Controversies in TBI Management

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Will refer repeatedly to the EPIC Project
- 1R01NS071049 (Adults)
- 3R01NS071049-S1 (EPIC4Kids)

Disclosures

Format
- A series of controversies in TBI
- Q/A at the end
  - Write down your questions
Controversy #1: Should TBI Patients Be Intubated... At All?

- NAEMSP 2013
  - Gaither; Annals, 2012
  - This battle has raged in the literature for a decade
- My opinion: Much of the EMS intubation controversy has been fought on an overly-simple battleground.

Should TBI Patients Be Intubated By EMS... At All?

- Numerous studies:
  - Poorer outcomes in TBI patients intubated in the field
  - Severity-adjusted outcomes (field vs. ED ETI):
    - Death: aOR 4.0
    - Poor neuro outcome: aOR 1.6
    - Moderate/severe functional impairment: aOR 1.9


Should TBI Patients Be Intubated... At All?

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

  Davis, Hoyt, Ochs: J Trauma; 2003
So… is prehospital ETI bad for TBI patients?

- Many experts believe ETI should be delayed until arrival at the ED

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;54:367-11
- Arbabi: J Trauma 2004;56:1029-32

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
So...Should TBI Patients Be Intubated in the Field???

- The question isn’t nearly that simple!!!
  - Focusing solely on the procedure ignores an incredibly important factor

Should TBI Patients Be Intubated... At All?

- Randomized: PM RSI vs. ED intubation
- Meticulous ETCO₂ management post-ETI
- Favorable Neuro Outcome (GOS-E 5–8)
  - PM RSI: 51% (80/157)
  - ED ETI: 39% (56/142)
  - aOR 1.28
  - Note: 97% ETI success rate


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

Hyperventilation is Really Bad for TBI
- Even moderate hyperventilation
  - Quickly kills brain cells
  - Debilitating morbidity/death
- Davis: ETCO$_2$ increments of 3 mmHg < 32
  - Statistically identifiable decrements in survival

AXIOMS of Manual Ventilation in Emergency Settings
- AXIOM #1: NO ONE can properly ventilate manually without ventilation adjuncts
- AXIOM #2: NO ONE can properly ventilate manually without ventilation adjuncts
- AXIOM #3: NO ONE can properly ventilate manually without ventilation adjuncts
- AXIOM #4: NO ONE can properly ventilate manually without ventilation adjuncts
- AXIOM #5: NO ONE can properly ventilate manually without ventilation adjuncts

Why???
- Because 100% of emergency care providers have a specific, well-documented, neuropsychiatric disorder…

Inadvertent Ventilatory Inattentiveness (IVI)
Why do 100% of emergency providers have IVI???
- We’re too busy saving the patient’s life…and too proud of getting the tube in…to pay attention to something as trivial as ventilation.

The syndrome: During manual ventilation…without meticulous prevention…everyone hyper/over-ventilates!!!
- Studies: Typical rate: 24-40+ bpm

The causes of IVI:
- Distraction is inevitable
- Proper ventilation is remarkably gentle
  - Far too gentle for a distracted human to do
- Our epi level is higher than the patient’s
- Proper ventilation just doesn’t “feel right”:
  - If you ventilate at the proper rate/volume…it feels like you’re killing the patient
Inadvertent Ventilatory Inattentiveness (IVI)

- **The Cure:** Meticulous, multifaceted, active, adjuncts to help prevent hyperventilation and over-ventilation

Adjuncts for Preventing Hyperventilation

- Until on a ventilator:
  - **Ventilation Rate Timer:** Timed flashing light
    - Adults: 10 bpm
    - Peds <15 yrs: 20 bpm
    - 1 sec breath

- **Flow-controlled bag**
  - Helps prevent hyper and over-ventilation
Adjuncts for Preventing Hyperventilation

- Continuous ETCO₂ monitoring
  - Target: 40 mmHg
  - Range: 35-45 mmHg

It’s Time!!!

- In EMS and the ED
- Until the patient is on a vent... *every breath* should be administered with ventilatory adjuncts

Warning #1: Beware the Myth!!!

- “We don’t need the VRT/FCB because we immediately put our patients on a ventilator.”
  - NO YOU DON’T!!!
  - Routinely 5-15 minutes
  - Neurons: Begin dying with just 4-5 minutes of hyperventilation
Warning #2: Beware of ETCO₂ Monitoring That ISN’T!!!

Early findings in EPIC Study:
- Many providers:
  - Use ETCO₂ to confirm tube placement and then…
  - Nicely document inadvertent hyperventilation!!!
  - "ETCO₂ monitoring that ISN’T"

Med Directors/Managers/Educators/QI Teams:
- ETCO₂ monitoring:
  - Use it…check it…QI it…report it…ask about it…demand to see the waveforms…be maniacal!!!
  - Don’t let ETCO₂ monitoring be a tool that simply documents you’re killing patients!!!
ETI without meticulously-controlled ventilation is a downgrade from BLS care.

Because of the universal syndrome of IVI... intubation with unaided manual ventilation is reliably harmful!!!

EMS and in-hospital

Take Home Messages

With ventilation adjuncts and meticulous attention to prevent hyperventilation... ETI may improve TBI outcomes in the setting of:
- A busy EMS system
- Careful ETCO₂ QI feedback
- Active medical direction
- Very high intubation success rates

If your EMS system doesn’t have VRTs/FCBs/ETCO₂ monitoring... you should not be intubating TBI patients
Caution to ALL Intubators:
A Good Reminder

- 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)

A Good Reminder

- 2nd attempt TRIPLES complication rates
  - Hypoxia and aspiration most common
  - EPIC: A single episode of hypoxia quadruples mortality in TBI
- Major goal: “First Pass Success”
  - Ego kills in our business
  - Quickly return to BLS…or move to rescue airway!!!

Controversy #2:
Isn’t Too Much Oxygen Toxic???

- EMS Guideline:
  - High-flow NRB on anyone who has lost consciousness
  - Keep TBI patients on HF/NRB or…if intubated, 100% FIO2 until arrival at the TC
What About Too Much Oxygen???

- But...doesn't hyper-oxygenation worsen post-ischemic cellular damage?
  - Increases inflammatory response
- Studies: Hyper-oxygenation →
  - Causes alveolar damage → ARDS
  - May worsen the effects of neuronal ischemia
  - May worsen neuro outcome

What About Too Much Oxygen???

- Shouldn't we titrate oxygen in TBI patients?
  - Why not aim for POx 94-98% range?
  - If the POx is 100%...
    - Not being bagged:
      - Why not put them on nasal cannula and turn down the flow?
    - If on ventilator...why not turn down the FIO₂ to 50%?

What About Too Much Oxygen???

- How to use evidence in medicine
  - Know the setting...the methodology...and the assumptions of the studies
  - Be careful when transferring evidence from one setting to another...and...weigh what you really know...vs. what you think you know.
Evidence is from in-hospital studies:
- Hyper-oxygenation—Hours/days
- Most evidence is in non-hemorrhagic stroke
- Brief episodes of hyper-oxygenation
  - Impact in TBI is unknown
- Some experts believe that hyper-oxygenation may be beneficial in early TBI care

So...what do we really know??
- Hypoxic events are REALLY common
- Hypoxia is REALLY bad: Scores of studies
  - EPIC: 10,000 cases, >500 hypoxic cases
  - aOR for death is 4.1
- Theoretical risk (hyper-oxia) versus established evidence (hypoxia)
- Preventing hypoxia is paramount

The science of judicious oxygen use comes primarily from university critical care settings
- The EMS environment is a different Galaxy!!!
What About Too Much Oxygen??

- The different Galaxy!!
  - Scene safety
  - Patient movement
  - Traffic control
  - Extrication
  - Moving rotor systems
  - Strangers doing complex tasks together
  - Noise/light/environment compromising patient assessment
  - Code 3 transportation

What About Too Much Oxygen??

- What can go wrong?
  - Tubes pulled
  - Tubes kinked
  - O₂ source disruption
  - Taking patients to altitude

What About Too Much Oxygen??

- In the field…many things can lead to unexpected hypoxic events
  - Perhaps explains studies showing improved outcome from early "hyper-oxygenation"
  - It's naive to assume that the careful tweaking of oxygenation…developed and studied in highly-controlled critical care settings…should be used in EMS without concern for the high-risk environment
What About Too Much Oxygen???

- Another way to look at “hyper-oxygenation:
  - "Tweaking" oxygen delivery to “prevent hyper-oxygenation” actually removes the protection of PRE-oxygenation for the next, unexpected event.”

- Perhaps...any benefit of preventing hyper-oxygenation by decreasing O₂ delivery is overwhelmed by the increased risk for a hypoxemic event!!!

What About Too Much Oxygen???

- Err on the side of high FIO₂
- Our approach: “More than 100%®” is a preemptive strike on hypoxia:
  - The EPIC Project: Since hypoxia is such a mortal event...if we could use hyperbaric oxygen during theprehospital care...we would!!!
Controversy #3: What About Too Much Glucose???
- EBG: Treat BG <70 with full amp of D50
- Isn’t hyperglycemia bad for neuro outcomes?
  - Should we give less glucose when they’re hypoglycemic?

What About Too Much Glucose???
- Evidence is from in-hospital studies:
  - Hyperglycemia in poorly-controlled diabetics
  - Days of hyperglycemia
- Brief episodes of hyperglycemia from D50?
  - Impact in TBI is unknown
- Theoretical risk vs. established evidence
  - Hypoglycemia is really bad for neurons

Controversy #4: Management of Blood Pressure
- Guideline: In patients with TBI:
  - Start at least one IV
  - Carefully monitor BP
- Treatment of hypotension (classic approach):
  - 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
Multisystem Trauma With TBI: Treat Hypotension???

- Multisystem Trauma:
  - Will fluids increase internal bleeding if it hasn’t been controlled yet???
- “Permissive hypotension”??
  - Literature:
    - Animal studies: None done with TBI
    - Human studies: Penetrating torso wounds
      - TBI excluded!!

Why???
1) The National Guidelines recommend treating
2) All evidence supporting Permissive Hypotension comes from studies without TBI
3) In most patients…outcome will be determined by the TBI
   - Hypotension kills neurons
   - A live body…with a dead brain…is a dead patient
4) Preliminary findings from EPIC

EPIC: Blood Pressure and Survival

- Evaluated 8,282 patients with major TBI
  - Analyzed association between:
    - Each patient’s lowest prehospital SBP
    - Mortality
Historically: 90 an important value

- Current treatment threshold
- Many studies have dichotomized BP at 90

Why?
- Most studies too small to treat BP as continuous
  - Forced to use “low” vs. “not low”
- The “hypotensive” side of the plot is instructive

Is 90mmHg Special?
Blood Pressure

Between SBP 40-130 mmHg:
- Each 10-point decrease →
  - Increased odds of death by 11%
  - Holds throughout the entire range of 40-130
- No “inflection point”...anywhere

No Threshold???

Discussion

- Why has the literature missed this?
  - Few large studies have linked, detailed, EMS data
  - Not looking for it:
    - Focused on hypotension
    - Enamored with “permissive hypotension”
    - In essence: “Low BP isn’t an issue until it’s really low”
    - This may be ABSOLUTELY wrong in TBI!!!
Conclusions

- Optimal range may be:
  - Relatively narrow
  - Much higher than previously thought

Conclusions

- The 90 mmHg “hypotension threshold” may not be real:
  - Risk of mortality may be continuous…not dichotomous
  - No evidence of any “cut-point”
  - Clinically meaningful “hypotension” may occur at pressures much higher than 90 mmHg

Conclusions

- This doesn’t mean we should treat them to get them up to the 140s…but…it may mean that 90 mmHg is way too low!!!
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

Problem:
- Every commonly-used sedative (both narcotics and benzos) are vasodilators
- Vaso-physiology of sedatives
  - Decreased cardiac after-load
  - Very significant decreased pre-load

Vasodilation/hypotension are really bad
- BP can plummet in compensated shock
  - And you don’t know who’s got it!!!
- Reversing agents (narcs/benzos):
  - Work centrally in CNS
  - Do not reverse the direct vascular effects
  - You can’t “take it back”
Should TBI Patients be Sedated?

- How did the “comfort of anesthesia for elective surgery” ever come to drive the approach to saving critically injured, dying patients???
- Who cares if they remember the discomfort of the tube if it saves their brain and allows them to be able to remember…anything??!!

Take Home Message

- In the setting of TBI…
  err on the side of under-sedation!!!
Controversy #6: “Therapeutic Hyperventilation”

- What about patients with impending cerebral herniation?

Cerebral Herniation

- It’s **RARE** in the prehospital environment
- It has a very bad prognosis
  - No matter what you do
  - No matter what the neurosurgeon does
  - 25 years of experience: No survivors

Impending Cerebral Herniation
### Cerebral Herniation

- Most patients with severe TBI are not herniating.
- Real-world “translation”:
  - The worse the TBI…the faster we ventilate
- Many patients harmed →
  - Probably no one helped

### Treating Cerebral Herniation

- Two approaches to treatment:
  - #1: EPIC recommendation:
    - Based upon complete lack of evidence supporting…and good reasons not to hyperventilate →
    - 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* hyperventilation
  - Adults/adolescents (>15): 20 bpm (10)
  - Children (2-14): 25 bpm (20)
  - Infants (0-24 mo.): 30 bpm (25)

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**Treating Cerebral Herniation**

- **NOTE:**
  - These rates are *not* evidence-based, they are completely arbitrary!!!
    - Like most EMS
  - Even if following Option #2…when in doubt…don’t hyperventilate!!!

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**Treating Cerebral Herniation**

- If ETCO₂ monitoring available…and you are going to hyperventilate:
  - Maintain at 30-35mmHg
  - *Avoid* ETCO₂ <30mmHg
    - It KILLS neurons!!!
**Treating Cerebral Herniation**

- **IRONY**: Many adult TBI patients are *routinely* being ventilated at *higher* rates than the recommended *hyper-ventilation* rate for infants (>30)
- In the real world...we would often have to *slow down* to get to the proper *hyper-ventilation* rate!!!

**QUESTIONS???