

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

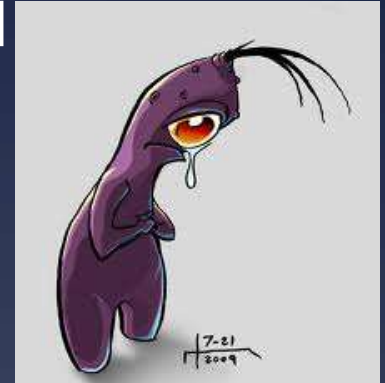
Primary Brain Injury

- * 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*

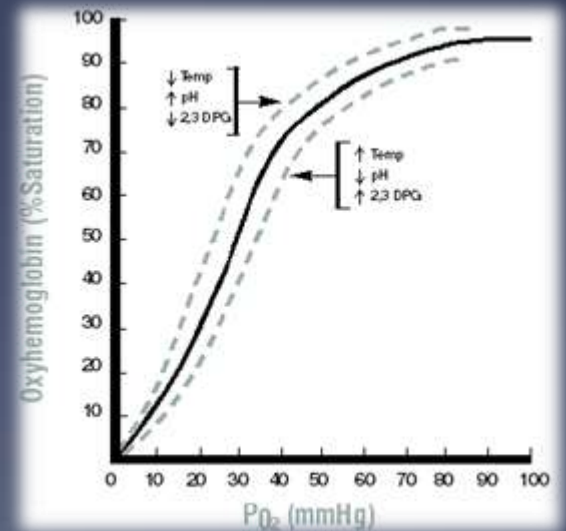


The Science of the “H Bombs”

➤ Hypoxia:

- Hypoxia in the field is very common
55% of patients with severe TBI
- A single O_2 sat of $<90\%$ is independently associated with at least a doubling of mortality

One study: Tripled mortality



The Science of the “H Bombs”

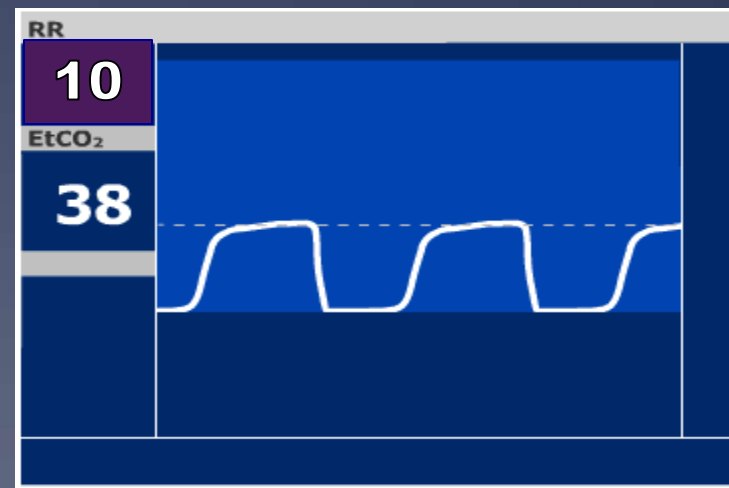
➤ Hypotension:

- 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

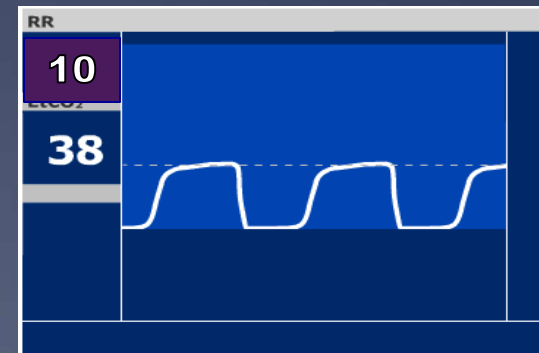
* Prevent and aggressively treat hypoxia



* Prevent and aggressively treat hypotension



* Meticulously prevent and rapidly correct hyperventilation

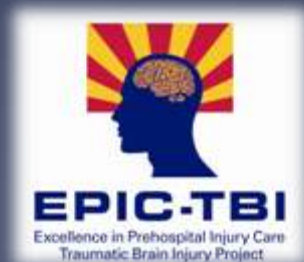


Paradigm Shift

- * 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

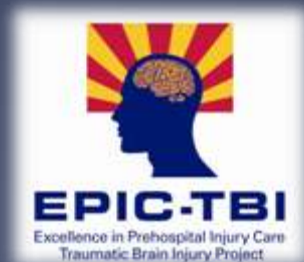
The Arizona EPIC Project

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 Brain Trauma Foundation (BTF) – TBI CARE Guidelines

Hospital

1995
1st
Edition

1999
2nd
Edition

2007
3rd
Edition

EPIC Master Trainers begin TBI Guideline implementation in Arizona hospitals 2013

Pre-Hospital

2000
1st
Edition

2007
2nd
Edition

2012
EPIC begins TBI training in AZ EMS agencies

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

Wang: Ann Emerg Med 2004;44:439-450.



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
- * Denninghoff: West J Emerg Med 2008;9:184-9
- * Murray: J Trauma 2000;49:1065-70
- * Wang: Ann Emerg Med 2004;44:439-50
- * Wang: Prehosp Emerg Care 2006;10:261-71
- * Eckstein: Ann Emerg Med 2005;45:504-9
- * 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
- * Klemen: Acta Anaesthesiol Scand 2006;50:1250-4
- * Warner: Trauma 2007;9:283-89
- * Davis: Resuscitation 2007;73:354-61
- * Davis: Ann Emerg Med 2005;46:115-22
- * Bulger: J Trauma 2005;58:718-23
- * Bernard: Ann Surg 2010;252:959-965



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

Gaither, Spaite, Bobrow: Ann Emerg Med; 2012



Three Major Problems With Manual Ventilation

1. Hyperventilation:

-Bagging faster than one breath every six seconds (10 bpm) or $ETCO_2 < 35$

-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



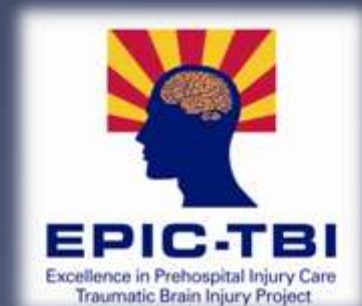
Inadvertent Ventilatory Inattentiveness (IVI)

- ▣ 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



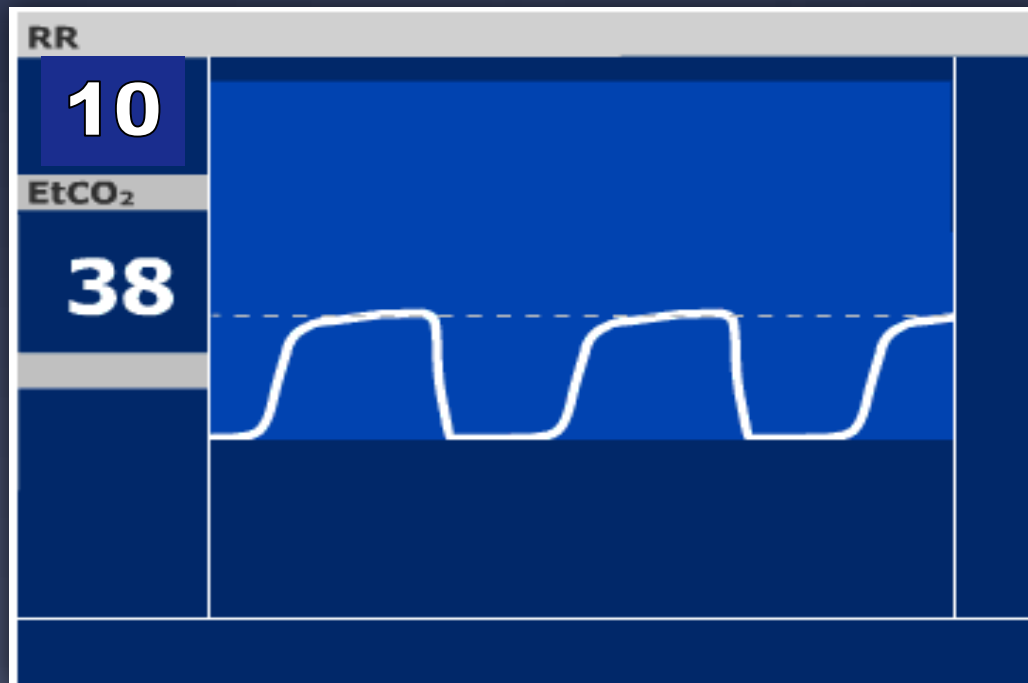
Adjuncts for Preventing Hyperventilation

- * 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



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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

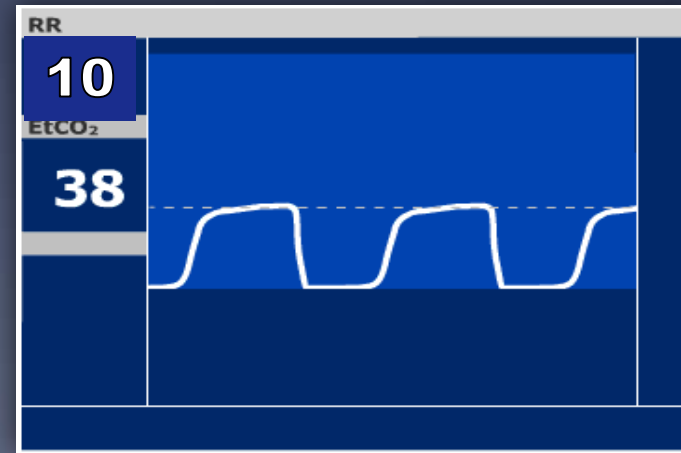


* Next Best:

- * 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 “Definitive” Care of TBI Begins in the Field?

- 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”

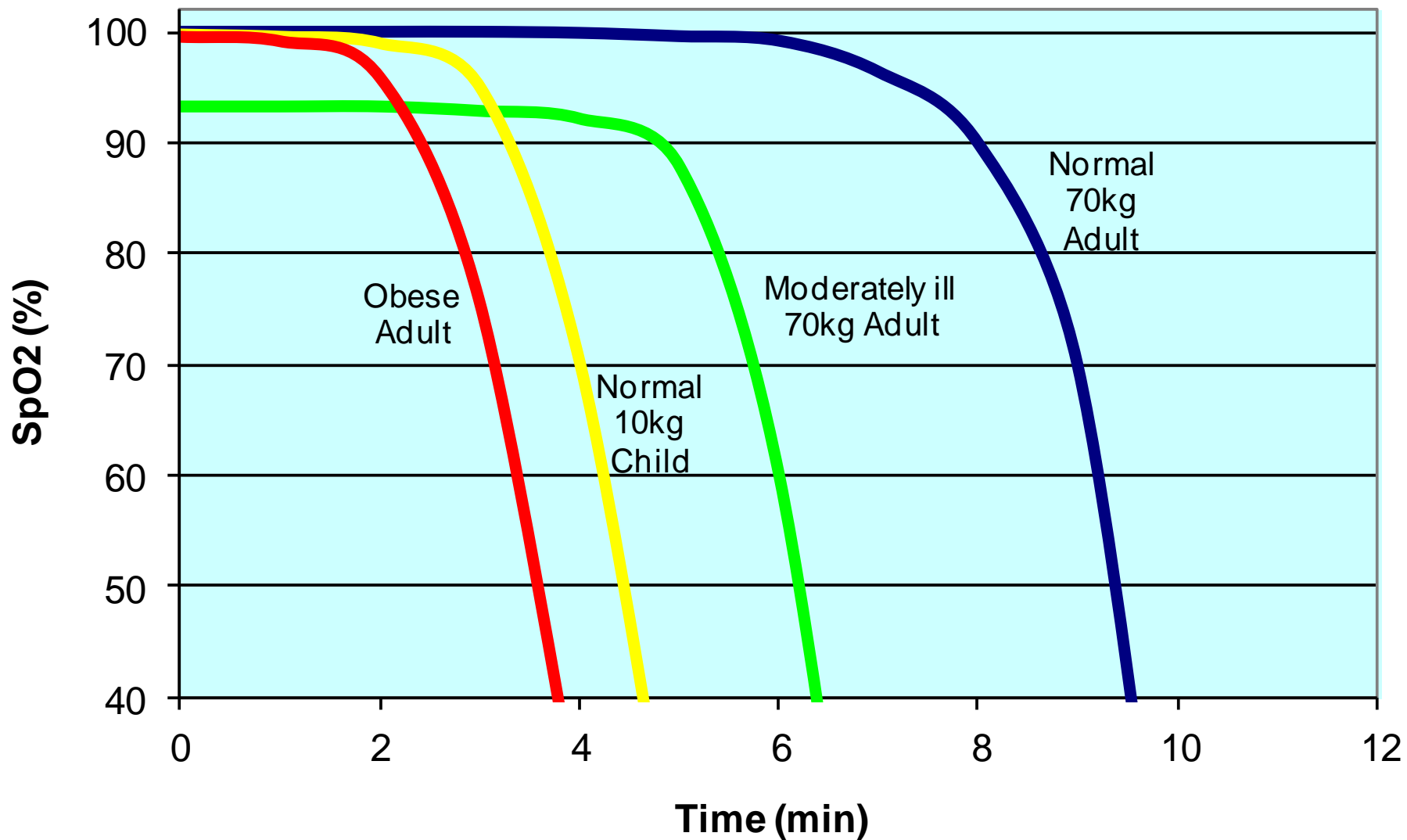
EPIC Evidence

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

Strongly emphasize high-flow oxygen



Full Pre-Oxygenation & Time



Sweet or Un?

Glucose

What About Too Much 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



What About Too Much Glucose???

- * 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

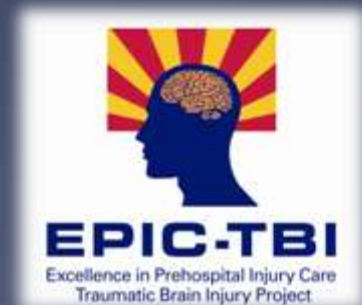
Multi-System Trauma With TBI

- * Multisystem Trauma:

- * Will fluids increase internal bleeding if it hasn't been controlled yet???

- * "Permissive hypotension"??

- * Literature: Penetrating torso wounds



Serious about Sedation

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

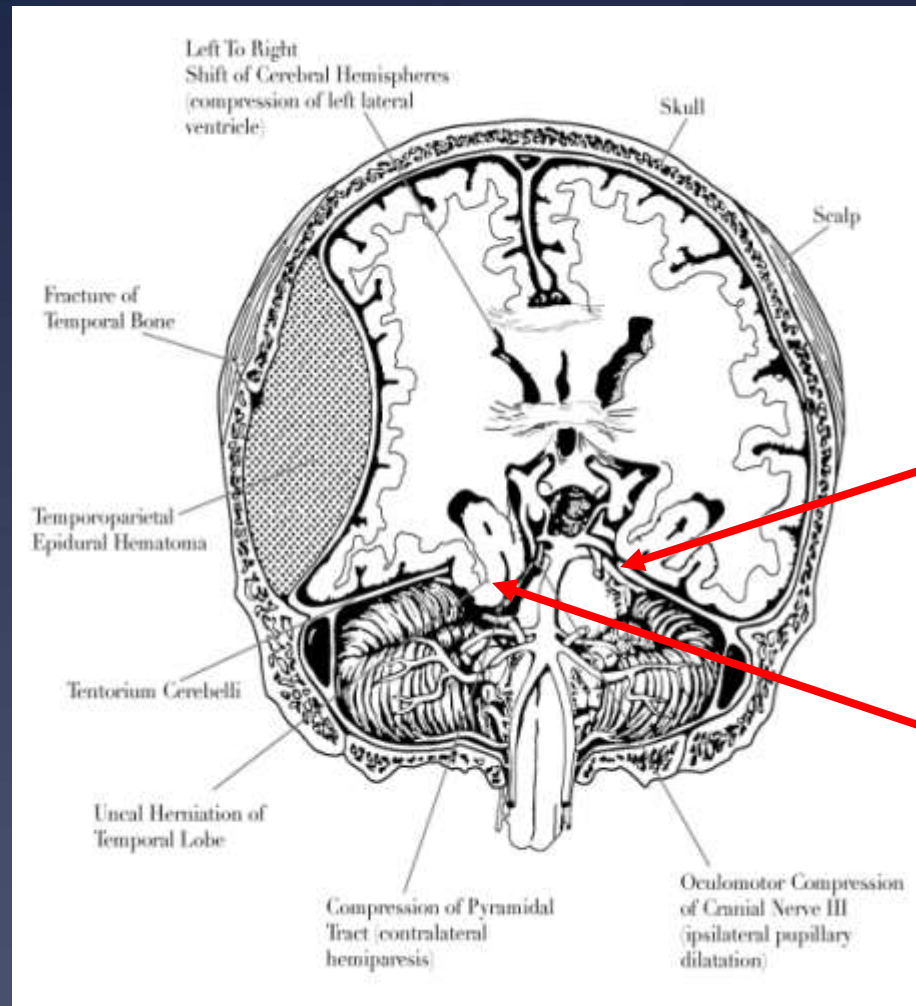
Therapeutic
Hyperventilation

“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

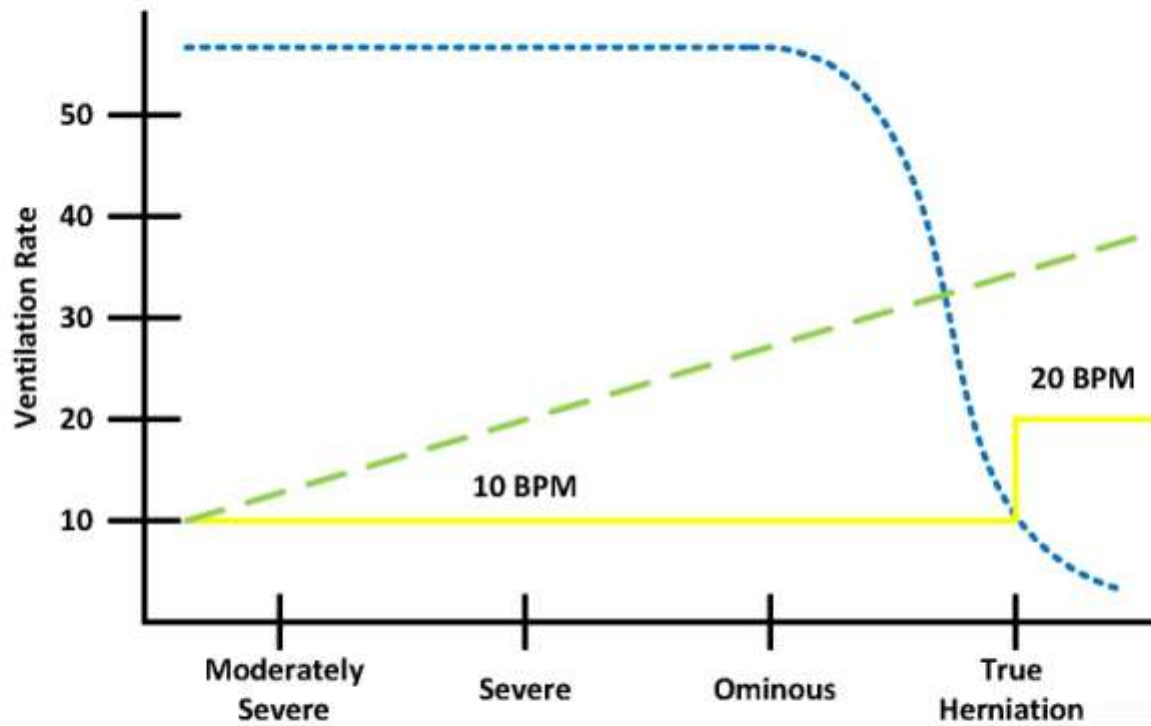





Cerebral Herniation

- * 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



Ventilation Rates in Intubated TBI Patients



-  Risk of further secondary brain injury from hyperventilation
-  Translation of concept into practice
-  Theoretical optimum rates



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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** $\text{ETCO}_2 < 28\text{mmHg}$
 - * 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

and make more of this

This...

Special thanks to the EPIC Partners



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www.EPIC.Arizona.edu



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