

International Prehospital Medicine Institute



IPHMI Literature Review

Keeping You Up To Date with Current EMS Literature and Studies

Vol. 4.7

- 1. Prehospital end-tidal carbon dioxide is predictive of death and massive transfusion in injured patients: An Eastern Association for Surgery of Trauma multicenter trial.** Campion EM, Cralley A, Sauaia A, et al. *J Trauma Acute Care Surg.* 2022;92: 355-361.
- 2. Naloxone-associated pulmonary edema following recreational opioid overdose: A case series.** Kummer RL, Kempainen RR, Olives TD, Leatherman JW, Prekker ME. *Am J Emer Med* 2022;53:41–43.
- 3. Characteristics and Outcomes of Prehospital Tourniquet Use for Trauma in the United States.** Hashmi ZG, Hu PJ, Jansen JO, Butler FK, Kerby JD, Holcomb JB. *Prehosp Emerg Care.* 2022; Published on-line. DOI: 10.1080/10903127.2021.2025283
- 4. Use of Topical Hemostatic Dressings in an Extended Field Care Model.** Welch M, Barratt J, Peters A, Wright C. *J Spec Oper Med* 2021;21(4):63-65.

- 1. Prehospital end-tidal carbon dioxide is predictive of death and massive transfusion in injured patients: An Eastern Association for Surgery of Trauma multicenter trial.** Campion EM, Cralley A, Sauaia A, et al. *J Trauma Acute Care Surg.* 2022;92: 355-361.

Prehospital identification of the trauma patient in severe shock remains challenging. Traditional methods of identifying shock, such as systolic blood pressure (SBP), heart rate, and shock index (SI) are often late signs. Early identification of these patients is crucial so the prehospital provider can initiate resuscitation and transport the patient to the appropriate trauma facility.

End-tidal carbon dioxide (ETCO₂) measures the amount of carbon dioxide in exhaled air at end-expiration. It has been shown to correlate with the plasma level of carbon dioxide to within 2-5 mm Hg. Inadequate perfusion during hemorrhagic shock leads to poor gas exchange within the alveoli of the lungs resulting in a decrease in ETCO₂. Low levels of ETCO₂ have been shown to correlate with injury severity and mortality in several hospital-based studies. Data from earlier small studies suggest this may also be the case for prehospital prediction, but this has yet to be studied on a large scale.

This was a retrospective, multicenter study performed in 24 trauma centers throughout the United States. Trauma patients were included if they underwent prehospital intubation with at least one measurement of ETCO₂. Traditional parameters of shock (SBP and SI) were compared to ETCO₂. Massive transfusion (MT) was defined as delivery of at least 10 U packed red blood cells in the first six hours after arrival to the ED or death in the first six hours after requiring at least 1 U of blood. Hypotension was defined as a SBP ≤ 90 mm Hg.

During the 2-year study period, 1324 patients met criteria and were included in the study. Of these, 20% had a penetrating injury mechanism, 30% had prehospital cardiopulmonary resuscitation, and 57% had a traumatic brain injury. In analysis of the overall cohort patients, ETCO₂ was significantly better in predicting mortality than SI and SBP. For those requiring MT, there was not a statistically significant difference in the predictive ability of ETCO₂ as compared to SI and SBP.

International Prehospital Medicine Institute

The most challenging aspect for prehospital providers in treating a trauma patient is often predicting clinical decline in the patient in occult shock, meaning they are normotensive but about to decompensate. This subgroup of 615 normotensive trauma patients was analyzed by the authors. The ETCO₂ was significantly better at predicting mortality than SBP and SI. The ETCO₂ cutoff value for mortality was 31 mm Hg. This equated to a positive predictive value of 39% and a negative predictive value of 83%. In the subgroup of 33 patients in occult shock who eventually required MT, the differences did not reach statistical significance, although the authors suspect this was due to the low number of patients in this group (33).

There are several limitations to this study which the authors acknowledged. It is a retrospective study and subject to errors in clinical documentation and survival bias. A specific cause of death was not available for the patients in this study, so the authors could not confirm that all patients died from hemorrhagic shock versus other causes. They used only intubated patients for the study so that ETCO₂ could easily be measured. Therefore, the large number of trauma patients who are potentially in shock but not intubated were not able to be analyzed.

In conclusion, this well done multi-institutional study of intubated prehospital trauma patients demonstrates that low ETCO₂ is significantly better at predicting future mortality and blood transfusion requirement than the traditional measures of SBP and SI. These findings are most significant in predicting transfusion requirements in the patient in occult shock. A trauma patient with a low ETCO₂ should heighten concern for occult shock and prompt the provider to consider transport to a trauma center.

2. Naloxone-associated pulmonary edema following recreational opioid overdose: A case series.

Kummer RL, Kempainen RR, Olives TD, Leatherman JW, Prekker ME. *Am J Emer Med* 2022;53:41–43.

Naloxone is a widely used opioid agonist administered by healthcare providers, first responders and laypersons alike to reverse the respiratory depression effects of an opioid overdose. The primary goal of opioid reversal is to restore spontaneous respirations. Naloxone is often thought to be a benign drug with few side effects. Those side effects may include hypertension, ventricular dysrhythmias, seizures, and rarely, pulmonary edema or cardiac arrest. It is not well understood why some patients experience pulmonary edema post naloxone administration. One theory is that the acute agonist effects of naloxone on opioid analgesia results in a large release of catecholamines, causing sudden increased pulmonary blood flow and permeability of the pulmonary capillaries.

The authors conducted an IRB approved, retrospective study of presumed naloxone associated pulmonary edema patients after recreational opioid use treated at Hennepin County Medical Center during the 33-month period ending 30 September 2019. They defined naloxone induced pulmonary edema as acute shortness of breath, hypoxemia and a radiologic finding of pulmonary edema following naloxone reversal of opioid intoxication and ruling out aspiration of gastric contents.

Initially 12 patients were identified however two were eliminated. The first due to suspected pneumonia from aspiration of gastric contents and the second for incomplete hospital records. The remaining 10 patients had a median age of 23 years old. They were overwhelmingly male (9/10) and various ethnicity (White – 4, Black - 3, American Indian – 2 and Hispanic - 1). The opioids involved were heroin (8 patients), oxycodone (1 patient) and methadone (1 patient). Six of the ten had evidence of another intoxicant beside opioids in their system. Nine of the 10 patients were given their initial dose of naloxone by prehospital providers. The median first dose was 2 mg of naloxone, with the most frequent one-time dose being 4 mg administered intranasally. Seven patients required mechanical ventilation for their acute pulmonary edema. The remaining three were treated with BiPAP or CPAP non-invasive ventilation. All ten patients survived to hospital discharge.

International Prehospital Medicine Institute

Limitations of this study include the fact that it is a retrospective review. In addition, pre-existing conditions which could have caused the development of pulmonary edema prior to naloxone administration could not be excluded. Specifically, opioid overdose, by itself, can induce pulmonary edema.

The incidence of naloxone induced pulmonary edema is low but can be severe when it does occur (a previous publication that suggested 1.2% of patients that received naloxone for an opioid overdose experienced post-naloxone pulmonary edema). In this case study series, 70 percent of the patients that developed post naloxone pulmonary edema required intubation and all ten needed some type of ventilatory support for their hypoxemia. Providers of all levels should remember that no medication is truly benign 100% of the time. All patients should be monitored for post medication sequelae, regardless of how frequently the medication is given without side effects. The lowest possible dose of naloxone needed to restore spontaneous respiration is probably the best dose to administer to patients

3. Characteristics and Outcomes of Prehospital Tourniquet Use for Trauma in the United States.

Hashmi ZG, Hu PJ, Jansen JO, Butler FK, Kerby JD, Holcomb JB. *Prehosp Emerg Care*. 2022; Published on-line. DOI: 10.1080/10903127.2021.2025283

The use of tourniquets (TQs) is well studied and has proven life-saving in the military environment. As with many devices and procedures used for trauma patients during wartime, TQs have been incorporated into civilian practice without a great deal of academic rigor. While it seems intuitive that TQs should translate well into the civilian EMS and trauma care system, there are many factors that could potentially affect outcome, such as different wounding mechanisms.

This retrospective review study examined the use of TQs in civilian EMS. The authors accessed the National EMS Information System 2019 data base of EMS calls with data from 47 states and territories within the USA. They identified all trauma team activations and searched for patients who had tourniquets applied. They then matched these patients to similar patients who did not have one placed. The two groups were then compared for differences in outcome as well as trauma activation criteria.

Of over four and half million trauma activations, a total of 7,616 TQs were applied (1.6 applications per 1000 activations). The patients in the TQ application group were predominantly male, with the primary mechanism of injury of either gunshot or stab wound. The patients in the TQ group had a shorter response time, higher acuity level, lower scene times and greater survival to the hospital. Of note, there were 141,471 trauma victims with documented extremity injury and a shock index ≥ 1 and no tourniquet documented.

The authors concluded that “Prehospital tourniquet use by EMS in the United States is associated with lower scene-time and improved survivability to hospital. As a result, patients might benefit from wider tourniquet use in the civilian prehospital setting.”

This study is limited by the fact that the NEMSIS data base is not all inclusive and EMS participation is voluntary. In addition, the data set only includes hospital disposition data on approximately 50% of the patients, thus limiting reporting of long-term outcome.

This study provides an important contribution to the research on civilian TQ application, while also identifying a need for wider application of this intervention. To better define the benefits of TQ application, a study that allows for tracking of EMS patient data through to hospital discharge would be beneficial. In addition, a study designed to look at different environments would help to better define the use of tourniquets in more rural environments and for prolonged transport.

International Prehospital Medicine Institute

4. Use of Topical Hemostatic Dressings in an Extended Field Care Model. Welch M, Barratt J, Peters A, Wright C. *J Spec Oper Med* 2021;21(4):63-65.

The proper application of hemostatic agents can be a lifesaving intervention for exsanguinating external hemorrhage. Packing wounds not amenable to tourniquet placement, especially in junctional areas (neck, shoulder, axilla, and groin), is a well-practiced skill by both military and civilian providers. Multiple studies and articles have validated the efficacy of hemostatic agents.

Military forces operate in all areas and conditions. As military operations shift to austere environments, evacuation of casualties to definitive care becomes longer and involves greater distances. An unanswered question is whether or not the hemostasis achieved using hemostatic agents will last long enough for the injured to reach higher levels of care or will bleeding resume due to the prolonged transport time and movement while in transit?

The authors examined how long Celox gauze, a hemostatic agent commonly used by the British and US military, would curtail hemorrhage using limited resources. The authors had access to a single anesthetized swine which was previously used by another team and treated surgically for a simulated thoracic injury with minimal blood loss. For this study, the animal received bilateral femoral arteriotomies. Army physicians packed both surgical wounds with Celox gauze. Hemostasis was achieved and the packed wounds were wrapped tightly with standard gauze. The animal received fluid therapy and standard anesthetic sedation for eight hours before being euthanized. During that eight-hour period, the dressings were checked every two hours for a return of bleeding or leakage.

There was no reoccurrence of bleeding seen. The swine's vital signs remained predominantly normal, although the blood pressure did vary slightly, which was attributed to the medications used for anesthesia. After euthanasia, the dressings and Celox were removed. There was no obvious adverse reaction to the skin, blood vessels or wound around the surgical incisions. A basic autopsy was also performed to assess for thoracic bleeding from the prior surgical study and no bleeding or adverse effects were seen.

By using bilateral femoral arteriotomies the authors were able to study two junctional wounds on one animal. They acknowledge that more research needs to be completed with more than one test subject and two test sites. Further research needs to be done using different hemostatic products, various lengths of time, and a mobile environment to simulate patient movement and extended transport times and distances to higher levels of care.

This limited research does suggest that hemostatic agents, in this case Celox gauze, can be effective in maintaining hemostasis for longer than the acute phase of wound care without causing tissue damage to the surrounding structures. This study has important implications, not only for the military, but also for the use of these agents in civilian prehospital care in rural and wilderness settings which involve prolonged transport.