The Arizona EPIC Project & Controversies in TBI Management

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Impact of TBI

- Leading cause of death / disability worldwide

- In USA – TBI
  - 5.3 million Americans or 2% of the population have moderate to severe disability require long term assistance with daily activities
  - DIRECT cost
    - $60 billion/year (2000) cause of death / disability worldwide
**Primary** Brain Injury

- Damage that occurs at the moment of impact
- We can’t fix it
- Neuro-Surgeon can’t fix it either

- Damage is already done
Secondary Brain Injury

- Occurs after the initial trauma
  - Caused By:
    1) Systemic hypoxia
    2) Poor CNS blood flow
  - Major impact in TBI outcome

Do EVERYTHING you can to PREVENT secondary brain injury
The Stakes Are High

A mild to moderate primary TBI can be converted into a severe TBI from secondary injury due to improper management.
The ESSENCE of the Science

- What happens in the first few minutes profoundly impacts outcome

- The “H-Bombs” for TBI
  - Hypoxemia
  - Hypotension
  - Hyperventilation
Hypoxia:

- Hypoxia in the field is very common
  55% of patients with severe TBI
- A single O₂ sat of <90% is independently associated with at least a doubling of mortality
  One study: **Tripled** mortality
Hypotension:

- A single episode of SBP < 90mmHg is independently associated with at least a doubling of mortality

  - Repeated episodes: 800% increase in death
The Science of the “H Bombs”

- **Hyperventilation**: (intubated pts)
  - Hyperventilation is *independently* associated with *at least* a doubling of mortality
    - One study showed a *six-fold* increase
Why is Hyperventilation So Bad??

* How could something that decreases ICP cause a six-fold increase in mortality?
* The decreased ICP occurs because of profound cerebral vasoconstriction
* All advantages gained from lower ICP are overwhelmed by the CNS ischemia
The Essence of the Guidelines

- **Prevent** and *aggressively* treat hypoxia
- **Prevent** and *aggressively* treat hypotension
- *Meticulously* prevent and *rapidly* correct hyperventilation
Paradigm Shift

- These are simple changes in the way we treat TBI patients
- Simple is not always easy
- These treatments change the way we have done business for years
- **Constant Focus** is the key to changing these habits
The Arizona EPIC Project

The Excellence in Prehospital Injury Care (EPIC) Project is a unique effort to improve survival and neurologic outcome for victims of major TBI who are cared for by all Arizona EMS agencies.
The Arizona EPIC Project

An Arizona public health initiative:

- **Implementing** the nationally-vetted, evidence-based EMS TBI guidelines throughout the state
- **Measuring** the impact of implementation by linking EMS data with hospital data
Implementation of evidence based protocols takes a long time!
Controversy #1

Intubation
Should TBI Patients Be Intubated... At All?

- Numerous studies:
  - Poorer outcomes in TBI patients intubated in the field

- Severity-adjusted outcomes (field vs. ED ETI)
  - Death: aOR 3.99
  - Poor neuro outcome: aOR 1.61
  - Moderate/severe functional impairment: aOR 1.92

Should TBI Patients Be Intubated… At All?

* San Diego RSI Trial
  * Field ETI vs. non-intubated EMS controls
  * Risk of death: 24.2% vs. 33.0% (RI = 36.4%)
  * Trial was terminated early by the DSMB due to increased mortality with RSI

Davis: J Trauma; 2003
Should TBI Patients Be Intubated... At All?

* So... is ETI *bad* for TBI patients?

* Many experts:
  * ETI should be delayed until arrival at the ED
ETI is Bad???

Studies showing worse outcomes with ETI

- Stiell: CMAJ 2008;178:1141-52
- Davis: J Trauma 2003;54:444-53
- Davis: J Trauma 2005;58:933-9
- Davis: J Trauma 2005;59:486-90
- Murray: J Trauma 2000;49:1065-70
- Wang: Prehosp Emerg Care 2006;10:261-71
- Bochicchio: J Trauma 2003;54:307-11
- Arbabi: J Trauma 2004;56:1029-32
But….Wait a Minute!!!

Studies showing better outcomes with ETI

- Winchell: Arch Surg 1997;132:592-7
- Warner: Trauma 2007;9:283-89
- Davis: Resuscitation 2007;73:354-61
- Bulger: J Trauma 2005;58:718-23
Should TBI Patients Be Intubated... At All?

- Randomized: PM RSI Vs. ED intubation
- Meticulous ETCO$_2$ management post-ETI
- Favorable Neuro Outcome (GOS-E 5–8)
  - PM RSI: 51% (80/157)
  - ED ETI: 39% (56/142)
  - aOR 1.28

Bernard. Ann Surg; 2010
So...Why the Dramatic Differences in the Studies???

- The "Intubation-Hyperventilation Paradox"
  - If done well, intubation has the potential to:
    - Protect the airway
    - Provide good ventilation and oxygenation
  - Ironically...it also makes it much easier to:
    - Over-ventilate
    - Hyper-ventilate

Three Major Problems With Manual Ventilation

1. **Hyperventilation:**
   - Bagging *faster* than one breath every *six* seconds (10 bpm) or ETCO2 <35

   - Even *moderate* hyperventilation kills brain cells and causes *major, debilitating morbidity or death*
Three Major Problems With Manual Ventilation

2. **Over-ventilation**: Squeezing the bag too hard/too aggressively/too deeply →
   - High airway pressure →
     - Increased JVP and ICP
   - Decreases venous return...decreasing cardiac output and cerebral perfusion
   - Lung damage → ARDS
Three Major Problems With Manual Ventilation

3. *Inadvertent Ventilatory Inattentiveness*:

- A recent landmark discovery:

- *Every* healthcare provider has this neuro-psychiatric disorder
Inadvertent Ventilatory Inattentiveness (IVI)

- The syndrome: During manual ventilation... without *meticulous* prevention... *everyone* inevitably gets distracted and hyper/over-ventilates.

- Studies: Typical rate: 24-40+ bpm
  - Our serum epi level is higher than the patient’s!
Inadvertent Ventilatory Inattentiveness (IVI)

- Studies show we **cannot** “wing it”
  - Without adjuncts...**everyone** manually ventilates...**wrong**
  - Even anesthesiologists and RTs
- Three things are **unavoidable**:
  - Death, Taxes...and IVI
- Hyperventilation is still the leading cause of secondary brain injury
Adjuncts for Preventing Hyperventilation

- **Cadence Device**
- Visual Rate Timer
- 10 bpm
- 1 sec breath
Adjuncts for Preventing Hyperventilation

* Pressure-controlled bag
  * Helps prevent hyper *and* over-ventilation
  * Will also soon be available for EPIC agencies
Adjuncts for Preventing Hyperventilation

- **Continuous ETCO$_2$ monitoring**
  - Target: 40 mmHg
  - Range: 35-45 mmHg
EPIC Plan to Prevent IVI: The “Ventilator EMT”

The V-EMT’s job:

- Maniacal about ventilatory rate/depth
- Meticulously uses ventilatory adjuncts
- Should not be disturbed
- Only function is ventilation
Optimal Ventilation for TBI

* **Best:**
  - Initial cadence device/PC bag followed by…
  - ETCO₂ monitoring to modulate ventilation rate *asap* followed by…
  - Mechanical ventilator *asap* @ 7cc/kg

* **Next Best:**
  - Cadence device/PC bag
  - ETCO₂ monitoring

* **Acceptable**: Cadence device/PC bag
If You Choose To Intubate

- You take on the responsibility to meticulously monitor ventilations.
- If you don’t meticulously monitor ventilations:
  
  Your ALS airway is actually WORSE than a BLS airway.
**Caution to ALL Intubators**

- 1850 ED intubations
- # of attempts vs. complication rates
  - 1 Attempt: 14.6% (197/1349)
  - 2 Attempts: 46.3% (157/339)
  - 3 Attempts: 61.3% (68/111)
  - 4+ Attempts: 72.5% (37/51)

- 2nd attempt *TRIPLES* complication rates

- Most common complications:
  - Hypoxia and aspiration
    - Markedly increases mortality in TBI

- “First Pass Success” → BLS or rescue quickly
If You Choose To Intubate

- Our work is not done once intubation is complete!
- There is great chance of harming our patients when we intubate and hyperventilate
- There is great potential benefit to our patients with intubation and proper ventilation
EPIC

Lesson Learned

Definitive Care
The Classic Mantra: “Trauma is a surgical disease”

So...how can EMS begin “Definitive Care”? →

The “Neuronal Clock” is so short!!!

Lost neurons don’t come back no matter how spectacular the neurosurgeon is

Proper EMS care is powerfully synergistic with subsequent surgical and critical care

“One live brain...”
EPIC
Truth in O2

Oxygen
Isn’t Too Much Oxygen Toxic???

EPIC Guideline:
- High-flow NRB on *anyone* who has a positive LOC or has an altered level of consciousness.
- “Pre-oxygenation” is very effective at preventing hypoxia in patients who *subsequently* deteriorate.
- Acute epidural

- Keep TBI patients on HF/NRB or...if intubated, *100% FIO₂* until arrival at the TC
EPIC numbers

- We use GCS as a primary determinate of TBI
- What percentage of patients have a GCS of 15 then later deteriorate?
- OVER HALF!!! 52%

- Being at “more than 100%” is a preemptive strike on hypoxia
  - Give the patient “BREATHING ROOM”
EPIC Evidence

- Theoretical risk vs. established evidence
- Hypoxia is disastrous
- Hypoxia is very common

Strongly emphasize high-flow oxygen
Full Pre-Oxygenation & Time

- Normal 70kg Adult
- Obese Adult
- Moderately ill 70kg Adult
- Normal 10kg Child

SpO2 (%) vs. Time (min)
Sweet or Un?

Glucose
Isn’t hyperglycemia bad for neuro outcomes?

Should we give less glucose when they are hypoglycemic?

EBG: Treat BG <70 with full amp of D50
Evidence is from in-hospital studies:
- Hyperglycemia in poorly-controlled diabetics—Days

Brief episodes of hyperglycemia
- Impact in TBI is unknown

Theoretical risk vs. established evidence →
- Hypoglycemia is bad for neurons
EPIC Perfusion

Blood Pressure
Management of Blood Pressure

- The Guideline

- When patient even has the *potential* for TBI:
  - Start at least one IV
  - Carefully monitor BP

- Treatment of hypotension:
  - *Any* SBP <90 mmHg → Initial bolus 1L NS/LR
  - Continue *aggressive* fluid resuscitation if hypotension not corrected
  - Follow initial boluses with sufficient rate to keep SBP ≥90
Multi-System Trauma With TBI

★ Multisystem Trauma:
★ Will fluids increase internal bleeding if it hasn’t been controlled yet???

★ “Permissive hypotension”??
★ Literature: Penetrating torso wounds
Serious about Sedation
Should TBI Patients be Sedated

★ Classic approach to TBI

★ “You can’t over-sedate a TBI”

★ Assumption: We don’t want them moving around or fighting or agitated…so…keep them snowed
Should TBI Patients be Sedated

Problem:

- Every commonly-used sedative (both narcotics and benzos) are vasodilators
- Physiology of sedatives
  - Decreased cardiac after-load
  - Significantly decreased pre-load
Should TBI Patients be Sedated

- Vasodilation/hypotension are really bad
- All commonly-used agents can cause hypotension
- BP can PLUMMET when they are given in compensated shock
- And you don’t know who’s got this!!!

Reversing agents:
- Work centrally in CNS
- Do NOT reverse vascular effects
EPIC Evidence

Therapeutic Hyperventilation
“Therapeutic Hyperventilation”

What about patients with cerebral herniation?
Cerebral Herniation
Cerebral Herniation

- It’s *RARE* in the prehospital environment
- It has a very bad prognosis
- Inability to confirm in the field
Cerebral Herniation

* Most patients with **severe** TBI are **not** herniating

* Real-world “translation”:
  * The worse the TBI, the faster we ventilate

* Many more patients harmed than helped
Treating Cerebral Herniation

¢ Two approaches to treatment:
¢ #1: EPIC recommendation:
¢ Based upon this information...

Don’t Hyperventilate under any circumstance
Treating Cerebral Herniation

**Option #2**

* If your local protocols/MD call for hyperventilation… *only* hyperventilate for *obvious, unequivocal* signs of herniation

* Administer *mild/moderate* hyperventilation
  * Adults (>15): 20 bpm
  * Children (2-14): 25 bpm
  * Infants (0-24 mo.): 30 bpm
Treating Cerebral Herniation

* NOTE:
  * These rates are *not* evidence-based, they are completely arbitrary!!
  * Like most EMS
  * When in doubt, don’t hyperventilate
Treating Cerebral Herniation

- If ETCO$_2$ monitoring available and you are going to hyperventilate:
  - Maintain at 28-31mmHg
  - Avoid ETCO$_2$ <28mmHg
    - It KILLS neurons!!!
Parting Thoughts

The EMS care of TBI patients REALLY matters
Parting Thoughts

Avoid the H-Bombs!

- Hypoxia
- Hypotension
- Hyperventilation
Proper EMS care can often help prevent this... and make more of this
Special thanks to the EPIC Partners

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