

An Evaluation of Tactical Combat Casualty Care Interventions in a Combat Environment

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Previously published in the *Journal of the American College of Surgeons*, Vol. 207, No. 2, August 2008. Republished in *JSOM* with permission of Elsevier.

Background: Tactical combat casualty care (TCCC) is a system of prehospital trauma care designed for the combat environment. Although widely adopted, very few studies have reported on how TCCC interventions are actually delivered on the battlefield, from a quality of care perspective. **Study Design:** This was a prospective study of all trauma patients treated at the Role 3 multinational medical unit (MMU) at Kandahar Airfield Base from February 7, 2006 to May 30, 2006. Primary outcomes were whether or not two TCCC interventions were underused, overused, or misused. Interventions studied were needle decompression of tension pneumothoraces and tourniquet application for exsanguinating extremity injuries.

Results: One hundred thirty-four trauma patients were treated at the Role 3 MMU during the study period. Six patients had eight tourniquets applied. Five tourniquets were applied to four patients appropriately and saved their lives. There was one case of misuse where a venous tourniquet was applied. There was one case of overuse where one patient had two tourniquets placed for 4 hours on extremities with no vascular injury. There were seven cases where needle decompression was underused: Seven patients presented with vital signs absent with no needle decompression. There was one case of overuse of needle decompression. There were seven cases of misuse where the patients were decompressed too medially.

Conclusions: Tourniquets save lives. Needle decompression can save lives, but is usually performed in patients with multiple critical injuries. TCCC instructors must reinforce proper techniques and indications for each procedure to ensure that the quality of care provided to injured soldiers on the battlefield remains high.

ABBREVIATIONS AND ACRONYMS

ND	needle decompression
Role 3 MMU	Role 3 multinational medical unit
TCCC	tactical combat casualty care

Tactical combat casualty care (TCCC) is a system of prehospital trauma care designed for the combat environment that has been widely adopted by many different military medical organizations.¹⁻⁵ The premise of TCCC is that tactical awareness and appropriate performance of simple prehospital interventions will reduce combat deaths. These interventions include needle decompression (ND) of tension pneumothoraces and tourniquet application for exsanguinating extremity injuries.

Many public agencies have lauded TCCC initiatives, citing anecdotal reports where TCCC interventions have prevented combat deaths.^{6,7} No study has rigorously analyzed battlefield application of both these devices to determine if they are being used appropriately in the field. We prospectively studied all trauma patients who were treated at a multinational field hospital at Kandahar Airfield Base to determine whether or not TCCC interventions are being appropriately applied on the battlefield.

METHODS

This was a prospective study of all trauma patients treated at the Canadian-led Role 3 multinational medical unit (Role 3 MMU) established at Kandahar Airfield Base in support of Operation Enduring Freedom in Afghanistan. This hospital is roughly equivalent to a US Combat Support Hospital with regard to capability. All trauma patients treated at

this facility from February 7, 2006 to May 20, 2006 were studied. Inclusion criteria included receiving tourniquet application, ND, or both, in the prehospital setting. Inclusion criteria included patients if they had prehospital indications for either tourniquet application, ND, or both, but did not receive the interventions. These indications were defined a priori, and are listed here. Patients who fulfilled these inclusion criteria were subject to a full chart review by the study investigators.

The Canadian Trauma Registry for this institution was used to identify demographics and injury data. This trauma registry was a pilot project initiated by HT to determine whether or not such a registry could help with quality improvement of trauma care at the Role 3 MMU. The Canadian Trauma Registry contains only information about each patient, including basic demographics, basic injury data (mechanism and injury severity scores), some basic physiologic data on presentation, blood products transfused, and surgical procedures performed. It also lists basic outcomes from Kandahar only, including length of stay, days on ventilator, and alive or dead. It does not have any data on the nationality of the prehospital providers, as often the Helivac team does not present this information. We are unable, as a result to discern any difference between Afghan versus coalition prehospital care providers. Study investigators (HT or JM) reviewed the clinical history of each patient. Trauma-room records, operative reports, radiologic reports, and hospital records were also reviewed. Autopsy reports were not reviewed. Autopsies are not performed on Afghans who die at the Role 3 MMU facility. We are not privy to autopsy reports (if any) of non-Canadian coalition soldiers who die at

the Role 3MMU. All Canadian soldiers who die in Kandahar are autopsied back in Canada. Information about these results, as a rule, is not relayed back to the surgical team at Kandahar. The primary outcomes were the appropriateness of each TCCC intervention, ie, ND, tourniquet application, or both.

Healthcare interventions are appropriate if performed properly for accepted indications. Conversely, inappropriate care occurs when an intervention is misused (improperly performed), overused (performed for an improper indication), or underused (not performed despite proper indications).⁸ We then created criteria for evaluating tourniquet application and ND for tension pneumothoraces using this framework. Criteria will be listed here.

Tourniquet application

Prehospital use of tourniquets was considered inappropriate by:

1. Underuse criteria: if a patient arrived with arterial bleeding from an extremity injury without a tourniquet;
2. Overuse criteria: if a patient without major arterial bleeding from an extremity injury arrived with a tourniquet applied for longer than 3 hours; and
3. Misuse criteria: if a patient arrived with arterial bleeding from an extremity injury despite having a tourniquet applied (venous tourniquet).

ND for tension pneumothoraces

Prehospital use of ND was considered inappropriate by:

1. Underuse criteria: if a patient presented with a history of unexplained prehospital hemodynamic instability, respiratory distress, or unilateral or bilateral penetrating chest trauma without having a ND performed. Patients with explained hemodynamic instability were considered to not have criteria for ND;
2. Overuse criteria: if a patient presented with ND without the indications listed previously; and
3. Misuse criteria: if a patient presented with NDs performed for appropriate indications, but in an inappropriate location (>2cm medial to the midclavicular line).

This study was reviewed by our institutional review ethics board and approved for waived consent as no intervention was studied. Patients frequently had altered level of consciousness or spoke different languages, making communication more difficult. This study was also reviewed and approved by the Surgeon General of the Canadian Forces Health Services.

RESULTS

During the 4-month study period, 134 patients were treated at the Role 3 MMU in Kandahar, Afghanistan. Thirty-two percent had suffered penetrating injuries and 22% had blunt injuries. Blast injuries constituted 34% of the total and 12% of the patients had suffered burns. Five patients were women, and the mean age of patients was 26 (\pm 13) years. Mean injury severity score of these patients was 16.

Tourniquets

During this study period, six patients had a total of eight tourniquets placed. Four patients had five tourniquets

placed on injured lower extremities with arterial injuries. All of these had suffered blast injuries. On removal of these tourniquets in the operating room arterial bleeding recommenced. We believe the tourniquets saved their lives.

Underuse criteria

No patients arrived with arterial bleeding from an injured extremity without a tourniquet.

Overuse criteria

One Afghan soldier arrived with one tourniquet on each leg after suffering a penetrating gunshot wound through each thigh. The tourniquets had been on for 4 hours, and each leg was clearly ischemic on initial physical examination. On removal of the tourniquets, both legs regained normal perfusion. On additional assessment, neither leg had any hard or soft signs of vascular injury, and had normal ankle-brachial indices. Fortunately, the compartments of both legs remained soft on repeat physical examination and fasciotomies were not required.

Misuse criteria

One coalition soldier arrived after suffering a partial amputation to the upper limb from an improvised explosive device. The ulnar artery was injured, but the radial artery was intact. A tourniquet had been placed, but Doppler examination revealed ongoing flow to the distal radial artery. No other injuries were identified, and the patient remained hemodynamically stable. The ulnar artery was easily controlled in the operating room.

ND OF TENSION PNEUMOTHORACES

Underuse criteria

Seven (two coalition military, five Afghan army) soldiers presented with vital signs absent. One was from blunt trauma, three were from penetrating thoracic injury, and three were from blast injuries. None received NDs in the field.

Overuse criteria

One Afghan soldier fell from standing during a unit physical fitness session. He reported unilateral chest pain but was otherwise stable. He was needle-decompressed twice in the field. Apparently, no "gush of air" was detected after each procedure was performed, so each needle was removed and the puncture sites were covered with sterile dressings. Fortunately, a chest radiograph at hospital revealed no pneumothorax, despite the initial fall and subsequent attempts at ND.

Misuse criteria

Seven NDs were performed on five soldiers for appropriate indications. All of these were Afghan army soldiers. All seven decompressions were performed at least 2cm medial to the midclavicular line. No major complications resulting from the NDs were identified.

DISCUSSION

Bellamy⁹ analyzed the causes of death from land combat using historic wound data collected by researchers interested in the effectiveness of different munitions during the Vietnam War. He defined preventable combat deaths as acute

airway obstruction, tension pneumothorax, and exsanguinations from traumatic amputation based on the availability of effective prehospital treatment modalities for these conditions. Subsequently, Bellamy found that 15% of all combat deaths were preventable: traumatic amputations caused 9% of deaths, tension pneumothorax caused 5%, and airway obstruction caused 1%.

Based on this study, and reinforced by an analysis of casualties sustained during the American mission to Somalia in 1993,¹⁰ Butler and colleagues¹ derived a system of prehospital trauma care called tactical combat casualty care. TCCC has replaced Basic Trauma Life Support and ATLS as the basis for the prehospital trauma management of injured soldiers in the tactical environment.² Versions of TCCC have now been adopted by the US military,² Israeli Defense Force,³ British Army,⁴ and Canadian Forces.⁵ The expectation of these agencies is that simple prehospital interventions, such as ND of tension pneumothoraces and tourniquet application, will reduce combat deaths.

Despite widespread use of TCCC in combat care, very little has been reported on how TCCC interventions are actually being applied on the battlefield. This is particularly important as these skills have potential complications, and are being taught to many soldiers with nonmedical backgrounds before overseas deployments.^{1,2}

Like other studies,¹¹ we believe that tourniquets save lives. Tourniquets are being placed appropriately on soldiers suffering traumatic amputations from blast injuries. TCCC courses must reinforce the distinction between venous and arterial tourniquets in patients without amputations. Venous tourniquets do not occlude arterial inflow to an extremity but promote venous congestion. Venous tourniquets increase bleeding from injured extremities and must be avoided.⁵

TCCC courses must also reinforce the need to remove tourniquets to reassess extremity bleeding in patients without traumatic amputations once the patient and caregiver are no longer under effective enemy fire (tactical field phase of care). Although there is some controversy surrounding this issue,¹²⁻¹⁵ we believe that the risks of iatrogenic ischemic injury outweigh the risk of increased blood loss, especially in situations where evacuation times to surgical facilities are variable. We believe that pressure dressings need to be considered for replacing tourniquets if no arterial bleeding is observed on re-assessment.

We were unable to determine if NDs actually saved lives or if failure to perform NDs (despite appropriate indications) resulted in preventable deaths. Most of these patients suffered severe multisystem injuries. Patients who had NDs performed in the field still presented with ongoing instability at the Role 3 MMU, despite ND. Likewise, patients who presented with vital signs absent also had either accompanying severe brain injury, exsanguinating hemorrhage, or both, which might have accounted for their death, despite the lack of ND. Even so, TCCC courses can reinforce the concept that patients presenting with appropriate indications (especially patients who are vital signs absent) should receive bilateral ND — very little extra harm can arise from such a recommendation.

We were able to identify a consistent trend in technical errors in performing ND in the field. All NDs were performed at least 2cm medial to the midclavicular line, and well

within the cardiac box.¹⁶ This error in technique risks inadvertent injury to the heart or great vessels,¹⁷ especially with the growing tendency for using longer needles in the military setting.¹⁸ This finding is consistent with studies of NDs performed in volunteer studies of emergency physicians.¹⁹ TCCC courses must reinforce landmarks for performing ND. Soldiers often have to perform this procedure in the dark and under difficult conditions. They might forget that the clavicle extends into the shoulder apparatus. Soldiers should be cautioned, as an extra precaution, about performing NDs if their landmark appears medial to the nipple line.

LIMITATIONS OF THE STUDY

The major limitation of this study is its small size. The magnitude of the trends noted in this study is unknown because of its size. Nevertheless, larger prospective studies of care delivered on the battlefield are difficult to conduct because of limited resources and personnel at field hospitals. The conclusions of this study are easy to implement, have no additional costs, and risk no additional harm to patients.

Another major limitation is the heterogeneous nature of prehospital training and care provided by the medics involved with this study. Many nations participate or have participated in Operation Enduring Freedom, and medic training and protocols can vary. This report, as such, makes no comment on the TCCC training conducted by any one country.

Another limitation of this study is that we used explicit criteria to assess the appropriateness of care delivered on the battlefield. There are two common methods used to determine “appropriateness of care”: implicit review and explicit review.²⁰

In implicit review, a reviewing panel determines the “appropriateness of care” for each patient by comparing the actual process of care against his or her own knowledge and opinion of what optimal care is. Implicit review is highly idiosyncratic and reviewer-dependent. We used explicit review, where we compared the actual process of care against a set of criteria that spell out what the elements of adequate process should have been. There can be some debate about the selection of the criteria, but judgments made by explicit review can be almost reviewer-independent.²¹ Explicit review also tends to be insensitive to nuances of care.²² In explicit review, the burden of accuracy falls on the criteria, not on the reviewer.

In this study, we prospectively studied the appropriateness of TCCC interventions being performed on the battlefield. We found that tourniquet application saved lives from exsanguination. We were unable to demonstrate that NDs saved lives. Even so, TCCC instructors must continually reinforce the appropriate indications and techniques for conducting these procedures to avoid systematic errors that detract from the quality of care delivered on the battlefield to injured soldiers.

AUTHOR CONTRIBUTIONS

Study conception and design: Tien

Acquisition of data: Tien, Acharya, MacDonald

Analysis and interpretation of data: Tien, Jung, Rizoli, Acharya, MacDonald

Drafting of manuscript: Tien, MacDonald

Critical revision: Tien, Jung, Rizoli, Acharya, MacDonald

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