



## Research critique

# Balancing strategies towards the minimisation of post tourniquet application syndrome

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With increasing utilisation of pre-hospital tourniquet (PHTQ) application for the management of penetrating limb injuries for both military and civilian trauma care, casualty exposure to iatrogenic post-tourniquet application syndrome (PTAS) increases. From an organisational perspective, PTAS risk may be mitigated by initiatives such as restricting the criteria for tourniquet application or liberalising forward tourniquet de-escalation.<sup>1</sup> Multiple factors influence policy direction in order to achieve both pre-hospital haemorrhage control and low PTAS rates, however our judgement is ultimately guided by clinical evidence. We note the recent contributions of Hedger et al<sup>2</sup> in this respect. The purpose of this correspondence is to provide JHTAM readership with our contextualised interpretation of this research.

Hedger et al reported an 11 year retrospective observational cohort review of casualties managed with PHTQ application prior to transfer to a Level 1 Trauma centre in Newcastle, Australia. The primary aim of their study was to determine the incidence of PHTQ application without medical necessity. Recorded metrics included casualty profiles, management requirements and clinical outcome measures to determine the rates of “non-indicated” PHTQ use and the complications associated with their application. Results describe 86 casualties requiring the application of 88 tourniquets, of which 68 (77%) were assessed as medically not indicated, with increasing incidence over the duration of the study period selected. At least one tourniquet associated complication was reported in 33/86 (33%) of casualties. The authors conclude that given the (significant) complication rates associated with unnecessary PHTQ application, policy guidelines (to restrict) PHTQ application require urgent reinforcement.

In response to this research, we provide the following commentary about the findings and what practical lessons might be learned:

## Comment 1: Significant injury profiles are described within the casualty cohort, indicating a relatively conservative threshold for PHTQ application

Hedger et al describe a cohort of patients presenting with significant extremity trauma, as depicted by clinical markers and treatment requirements including: Injury Severity Score (ISS) (26/86 ISS>15; 30%); Intensive Care Unit admission (23/86; 27%); death attributable to exsanguination (3/86; 3.5%); polytrauma diagnosis (14/86; 16%); prehospital intubation (13/86; 15%); median recorded pre-hospital blood loss (1000mL); pre-hospital blood product administration (13/86; 15%); initiation of massive transfusion protocols (21/86; 24%), surgical intervention for arterial vascular injury (39/86; 45%) and limb amputation or reimplantation rates (12/86; 14%). Despite the significant nature of these injuries, a documented attempt at haemorrhage control prior to PHTQ application was made in over one third of cases and a significant number of tourniquets were de-escalated prior to hospital transfer. While PHTQ application may well have been avoided in individual cases, the severity of the injuries described for this casualty cohort would suggest a generally cautious approach to tourniquet use by the pre-hospital providers of that region.

## Comment 2: The article fails to adequately describe complication rates specifically attributable to tourniquet application

Hedger et al report complication rates from PHTQ use far higher than those previously described in comparable literature series within both military and civilian trauma care (33/86; 38%).<sup>3-12</sup> Most of the complications described in the article are, however, not reasonably attributable to PHTQ application but are instead representative of the underlying traumatic injuries sustained. For example, 11/16 (79%) of the nerve injuries sustained were found during operative exploration to be as a direct result of

the primary injury. Aetiology of the remaining nerve injuries was not described. Also 2/4 (50%) of deep venous thromboses were on the opposite limb to tourniquet application, which regardless of side, may or may not be attributable to PHTQ application. Of the nine amputations sustained, none were attributable to PHTQ use. The paper also lacks sufficient detail to support a causal link between tourniquet application and other reported complications, such as wound infection, renal injury or rhabdomyolysis, all of which could reasonably be explained by the nature and extent of the primary trauma. Presenting these complications as consequences of PHTQ use, without adequate justification or differentiation, risks misleading readers and misinterpreting the dataset. In contrast, the overwhelming message from comparable military and civilian literature demonstrates PHTQ application as both exceptionally safe and effective, particularly if de-escalation is conducted within two hours of tourniquet application.

**Comment 3: The criteria used to define the necessity of tourniquet application are not appropriate to evaluate the performance of pre-hospital health care providers**

The primary outcome measure evaluated by Hedger et al was the clinical necessity for PHTQ application, as defined by the presence of an arterial injury resulting in haemorrhage unable to be controlled by direct compression within a hospital environment (operating theatre or emergency department). While this definition may serve as a reasonable working model in some contexts, caution should be exercised in generalising it as a metric for evaluating the quality of prehospital care. Pre-hospital trauma care is, by definition, austere in comparison to hospital management. Tactical safety, challenging operational working environments, minimised resources, undifferentiated injury patterns and conflicting transportation priorities are among the unique demands frequently encountered by pre-hospital health care providers. Placing a tourniquet can rapidly offload the problem of extremity haemorrhage, allowing the pre-hospital provider to focus on additional problem sets and other resuscitation priorities. In this respect, we disagree that assessment of “non-indicated” PHTQ application can be appropriately conducted by a retrospective review of case notes originating from within a hospital emergency department or operating theatre. Accurate wound assessment and compression wound packing for arterial injuries takes time and is substantially more difficult to achieve adequately in a dynamic pre-hospital setting. Now factor in poor lighting, a combative poly-trauma patient with significant pain and time critical undifferentiated injuries. PHTQ represents a rapid and highly effective tool for the management of undifferentiated high flow rate haemorrhage, regardless of whether caused by transection of a single large artery, numerous smaller intramuscular arterioles or even a large venous injury. While we support the concept of graduated haemorrhage control measures, early tourniquet de-escalation

by pre-hospital conversion or tourniquet replacement represents a more pragmatic method of achieving this outcome, particularly where tourniquet application times greater than two hours are anticipated.<sup>1,13-18</sup>

**Comment 4: The nature of the dataset renders it unsuitable to inform clinical practice guidelines relating to pre-hospital tourniquet application for penetrating trauma**

The dataset used by Hedger et al evaluates patients on whom PHTQ were applied and where casualties were alive on arrival to hospital. Data relating to casualties where PHTQ were not applied and in patients who died on scene due to exsanguination, with or without the use of tourniquets, is not captured. It is therefore important to acknowledge that Hedger et al present only a limited perspective of the broader discussion relating to PHTQ use. The danger of the associated narrative is that both selection and survivorship biases exist within the dataset, as only a portion of the outcomes within an active intervention cohort are exclusively considered. How many patients with penetrating limb wounds were harmed by failing to apply a tourniquet where indicated? What was the complication rate associated with the therapeutic alternatives to PHTQ? Was hesitancy in PHTQ application associated with harm? How many patients with penetrating limb wounds were unsuccessfully managed by pre-hospital providers using compression wound packing alone? For pre-hospital care providers, avoidable death or severe haemorrhage due to compressible limb haemorrhage represents a sentinel “no fail” event.<sup>11,12,19,20</sup> In military applications, avoidable death due to compressible limb haemorrhage dramatically decreased after transitioning from protocols of compression wound dressing application to the aggressive point of injury application of combat tourniquets.<sup>45</sup> If realising the benefits of PHTQ application necessitates the application of a quantity of limb tourniquets, which are in retrospect considered medically unnecessary, this practice would be strongly supported by the risk to benefit analysis demonstrated within the associated broader literature. The article by Hedger et al provides nothing to dissuade this position. If anything, pre-hospital care providers of the region under evaluation probably should have been more aggressive in their application of tourniquets, given the dataset presented. Rather than concluding that many prehospital tourniquets are not indicated, we strongly encourage the readership to conclude that prehospital de-escalation of tourniquets is frequently possible and all prehospital providers should be trained to avoid the known complications of prolonged tourniquet syndromes.

**Author attribution**

All listed authors contributed to this manuscript.

**Conflict of interest**

The authors declare no conflicting interests in respect to this manuscript.

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