

## ABSTRACT

**Introduction:** End tidal carbon dioxide (ETCO<sub>2</sub>) is a measure of both ventilation and perfusion. Emergency Medical Services (EMS) providers commonly use ETCO<sub>2</sub> to verify endotracheal tube placement. We hypothesized that low ETCO<sub>2</sub> values in the prehospital setting could be used to predict hemorrhagic shock in intubated trauma patients.

**Methods:** This retrospective observational study evaluated adult trauma patients intubated in the prehospital setting and managed at a single Level 1 trauma center over 2 years. Continuous ETCO<sub>2</sub> data was downloaded directly from the cardiac monitor and linked with prehospital and hospital data from the EMS and trauma registries. The primary outcome was hemorrhagic shock, defined as either Emergency Department (ED) systolic blood pressure (SBP)  $\leq$  90 mmHg or initial shock index (SI)  $>$  0.9, and transfusion of at least one unit of blood products. Deaths from hemorrhage in the ED prior to transfusion were also included. To determine a representative minimum ETCO<sub>2</sub> value for each patient, we calculated the median ETCO<sub>2</sub> every 30 seconds. We then selected the minimum value from the 30-second median values. Various threshold values of minimum prehospital ETCO<sub>2</sub> were evaluated for their predictive value of hemorrhagic shock. Sensitivity analyses were also performed to evaluate subgroup performance based on mechanism of injury, sex, and injury severity score (ISS). Results were analyzed for statistical significance using Wilcoxon Rank Sum tests.

**Results:** We included 175 intubated patients (84% male, 36% penetrating injury, 26% overall mortality), 75 of which were in hemorrhagic shock on ED arrival. Patients in hemorrhagic shock had a higher mortality (45% vs. 11%), a higher median ISS (29 vs. 16), a higher median initial ED lactate (6.8 vs. 3.0), and a higher occurrence of penetrating injury (52% vs. 24%). Patients in hemorrhagic shock had significantly lower median ETCO<sub>2</sub> values (see table). This pattern was consistent when stratified by mechanism of injury, ISS, sex, and mortality (see table). Of the 52 patients with a minimum prehospital ETCO<sub>2</sub>  $\leq$  25 mmHg, 69% were in hemorrhagic shock on ED arrival; and of the 35 patients with an ETCO<sub>2</sub>  $\leq$  20 mmHg, 83% were in hemorrhagic shock. The area under the receiver operating characteristic (ROC) curve for minimum ETCO<sub>2</sub> was 0.71 (95% CI, 0.62 – 0.79).

**Conclusions:** Intubated patients with hemorrhagic shock upon ED arrival had significantly lower prehospital ETCO<sub>2</sub> values, and minimum ETCO<sub>2</sub> values  $<$  25 mmHg were highly predictive of hemorrhagic shock. Incorporating ETCO<sub>2</sub> assessment into prehospital care for trauma patients could support decisions regarding prehospital blood transfusion, triage to higher-level trauma centers, and trauma team activation.

Minimum ETCO <sub>2</sub> (mmHg) Values with IQR			
	Hemorrhagic Shock (n = 75)	No Hemorrhagic Shock (n = 100)	p-value
<b>Overall (n = 175)</b>	27 (13 – 32)	33 (29 – 37)	$<$ 0.0001*
<b>Mechanism of Injury</b>			
<i>Penetrating (n = 104)</i>	20 (9 – 32)	33 (28 – 39)	0.0003*
<i>Blunt (n = 63)</i>	29 (21 – 35)	33 (29 – 37)	0.020*
<b>ISS</b>			
$<$ 15 (n = 61)	28 (17 – 32)	34 (30 – 40)	0.013*
$\geq$ 15 (n = 114)	26 (12 – 33)	32.5 (29 – 36)	0.0003*
<b>Sex</b>			
<i>Female (n = 28)</i>	23 (20 – 29)	31 (24 – 35)	0.08
<i>Male (n = 147)</i>	27 (10 – 33)	34 (29 – 38)	$<$ 0.0001*
<b>Mortality</b>			
<i>Alive (n = 130)</i>	29 (23 – 33)	34 (30 – 38)	0.003*
<i>Dead (n = 45)</i>	13 (8 – 31)	28 (22 – 33)	0.051

\* Indicates significant difference between median values as determined by Wilcoxon Rank Sum Test

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