Traumatic Events:
Cautions about $ETCO_2$ Analysis in Trauma

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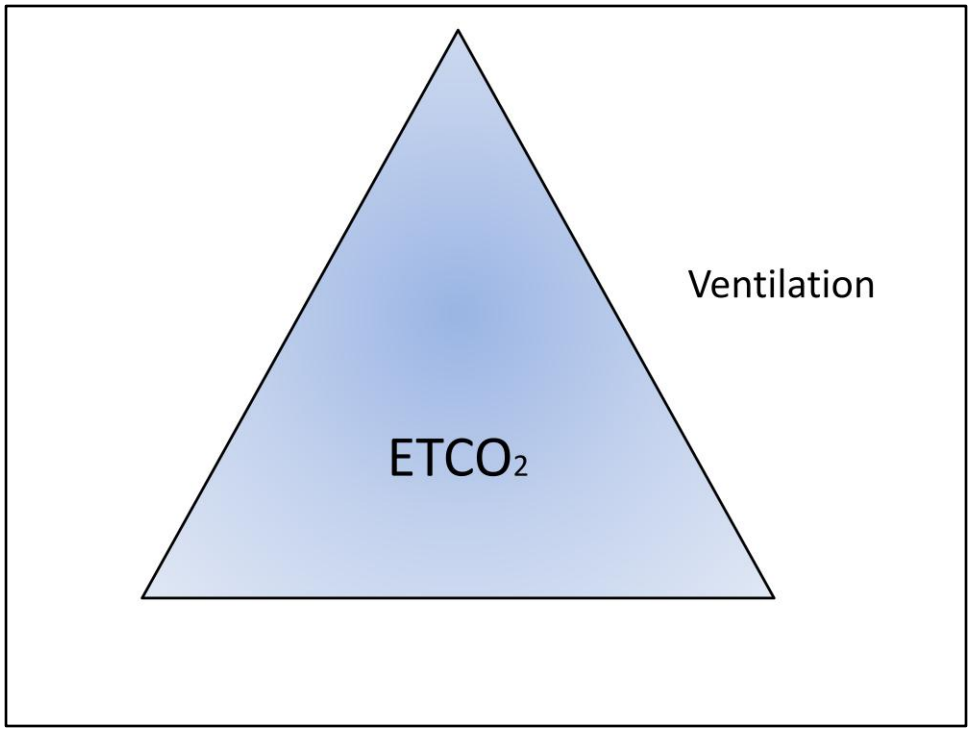
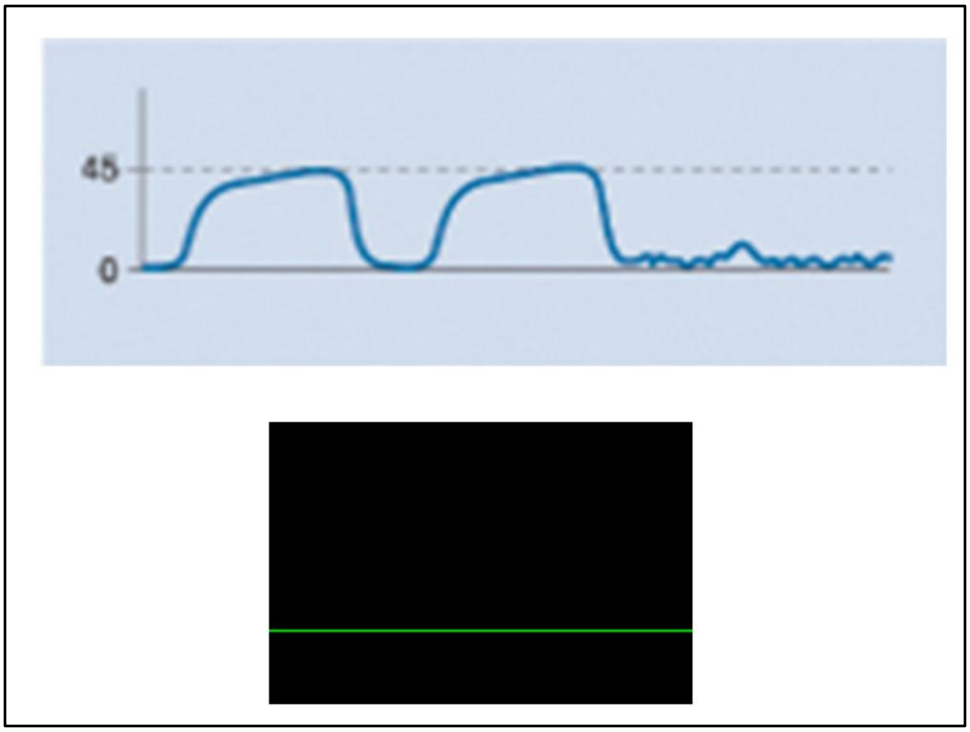
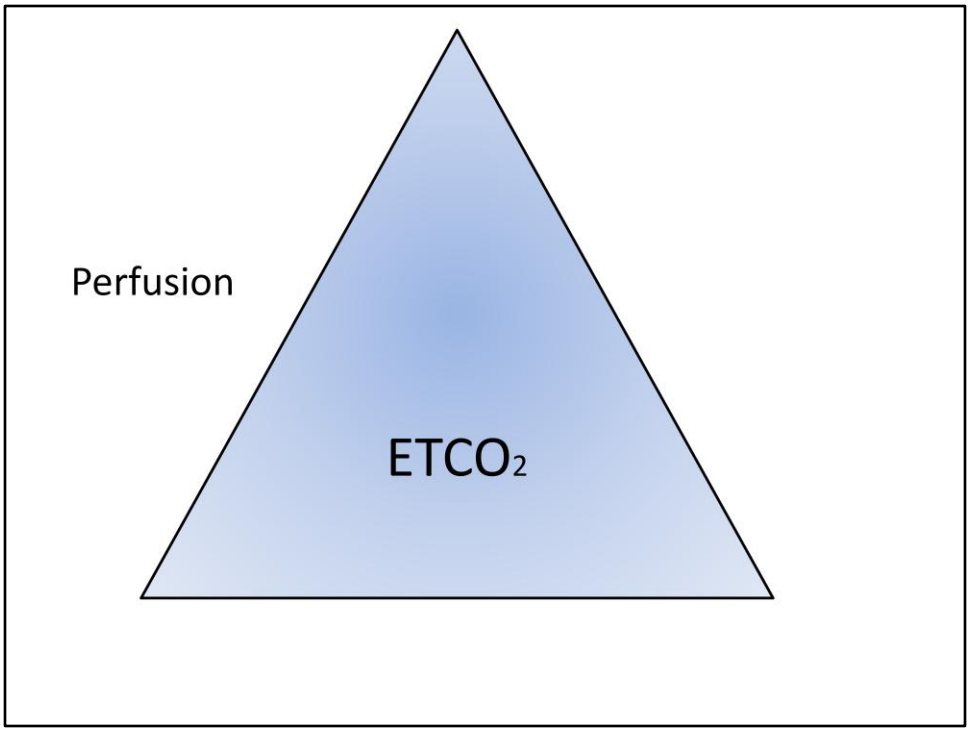
No direct financial conflicts to disclose



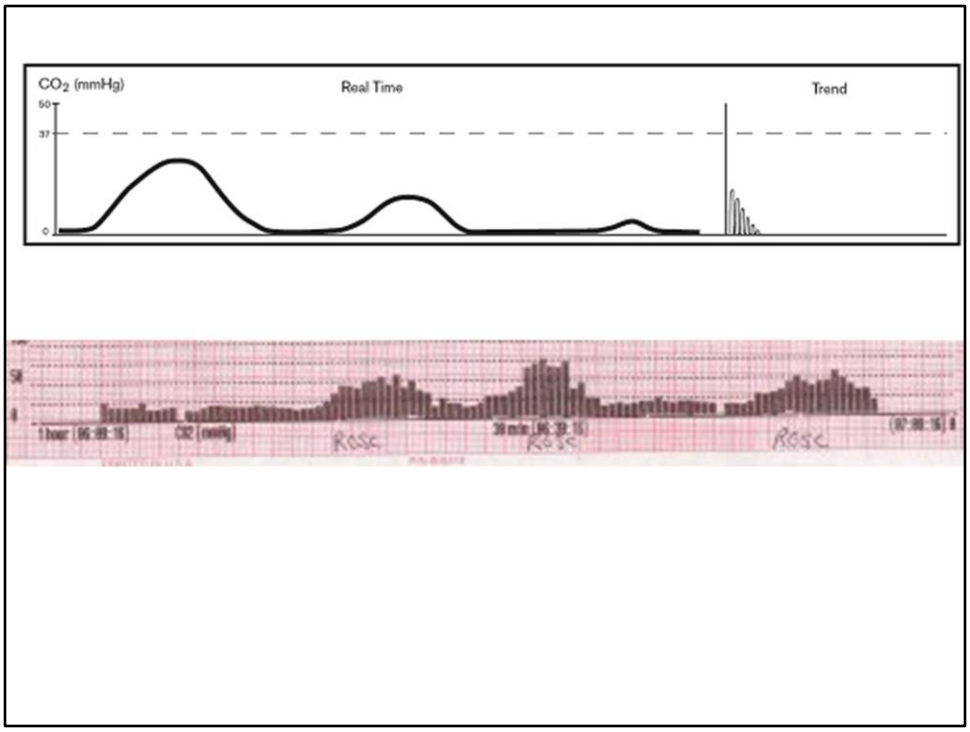
End-tidal CO2 depends on 3 physiologic variables: ventilation, perfusion, and metabolism. As such, ETCO2 can be used to monitor these three variables. Perhaps the most important is ventilation.



(images from capnography.com and emscapnography.com)
ETCO2 provides a breath-by-breath confirmation of proper endotracheal tube placement (because of ventilation).



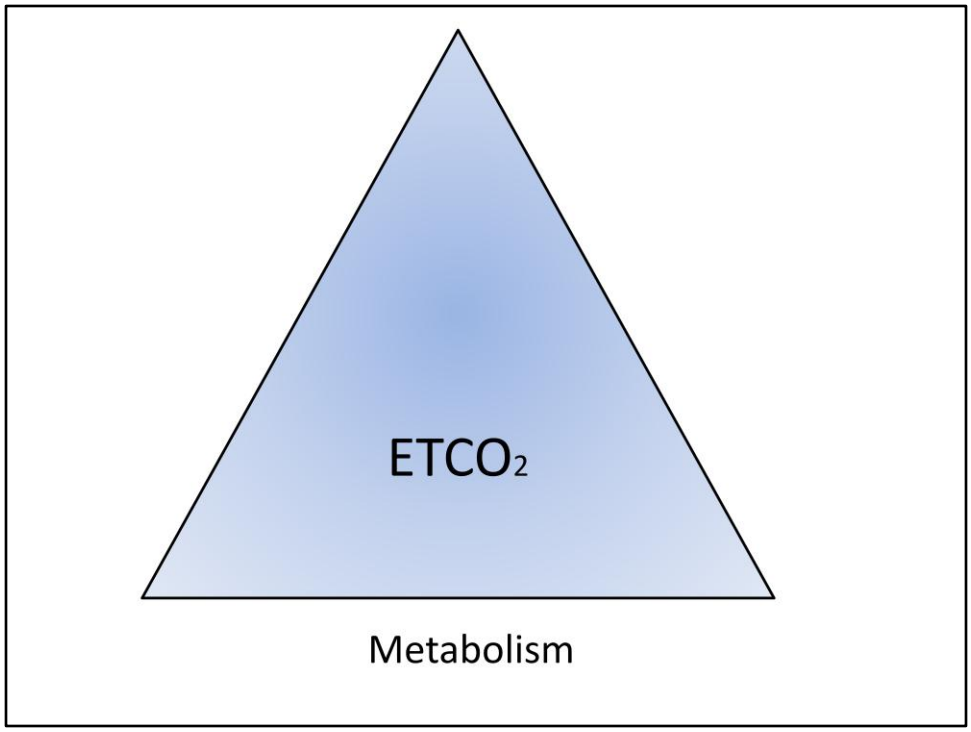
Perfusion status can be assessed with ETCO2.



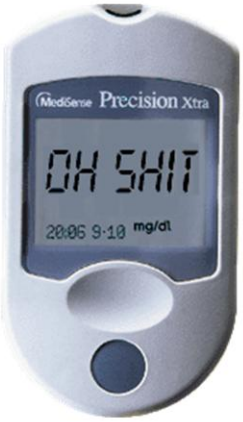
Perfusion status in CPR is one example of ETCO2 usage. In the top image, falling ETCO2 shows either: fatiguing CPR provider and ineffective compressions or futile resuscitation.

The bottom image shows 3 episodes of significant rises in ETCO2 that correspond with ROSC. Bicarbonate administration can be a mimic of this.

(Images found through Google Image search—apologies for not being able to provide specific references or acknowledgements.)

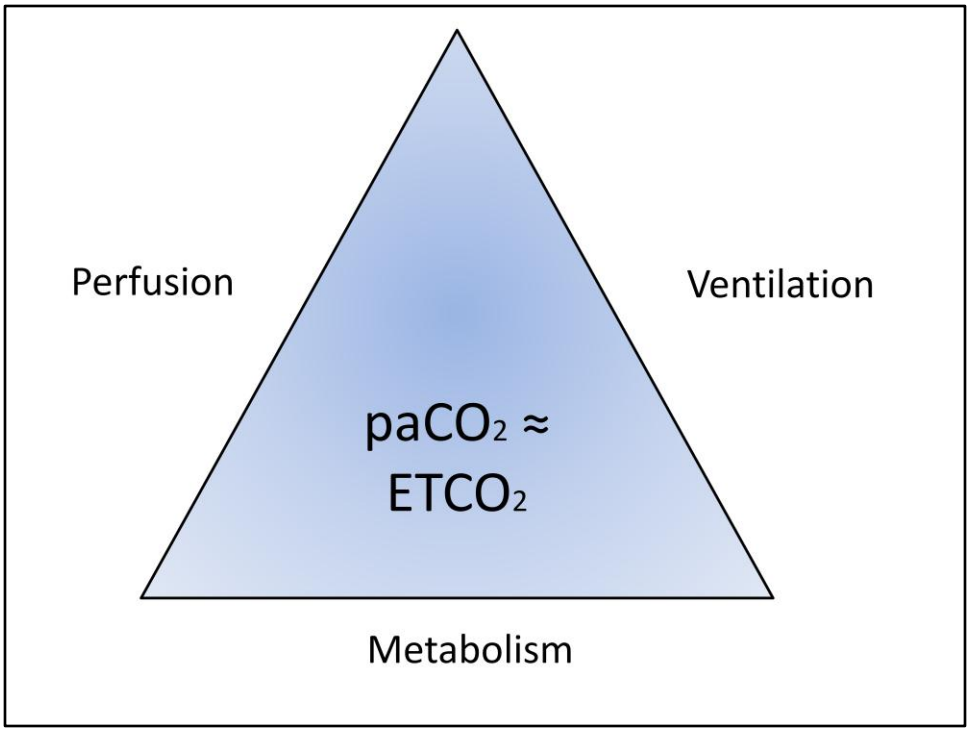


ETCO2 is also affected by cellular metabolism; as such, acid-base abnormalities can be monitored with ETCO2.

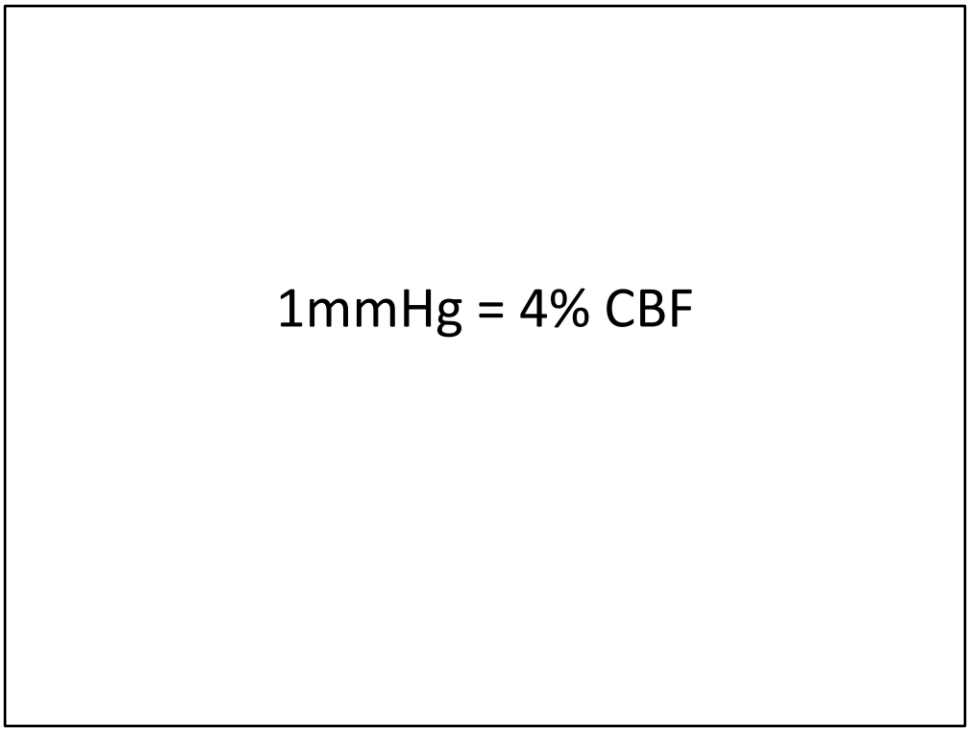


Examples are DKA (high blood glucose + low ETCO2) and sepsis (infection + low ETCO2).

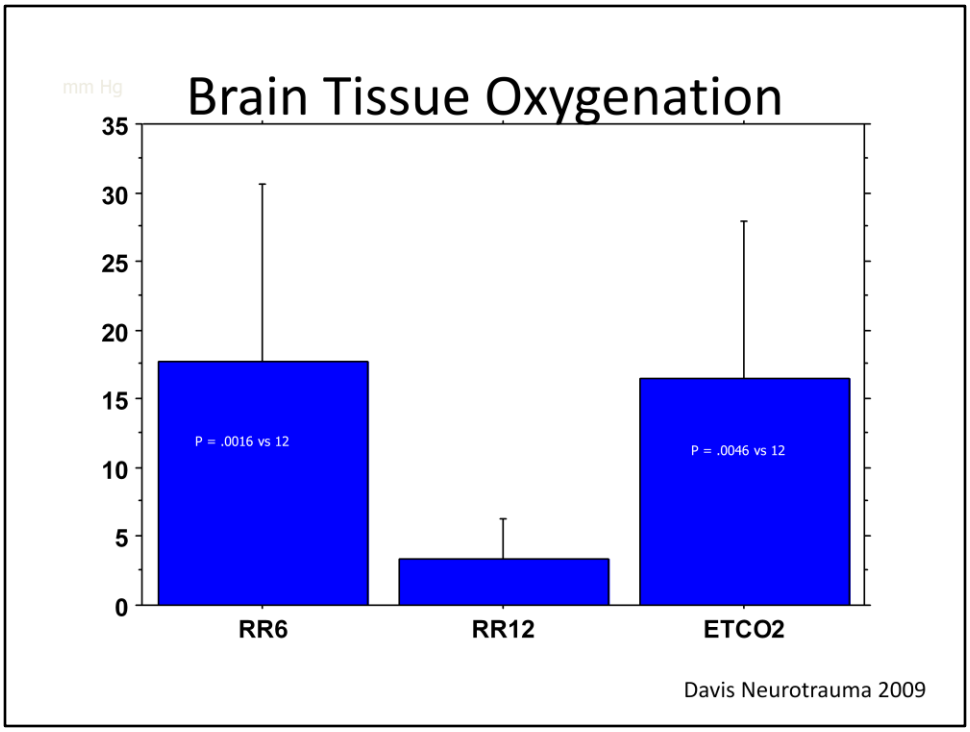
(Images found through Google Image search—apologies for not being able to provide specific references or acknowledgements.)



Finally, when perfusion, ventilation, and metabolism are all normal, ETCO2 reliably reflects paCO2, and can be used to guide ventilatory management in ***isolated*** traumatic brain injury.



The goal of TBI management is intracranial pressure control. Without herniation, guidelines recommend keeping ETCO2 between 35-40mmHg. For acute herniation control, the goal ETCO2 is 30-35mmHg. This 5-point delta results in a 20% reduction in cerebral blood flow. This decreases cerebral blood volume and can compensate for increased ICP; over-ventilating, or hyperventilating when herniation is not present, can cause significant harm.



(Slide from a Neurotrauma conference presentation slide set available on the web.)

Brain tissue oxygenation is very sensitive to respiratory rate—moving from 6 to 12 can have profound effects. This underscores the need to guide ventilations through an objective measure, such as ETCO2.

Variable	Baseline	Hemorrhage	
		Mild	Severe
Pa_{O_2} (torr)	85.4 ± 7.5	105.2 ± 9.6*	116.0 ± 6.3*
Pa_{CO_2} (torr)	38.0 ± 4.8	28.5 ± 4.8*	17.2 ± 3.0*
Pe_{CO_2} (torr)	46.3 ± 6.2	42.8 ± 5.0	36.9 ± 3.0*

Totapally et al. Critical Care 2003 7:79

What must be remembered, though, is that perfusion, ventilation, and metabolism must be NORMAL; otherwise, the differences between paCO2 (in the blood) and ETCO2 become too great.

In this study of hemorrhage in rats, severe hemorrhage (decreased perfusion) causes significant discrepancies in values.

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Original Contributions

Correlation of arterial P_{CO_2} and P_{ETCO_2} in prehospital controlled ventilation

Vanessa Belpomme MD*, Agnès Ricard-Hibon MD, Cyrille Devoir MD, Sylvie Dileseigres MD, Marie-Laure Devaud MD, Charlotte Chollet MD, Jean Marty MD

Table 4 T_0: $PaCO_2$ − $PETCO_2$ gradient (mm Hg) among hypercapnia, hypocapnia, and normocapnia

Variables (T_0)	Mean of $ETCO_2$ (mm Hg)	Mean of $PaCO_2$ (mm Hg)	Mean of gradient
Hypercapnia (n = 60)	44.3 ± 14.4	57 ± 17.3	13.3 ± 14.9
Hypocapnia (n = 15)	29 ± 4.5	29.4 ± 4.5	1 ± 6.3
Normocapnia (n = 21)	36.1 ± 7.5	39 ± 2.4	2.6 ± 7.2

Values are presented as mean ± SD (range).

In this study of all comers (trauma, sepsis, neuro, etc.) the correlation in hypercapnea is not very good.

Session VI

Paper 38 9:00 AM

END-TIDAL CO2 IS NOT A RELIABLE MARKER OF VENTILATION STATUS IN THE TRAUMA PATIENT

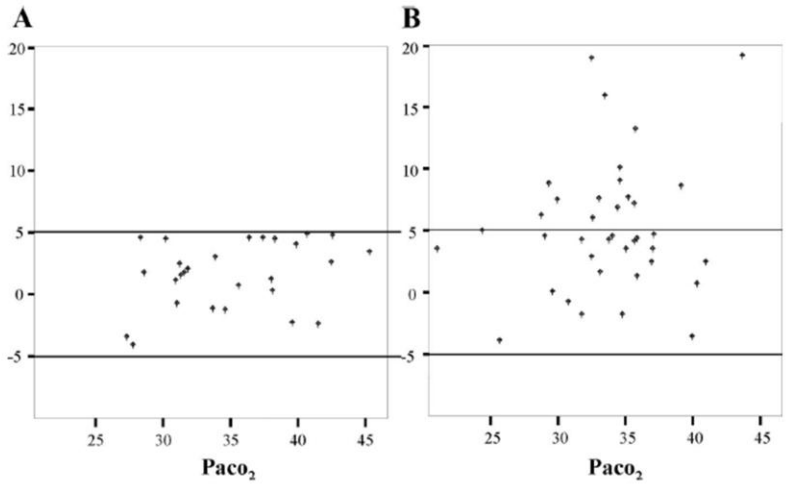
Results: Between 01/01/07 –12/31/07, 185 patients were evaluated. The overall EtCO2-PaCO2 correlation was R^2=0.289, but variedly greatly with admission base deficient: BD --2 to 2 had a correlation of R^2= 0.65; BD 2-6 R2=0.24; and BD > 6 R2=0.26. Patients ventilated in the commonly recommended EtCO2 range of 35-40 were likely to be under ventilated (PaCO2>40mmHg) 80% of the time, and severely under ventilated (PaCO2>45mmHg) 30% of the time.

Conclusion: The use of EtCO2 as a ventilation guide in trauma patients with significant BD has poor correlation. Better strategies for guiding prehospital and emergency department ventilation are needed.

This paper by Copass et al shows further evidence that altered metabolism (base deficits in trauma patients are signs of acid-base imbalance due to poor perfusion) significantly affects the correlation.

Concordance of End-Tidal Carbon Dioxide and Arterial Carbon Dioxide in Severe Traumatic Brain injury

Sung-Woo Lee, MD, PhD, Yun-Sik Hong, MD, PhD, Chul Han, MD, Su-Jin Kim, MD, PhD, Sung-Woo Moon, MD, Jung-Ho Shin, MD, and Kwang-Je Baek, MD, PhD



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A: no severe chest trauma, hypotension, or metabolic acidosis (100% concordance);
B: chest trauma, hypotension, or acidosis (60% concordance)

Finally, when chest trauma, hypotension, or altered metabolism are present, there is poor agreement. Please notice, though, that ETCO2 generally overstates paCO2.

What's the bottom line?

- In polytrauma, high $ETCO_2$ likely represents high $paCO_2$
  - Can probably be used to titrate therapy
- Low $ETCO_2$ in polytrauma unreliable
  - May reflect hypoperfusion, not hyperventilation


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