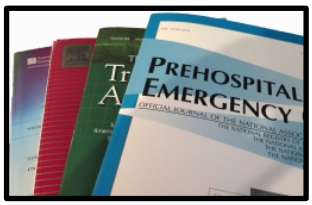
International Prehospital Medicine Institute



IPHMI Literature Review

Keeping You Up To Date with Current EMS Literature and Studies

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1. **Prehospital End Tidal Carbon Dioxide Predicts Hemorrhagic Shock Upon Emergency Department Arrival.** Bulger N, Harrington B, Krieger J, et al. *J Trauma Acute Care Surg.* ePub online ahead of print. 2021. DOI: 10.1097/TA.0000000000003312
2. **Implications of the National Stop the Bleed Campaign: The Swinging Pendulum of Prehospital Tourniquet Application in Civilian Limb Trauma.** Mikdad S, Mokhtari AK, Luckhurst CM, et al *J Trauma Acute Care Surg.* ePub online ahead of print. 2021. DOI: 10.1097/TA.0000000000003247
3. **Clinical Characteristics of Patients Undergoing Needle Thoracostomy in a Canadian Helicopter Emergency Medical Service.** Newton G Reay G, Laing CM, King-Shier K. *Prehosp Emerg Care* 2021; ePub online ahead of print. DOI.org/10.1080/10903127.2021.1912226
4. **Prehospital Needle Decompression Improves Clinical Outcomes in Helicopter Evacuation Patients With Multisystem Trauma.** Henry R, Ghafil C, Golden A, et al. *J Spec Oper Med*. 2021;21:49-54.

1. Prehospital End Tidal Carbon Dioxide Predicts Hemorrhagic Shock Upon Emergency Department Arrival.

Bulger N, Harrington B, Krieger J, et al. *J Trauma Acute Care Surg.* ePub online ahead of print. 2021. DOI: 10.1097/TA.0000000000003312

End-Tidal Carbon Dioxide (ETCO2) measurement is commonly utilized by Emergency Medical Services (EMS) to assess correct endotracheal tube (ETT) placement and monitor the quality of chest compressions during cardiopulmonary resuscitation (CPR). ETCO2 measurement serves a number of purposes: it reflects both perfusion and ventilation and also is a non-invasive method to measure cardiac output. Recent prehospital trauma literature suggests a correlation between ETCO2 and hemorrhagic shock. An additional study demonstrated that low prehospital ETCO2 predicts the need for massive transfusion upon arrival to the trauma center, as well as predicts a higher mortality following severe injury.

The authors conducted a retrospective, observational cohort study reviewing trauma patients who were intubated and transported by the Seattle Fire Department paramedics during the three-year period from Jan 1, 2016 through December 31, 2019. The authors hypothesized that a prehospital ETCO2 < 25 mmHg predicted hemorrhagic shock upon arrival to the ED. The paramedics used direct laryngoscopy for endotracheal intubation following a standardized rapid sequence intubation airway management algorithm. Indications for prehospital intubation were the inability to protect the airway from aspiration due to altered mental status, ineffective spontaneous respiration, and concern for airway obstruction dur to trauma to the face or neck.

The primary outcome measure was hemorrhagic shock, defined as the need for transfusion of at least one unit of blood upon arrival to the ED along with either hypotension (SBP ≤ 90 mmHg) or an initial shock index > 0.9 in the ED. Shock index is defined as heart rate divided by systolic blood pressure. The normal range is 0.5-0.7 in healthy adults. Subgroup analyses including stratification based on

mechanism of injury (blunt vs penetrating), injury severity (ISS ≥ 15), traumatic brain injury (head abbreviated injury score > 2), and mortality.

The study included 307 trauma patients who were eligible. Of these, 82% were male, 34% had penetrating trauma, 42% were in hemorrhagic shock upon arrival to the hospital, and 27% died in the hospital. Patients in hemorrhagic shock had a significantly lower median ETCO2 than those not in hemorrhagic shock (26.5 vs 32.5). The pattern was consistent across all subgroups (mechanism of injury, injury severity, traumatic brain injury, and mortality). The degree of low ETCO2 correlated with mortality in a dose-response relationship. Sixty-nine percent of the 87 patients with a minimum median prehospital ETCO2 of 25 mmHg were in hemorrhagic shock upon arrival to the ED, compared to 82% of the 56 patients with an ETCO2 < 20 mmHg, . Patients with a prehospital ETCO2 < 25 mmHg were 3 times more likely to be in hemorrhagic shock upon arrival to the ED than patients with an ETCO2 ≥ 25 mmHg.

Limitations of the study include its retrospective design. Additionally, the study is limited by its generalizability, as it only reflects intubated trauma patients treated and transported by a single urban EMS system with short transport times. A few patients received rocuronium during their course of care, which can elevate the ETCO2. Finally, the study required the patient to be intubated to measure the ETCO2.

The results of this study are interesting and can be utilized to predict hemorrhagic shock and the subsequent need for early transfusion. Prehospital ETCO2 may be more useful than other parameters to indicate shock, such as systolic blood pressure (SBP) and heart rate. SBP does not decline until the later stages of shock, when the body can no longer compensate. Tachycardia is almost ubiquitous among trauma patients and is not reliable as a stand-alone marker for shock. Prehospital ETCO2 has the added advantage of continuous monitoring, so EMS systems which utilize blood product transfusion can monitor for the effectiveness of their treatment.

In conclusion, this study demonstrates the usefulness of prehospital ETCO2 in predicting hemorrhagic shock upon arrival to the ED. An ETCO2 < 25 mmHg predicts hemorrhagic shock and can be a useful tool to identify trauma patients that require trauma team activation and early blood product transfusion upon arrival to the hospital.

2. **Implications of the National Stop the Bleed Campaign: The Swinging Pendulum of Prehospital Tourniquet Application in Civilian Limb Trauma.** Mikdad S, Mokhtari AK, Luckhurst CM, et al *J Trauma Acute Care Surg.* ePub online ahead of print. 2021. DOI: 10.1097/TA.0000000000003247

The use of prehospital tourniquets (PHT) has increased over the last ten years due to successful adoption by the US military. In recent years as a result of the Stop the Bleed campaign, the application of tourniquets has increased in the civilian setting, even prior to EMS arrival.

In this retrospective observational study, the authors evaluated the prehospital application of tourniquets to all adults arriving to two (2) level 1 trauma centers in the Boston Metropolitan area between January 2015 and December 2019. Trained researchers reviewed patient care data looking for signs of appropriate tourniquet placement including “limb amputation, vascular hard signs, injury requiring hemostasis procedure, or significant documented blood loss”. In cases that the tourniquet application was deemed not appropriate the researchers evaluated the data for complications.

One hundred forty-seven (147) patients met inclusion criteria and were enrolled in the study. In 2015 the first year of the study 87.5% of tourniquet applications were performed by EMS. In the final year of the study a shift took place with only 45% being placed by EMS and 52% of the placements being accomplished prior to EMS arrival. Of the tourniquets applied prior to EMS arrival, 30% of those were non-commercial improvised tourniquets. The majority of the applications (61%) were for penetrating trauma. Fifty-one percent (51%) of the cases reviewed did not demonstrate a clinical need for tourniquet application. Of thirty-nine (39) tourniquets that were determined to have been

inappropriately applied, the most common issues were prolonged tourniquet time of greater than two hours (20 patients), venous tourniquet not occluding arterial flow (13 patients), and application below the wound (4patients). Of those, five (5) patients had significant morbidity associated with the application. Complications included 2 patients who developed nerve palsy, 2 patients who developed compartment syndrome, and 1 patient in shock from blood loss due to a venous tourniquet.

This paper raises many questions regarding standard Stop the Bleed Training and the protocols that are in place for EMS personnel. Reassessing any tourniquet placed prior to EMS arrival for necessity and possible conversion to other methods of hemorrhage control should be standard practice. For those tourniquets placed prior to EMS arrival, it raises the question of what training the person had. In this study, over 50% the cases did not warrant a tourniquet and 39 were applied incorrectly. In an urban setting, reassessment should be accomplished by either responding EMS personnel or upon arrival to the ED. The study also points out that the risk of tourniquet application cannot be overlooked.

While there is no question that tourniquets save lives, studies such as this begin to define training gaps and the need for adjustments in the training courses to emphasize direct pressure as the primary control method before the application of a tourniquet and the need for reassessment and conversion to other hemorrhage control methods if a tourniquet has been placed.

3. **Clinical Characteristics of Patients Undergoing Needle Thoracostomy in a Canadian Helicopter Emergency Medical Service.** Newton G Reay G, Laing CM, King-Shier K. *Prehosp Emerg Care* 2021; ePub online ahead of print. DOI.org/10.1080/10903127.2021.1912226

Needle decompression of tension pneumothorax has long been the standard of non-physician prehospital care providers for decades. Failure to recognize and treat tension pneumothorax can have life-threatening consequences. However, recently the efficacy of needle thoracostomy (NT) has come into question.

The authors of this 7 year, ending 2018, retrospective chart review examined patients who had a needle decompression performed by a Canadian helicopter EMS (HEMS) service with a nurse and paramedic flight team. This chart review included patients that were at least 18 years old and had at least one needle thoracostomy attempted using a standard 14-gauge 8.3 cm needle.

During the study period 12,407 patients were attended to by the HEMS service. Of these patients, 163 patients received a total of 208 NT attempts. Two patients were excluded from the study because a non-standard catheter was used. The patients enrolled in the study were comprised of blunt trauma (86.3%), medical patients (9.9%), and penetrating trauma (3.7%). Of the 161 patients, 88.5% received positive pressure ventilation prior to NT and CPR was performed 51.9% of the time prior to NT. The anterior approach was performed in 87.5% of the cases and lateral in 12.5%. Bilateral NT was performed in 50% of insertions. It was noted that 37% of the patients had a positive response to NT. Heart rate improved in 13.5%, SPO2 in 9.1% and BP in 18.8% of the patients. Ten patients demonstrated Return of Spontaneous Circulation (ROSC) after NT was performed.

As the authors note, the main limitation of this study was the inability to relate the procedure to mortality and morbidity of the patients involved.

This study, as have others, demonstrates a low utilization of NT in the prehospital setting. Only one-third of patients were reported to have improved with the intervention. Of interest are the 10 patients that demonstrated ROSC after NT. However, without patient outcome date, this finding by itself is of little use. Future studies with the ability to link prehospital data with hospital outcome data are needed to better analyze the benefit or lack thereof of NT.

4. **Prehospital Needle Decompression Improves Clinical Outcomes in Helicopter Evacuation Patients With Multisystem Trauma.** Henry R, Ghafil C, Golden A, et al. *J Spec Oper Med*. 2021;21:49-54.

The US Military Tactical Combat Casualty Care (TCCC) course teaches that tension pneumothorax is the second most common of preventable deaths on the battlefield. Following the Vietnam conflict, needle decompression (ND) has been widely used to relieve tension pneumothorax by military prehospital providers, decreasing the mortality from tension pneumothorax by 90%. Civilian prehospital providers are also taught ND and many protocols allow for the procedure to be performed. The liberal use of ND for presumed tension pneumothorax in the predominately blunt trauma, civilian population has come under question where the presumed incidence is low, the potential benefit is minimal, and the risk of injury from procedural complications is high.

The authors of this paper performed an IRB approved, retrospective chart review of one aeromedical program's use of ND over an 11-month period in the southwest and Midwestern United States. ND was performed by both flight paramedics and flight registered nurses. Patients were transported to 79 participating trauma centers. A total of 143 patients, predominately male (75%) with a mean age of 44 years, and 172 ND attempts were included in the study.

Indications for the procedure, the outcome, who performed the procedure, and what size and length catheter was used to relieve the tension pneumothorax were evaluated. Indications for ND were grouped as cardiac arrest, hemodynamic compromise, hypoxia, combined objective findings (cardiac arrest, hemodynamic compromise and / or hypoxia), or a combination of objective and the provider's subjective findings. Outcomes post-ND were defined as improvement in vital signs, improvement in subjective assessment or improvement in physical examination findings.

Hypoxia (absent or diminished breath sounds with or without low SpO2) was the most often noted reason for ND. A rush of air or blood was documented as the most prevalent outcome from ND (80%). There were no statistically significant differences in success rates for ND's performed by paramedics (86%) or nurses (77%) or between 10-gauge catheters or 16-gauge catheters (although the raw success rate was 67% versus 85% respectively). The authors also reported no significant difference in success rate based on catheter length. The mean length of catheters used was 7.62cm. Interestingly, 29 NDs were repeated because of "misplaced" catheters, although this was not further described.

The authors did note in their study limitations that all included patients were cared for and transported by an aeromedical program. They did not determine if ND success was ascertained in flight or on the ground. There was no accounting for the effects of altitude on tension pneumothorax and the subsequent outcomes from ND. The study looked at positive outcomes (resolution of symptoms and hemodynamic improvement) but did not look at complications nor were they able to determine if all patients that received ND were suffering from tension pneumothorax prior to the ND.

The authors concluded that when ND is performed by pre-hospital providers for resolution of hypoxia versus cardiopulmonary arrest, a large number of patients will show improvement in symptoms. They also determined that the role of the prehospital provider performing ND did not influence outcome. Most interestingly, unlike other studies, ND catheter size and length were not related to patient improvement.