

Civilian Prehospital Tourniquet Use Is Associated with Improved Survival in Patients with Peripheral Vascular Injury

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- BACKGROUND:** Tourniquet use has been proven to reduce mortality on the battlefield. Although empirically transitioned to the civilian environment, data substantiating survival benefit attributable to civilian tourniquet use is lacking. We hypothesized that civilian prehospital tourniquet use is associated with reduced mortality in patients with peripheral vascular injuries.
- STUDY DESIGN:** We conducted a multicenter retrospective review of all patients sustaining peripheral vascular injuries admitted to 11 Level I trauma centers (January 2011 through December 2016). The study population was divided into 2 groups based on prehospital tourniquet use. Baseline characteristics were compared and factors associated with mortality identified. Logistic regression, adjusting for demographic, physiologic and injury-related parameters, was used to evaluate the association between prehospital tourniquet use and mortality. Delayed amputation was the secondary end point.
- RESULTS:** During 6 years, 1,026 patients with peripheral vascular injuries were admitted. Prehospital tourniquets were used in 181 (17.6%) patients. Tourniquet time averaged 77.3 ± 63.3 minutes (interquartile range 39.0 to 92.3 minutes). Traumatic amputations occurred in 98 patients (35.7% had a tourniquet). Mortality was 5.2% in the non-tourniquet group compared with 3.9% in the tourniquet group (odds ratio 1.36; 95% CI 0.60 to 1.65; $p = 0.452$). After multivariable analysis, the use of tourniquets was found to be independently associated with survival (adjusted odds ratio 5.86; 95% CI 1.41 to 24.47; adjusted $p = 0.015$). Delayed amputation rates were not significantly different between the 2 groups (1.1% vs 1.1%; adjusted odds ratio 1.82; 95% CI 0.36 to 9.99; adjusted $p = 0.473$).
- CONCLUSIONS:** Although still underused, civilian prehospital tourniquet application was independently associated with a 6-fold mortality reduction in patients with peripheral vascular injuries. More aggressive prehospital application of extremity tourniquets in civilian trauma patients with extremity hemorrhage and traumatic amputation is warranted. (J Am Coll Surg 2018; ■:1–8. © 2018 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

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Additional members of the Texas Tourniquet Study Group are listed in the [Appendix](#).

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Abbreviations and Acronyms

ISS = Injury Severity Score
OR = odds ratio
TCCC = Tactical Combat Casualty Care

Bleeding is a major cause of potentially preventable deaths both on the battlefield¹ and in the civilian setting.² Recent evidence, however, demonstrated that the use of a hemorrhagic control bundle including prehospital tourniquet might have contributed to a decrease in hemorrhagic deaths.³ Tourniquets have been proven effective in achieving temporary hemostasis and reducing mortality from extremity wounds incurred on the battlefield, with minimal risks of complications related directly to tourniquet application.⁴⁻¹⁰ One of the key military lessons learned was that early (at the point of injury) tourniquet application was essential to improved survival. Contemporary evidence suggests that the current military policy of liberal tourniquet application for extremity injuries put forth by the Tactical Combat Casualty Care (TCCC) Committee is being followed by battlefield medics and soldiers¹¹ and that tourniquets are being applied correctly.¹²

Initial opposition to the use of tourniquets in the civilian setting was based primarily on the premise that combat wounds are more severe due to high-velocity weapons and explosive devices, and time to definitive repair is longer. The austere environment of the battlefield also requires that any hemostatic maneuvers be expedited, minimizing the risk for the emergency care provider.¹³ However, death from isolated extremity wounds resulting from civilian trauma can occur, and most of these injuries are amenable to hemostatic control with a tourniquet.¹⁴ Both the Eastern Association for the Surgery of Trauma and the American College of Surgeons Committee on Trauma have published evidence-based guidelines that currently recommend the use of tourniquets as a temporary measure when extremity bleeding cannot be controlled by direct pressure. These recommendations, however, are largely based on military data.^{15,16} After empirically transitioned from the military to the civilian prehospital environment, the use of tourniquets has been shown to be safe,¹⁷ and effective in achieving hemostasis when properly applied to an extremity with exsanguinating wounds.¹⁷⁻²⁰ Despite these promising results, an attributable survival benefit remains to be demonstrated in the civilian setting.

The purpose of this study was to investigate the prehospital use of tourniquet for patients with extremity vascular injuries in the civilian setting. We hypothesized that civilian prehospital tourniquet use is associated

with reduced mortality in patients with peripheral vascular injuries.

METHODS

This study was a multi-institutional retrospective review of all patients sustaining peripheral vascular injuries admitted to all 11 urban Level I trauma centers in the state of Texas from January 2011 to December 2016. The study was approved by the IRBs from each of the participating sites and the need for informed consent was waived. Standardized electronic data collection spreadsheets were used for data gathering at each of the study sites and consolidated into a single database at the primary study institution (University of Texas at Austin).

Data points collected from the trauma registries and electronic medical records review at each participating center included patient demographic characteristics, mechanism of injury, vital signs and Glasgow Coma Scale score on admission, Abbreviated Injury Scale score, Injury Severity Score (ISS), specific anatomic location of the vascular injuries sustained, presence of associated non-extremity injuries, blood product transfusion, and tourniquet use. Continuous variables were converted into dichotomous variables using clinically relevant cutoffs: systolic blood pressure <90 mmHg, Glasgow Coma Scale ≤ 8 , ISS ≥ 16 , and Abbreviated Injury Scale ≥ 4 . Presence of a vascular injury included a documented injury to any named vessel in the upper or lower extremity, using the ICD-9 codes (eTable 1). Arterial and venous injuries in the femoropopliteal segment and injuries to the brachial artery were further classified as major vascular injuries. Delayed amputation was defined as an amputation performed after 24 hours of hospital admission. Criteria for prehospital tourniquet application were at the discretion of the Emergency Medical Services teams, and no uniform protocol was in place across the study sites.

The primary outcomes measure of the study was in-hospital mortality. Secondary outcomes included delayed amputation, thromboembolic complications, respiratory complications, cardiac complications, infectious complications, hospital length of stay, ICU length of stay, and ventilator days.

The study population was divided into 2 groups based on the prehospital tourniquet use. Differences in baseline demographics and injury characteristics between the 2 study groups were assessed using univariate analysis. Continuous variables were compared using 2-tailed unpaired Student's *t*-test or Mann-Whitney U test and dichotomous variables were compared using chi-square test or Fisher's exact test as applicable and $p < 0.05$ was considered significant. To investigate the association

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