

# The Arizona EPIC Project & Controversies in TBI Management

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## Contributions

- Dr. Dan Spaite, MD, FACEP
- Dr. Ben Bobrow, MD, FACEP
- Bruce Barnhardt, RN, CEP
- John Tobin, CEP
- Amy Boise, NREMT-P, FP-C

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## Disclosures

- \*This project is funded by the NIH
- \*1R01NS071049-01A1 (Adults)
- \*3R01NS071049-S1 (EPIC4Kids)



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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

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## 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



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## 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

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## The Stakes Are High

A mild to moderate *primary* TBI can be converted into a severe TBI from *secondary* injury due to improper management

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## The ESSENCE of the Science

➤ What happens in the first few minutes profoundly impacts outcome



➤ The “H-Bombs” for TBI

- Hypoxemia
- Hypotension
- Hyperventilation



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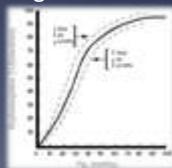
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## The Science of the “H Bombs”

➤ **Hypoxia:**

- Hypoxia in the field is very common  
55% of patients with severe TBI
- A *single* O<sub>2</sub> sat of <90% is *independently* associated with at least a doubling of mortality  
One study: *Tripled* mortality



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## 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



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## 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



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## 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



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## The Essence of the Guidelines

\* Prevent and aggressively treat hypoxia



\* Prevent and aggressively treat hypotension



\* Meticulously prevent and rapidly correct hyperventilation



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## 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

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## 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



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## 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



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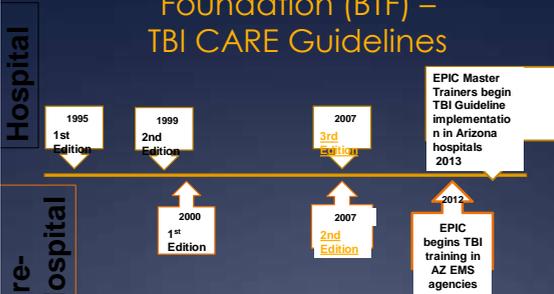
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## Implementation of Brain Trauma Foundation (BTF) – TBI CARE Guidelines



Implementation of evidence based protocols takes a long time!

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# Controversy #1

## Intubation

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## 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.



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## 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



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## 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



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## ETI is Bad???

- \* Studies showing worse outcomes with ETI
- \* Sfiell: 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
- \* Boicicchio: J Trauma 2003;54:307-11
- \* Arbabi: J Trauma 2004;56:1029-32



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## 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



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

- \* Randomized: PM RSI Vs. ED intubation
- \* Meticulous ETCO<sub>2</sub> 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



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## 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



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## Three Major Problems With Manual Ventilation

### 1. Hyperventilation:

-Bagging faster than one breath every six seconds (10 bpm) or ETCO<sub>2</sub> <35

-Even moderate hyperventilation kills brain cells and causes major, debilitating morbidity or death



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## 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



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## Three Major Problems With Manual Ventilation

3. Inadvertent Ventilatory Inattentiveness:
  - A recent landmark discovery:
  - Every healthcare provider has this neuro-psychiatric disorder



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## 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!



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## 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



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## Adjuncts for Preventing Hyperventilation

- \* Cadence Device
  - \* Visual Rate Timer
  - \* 10 bpm
  - \* 1 sec breath



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## Adjuncts for Preventing Hyperventilation

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



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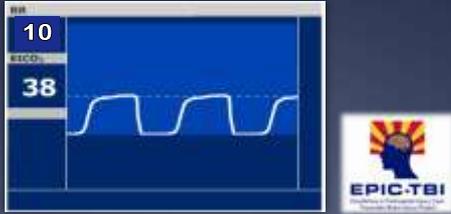
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## Adjuncts for Preventing Hyperventilation

- Continuous  $\text{ETCO}_2$  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



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## Optimal Ventilation for TBI

- \* Best:
  - \* Initial cadence device/PC bag followed by...
  - \*  $\text{ETCO}_2$  monitoring to modulate ventilation rate asap followed by...
  - \* Mechanical ventilator asap @ 7cc/kg
- \* Next Best:
  - \* Cadence device/PC bag
  - \*  $\text{ETCO}_2$  monitoring
- \* Acceptable: Cadence device/PC bag



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## 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

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## 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)
- \* 2<sup>nd</sup> attempt TRIPLES complication rates
- \* Most common complications:
  - \* Hypoxia and aspiration
    - \* Markedly increases mortality in TBI
- \* "First Pass Success" → BLS or rescue quickly

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## 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

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# EPIC Lesson Learned

Definitive Care

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## 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...”



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# EPIC Truth in O2

Oxygen

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## 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% FIO<sub>2</sub> until arrival at the TC



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## 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"

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## EPIC Evidence

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

Strongly emphasize high-flow oxygen



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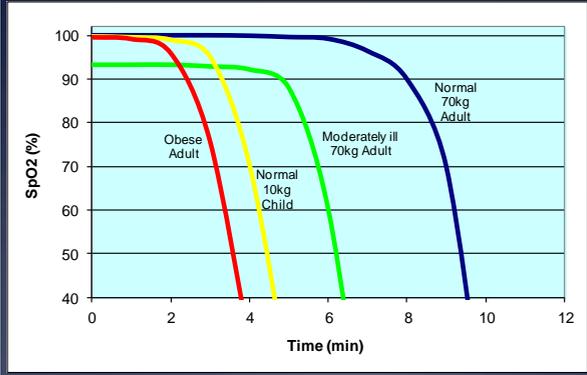
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## Full Pre-Oxygenation & Time



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## Sweet or Un?

Glucose

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### 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



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## 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



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## EPIC Perfusion

### Blood Pressure

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## 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

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## 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



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## Serious about Sedation

Sedation

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## 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



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## 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



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## 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



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## EPIC Evidence

Therapeutic  
Hyperventilation

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## “Therapeutic Hyperventilation”

What about patients with cerebral herniation?



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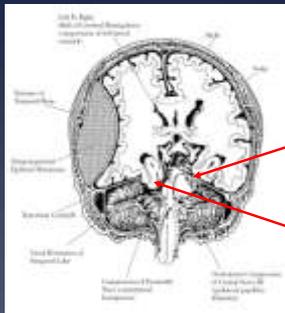
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## Cerebral Herniation



tentorium

herniation

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## Cerebral Herniation

- \* It's RARE in the prehospital environment
- \* It has a very bad prognosis
- \* Inability to confirm in the field



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## 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



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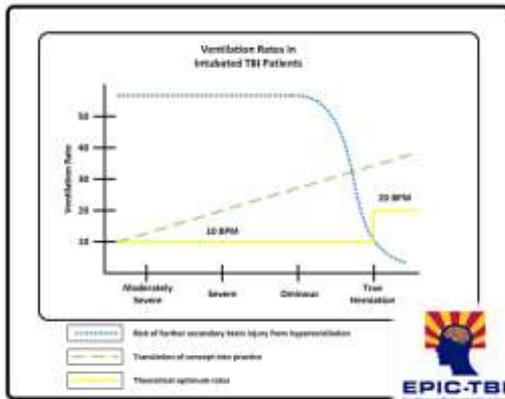
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## Treating Cerebral Herniation

- \* Two approaches to treatment:
  - \* #1: EPIC recommendation:
  - \* Based upon this information...

Don't Hyperventilate  
under any circumstance



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## 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



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## Treating Cerebral Herniation

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



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## Treating Cerebral Herniation

- \* If ETCO<sub>2</sub> monitoring available and you are going to hyperventilate:
  - \* Maintain at 28-31mmHg
  - \* Avoid ETCO<sub>2</sub> <28mmHg
    - \* It KILLS neurons!!!



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## Parting Thoughts

The EMS care of TBI patients  
REALLY matters



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## Parting Thoughts

Avoid the H-Bombs!

- \* Hypoxia
- \* Hypotension
- \* Hyperventilation



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Proper EMS care can often help prevent  
This...

and make more of this

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Special thanks to  
the EPIC Partners



[www.EPIC.Arizona.edu](http://www.EPIC.Arizona.edu)

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