Tourniquet Use in Combat Trauma: UK Military Experience

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Abstract

Aim: To determine the prevalence of tourniquet use in combat trauma, the contribution to lives saved and the complications of their use in this environment. **Population:** All casualties treated at UK field hospital facilities in Iraq and Afghanistan and meeting criteria for entry into UK Joint Theatre Trauma Registry (JTTR) from 04 Feb 03 to 30 Sep 07. **Methods:** Cases were identified from UK JTTR. Casualties from Permanent Joint Overseas Bases (PJOBs) were excluded. ISS, NISS, TRISS and ASCOT were calculated automatically within JTTR from AIS 2005 (Military) codes. **Results:** 1375 patients met UK JTTR entry criteria for the period specified (excluding PJOBs). 70/1375 patients (5.1%) were treated with one or more tourniquets (total 107 tourniquet applications). 61/70 (87%) survived their injuries. 17/70 (24%) patients had 2 or more tourniquets applied. 64/70 patients received a tourniquet after April 2006, when tourniquets were introduced as an individual first aid item. 43/70 (61%) patients were UK military. **Conclusions:** ISS and TRISS are poorly representative of injury severity and outcome for combat trauma involving isolated multiple limb injuries and cannot be used to discriminate whether a tourniquet is life-saving. The presence of severe isolated limb injuries, profound hypovolaemic shock and the requirement for massive transfusion reasonably identifies a cohort where the use of one or more tourniquets pre-hospital to control external bleeding can be said to be life-saving.

Background

Haemorrhage from limb injuries has been identified as the most important cause of avoidable battlefield death.[1] The treatment paradigm has shifted in the UK military from ABC to <C>ABC to reflect the importance of rapidly controlling external hemorrhage.[2] This concept is firmly embedded in training at all levels of provider in the early management of severe trauma.[3] Commercial tourniquets (Combat Application Tourniquet, C-A-T™, Phil Durango LLC, USA; Figure 1) are issued to individual deploying soldiers as part of their personal first aid equipment with encouragement to use the device for severe limb bleeding during care under fire and to immediately re-evaluate the requirement when the fire-fight is won (tactical field care phase). This is pictorially represented in the haemostasis ladder, an escalator of interventions for uncontrollable haemorrhage.[4]

However, the use of tourniquets on traumatic amputations has been criticized as contributing to unnecessary limb loss.[5,6]

This article examines the UK military experience of tourniquets in combat to determine compliance with guidelines, their efficacy (contribution to saving lives) and their complications (in particular, unnecessary limb loss).

Methods

Cases were identified from UK Joint Theatre Trauma Registry (JTTR) for the period 04 February 2003 to 30 September 2007 covering Operation TELIC (Iraq), Operation HERRICK (Afghanistan) and Operation VERITAS (Oman/Afghanistan).

JTTR is a continual database of all seriously injured casualties treated in deployed UK field hospitals (Role 2 Enhanced or Role 3), with registry entry defined by any patient who meets predetermined Trauma Team activation criteria (UK Service, coalition forces, detainees, local civilians). UK Service personnel who have received treatment in deployed coalition field medical facilities and are evacuated to UK are included. In 2007, registry entry was extended to include all injured UK Service personnel evacuated to UK for inpatient treatment.

Casualties from Permanent Joint Overseas Bases (PJOBs, for example Gibraltar, Cyprus and the Falkland Islands) form part of JTTR, but these were excluded from analysis as Service personnel from these areas are not directly involved in combat operations.

Figure 1: The Combat Application Tourniquet

Unexpected outcomes were assessed mathematically by TRISS[7] and ASCOT[8] methodologies, and by identifying the cohort with injuries which were likely to be unsurvivable whose Injury Severity Score and/or New Injury Severity Score was maximal or near-maximal (ISS and/or NISS 60-75).

Results

1375 patients met UK JTTR entry criteria between 04 February 2003 and 30 September 2007 (excluding PJOBs). 107 tourniquets were used on 70 casualties (5.1% JTTR population).

Outcomes

61/70 (87.1%) of the casualties survived their injuries. Of the 9/70 (12.9%) deaths, 3 were killed in action (KIA, died before entering a medical treatment facility following hostile action); 4 died of wounds (DOW, died after entering a medical treatment facility following hostile action); 2 died on operations (DOP, died before entering a medical facility following non-hostile action).

For the survivors the median Injury Severity Score was 16 (range 1 to 42); the median New Injury Severity was 21 (range 1 to 50). Only 6/9 deaths could be reliably scored, as 3 deaths related to the local population and autopsies are not performed in the deployed setting: for the 6 deaths with autopsy confirmation median ISS was 50 (range 13 to 75) and median NISS was 57 (range 14 to 75). There were no unexpected survivors in this cohort identified by TRISS Ps <50% or ASCOT Pd >50% or ISS 60-75 or NISS 60-75. One case was identified as an unexpected death by both TRISS and ASCOT: this was revised to an expected death following assessment by multidisciplinary expert peer review panel (ISS 50, NISS 57; liver disruption, diaphragm disruption, haemothorax and lung contusion; tourniquet placed for comminuted compound fracture of forearm).

Nationality

43/70 (61%) patients were UK Service; 18/70 (26%) were coalition forces (NATO allies and Afghan National Army); 5/70 (7%) were coalition civilians (Afghan National Police; contractors) and 4/70 (6%) were local civilians.

Use post-CAT implementation

64/70 (91%) patients received a tourniquet after April 2006, when tourniquets were introduced as an individual first aid item. Only 6 patients (9%) are recorded to have received a tourniquet as an early intervention in severe trauma in 3 years of operations in Iraq from 04 February 2003 through to 31March 2006; there were only 3 trauma patients on OP VERITAS for this period and none received a tourniquet.

For patients treated after the introduction of Combat Application Tourniquet, 59/64 (92%) suffered injuries as a result of hostile action; 47/59 were injuries from an explosion (IED 21/59; mortar 7/59; mine 6/59; RPG 6/59; bomb 2/59; rocket 1/59; unspecified 4/59). Of the 5 non-hostile casualties, 3 were injured from weapon discharges; 1 followed a motor vehicle crash; and 1 was the result of a "friendly fire" aerial bomb.

Multiple tourniquet use

17 patients received more than 1 tourniquet. 5/17 needed two tourniquets applied for the same injury (Figure 2, juxtaposed tourniquets). 12/17 had tourniquets applied bilaterally. One patient needed three tourniquets applied to two separate injury sites and one patient needed a total of 4 tourniquets, 2 to each leg injury.

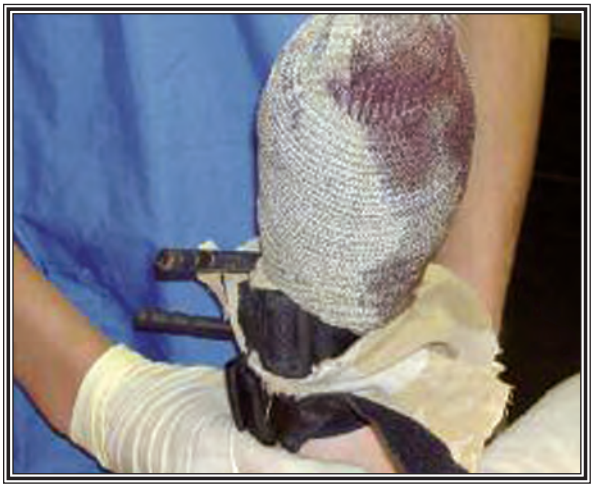

Figure 2: Juxtaposed tourniquets

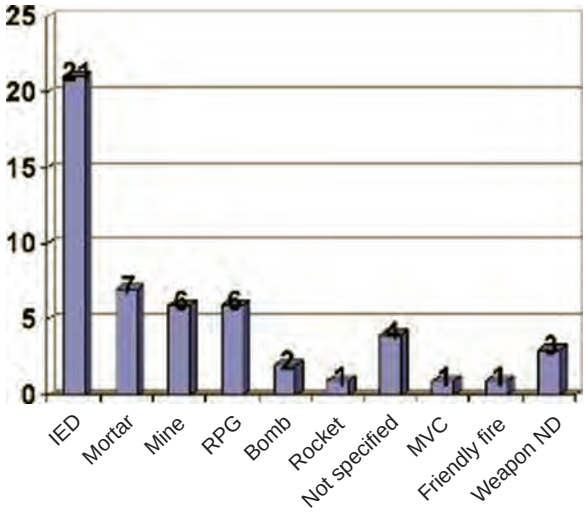

Figure 3: Injury mechanisms for hostile and non-hostile action casualties where tourniquet(s) used in early treatment (RPG = rocket propelled grenade; MVC = motor vehicle crash; ND = negligent discharge)

Injury mechanisms and types

Injury mechanisms are shown in Figure 3. The tourniquet was used to control external bleeding following one or more traumatic amputations (25/70 patients), one or more compound limb fractures (25/70 patients), vascular injury following penetrating trauma (5/70 patients; all gunshot wounds; 1 x femoral artery, 1 x popliteal artery, 1 x radial artery, 2 x ulna artery injuries) and limb soft tissue injury (15/70 patients; 10 as a result of IED, mine, RPG and mortar; 5 resulting from gunshot wounds). Figure 4 summarizes the principal indication for tourniquet application. The anatomical distribution of primary traumatic amputations (amputation occurring at the time of the injury) is shown in Figure 5.

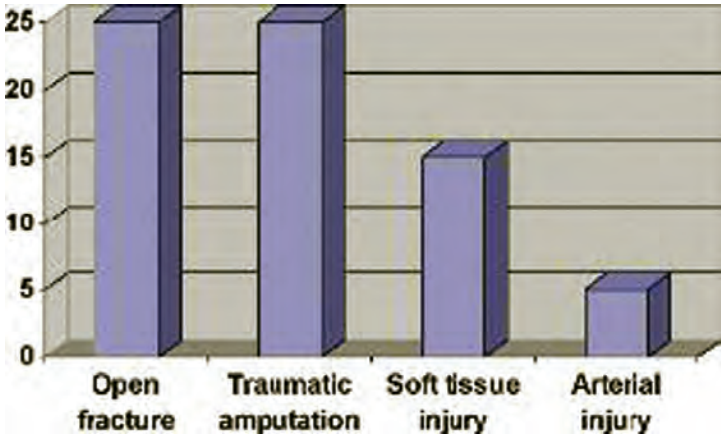

Figure 4: Clinical indications for application of a tourniquet (principal indication for each of 70 patients)

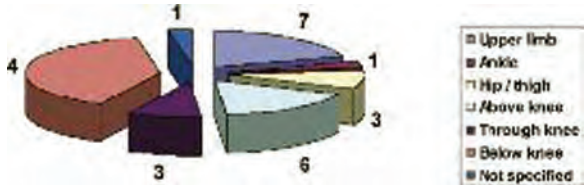

Figure 5: Distribution of primary amputations in casualties managed with a tourniquet.

Secondary amputations

8 patients underwent secondary amputation (where limb amputation was the preferred surgical treatment): all were open fractures with 1 case involving the humerus/radius/ulna, 1 case the femur, 5 cases the tibia (1/5 required bilateral amputations) and 1 case the foot.

Location of application

106/107 tourniquets were recorded to have been applied prehospital: One was applied in the emergency department. 11/107 tourniquets were recorded as having been removed in the emergency department. 3 tourniquets were recorded as having been removed pre-hospital after re-assessment of their need during tactical field care or field resuscitation.[9]

Complications

Three direct complications from the use of the tourniquets were identified. Two were cases of compartment syndrome (one in the thigh; one in the lower leg): The thigh compartment syndrome was attributed by the field surgeon to a venous tourniquet effect from the tourniquet being applied over a trouser pocket containing a book. The underlying mechanism of injury was gunshot wound in both cases. The third complication was ulna nerve palsy from a tourniquet applied to the upper arm: the tourniquet was applied during care under fire for an extensive soft tissue forearm ballistic wound with radial artery injury.

Other haemostatics

HemCon® (chitosan topical haemostatic bandage) was used concomitantly in 10/64 (16%) patients where a tourniquet was applied after the introduction of HemCon® in April 2006. QuikClot® (zeolite powder) was used in 3/69 (4%) patients where a tourniquet was applied after the introduction of QuikClot® in April 2005. No patient receiving a tourniquet is recorded as having HemCon® and QuikClot® used together.

Recombinant factor VIIa (rFVIIa) was used in 7/70 (10%) patients who had received one or more tourniquets and defines a population that is clinically very seriously injured as rFVIIa is used as an adjunct to a massive transfusion protocol: All of these 7 patients survived. 4/7 of these patients had isolated limb injuries. Case A (952), ISS 17, had Grade IV hypovolaemic shock following a below knee amputation; Case B (205), ISS 25, had Grade IV shock following an above knee amputation; Case C (1393), ISS 26, had Grade IV shock following bilateral amputation (one above knee, one below knee); Case D (1396), ISS 26, had Grade IV shock following bilateral amputation (one above knee, one below knee). In these cases the use of tourniquets may be reasonably regarded as life saving.

Discussion

The use of a tourniquet as an early intervention in the management of combat trauma has increased 20 fold since the introduction of the Combat Application Tourniquet as an individual issue first aid item (64 patient uses in 18 months of TELIC 8-10 and HERRICK 4-6, compared to 6 patient uses in preceding 3 years of TELIC 1-7), Figure 6. This probably reflects the availability of such a simple and effective treatment at point of wounding, together with a predeployment training message that has received wide acceptance from individual soldiers.

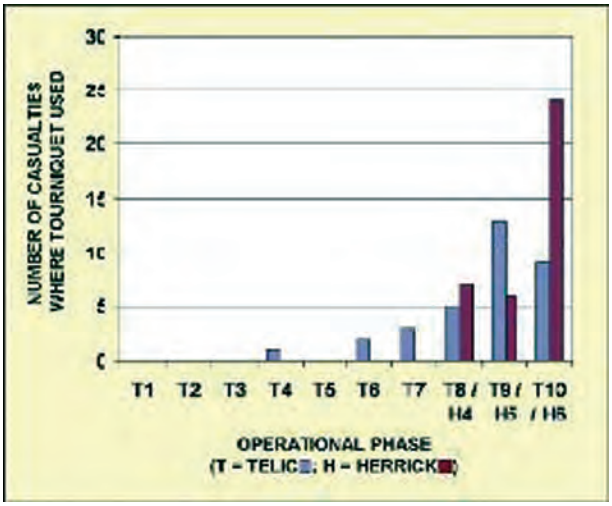

Figure 6: Number of casualties where a tourniquet used by operational phase

The use of tourniquets has been very closely monitored within Defence Medical Services with near real-time feedback via the weekly Joint Theatre Clinical Care Conference (an international telephone conference) if any compli-

cation is identified. The application of a tourniquet over a full trouser pocket led to an immediate training refinement to emphasize the need to check the pocket first. Training has also been central to the concept of early re-evaluation of the need for a tourniquet, should it have been applied during care under fire.

While the content of pre-deployment training is strictly controlled, unwanted and erroneous practice messages from external sources have reached deployed soldiers. An example is the message that a tourniquet must only be applied over a single bone (humerus or femur). This doctrine is believed to have arisen from porcine animal haemorrhage models with nonballistic injuries. The model neither reflects human anatomy, nor the way a limb mangled by ballistic trauma will respond to circumferential compression.

The Injury Severity Score is well recognized to underestimate multiple injuries in the same body region:[10] A single traumatic limb amputation will score the same as a bilateral amputation. This is a weakness of TRISS when predicting unexpected outcomes. The New Injury Severity Score (NISS) provides a more representative injury severity, but NISS is not traditionally used to calculate TRISS. Future tracking of the effectiveness of tourniquets as life-saving interventions cannot rely on TRISS methodology.

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