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COLUMNS ISSUES ABOUT

Tourniquet Replacement & Conversion for the Wilderness Medicine Provider: Renewed Interest on Tourniquet Lessons Learned from Ukraine and Israel

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Introduction

Prior to 2001, tourniquets (TQ) were inferiorly made, lacked evidence and effective training, and their use was discouraged. However, with effective modern TQ science,

development, and TQ inclusion into the Tactical Combat Casualty Care (TCCC) guidelines, TQs became universally accepted by 2006 in the military as the primary option for extremity arterial bleeding. Eventually TQ use transitioned with success to civilian Emergency Medical Service/Fire Department personnel, Law Enforcement personnel, and first responders. Yet, there still is a need to overcome TQ myths (Table 1). Additionally, history reveals from WWII to present that mistakes will occur when applying a TQ (Table 2). For instance, many TQs have been applied to injured extremities without life-threatening bleeding in both military and civilian casualties. Many of these applied TQs were inappropriate since many were placed without visualizing the wound when not in a direct threat environment. In addition, when TQs are applied for over 2 hours, there will be progressive damage that may result in muscle necrosis, need for fasciotomy, renal failure, amputation, and death. This suggests a greater need for TQ education and training.

Tourniquet Myths	
Myth	**Fact**
All tourniquets should be applied "High & Tight"	"High & Tight" tourniquets are appropriate in Care Under Fire (threat environment) when it is difficult to identify the exact site of life-threatening bleeding.
Once a tourniquet is applied, leave it alone.	Previously applied tourniquets should be reassessed in the Tactical Field Care for tourniquet necessity and proper placement.
Tourniquets can only be removed or converted by a surgeon.	Tourniquets should be reassessed and either properly placed on the limb or converted to a hemostatic gauze and pressure dressing by anyone trained to do so.

Table 1. Tourniquet myths in TCCC and in any civilian setting. Holcomb et al 2023.

Tourniquet Mistakes to Avoid
• Not using one when you should, or waiting too long to put it on. • Not pulling all the slack out before tightening. • Not making it tight enough resulting in a venous tourniquet – the tourniquet should STOP the bleeding, and eliminate distal pulse. • Not using a second tourniquet (side-by-side) with the first if needed. • Using a tourniquet for minimal bleeding while not under a direct threat. • Using a training tourniquet for real-world application. • Periodically loosening the tourniquet to allow blood flow to the injured extremity. • Putting it on too proximally if the bleeding site is clearly visible. • Not taking it off or converting it when indicated or feasible. • Taking it off when the casualty is in shock or has only a short transport time.

Table 2. Failure points for tourniquet application and removal based on CoTCCC lessons learned.

As an outcome from recent TQ lessons learned in the Ukraine and Israel wars, an article by Colonel John Holcomb, MD and colleagues was recently published in the *Journal of Trauma*, December 2023. They describe a renewed attention and education about how to avoid prolonged TQ application as recommended in the TCCC guidelines (See Massive Hemorrhage and Circulation sections – Table 3). It is our intent to provide the wilderness medical provider information about: 1) TQ replacement and TQ conversion (ideally performed no later than 2 hours after being applied); and 2) ensure the reader has up-to-date CoTCCC resources with the current TQ replacement/TQ conversion education and training.

Background

The CoTCCC has provided TQ guideline recommendations for application procedures and a timeline when to convert to hemostatic gauzes and pressure dressing - See Table 3. However, the recommendations for TQ conversion were not explicitly detailed until two articles were published in 2015 by Captain Brendon Drew DO, USN, and Colonel Stacy Shackelford MD, USAF. TQ conversion is attempting to convert a TQ to a hemostatic gauze and a pressure bandage. TQ replacement is attempting to exchange a TQ placed

"High & Tight" over garments on the extremity with a new TQ placed on the skin 2–3 inches above the life-threatening bleeding site. TQ replacement is also done when conversion to a hemostatic gauze and a pressure dressing is unsuccessful for hemorrhage control, or when the injury caused a total or near total amputation and conversion is not indicated. Both maneuvers focus on minimizing ischemia in healthy tissue. Holcomb et al 2023 have recommended increased education on the indications for TQ replacement/TQ conversion (Table 4).

Tactical Combat Casualty Care Guidelines: Tourniquet (TQ) Application & Removal	
Phase on Care	Battlefield/Wilderness
Care Under Fire/ Threat Environment	Use a CoTCCC-recommended limb TQ. Apply TQ over the uniform proximal to the bleeding site. If the severe bleeding site is not readily apparent, place the TQ "High & Tight" (as proximal as possible) on the injured limb over uniform or outerwear.
Tactical Field Care/ Non-Threat Environment	Apply TQ directly to the skin 2-3 inches above the bleeding site. If bleeding is not controlled with the first TQ, apply a second TQ side-by-side with the first. Expose the wound and determine if a TQ is needed. If it is needed, replace any TQ placed "High & Tight" and anywhere over the uniform with one applied directly to the skin 2-3 inches above the bleeding site. Ensure that bleeding is stopped. If there is no traumatic amputation, a distal pulse should be checked. Consider additional tightening of the TQ or the use of a second TQ side-by-side with the first to eliminate both bleeding and the distal pulse.
Reassessment with Ongoing Care < 2 Hours	If the reassessment determines that the prior TQ was not needed, remove the TQ. Limb TQ should be converted to hemostatic or pressure dressings as soon as possible if three criteria are met by a trained medical professional (Tiers 2, 3, 4):

	1) The casualty is not in shock; 2) It is possible to monitor the wound closely for bleeding; and 3) The tourniquet is not being used to control bleeding from an amputated extremity. Every effort should be made to convert tourniquets in less than 2 hours if bleeding can be controlled with other means.
Reassessment with Ongoing Care >2 - 6 Hours	Same as above: Limb tourniquets should be converted to hemostatic or pressure dressings as soon as possible if three criteria are met: 1) The casualty is not in shock; 2) It is possible to monitor the wound closely for bleeding; and 3) The tourniquet is not being used to control bleeding from an amputated extremity.
Reassessment with Ongoing Care > 6 hours	Do not remove a tourniquet that has been in place more than 6 hours unless close monitoring and hospital lab capability are available.

Table 3. Condensed version of TCCC Guidelines (2021) for tourniquet application, replacement and conversion.

Indications for TQ Replacement	Indications for TQ Conversion	Indications to Leave a TQ in Place
When a "High & Tight" tourniquet previously applied in a high threat situation can be better assessed for proximity to bleeding site.	Availability of alternative methods: when other methods of bleeding control, such as direct pressure, hemostatic gauzes, or wound closure become feasible and are readily available.	A TQ is controlling bleeding for an obvious amputation or a failed conversion attempt.
If the initial application of the TQ was not effective in controlling bleeding, adjusting the placement or tension of the TQ may be necessary. In such cases, replacing the TQ allows for a more secure and appropriate application.	Wound is amenable to a hemostatic gauze or pressure dressing and three criteria for conversion are met: 1. Casualty is not in shock. 2. Possible to monitor wound for rebleeding. 3. TQ is not being used to control bleeding from amputation.	Tourniquet has been in place for more than 6 hours.
Every effort should be made to replace TQs more distally in less than 2 hours.	Every effort should be made to convert TQs in less than 2 hours if bleeding can be controlled by other means.	

Table 4. Indications for tourniquet (TQ) replacement and conversion recommendations. Holcomb et al 2023

The Problem

Given rapid evacuation transport times over the past 20 years of military conflicts, TQ replacement and TQ conversion were rarely indicated. As a result, providers acquired very little experience with TQ replacement/TQ conversion. More recently, in remote areas of Africa and Indo-Pacific region, operations have shown that prolonged evacuation time will be expected. Unfortunately, this is the same scenario in the ongoing wars in Ukraine and Israel that has resulted in prolonged TQ application without any attempt for TQ replacement/TQ conversion. Several factors, including "High & Tight" TQs being placed outside the direct threat phase, and a lack of medical personnel, contributed to significant morbidity and mortality in the Ukraine. Similarly, in Israel, community members acted as first responders in applying TQs to wounded neighbors during the Hamas assault on their communal kibbutz, but these first responders were without the training for TQ replacement/TQ conversion. In the US, the TCCC guidelines

were only updated in September 2023 specifying which personnel (Tier 2, 3, 4) with TQ replacement/TQ conversion training can perform these skills to prevent prolonged TQ time.

Recommended Solutions

Holcomb et al provided a series of recommendations for prolonged TQ challenges in support of the senior surgeons and other clinicians in the Ukraine and Israel, and for US military and civilian personnel. They stated:

1. Carry at least two CoTCCC recommended TQs to avoid counterfeit or others that are not evidenced-based without research showing effectiveness and safety that meets the TQ criteria;
2. All military and civilian training (medical and non-medical personnel) courses must train and drill the indications for TQ replacement/TQ conversion including the principles of ongoing reassessment of the injured limb with equal importance;
3. Should medical personnel NOT be immediately available in the prehospital setting, OR if the TQ has been in place for 2 hours, TQ replacement/TQ conversion should be attempted by anyone who has been trained to perform these tasks.

Training & Education Resources

Based on these lessons learned from the Ukraine, leadership within the Joint Trauma System (JTS) and CoTCCC have developed best practices training resources for TQ replacement/TQ conversion as located in the CoTCCC website deployedmedicine.com:

TCCC Study Guide - A consolidation of the TCCC tourniquet guidelines and procedures.

Tourniquet Application

Tourniquet Reassessment

Tourniquet Replacement

Tourniquet Conversion

TCCC Tourniquet Conversion Training Video

TCCC Tourniquet Replacement Training Video

Application to the Wilderness Medical Provider

Holcomb et al clearly stated that the principles of TQ replacement/TQ conversion are very applicable to the austere and wilderness environments since the medical response to an injured person and the ultimate evacuation to a trauma center will be beyond 2 hours. Consequently, we recommend that anyone (even non-medical) who carries a TQ into the backcountry that you be well prepared to complete TQ replacement/TQ conversion. Previously, we recommended what items to carry as part of your hemorrhage control kit into the backcountry. Also, we recommended to seek out hands-on training on how to correctly develop an improvised TQ, particularly if you decide not to use CoTCCC recommended TQs. The majority of studies comparing commercial versus

improvised TQs report that CoTCCC recommended TQs are far superior for rapid access, ease of use, and the ability to stop severe extremity bleeding.

Finally, see the recent article by Kragh et al, that presents evidence for the increased risk of extremity frostbite following the application of a limb TQ. Consequently, it will be essential to provide extra layers of insulation to the affected extremity to prevent tissue freezing, but yet keep the extremity cool and without providing a warming source directly on the ischemic tissue. This rationale is based on hand surgery studies that report a cooler extremity can tolerate longer ischemic duration. There is also a single case report of a military aviator who landed his helicopter on a snow-covered mountain top during a tactical mission, and was shot in the hand/wrist. He survived without an amputation or loss of extremity function following 16-hour TQ application.

Final Thoughts

Battlefield tourniquets are estimated to have saved up to 2,000 US soldiers' lives in the past two decades in Afghanistan and Iraq. However, it is essential to recognize the common TQ mistakes, such as prolonged use over 2 hours without TQ replacement/TQ conversion. Initially, TQ replacement and TQ conversion were conducted only by trained medical personnel. However, a key takeaway point from Holcomb et al 2023 is that TQ education and skills training are essential for all military service members and civilians, and for anyone in austere/wilderness environments, so that they are trained to safely apply, convert, or replace a tourniquet.

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Brendon Drew is a retired Navy Captain and board-certified emergency physician. During his 32-year Navy career, he completed eight deployments throughout Asia, Africa, Afghanistan and Iraq. He also served as a command surgeon with the Marine Corps at the battalion, regimental, division and force level, and the Navy Surgeon General's Specialty Leader for Emergency Medicine. In his final tour, he also served as the Chair of the Committee on Tactical Combat Casualty Care, Joint Trauma System. Brendon is a Fellow of the Academy of Wilderness Medicine, and an avid outdoorsman.

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Brad is an applied physiologist, who has served as a subject matter expert in the Department of Defense, Committee on Tactical Combat Casualty Care from 2003-2022; former CONTOMS tactical paramedic and instructor. He served the Wilderness Medical Society (WMS) Board of Directors from 2007 to 2014; and President, WMS from 2014 to 2016. Dr. Bennett currently serves as the Section Editor for Operational and Tactical Medicine, Wilderness & Environmental Medicine journal, and Section Editor, Tactical Wilderness Medicine Column, Wilderness Medicine Magazine. He is a Master Fellow of the Academy of Wilderness Medicine. Currently an Adjunct Professor, and former Vice Chair in the Military & Emergency Medicine Department, F. Hébert School of Medicine, Uniformed Service University of the Health Sciences, Bethesda, MD; and served as the Commanding Officer, Field Medical Service School, US Marine Corps Base, Camp Pendleton, CA, and the Commanding Officer, Naval School of Health Sciences, Portsmouth, VA.