Tactical Combat Casualty Care in the Canadian Forces: lessons learned from the Afghan war

LCol Erin Savage, MD*
Maj Colleen Forestier, MD*
LCol Nicholas Withers, MD*
Col Homer Tien, OMM CD, MD, MSc*†‡
Capt Dylan Pannell, MD, PhD*‡

From the *Canadian Forces Health Services, and the Divisions of General Surgery, †Sunnybrook Health Sciences Centre and ‡Department of Surgery, University of Toronto, Toronto, Ont.

Correspondence to:
LCol E. Savage
Directorate of Health Services Operations
Canadian Forces Health Services
1745 Alta Vista Dr.
Ottawa ON K1A 0K6
erin.savage@forces.gc.ca

DOI: 10.1503/cjs.025011

Tactical Combat Casualty Care (TCCC) is intended to treat potentially preventable causes of death on the battlefield, but acknowledges that application of these treatments may place the provider and even the mission in jeopardy if performed at the wrong time. Therefore, TCCC classifies the tactical situation with respect to health care provision into 3 phases (care under fire, tactical field care and tactical evacuation) and only permits certain interventions to be performed in specific phases based on the danger to the provider and casualty. In the 6 years that the Canadian Forces (CF) have been involved in sustained combat operations in Kandahar, Afghanistan, more than 1000 CF members have been injured and more than 150 have been killed. As a result, the CF gained substantial experience delivering TCCC to wounded soldiers on the battlefield. The purpose of this paper is to review the principles of TCCC and some of the lessons learned about battlefield trauma care during this conflict.

Le programme de Secourisme en situation de combat (SSC) a pour objet de dispenser les premiers soins sur le champ de bataille afin de prévenir les décès par des interventions immédiates. On reconnaît toutefois que l'administration des soins, si elle se produit au mauvais moment, peut mettre en danger la vie du soignant et parfois même compromettre la mission. Le SSC classe donc les situations tactiques en 3 phases aux fins de la prestation des soins de santé (soins sous feu ennemi, soins tactiques, soins évacuation) et n'autorise que certaines interventions selon les phrases et en fonction du danger pour le soignant et pour le blessé. Au cours des 6 années pendant lesquelles les Forces canadiennes (FC) ont participé à des missions soutenues de combat à Kandahar, en Afghanistan, plus de 1000 membres des FC ont été blessés et plus de 150 autres ont perdu la vie. En résultat, les FC ont acquis une grande expérience de la prestation de SSC à des soldats blessés. Cet article passe en revue les principes du SSC et quelques-unes des leçons apprises au sujet des traumatismes sur le champ de bataille au cours de ce conflit.

> The fate of the wounded lies in the hands of the ones who apply the first dressing.
> Dr. Nicholas Senn

In 2002, the Canadian Forces (CF) first deployed to Kandahar, Afghanistan, as part of the United States–led "War on Terror" in response to the Sept. 11, 2001, terrorist attacks. This was the first time Canada had deployed soldiers on combat operations since the Korean War. Prior to this deployment, the CF introduced a then-novel paradigm of prehospital trauma care designed for the battlefield: Tactical Combat Casualty Care (TCCC). Fortunately the CF sustained few casualties on that mission, but it did emerge from that phase of the conflict with a determination to further develop TCCC within the CF.

The CF subsequently deployed to Kabul, Afghanistan, in 2003 as part of the International Security Assistance Force (ISAF), which was formed under the Dec. 20, 2001, United Nations Security Council Resolution 1386. The ISAF's initial mandate was to maintain security in and around Kabul so employees of the Afghan Interim Authority (the body governing Afghanistan) and the United Nations could operate in a secure environment. In 2005, the ISAF began to extend its operations beyond Kabul to support the development and growth of Afghanistan's governmental institutions, especially its national security forces. As part of these efforts, a Canadian whole-of-government mission, including the CF, returned to Kandahar province in 2005 and relieved a US Army Task Force who had deployed under the original "War on Terror" mandate.[1]

As part of the ISAF, the CF was responsible for combat operations in Kandahar province from 2005 until our recent handover to the US Army on July 7, 2011. The 6 years of sustained combat operations in the volatile province have

resulted in more than 1000 CF members being injured and in more than 150 being killed. As a result, the CF gained substantial experience delivering TCCC to wounded soldiers on the battlefield. The purpose of this paper is to review the principles of TCCC and some of the lessons learned about battlefield trauma care during this conflict.

Background

Tactical Combat Casualty Care was originally developed for Special Operations Forces in 1996 by US Navy Capt (Ret.) Frank Butler and Lt. Col. (Ret.) John Hagmann. A review and analysis of the literature and historical medical data from the Vietnam War, the Korean War and World War II revealed that potentially preventable causes of death remained constant: about 9% of casualties died from extremity wounds, 5% from tension pneumothorax and 1% from airway obstruction.[2] Consequently, recommended treatments were tourniquet application for bleeding extremity wounds, needle decompression for tension pnemothoraces, nasopharyngeal airway placement for airway obstruction secondary to decreased level of consciousness and surgical cricothyrotomy for airway obstruction secondary to maxillofacial trauma. Butler and colleagues[3] also recognized the unique challenges faced by combat medical personnel and the requirement to combine good medicine with good tactics. Although TCCC principles aim to treat potentially preventable causes of death on the battlefield, they also acknowledge that application of these treatments may place the provider and even the mission in jeopardy if performed at the wrong time. Therefore, TCCC classifies the tactical situation with respect to health care provision into 3 phases (care under fire, tactical field care and tactical evacuation) and only permits certain interventions to be performed in specific phases based on the danger to the provider and casualty. In addition, medics were being called on to practise their trade in the face of many other adverse conditions, including austere environment, low light, limited medical equipment, prolonged evacuation times and the need to triage and treat multiple casualties with minimal backup. It rapidly became clear that the prehospital trauma courses being taught to soldiers and medics did not address these challenges and that significant change was needed.

History within the CF

Tactical Combat Casualty Care was first introduced in Canada to our Special Operations Forces in 1999. However, the utility of this approach to battlefield care within Canadian conventional forces was only identified before the initial CF deployment to Kandahar in 2002. In preparation for deployment, CF members were given a 3-hour didactic lecture on the principles of TCCC.

During the initial deployment, most soldiers saw only sporadic combat, and the Canadian casualties sustained were the result of a friendly-fire incident from a US air-dropped bomb. The incident did, however, prompt the CF to review its prehospital trauma doctrine, the result of which was a TCCC pilot course for conventional forces. After the course, participants and other stakeholders were unanimous in their belief that TCCC was invaluable and would increase the ability of medics and soldiers to save lives on the battlefield. As such, TCCC gained further momentum within the CF and training became a regular part of each brigade's predeployment training schedules across the CF. In addition, an overarching organization was made to oversee TCCC. This organization was called the Combat Casualty Care Working

Table 1. Overview of skill sets among the various levels of combat casualty care in the Canadian Forces

CFA	TCCC	TACMED
• Stop major hemorrhage with pressure, tourniquet and wound packing with hemostatic agent	• Stop major hemorrhage with pressure, tourniquet and wound packing with hemostatic agent	• Stop major hemorrhage with pressure, tourniquet and wound packing with hemostatic agent
• Maintain an airway-recovery position	• Maintain an airway-recovery position, jaw thrust and NPA	• Maintain an airway-recovery position, jaw thrust, NPA, OPA, supraglottic airways, surgical cricothyrotomy
	• Seal open chest wounds with occlusive dressing • Identification and decompression of tension pneumothorax under direction of a medic	• Seal open chest wounds with occlusive dressings • Identification and decompression of tension pneumothorax
	• Identify signs of hemorrhagic shock	• Intraveous/intraosseous administration of hypertonic saline/dextran with permissive hypotension
	• Aid medic in application of pelvic binders and splinting fractures	• Management of bowel evisceration, application of pelvic binders and splinting fractures
	• Hypothermia prevention	• Hypothermia prevention
• Assist medic as required, including calling in TACEVAC request	• Assist medic as required, including calling in TACEVAC request	• Use of narcotics for pain management in trauma
		• Antibiotic use postinjury

CFA = combat first aid; NPA = nasopharygeal airway; OPA = oropharyngeal airway; TACEVAC = tactical evacuation care; TACMED = tactical medicine; TCCC = tactical combat casualty care.

Group (CCC WG) and had representatives from both the Canadian Forces Health Services (CFHS) and Combat Arms branches of the CF. The first meeting of the CCC WG was held in December 2005. Its goals were to regulate and standardize TCCC training throughout the CF and to adapt protocols and interventions based on the most recent casualty information.

Modern TCCC training in the CF

The CF currently have 3 different levels of TCCC providers (Table 1).

Combat first aid

The 2-day combat first aid (CFA) course is taught to every soldier before each deployment to Afghanistan. Its emphasis is on treating hemorrhage, using tourniquets and applying hemostatic dressings as well as basic casualty management from the point of injury all the way to the evacuation platform. The first day of training is in lecture and laboratory format, and the second day focuses on the provision of care during simulated combat scenarios.

TCCC

Participants with no prior medical training are selected by their chain of command for the intense 2-week TCCC course. The first week is in lecture and laboratory format, whereas the major goal of the second week is to confirm these skills in increasingly complex scenarios using simulation. Like in the CFA course, soldiers are taught how to apply tourniquets and hemostatic dressings in patients with bleeding extremity wounds. However, TCCC providers have an increased scope of practice, and they are taught how to insert nasal pharyngeal airways and how to perform needle decompression under the direction of a medic. Most importantly, TCCC providers function as medic extenders; they work under the direction of medics and can help them by anticipating their next steps. Currently, 1 in 8 soldiers are trained as TCCC providers.

Tactical medicine

The tactical medicine (TACMED) course is designed exclusively for medics. The CFHS organized the first course in 2007 to provide more realistic training in advanced TCCC skills. The course has evolved over the past few years; it is currently 2 weeks in length and represents the highest level of care provided by CF members in the prehospital battlefield setting. On the course, medics are taught to manage patients using the MARCHE protocol (see next section), and they learn to do this under realistic simulated combat scenarios. The TACMED course is intensive and challenging, and it pushes the limits of knowledge in both tactics and battlefield medicine using highly regulated live tissue training and effective simulation. On return from Kandahar, medics frequently state that this training was crucial to their effectiveness on the battlefield.

The MARCHE protocol

Currently the MARCHE protocol, as shown in Box 1, is followed. Its goal is to address the potentially preventable causes of death seen in modern warfare. Therefore, the algorithm prioritizes the treatment of exsanguinating hemorrhage with a combination of direct/indirect pressure, tourniquets and packing with hemostatic agents. Once massive hemorrhage is initially managed, medics progress to airway and breathing issues. They can insert nasopharyngeal airways, but are also trained to perform surgical cricothryotomies for patients with massive facial trauma. For breathing, medics can perform needle decompression of tension pneumothoraces and apply dressings to sucking chest wounds. After airway and breathing, medics return to their "circulation" by treating hypovolemic shock through careful fluid administration, guided by field-appropriate permissive hypotension responses, via an intravenous or intraosseous route. They also assess and splint pelvic and long-bone fractures during this phase. Medics are taught to be cognizant of the possibility of severe brain injury and to prevent hypothermia. They can administer antibiotics for all wounds and narcotics for pain relief. Medics are also taught the appropriateness of providing care based on the tactical situation. In an effort to accomplish this, TCCC interventions are carried out during distinct conditions, termed "phases of care."

Box 1. The MARCHE protocol

Massive hemorrhage control (tourniquets and hemostatic dressings)
Airway management (including surgical cricothyroidotomy for TACMED medics)
Respiratory management (occlusive dressings for open pneumothoraces and needle decompression for tension pneumothoraces)
Circulation (**BIFT**)
- **B**leeding control
- **I**ntravenous/intraosseous access
- **F**luid resuscitation (HSD as a volume expander)
- **T**ourniquet assessment and removal

Hypothermia
Head injury
Eye injury
Everything else (**M-PHAAT-D**)
- **M**onitoring
- **P**ain
- **H**ead to toe
- **A**ddress all wounds
- **A**ntibiotics
- **T**actical evacuation preparation
- **D**ocumentation of care

HSD = hypertonic saline/dextran; TACMED = tactical medicine.

The phases of care

There are 3 objectives to TCCC: treat the casualty, prevent further casualties and complete the mission. These are united together under the guiding principle of "providing the right medicine at the right time," which is divided into phases of care.

Care under fire

Care under fire (CUF) is a situation during active combat where both the casualty and the care provider are in danger from enemy fire, may or may not be behind adequate cover and may need to contribute to the firefight. It is commonly said that "the best battlefield medicine is fire superiority;" therefore, winning the firefight and establishing a secure cordon within which to operate is the primary objective during CUF. It is emphasized that only 2 medical treatments are appropriate during this phase: tourniquet use for massive hemorrhage and the recovery position for airway obstruction.

Tactical field care

Tactical field care is the care rendered once the casualty, the care provider and their unit are no longer under effective hostile fire. It also applies to situations in which an injury has occurred on a mission, but in which hostile fire has not yet been encountered. Equipment is limited to that carried by the care provider, casualty and their team. It is during this phase of care that the bulk of the TCCC interventions are performed.

Tactical evacuation care

Tactical evacuation care is care rendered during evacuation to a medical treatment facility, usually on a vehicle, aircraft or boat. This may include dedicated personnel and prepositioned equipment on these platforms.

In a hostile environment it is important to note that these phases are fluid; the first responders may find themselves in a situation where the phases are dynamic, and they must always be ready to adapt.

Lessons learned

One of the strengths of TCCC within the CF is the constant drive for adaptation. Feedback and lessons learned have been sought out, collected and implemented in an unprecedented, timely fashion. This has included provider feedback from the battlefield and data from clinical research. The following are some of the more important and perhaps contentious key lessons learned.

Tourniquet use, the principle intervention during CUF, was potentially the most important lesson learned from this conflict. Despite the fact that the leading cause of potentially preventable deaths on the battlefield in Vietnam was exsanguination from compressible extremity injuries,[2] tourniquets were not recommended by civilian trauma experts. As a result, they fell out of military favour, were to be considered only as a last resort and were even deemed to be "an instrument of the devil that sometimes saves a life."[4] The arguments made by TCCC challenged this thinking, and tourniquets have become commonplace in modern combat medicine. Furthermore, there is now hard evidence from operations in Iraq and Afghanistan to demonstrate that tourniquets save lives, especially when applied before the onset of shock,[5] and that their benefits far outweigh their risks in the military environment.[6] The strong belief, later reinforced by data, of the military community that tourniquets save lives on the battlefield was the impetus for evolution in their design. The initial CF tourniquet was improvised from surgical tubing[7] and progressed to field-durable, user-friendly, light windlass tourniquets that have proven themselves highly effective in the laboratory and on the battlefield. Currently every deployed CF soldier is trained to use and carries at least 1 commercially available windlass tourniquet, such as a Combat Application Tourniquet (CAT; Composite Resources). The CF medical technicians also carry other types of tourniquets to give them more options for different situations.

Junctional (i.e., axillary and inguinal) hemorrhage are areas not amenable to tourniquet use and continue to be significant causes of potentially preventable death among Canadian and US soldiers.[8,9] The need for a management plan for these injuries in the military environment was another important lesson of the conflict in Afghanistan. As a result, hemostatic agents have been developed with different modes of action and in different forms. Hemostatic agents can be found in granular format or issued as impregnated gauze. Granular agents can be poured into junctional wounds, or impregnated gauze can be used to pack these wounds to control hemorrhage. The mechanisms of action of these hemostatic agents typically focus on the liquid evapourative properties of zeolite and smectite, or the tissue sealant characteristics of chitosan. Currently, the granular agent WoundStat (TraumaCure Inc.) and Combat Gauze (Z-Medica Corp.) are thought to be the most effective topical agents available for junctional hemorrhage control in noncoagulopathic patients.[10–12]

Many issues regarding the ideal hemostatic dressing remain unresolved. Current hemostatic dressings are effective in noncoagulopathic patients, but a better understanding of how they perform in coagulopathic patients is needed.[13] Also, a recent paper has questioned the safety of granular hemostatic agents owing to their ability to cause intravascular clotting and embolism.[14] Furthermore, treating brisk bleeding from puncture wounds by pouring in an agent in powder form without concurrently packing and compressing the wound may render the treatment noneffective in

the field. Finally, feedback from the medics and TCCC providers on the battlefield suggested that, although effective, granular agents, such as the zeolite Quik Clot (Z-Medica Corp.), were difficult to handle in high-wind situations caused by, for example, helicopter rotor-wash. This, combined with the highly exothermic nature of the reaction, has led the CF to abandon their initial use of granular agents and choose impregnated gauze as the preferred hemostatic agent.

Tension pneumothorax is traditionally considered to be 1 of the 3 potentially preventable causes of death on the battlefield.[15,16] As such, the CF initially included needle decompression in the armamentarium of TCCC providers, who are nonmedical personnel with enhanced medical training. As the war progressed, the length of the needle used for decompression was increased as we learned that the chest wall thickness of military members was enough to make standard needle decompression ineffective up to 75% of the time.[17–19] However, as blast injuries became more commonplace, the CCC WG began to rethink the use of needle decompression on the battlefield. The crux of the argument centred on 2 issues: first, that tension pneumothoraces were less frequently noted in casualties, likely because of the advanced personal protective equipment that CF members were wearing[8,9] and, second, that providers continued to landmark incorrectly when performing needle decompression, risking injury to the heart and great vessels.[20,21] One proposed solution to mitigate this risk has been performing needle decompression laterally in the anterior axillary line. However, preliminary research conducted by the CF suggests that needle decompression performed laterally is also likely to be ineffective because of kinking of the catheter by the patients' adducted arms.[22] As the need for needle decompression continues to be debated, the CF has limited nonmedical providers to perform needle decompression only under the direction and supervision of a medic.

In the civilian prehospital environment, spinal immobilization is an integral part of trauma management and casualty transport. However, there are significant obstacles to spinal immobilization on the battlefield. It takes 2 prehospital care providers an average of 5 minutes to immobilize a casualty,[23] requiring a significant equipment load that simply cannot be carried easily into combat. Arishita and colleagues[23] reviewed data from the Vietnam War and discovered that 10% of casualties occurred during the treatment of other casualties and that only 1.4% of penetrating neck injuries may have benefited from spinal immobilization. Similar findings have been reported in studies of penetrating neck injuries in civilians[24] and in UK casualties in Afghanistan.[25] When all of this was taken into consideration, the very real risk of creating more casualties combined with a logistically difficult skill set that might benefit only a small group led initial TCCC guidelines to de-emphasize spinal immobilization. However, the pattern of injury seen in the war in Afghanistan has changed; blast has now become the predominant mechanism of injury. The magnitude of these explosions is increasing,[9] and CF casualties are sustaining spinal injuries consistent with blunt trauma.[26] The question of how to balance the need for spinal immobilization with the imperatives of tactical field care remains. In the interim, Canadian TCCC guidelines have been amended to re-emphasize spinal precautions, especially when transporting casualties with blunt or blast trauma.

Airway compromise from penetrating neck and maxillofacial injuries was historically the third leading cause of potentially preventable deaths on the battlefield.[2] This mechanism of injury, along with the knowledge that medics do not have the training or experience to be consistently successful in rapid-sequence intubation, posed a dilemma. Medics are skilled in the use of various supraglottic airways; however, it is understood that not only are most airway casualties not obtunded enough to tolerate these airways, but also that they are not the airway of choice for treating patients with facial injuries. This led the CCC WG to recommend surgical cricothyrotomy as the definitive airway of choice.[3] Standardized procedures, protocols and medical equipment have been scrutinized and amended to maximize the probability of successful cricothyroidotomy in the prehospital environment. The recognition of skill fade with this complex procedure is minimized with live tissue training that is delivered with combat simulation to replicate stresses during the course and then again just before deployment. One of the early lessons learned was the pitfall of using cut-down endotracheal tubes for cricothyroidotomies. There were at least 2 incidents noted in patients transported to the Role 3 Multinational Medical Unit (R3MMU) at Kandahar Airfield where cricothyroidotomies using cut-down endotracheal tubes had migrated into the right mainstem bronchus resulting in hypoxia and misdiagnosis of left tension pneumothorax. The CF has since adopted the commercially available Surgical Airway Set with a cuffed 6.0 tracheostomy tube to prevent these complications.[27] Despite successes with this advanced skill, there are still airway-related deaths in both the CF[8] and the US forces[28] as well as errors made in landmarking and placement of field cricothyroidotomies. As a result, the emphasis on education and training must continue to ensure that all casualties with airway compromise are treated consistently and correctly. This procedure likely will not be delegated to providers below the level of a medic who has specifically demonstrated proficiency in this technique.

Conclusion

For the first time in decades, the CF has been involved in a war in which its members have participated in sustained combat operations and have suffered increasingly severe

injuries. Despite this, the CF experienced the highest casualty survival rate in history. Though this success is multifactorial, the determination and resolve of CF leadership to develop and deliver comprehensive, multileveled TCCC packages to soldiers and medics is a significant reason for that and has unquestionably saved the lives of Canadian, Coalition and Afghan Security Forces. Furthermore, the CFHS was in a unique position: its extensive responsibility of providing battlefield medicine in one of the most volatile areas in Afghanistan while commanding the R3MMU presented continuous occasions to collect and reflect on lessons learned. This, combined with the cohesiveness and effects-oriented mindset of CF medical leadership, ensured that these lessons learned were implemented in a timely, efficient, effective and systematic manner resulting in world-class medical care.

Despite the many advances in battlefield medicine, the constant drive among allied forces for comprehensive feedback, research and improvement continues. Current efforts in TCCC are focused on methods to improve survival of casualties with truncal and junctional hemorrhage with improved hemostatic agents for junctional bleeding and lyophilized blood products, such as fresh frozen plasma, that can be used at the point of injury.

The introduction of TCCC has fundamentally changed the way medical care is provided by the CF on the battlefield. As our mission moves away from combat operations in Afghanistan, it is imperative that momentum is not lost. Rather, we must continue to teach our soldiers and medics principles that are flexible enough to be adapted to any future mission and continue to save lives.

Competing interests: None declared.

Contributors: All authors designed the study, reviewed the article and approved the final version for publication. Drs. Savage, Tien and Pannell acquired the data, which Drs. Savage, Withers, Tien and Pannell analyzed. Drs. Savage, Forestier, Tien and Pannell wrote the article.

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