mg/kg
Opiate (Fentanyl)	2 ug/kg
Atropine	0.02 mg/kg
Defasciculation	0.01 mg/kg

National Emergency Airway Course®

Lidocaine: What Do We Know?

Does lidocaine suppress the RSRL?	MAYBE
Does lidocaine suppress the cough reflex (direct reflex response to laryngoscopy)?	YES
Is there any evidence that lidocaine improves outcome in patients with TBI?	NO

Robinson N. *Emerg Med J* 2001; 18:453.

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Fentanyl: What Do We Know?

Does laryngoscopy precipitate a rise in blood pressure and pulse?	YES
Can this be deleterious in patients with acute CNS or cardiovascular disease?	YES
Does intravenous fentanyl blunt the blood pressure/pulse response?	YES
Can fentanyl cause hypotension & apnea in the compromised patient?	YES

Defasciculation: What Do We Know?

Do SCh-associated fasciculations increase ICP in certain at-risk patients?	YES
Does pretreatment with a non-depolarizer reduce this phenomena?	YES
Is there any evidence that SCh increases ICP in patients with TBI?	NO
Is there any evidence that SCh worsens outcome in patients with TBI?	NO

RSI Induction Agents

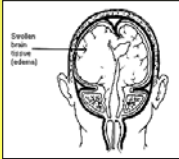
- Midazolam
- Thiopental
- Etomidate
- Propofol
- Ketamine

Succinylcholine

- ‘Quick on quick off’ a significant benefit
- Paralysis in 45 sec, duration 6-8 min
- No evidence of clinically important increases in intracranial pressure in TBI
- Relevant side-effects:
 - Hyperkalemia
 - Bradycardia [children; 2nd dose]

Best strategy for managing acute herniation: Decerebrate posturing, “blown pupil”

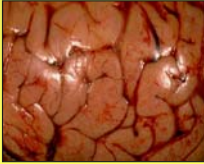
- A. Hyperventilate
- B. Mannitol
- C. Hypertonic saline
- D. Barbituate coma



The diagram shows a cross-section of a brain with the decerebrate posturing (arms extended) and a blown pupil on the right side. Labels point to the swollen brain tissue and the blown pupil.

Best strategy for managing increased ICP?


- A. Hyperventilate
- B. Mannitol
- C. Hypertonic saline
- D. Barbituate coma
- E. Hypothermia



The photograph shows a brain with a visible bulge and redness, indicating increased intracranial pressure.

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ICP Management



CPP = MAP – ICP

ICP : < 20 mm Hg
 MAP: 100 – 110
 CPP: near 70 mm Hg

Hyperventilation

- Aggressive hyperventilation has been the cornerstone of ICP management for the past 20 years
- Hyperventilation reduces ICP by causing cerebral vasoconstriction
- Focal/regional reduction in cerebral perfusion the consequence

Hyperventilation

Hyperventilation [PCO₂: from 36 to 29 mmHg] in 33 patients with severe TBI increased the volume on PET scanning of severely hypoperfused tissue within the injured brain, despite improvements in cerebral perfusion pressure and intracranial pressure.

Hypoperfusion associated with accumulation of cytotoxic byproducts including glutamate, pyruvate, and lactate

Coles JP. *CCM* 2002; 30:1950-9.
 Marion DW. *CCM* 2002; 30:2774-5

Hyperventilation

Prospective, randomized trial of 77 patients with severe TBI. 5 days of prophylactic hyperventilation [versus eucapnea]. At 3 and 6 months – outcome was significantly better in the control group.

Muizelaar JP. *J Neurosurg* 2001; 75:731-9

Hyperventilation: What Do We Know?

Does <u>chronic</u> hyperventilation worsen outcome in severe TBI?	YES
Does <u>acute</u> hyperventilation worsen outcome in severe TBI?	MAYBE
Is there a role for hyperventilation in acute severe TBI?	???

BTF Recommendations 2007

- Hyperventilation is recommended as a temporizing measure for the reduction of elevated intracranial pressure (level III)
 - Asymmetric pupillary response
 - Unilateral or bilateral pupillary dilatation
 - Motor posturing
 - Rapid neurologic decline
- Prophylactic hyperventilation (PaCO₂ of 25 mm Hg or less) is not recommended (level II)

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Hyperventilation

Prospective analysis of 37 intubated TBI patients without clinical herniation undergoing air transport to a Level I Trauma Center:

Assisted RR >14 bpm	60%
PaCO ₂ < 30 mm Hg	70%

Thomas S. *J Trauma* 2002; 52:47-53.

Mannitol

- Immediate plasma-expanding effect
 - Benefits CPP
 - Decrease hematocrit and blood viscosity
- Delayed osmotic effect, with onset in 15-30 minutes and duration from 1 to 6 hours
 - The later is responsible for ICP reduction

Mannitol

Prospective, randomized trial comparing mannitol to barbiturates for ICP control in 59 patients with severe brain injury

- Improved CPP control
- Lower mortality = 41% (M) vs. 77% (B)

Schwartz ML. *Can J Neurol Sci* 1984; 11:434

Mannitol: What Do We Know?

Does mannitol effectively reduce ICP in patients with severe TBI?	YES
Do we know the right dose?	NO
Bolus dosing better than infusion?	YES
BP 'floor' for safe administration?	???

Schierhout G. *Cochrane Systematic Reviews* 2000.

Hypertonic Saline

- Plasma volume expander
- Increases MAP without increasing ICP thus results in improved CPP
- Dehydrates tissue simultaneously improving perfusion and decreasing edema
- Does not cause osmotic diuresis
- Human studies using 7.5% - 29% concentrations report 20 – 50% decreases in ICP
- Not first line at this time


Hypertonic Saline

Prospective, randomized, double-blind trial comparing outcome in 229 patient with severe TBI and hypotension in the field:

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    graph TD
      A[Prospective, randomized, double-blind trial comparing outcome in 229 patient with severe TBI and hypotension in the field:] --> B[Hypertonic Saline  
250 cc 7.5%  
Lactated Ringers]
      A --> C[Control  
Lactated Ringers]
    
```

Cooper DJ. *JAMA* 2004; 291:1350.




Hypertonic Saline

Results


- No baseline differences between groups
- Mean GCS = 4, ISS = 38, fluid = 1250
- No difference in BP on ED arrival
- No difference in survival or outcomes

Cooper DJ. *JAMA* 2004; 291:1350.




Huizenga et al. Guidelines for the management of severe head injury: Are emergency physicians following them? *Acad Emerg Med* 2002; 9:806-812

- 319 / 566 survey responses (56%) to 3 cases
 - 78% corrected hypotension
 - 46% used prophylactic hyperventilation
 - 14% used glucocorticoids
 - 8% used prophylactic mannitol
- Authors conclusion: A majority of emergency physicians are managing TBI according to the guidelines
- My conclusion: 7 years post publication, a significant number of emergency physicians are not correctly managing severe TBI



Future Directions

- Induced hypothermia
- Neuroprotectants
- Neurogenesis



Conclusions

- Hypoxia and hypotension must be carefully assessed for and corrected in severe TBI patients
- Prehospital intubation has been associated with worse outcomes in severe TBI patients and its indications must be reassessed
- Hyperventilation is a temporizing measure in the management of elevated ICP
- Mannitol is the first line agent for managing elevated ICP; the indications for hypertonic saline are yet to be clearly defined

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