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Tourniquet use for peripheral vascular injuries in the civilian setting

Edward Passos [a], Brittany Dingley [b], Andrew Smith [b], Paul T. Engels [c], Chad G. Ball [b], Samir Faidi [a], Avery Nathens [d], Homer Tien [d,*] for the Canadian Trauma Trials Collaborative

[a] McMaster University, Department of Surgery, Canada
[b] University of Calgary, Department of Surgery, Canada
[c] University of Alberta, Department of Surgery, Canada
[d] University of Toronto, Department of Surgery, Sunnybrook Health Sciences Centre, Canada

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ABSTRACT

Background: Haemorrhage in peripheral vascular injuries may cause life-threatening exsanguination. Tourniquets are used extensively by the military, with increased interest in the civilian setting to prevent deaths. This is a retrospective study of trauma patients at two large Canadian trauma centres with arterial injury after isolated extremity trauma. We hypothesized that tourniquet use may decrease mortality rate and transfusion requirements if applied early.

Methods: The study group was all adult patients at two Level 1 Trauma Centres in two Canadian cities in Canada, who had arterial injuries from extremity trauma. The study period was from January 2001 to December 2010. We excluded patients with significant associated injuries. The intervention in this study was prehospital tourniquet use. The main outcome was in-hospital mortality. Secondary outcomes were length of stay, compartment syndrome, amputation, and blood product transfusion.

Results: 190 patients were included in the study, and only 4 patients had a prehospital tourniquet applied. They arrived directly from the scene of injury, had improvised tourniquets by police or bystanders, and showed a trend to be more hypotensive and acidotic. Four other patients had tourniquets applied in the trauma bay within 1 h of injury. There were no differences in age, sex, injury severity or physiologic presentation between patients who had an early tourniquet applied and those who died without a tourniquet. However, six patients died without a tourniquet, and all bled to death. Of the eight patients who had early tourniquets applied, none died.

Conclusions: Tourniquets may prevent exsanguination in the civilian setting for patients suffering either blunt or penetrating trauma to the extremity. Future studies will help determine the utility of deploying tourniquets in the civilian setting, given the rarity of exsanguinating haemorrhage from isolated extremity trauma in this setting.

Introduction

Haemorrhage is a leading cause of death in trauma patients [1,2]. Peripheral vascular injuries are common on the battlefield, but can also occur in the civilian setting. If haemorrhage is not controlled quickly, peripheral vascular injuries have the potential to cause life-threatening exsanguination. This is particularly true in the military setting and in rural, civilian areas, where the prompt definitive control of bleeding may be difficult [3–5].

Tourniquets are now used extensively by the military [6–12]. However, traditional civilian trauma training has frowned on tourniquet use. Advanced Trauma Life Support® recommends compression as the first line treatment for bleeding extremity wounds; an example of this treatment may include application of a tight bandage directly over a wound [13]. However, on some occasions, the application of a proper bandage may be time-consuming and technically more challenging than placing a tourniquet [12]. Furthermore, direct compression with a bandage may not completely control major arterial haemorrhage. For these reasons, and in the setting of long prehospital transport times, the tourniquet may be the instrument of choice to achieve temporary prehospital control of life threatening haemorrhage from the extremity [4].

One of the major reasons why the military has adopted tourniquets for the battlefield was Bellamy's epidemiological studies of causes of death of US service personnel during the Vietnam War [14,15]. More specifically, many US service personnel died during the Vietnam War solely from exsanguination from extremity wounds. As a result, Butler and colleagues devised a

* Corresponding author at: H171 – Sunnybrook Health Sciences Centre, 2075 Bayview Avenue, Toronto, ON M4N 3M5, Canada. Tel.: +1 416 480 5850.
E-mail address: homer.tien@sunnybrook.ca (H. Tien).

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system of prehospital care called Tactical Combat Casualty care, which called for the use of tourniquets on the battlefield [16].

Several studies outline both the morbidity and mortality following civilian extremity vascular injuries. Feliciano believes that tourniquets will soon become more commonly used by civilian emergency medical services [17]. In an excellent review of civilian patients who suffered cardiac arrest after penetrating extremity injury, Dorlac suggested that 57% were possibly preventable deaths, if tourniquets had been applied early [18]. Unfortunately, most civilian studies on tourniquet use have focused on penetrating injuries. Therefore, these studies do not document the full scope of the challenge in civilian trauma systems, as blunt mechanisms constitute the majority of traumatic injuries in North America [2]. As such, we performed a retrospective cohort study of all trauma patients at two large Canadian trauma centres who sustained arterial injury after isolated extremity trauma, from either blunt and penetrating mechanisms. We compared the mortality of patients who were treated with prehospital tourniquet use versus those who were not. We also examined all deaths in patients who did not have an early tourniquet application to determine if early tourniquet application may have altered survival. We hypothesized that early tourniquet use would be associated with decreased mortality and transfusion requirements in patients with isolated extremity arterial injuries.

Methods

Setting

The trauma registries at two large Level 1 Trauma Centres in Canada were used to identify all trauma patients evaluated from January 1, 2001 to December 31, 2010.

Inclusion criteria

The study group consisted of all adult patients (age 16–90 years old) with arterial trauma from isolated limb extremity injuries, via either penetrating or blunt mechanisms. These patients were identified using the following methodology:

(i) trauma registries were used to identify all patients with abbreviated injury score (AIS) of 3 or higher in the extremities, from either blunt or penetrating mechanisms; and
(ii) chart review was performed to identify patients with arterial injuries that required either revascularization surgery, or limb amputation. Patients were included whether or not they had associated other injuries to the extremity, such as bony, nerve, or soft tissue injury.

Exclusion criteria

We excluded all patients with AIS of their head/neck, chest, abdomen and pelvis of 3 or higher. We excluded these patients because we wished to analyze for possible mortality benefits of tourniquet use; severe brain injury and torso haemorrhage cause the majority of trauma deaths and would not be helped by tourniquet use. We also excluded patients with isolated venous injuries in their extremities, as these injuries should be adequately treated with compression. We also excluded burns, and patients injured in the military setting and who were transferred to our facilities for reconstructive care.

On chart review, we confirmed the accuracy of this methodology by ensuring that no patients with any other major sources of haemorrhage were included in the study cohort; we did this by confirming that no patients were included who required thoracotomy, chest tube insertion, laparotomy or angiography for torso bleeding. We also confirmed that no patients had severe brain injury that required craniotomy, or who died because of withdrawal of care. Our study cohort included patients admitted direct from the scene of injury, and those referred from a community hospital.

Intervention

The intervention in this study was prehospital tourniquet use. We performed chart review of both the EMS record and the initial trauma room record to determine if (i) a tourniquet was applied in the field; or (ii) if the patient arrived in the trauma room with a tourniquet.

Outcomes

The main outcome for this study was in-hospital mortality. Secondary outcomes included length of stay (LOS), Intensive Care Unit (ICU) stay, compartment syndrome, amputation, and units of blood products transfused. These outcomes were determined by a combination of electronic health record review, and focused "paper chart review".

Patient demographics, injury mechanism, Injury Severity Score (ISS), Abbreviated Injury Scale Scores (AIS), length of hospital stay (days), intensive care unit stay (days), total units of blood transfused, and in-hospital outcome (dead/alive) were determined from our trauma registry. ISS and AIS were calculated by trauma registry staff after discharge or death of each patient. This study was approved by institutional review ethics boards at both sites. Type of vascular injury, need for revascularization, and need for amputation were confirmed on review of operative reports.

Descriptive statistics were performed. Continuous data was presented using means and standard deviations, and compared using *T*-test. Categorical data was presented as proportions, and compared with Chi-square test, or Fisher's exact test. *P*-values were two-tailed. Statistic analysis was performed using SAS software (SAS version 9.2, SAS Institute Inc., North Carolina, USA).

Results

During the 10-year study period, 19,977 total patients were evaluated by our trauma services (Sunnybrook: 10,599; Foothills: 9378). Of these, 360 suffered arterial injuries to the limb that required revascularization surgery or amputation. We excluded 101 patients who had thermal injuries, electrical burns, transfer from another province or country, and military patients. We also excluded 69 patients with Abbreviated Injury Score for head and neck, chest, abdomen and pelvis equal or greater than 3. Our final cohort consisted of 190 patients who suffered isolated extremity injuries with arterial injury (119 from Sunnybrook and 71 from Foothills). We checked the accuracy of our methodology during review of the operative and discharge notes. None of these patients required laparotomy, tube thoracostomy, thoracotomy or embolization for bleeding. Our sample consists mostly of men (85%). Sixty eight percent of patients were brought directly from the scene of injury and 32% were transferred from a referring centre. Most of our patients suffered blunt trauma to the extremity. Baseline characteristics of the study group are presented in Table 1.

One hundred eighty-six patients arrived without prehospital tourniquet. Only four patients presented with a tourniquet present upon arrival. These four patients were all transferred to our hospitals directly from the scene of injury, and all four had improvised tourniquets by police or bystanders. Two patients suffered penetrating injuries, and two suffered blunt trauma. One of these patients had suffered a prehospital cardiac arrest, and cardio-pulmonary resuscitation (CPR) had been started. We were