2019 Recommended Limb Tourniquets in Tactical Combat Casualty Care

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ABSTRACT

Military and civilian trauma can be distinctly different but the leading cause of preventable trauma deaths in the prehospital environment, extremity hemorrhage, does not discriminate. The current paper is the most comprehensive review of limb tourniquets employable in the tactical combat casualty care environment and provides the first update to the CoTCCC-recommended limb tourniquets since 2005. This review also highlights the lack of unbiased data, official reporting mechanisms, and official studies with established criteria for evaluating tourniquets. Upon review of the data, the CoTCCC voted to update the recommendations in April 2019.

Goals: The primary goal of this comprehensive tourniquet review was to (1) review the previously recommended tourniquets, (2) determine if additional commercial tourniquets warrant CoTCCC recommendation, and (3) identify commercial tourniquets that require further review or do not currently warrant recommendation. A deep-dive analysis of medical literature on limb tourniquets primarily published since 2012 was used to extrapolate data to be scored against criteria established the CoTCCC tourniquet working group in 2018.

Scoring: For the purposes of this review, each component of tourniquet criteria was scored on a weighted scale of 0 to 10 or 0 to 5. As such, the maximum score a tourniquet could receive was 50 with a score of 40 being considered the cut-off for a nonpneumatic limb tourniquet to be recommended.

Scoring Criteria:

- Arterial occlusion was the most critical score as a limb tourniquet must adequately demonstrate that it can effectively occlude arterial blood flow of an extremity.
- Speed of application to achieve initial occlusion <60 seconds.
- The simplicity of application was determined as a combination of how easily the device can be applied, how many steps are required for application and/or the number of twists, turns, clicks or pumps necessary to achieve occlusion.
- Within optimal occlusion pressure range of 180 and 500mmHg.
- Specifications of ≥1.5 inches wide, ≥37.50 inches in length, a locking mechanism, time recording area, and weight <8 ounces.
- Known reported or published complications, failures, or safety issues of devices.
- Combat usage reports, civilian usage reports and user preferences in published literature; and logistics data.

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Recommended nonpneumatic limb tourniquets:

Combat Application Tourniquet, Generation 6 (CAT-6)
Combat Application Tourniquet, Generation 7 (CAT-7)
SOF Tactical Tourniquet – Wide, Generation 3 (SOFTT-W)
Tactical Mechanical Tourniquet (TMT)
Ratcheting Medical Tourniquet-Tactical (RMT-T) / TX2 / TX3 Tourniquets
SAM Extremity Tourniquet (SAM-XT)

Recommended pneumatic limb tourniquets:
Emergency and Military Tourniquet (EMT)
Tactical Pneumatic Tourniquet, 2 inch (TMT2)

Proximate Cause for This Proposed Change

The first two tourniquets recommended for use on the battlefield at the point of injury (POI) were the Combat Application Tourniquet (CAT) and the SOF Tactical-Tourniquet. These two tourniquets have performed well in combat casualty care, but there have been no updated TCCC tourniquet recommendations since 2005.

In the past, the CoTCCC recommended that periodic, comprehensive, and standardized testing of the commercially available tourniquets be conducted by the Department of Defense (DoD). This would be helpful both to study new tourniquets and to evaluate the impact of changes that have been made to previously recommended tourniquets. Both the CAT and the SOFT-T have been significantly modified from the version tested by Dr Walters in 2004.[1]

More recent tourniquet testing has been completed and published, but it has not been comprehensive or standardized, making comparative quality assessments of the available tourniquet options more difficult. Nonetheless, several factors make it important to review TCCC tourniquet recommendations at the present time despite the lack of comprehensive, standardized testing:

1. Although the CAT and the SOFT-T have performed well in combat, there may be newer tourniquet technology that offer advantages in cost, speed of application, ease of application, durability, ease of training, or other aspects of tourniquet performance over the two tourniquets currently recommended by TCCC.
2. Some commercially available tourniquets performed poorly – either in laboratory testing or in casualty care. These tourniquets need to be identified so that agencies are aware of these issues when making tourniquet purchasing decisions.
3. Some commercially available tourniquets lack substantial and objective evaluation. While these tourniquets may work well, without supporting data, they should not be recommended and identified.
4. The newer versions of the CAT and the SOFT-T need to be evaluated in comparison to other tourniquets to study the effect of post-2004 design changes on their performance.
5. Tourniquet use is increasing in the US civilian sector as a result of the Department of Homeland Security's "Stop the Bleed" campaign that seeks to translate the survival benefit seen in US combat casualties after the TCCC-led introduction of modern tourniquets. Many civilian agencies are requesting guidance from TCCC about which tourniquets to acquire for their agencies. These large-scale tourniquet acquisitions should be based on the best evidence currently available.

Therefore, it is incumbent that the CoTCCC:

- Ensure that we are providing the best-recommended tools to fulfill our guidelines for tactical combat casualty care.
- Perform comprehensive reviews of all tourniquet literature, data, studies, case reports, and product data.
- Assess and evaluate currently recommended commercial tourniquets.
- Assess and evaluate NEW tourniquets for consideration as CoTCCC recommended devices.
- Publish a clear statement as to why other tourniquets were either not recommended or considered.
- Publish a CoTCCC Preferred Features statement for future tourniquet studies, development, and RDT&E requirements.
- Assess and evaluate tourniquet-training methodologies for efficacies on performance on bleeding control.
- Codify CoTCCC protocol for reviewing previously recommended devices.
- Review methodology of "naming" specific commercial products in the TCCC Guidelines.

This review will NOT discuss the importance of limb tourniquets for hemorrhage control in TCCC or any other setting. The CoTCCC position and guidelines are not changed or effected as pertaining to the currently recommended TCCC Guidelines (01 AUG 2019). The critical need of tourniquets on the battlefield is well established and is not questioned. Reviews of medical literature have documented the unquestioned success of properly applied tourniquet in saving lives and decreasing the incidence of prehospital death from limb hemorrhage.

Background

The early and aggressive application of limb tourniquets has been the key pillar of TCCC since its inception. In the early years of TCCC implementation there were limited prefabricated limb tourniquet options available for units or the services to issue to troops. The device fielded by the DoD medical logistics system since the 1960s was the simple strap-and-buckle Tourniquet, Nonpneumatic (former NSN: 6515-00-383-0565 Non-pneumatic tourniquet) depicted in Figure 1. This device was completely inadequate as a true limb tourniquet.[2] The alternative was the classic stick-and-rag improvised windlass limb tourniquets. While the stick and rag improvised windlass limb tourniquet can be as effective as commercially available tourniquet, it has up to a 32% failure rate using the optimal materials in a lab setting.[3] Using this type of tourniquet may not be practical due to the necessity for the required materials, the low arterial occlusion rate, and the prolonged time necessary to properly apply it.

Through the efforts of innovative medics and physicians in the late 1990's and early 2000s, new concepts for prefabricated limb tourniquets began to emerge. While many quickly fell by the wayside, the CAT and SOFT-T have endured to this day. The tourniquet innovation did not slow down as several manufacturers continued to develop, produce and sell tourniquet devices to the point that there are several dozen options available today.[4] However, the efficacy of many of these tourniquet

FIGURE 1 *Tourniquet, Nonpneumatic fielded circa 1960s–2004.*

devices has not been clearly delineated through evidence-based research or science. Further, for the published evidence available, there has been a wide variance as to the efficacy study definitions, metrics and requirements.

In 2004, the USAISR conducted tests of 10 limb tourniquet designs based on requirements and specifications previously indicated by Calkins et al.[5] and feedback from the field of ongoing combat operations. The CoTCCC reviewed the test results and in 2005 identified the CAT, SOFT-T, and Emergency and Military Tourniquet (EMT) as the CoTCCC-recommended limb tourniquets for fielding to deploying forces.[1]

In subsequent years, the CoTCCC recommended tourniquets underwent several modifications based on continued feedback from real casualty applications in Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF). Additionally, other manufacturers developed alternative devices as both an innovative improvement to hemorrhage control as well as market share competition. Some of these devices underwent research and scientific efficacy studies as part of DoD-funded research projects and as independent studies through other organizations. However, in the subsequent years, the CoTCCC did not review and provide any additional recommendations regarding the tourniquets on the market. The military services generally have fielded tourniquets recommended by the CoTCCC.

Discussion

The primary goal of this comprehensive tourniquet review is to (1) review the previously recommended tourniquets; (2) determine if additional commercial tourniquets warrant CoTCCC recommendation; and (3) identify commercial tourniquets that require further review or do not currently warrant recommendation. The secondary goal is to establish a CoTCCC preferred features guideline for the research, development and testing of military limb tourniquets as well as the manufacture of battlefield limb tourniquets. The tertiary goal is to establish a model for future reviews of CoTCCC recommended devices and products on a recurring basis.

The process of reviewing commercial tourniquets was focused on analysis of the evidence published in medical literature and DoD reports. Between 2000 and 2018, there were over 6,800 articles found on a PubMed search using the search term tourniquet. The vast majority were related to in-hospital orthopedic and surgical tourniquets. About 150 articles were relevant to battlefield or prehospital tourniquets with many encouraging the use of tourniquets but not evaluating the devices. Of these, there were approximately 60 articles focused on the study or comparison of commercial tourniquet efficacy or performance. However, many included devices that were outdated or no longer in production. For example, articles published prior to 2009 provided evidence on CAT generations 4 and 5 which are no longer produced and should be out of the usable inventory. As such, the analysis of evidence primarily focused on medical literature since 2012 in order to assess data on the devices currently manufactured and available.

When reviewing the evidence to assess the efficacy, efficiency, and safety of tourniquets, it is incumbent upon the reader to understand that there is a difference between laboratory conditions and battlefield conditions. For example, a tourniquet may perform well when applied to the thigh while in a seated position in a lab with two hands. However, the same tourniquet may be difficult to apply to a thigh at night in a Care Under Fire situation. The data and evidence from laboratory studies and actual use are considered in the tourniquet review. Tourniquets with both laboratory and use in combat has a stronger level of evidence.

The reader also needs to consider factors that are known to affect occlusion pressure and tourniquet efficacy. In a lab setting, it can be difficult when using volunteers or trainers, to accurately control for and evaluate factors that are known to lead to loss of occlusion pressure such as application of a tourniquet to a contracted muscle, which subsequently relaxes; extremity circumference; blood pressure; increased blood pressure following resuscitation; or loss of extracellular fluid under the tourniquet. All of these factors are known to affect the successful application of an arterial tourniquet. Thorough understanding of the biomechanics of tourniquet use and frequent reassessment is critical to successful use of a tourniquet.

Methodology

Over the years, tourniquet requirements and assessment criteria has been published with most having similar criteria.[5,6] Several studies conducted by the Naval Medical Research Unit-San Antonio (NAMRU-SA) utilized the military tourniquet characteristics identified by the 2010 DoD Tourniquet Summit.[7] Additionally, Dr John F Kragh Jr outlined limb tourniquet requirements and guidelines in multiple papers.[6] In September of 2018, a breakout working group at the CoTCCC meeting outlined the critical criteria that would be used to further evaluate the available evidence. This working group panel included several voting members of the CoTCCC, representatives from AMEDDCandS-CDID, USUHS, DHA, and the Services. The working group prioritized the following assessment criteria going forward in this review and for CoTCCC preferred features of military limb tourniquets.

FDA Approved – In order to be included, all devices must be FDA approved as a tourniquet. At the time of writing, there were 1,627 devices approved by the FDA as tourniquets.

Scoring – For the purposes of this review, each component of tourniquet criteria was scored on a weighted scale of zero (0)

to ten (10) or zero (0) to five (5). The intent was to ensure that results with studies with N >20 were weighted over studies with N <20. As such, the maximum score a tourniquet could receive was fifty (50). It was determined by the senior author with consensus from co-authors that only non-pneumatic tourniquets with a score of 40 or higher would be considered for CoTCCC recommendations. As the pneumatic tourniquets in the combat setting are only recommended as tourniquet replacements, then speed of application and simplicity were not considered with same degree of importance and were not held to the same overall score of 40 as the non-pneumatic devices. As such, occlusion, pressure and specifications were the criteria for pneumatic recommendations.

Arterial Occlusion – First and foremost, a limb tourniquet must adequately demonstrate that it can effectively occlude arterial blood flow of an extremity. Evidence would be further scored high and as acceptable with a greater than 90% efficacy of occlusion on studies including total N >20 applications and medium-high and acceptable on studies with 90% efficacy including with N <20 applications. Studies with efficacy results of 80-89% were scored in the middle and categorized as concerning and requiring additional scrutiny. Devices with occlusion results of 70–79% were considered significantly concerning and scored low. Studies of devices with occlusion efficacy <70% were consider unacceptable and scored zero. Devices with occlusion efficacy <50% were scored zero and considered disqualified.

Additionally, only studies that determined occlusion efficacy using tourniquet application to humans assessed by Doppler ultrasonography or using high-fidelity limb tourniquet simulators were included in this review. A Doppler ultrasound is a noninvasive test that can be used to estimate the blood flow through blood vessels by bouncing high-frequency sound waves (ultrasound) off circulating red blood cells. A regular ultrasound uses sound waves to produce images but can't show blood flow.[8] The use of non-Doppler ultrasound, pulse oximetry, or palpable pulse were not considered to be definitive determinates of occlusion as they do not definitively assess blood flow.

TABLE 1 *Arterial Occlusion Scoring*

10	96–100% occlusion in studies with N>20 applications considered successful.
9	96–100% occlusion in studies with N<20 applications considered successful.
8	90–95% occlusion in studies with N>20 applications considered successful.
7	90–95% occlusion in studies with N<20 applications considered successful.
6	80–89% occlusion in studies with N>20 applications considered concerning.
5	80–89% occlusion in studies with N<20 applications considered concerning.
4	70–79% occlusion in studies with N>20 applications considered concerning.
3	70–79% occlusion in studies with N<20 applications considered concerning.
2	50–69% occlusion in studies with N>20 applications considered unacceptable.
1	50–69% occlusion in studies with N<20 applications considered unacceptable.
0	Any occlusion rates <50% considered unacceptable.

Time (or speed) of Application – The second critical criteria was how quickly the TQ device could be applied by trained individuals. While there has not been a firmly established standard for the speed of tourniquet applications, it is generally accepted that a hemorrhaging casualty can bleed out in 3–5 minutes.[9] While most of the studies held 1 minute (60 seconds) as an arbitrary time standard for tourniquet application, they did not all delineate the steps of the application procedure that were to be completed within time constraints. Additionally, most published DoD tourniquet application grading criteria include 60 seconds as the time standard for application. However, neither the studies nor some of the DoD publications clearly differentiate the time required to achieve occlusion and to complete further application steps such as securing the tourniquet or time recording. Furthermore, the studies did not have consistency in defining the start of timing of the procedure or standardization for tourniquet access for the test.

For future analysis, the working group determined that the most critical step in stopping hemorrhage, time to occlusion, should be differentiated from the additional steps of application. The optimal time to occlusion would be <60 seconds with an additional maximum of 90 seconds more to complete the tourniquet application, including securing the device and marking the time. Accordingly, devices with application speeds of <60 seconds to occlusion and <90 seconds completion in studies with N >20 applications were scored high and acceptable; <60 seconds and <90 seconds in studies with N <20 scored medium and acceptable. Devices with occlusion times of 61–90 seconds were scored low and considered concerning and devices with time to occlusion >90 seconds were scored zero and considered unacceptable.

TABLE 2 *Speed of Application Scoring*

5	<60 seconds to occlusion time in studies with N>20 applications considered successful AND <90 seconds to completed application time in studies with N>20 applications considered successful.
4	<60 seconds to occlusion time but with an N<20 considered acceptable AND/OR <90 seconds to completed application time in studies with N<20 applications considered acceptable.
3	61 to 90 seconds to occlusion time in studies with N<20 considered concerning.
2	61 to 90 seconds to occlusion time in studies with N>20 considered concerning.
1	Not used
0	Any time to occlusion >90 seconds considered unacceptable.

Simplicity of Application – The simplicity of application was determined as a combination of how easily the device can be applied, how many steps are required for application and/or the number of twists, turns, clicks or pumps necessary to achieve occlusion.[10] While most tourniquets in this review could likely gain arterial occlusion, there is the valid and important question of reproducibility in the larger population, which is why simplicity is an important criterion. In many aspects, training is the answer to the simplicity or difficulty of applying a tourniquet. However, it must be recognized that the complexity of the steps to apply, the retention of steps, or particularities increase the overall difficulty.

For this review, simplicity of application is defined as correctly applying the device after minimal training in a stressful combat setting of low–to–no light, high noise/distraction, extreme

wet/dry and hot/cold conditions. To be included, a tourniquet device was required to have established application instructions by the manufacturer.

Some studies included a user evaluation for ease, but the defined ratings for users to choose differed from study to study. The working group chose to highlight study results that included Easy or Very Easy and those rated as Difficult or Challenging.

Steps to complete scoring were based on both manufacturer's published instructions and/or established task/conditions/standards outlined in existing DoD training publications. It should be noted that steps were defined as separate actions even if written as single step in the manufacturer's instructions or a publication.

Some studies recorded the number of turns for windlass, clicks for ratchets, or pumps for pneumatics in the course of their analysis. Based on stated findings in those studies that impacted occlusion or application, the working group adopted a scoring measure that was balanced with the findings of the studies.

The scoring was a maximum of ten (10) from a combined score 0–5 for ease of use and 0–5 scored for steps to complete application and/or the number of turns, clicks, or pumps to apply the device.

TABLE 3 *Ease of Use Scoring*

5	>70% Rated as Easy/Very Easy with n>20.
4	>70% Rated as Easy/Very Easy with n<20.
3	50–69% Rated as Easy/Very Easy.
2	20–49% Rated as Easy/Very Easy.
1	<20% Rated as Easy OR <49% Rated as Difficult or Challenging.
0	<20% Rated as Easy OR >50% Rated as Difficult.

Combined with

Steps to Complete and/or Turns/Clicks/Pumps Scoring

5	≤ 6 steps to complete OR <4 turns of windlass OR <5 clicks OR <5 wraps OR <25 pumps.
4	7 steps to complete OR 4–5 turns of windlass OR 5–7 clicks OR 5–7 wraps OR 26–35 pumps.
3	8 steps to complete.
2	9 steps to complete OR 8–15 clicks.
1	10+ steps to complete OR 6+ turns of windlass OR >15 clicks OR 8+ wraps OR 36+ pumps.
0	Not used.

Tourniquet Pressures – It is well established that narrow-band tourniquets and higher tourniquet pressures contribute to iatrogenic injuries.[11] It is also noted that pressures under the tourniquet of applied tourniquets can change within minutes of application.[12,13] There has not been a specific optimal tourniquet pressure range established, but multiple studies have held that a range of 180 to 500mmHg can adequately occlude arterial flow. The predicted occlusion pressure formula is calculated as: (limb circumference/tourniquet width) × 16.67 + 67.[6,14] When using the anthropometric data of military personnel[15] and using the previously referenced formula for predicting the occlusion pressure, the calculated predicted occlusion pressure has a wide range. At the 99th percentile for males, the predicted occlusion pressure is (30.47 inches/1.5 inches) × 16.67 + 67 ≅ 405mmHg for the proximal thigh. The predicted occlusion pressure at the proximal thigh for females at 99th percentile is 388mmHg. The male mean proximal thigh circumference was 24.61 inches for a predicted occlusion pressure of 340mmHg. The mean predicted occlusion pressure for females (proximal thigh) was 336mmHg. As might be expected, the predicted occlusion pressures were significantly lower at the upper arm in both sexes.

TABLE 4 *Tourniquet Pressure Scoring*

5	Within optimal pressure range of 180 and 500mmHg in studies with n >20 considered successful.
4	Within optimal pressure range of 180 and 500mmHg in studies with n <20 considered successful.
3	Not used.
2	Not used.
1	No data.
0	Fails to achieve or exceeds optimal pressure range considered unacceptable.

Tourniquet Specifications – Moving forward with the military tourniquet characteristics established by the 2010 DoD Tourniquet Summit, the following minimum specifications were applied to the review process.[7] Each specification was scored a 1 meeting the requirement or a 0 for not. The critical requirements were determined to width, length, weight and a locking/safety/retention mechanism.

Width – A minimum of 1.5 inches (3.81cm) was established as a critical requirement. Nerve palsy, vascular injury, or indirect pressure injury not associated with the limb trauma have been associated with narrow tourniquets.[11] As the tourniquet width decreases below the optimal minimal width, the pressure that must be generated by that tourniquet to achieve arterial occlusion significantly increases. The localized increase in pressure beneath a narrow tourniquet results in a higher risk of significant underlying tissue injury.[6,14]

Length – A minimum of 37.5 inches (95.25 cm) or capable of achieving the 35 inches circumferential coverage per anthropometric of military personnel.[15] In the survey, it was determined that the mean proximal thigh circumference of a US male soldier was 24.61 inches (SD 2.30) (or 62.51 cm [SD 5.85]). The 99th percentile was 28.13 inches (71.46 cm).

Weight – <8 ounces (226.7 grams) to be considered for inclusion in Individual First Aid Kits (IFAK). A weight of <8 ounces (226.7 grams) has been the established critical limit for tourniquets considered for IFAK inclusion since 2004.[1]

Retention Mechanism – A means of securing the tourniquet so that it will not release. The tourniquet review group determined that in the military environment, a locking, safety or retention mechanism is a critical component of the tourniquet. As casualties must often undergo several methods and stages of evacuation from manual carries or drags to extrication or high-angle rescue to various types of litter movements, the tourniquet requires a mechanism to ensure it cannot easily become unsecure.

Time Recording – An identified location or means on the device for recording the time of application. While time recording

was not identified as a critical requirement, it is desirable as time of application is a need at next level treatment echelons. It was not determined critical in this review but is recommended for all future designs.

Complications and Safety – This review accounted for known reported or published complications, failures, or safety issues of devices and scored as high, medium or low risk. All tourniquets started with a score of 5 for having 0 failure or safety issues. Subsequent scores were based on known reporting through medical literature or official military message traffic. Word-of-mouth reports or rumors are unreliable as they cannot be cited from an official source. This is a critical shortcoming in the casualty documentation, safety and reporting system.

TABLE 5 *Complications Scoring*

5	No Failure Reports.
4	Minor Failure Point in Studies.
4	Mechanical Failure but tourniquet remains functional.
3	Training-based Failure.
2	>5 Mechanical Failure in Studies.
0	Life-threatening failure reported.

Complications were scored as minor if there was a reported failure or mechanical problem, but the tourniquet was still effective in controlling bleeding. There were also instances of training-based failures in many of the studies reviewed. The most common training problem that caused device failure was not pulling strap slack tight enough before twisting windlass rods or ratcheting devices. While this training error is not specifically a device failure, it can cause the device to fail. As some studies recorded such failures against the efficacy of a device, the working group attempted to identify these training failures as a complication for scoring. Mechanical failures that resulted in low scoring were generally reports in one or more studies.

TABLE 6 *Safety Scoring*

5	No safety issues identified.
4	Minor safety issue identified.
3	Environmental safety issue identified.
3	Manufacturer recall safety issue.
1	Significant safety issue identified.
0	Life-threatening safety issue identified.

Significant or life-threatening safety issues were defined by the working group as device problems that signaled a question of efficacy or potential for harm to a patient or rescuer. Environmental safety issues were identified by some studies and the scoring was based on whether the issue effected a device's efficacy and functionality.

Usage Reports – This review accounted for combat usage reports and civilian usage reports in published literature to include studies of deployed usage and/or case reports of usage on casualties. Vendor-supplied reporting was not included in this review. It can be assumed there are many applications of various tourniquets to trauma casualties worldwide, but without reliable documentation or reporting, that data is virtually impossible to capture and is unreliable. As such, all tourniquets started with a score of 2 and were further scored based on findings in the literature.

TABLE 7 *Combat and Civilian Usage Scoring*

5	Usage reports >50 applications.
4	Published case studies with efficacy reports.
3	Known or recorded usage without efficacy reported.
2	Unknown combat or civilian usage (starting score).
1	<80% efficacy reported in usage.
0	Reports of unsuccessful usage or efficacy.

User Preferences – The various tourniquet studies used a myriad of definitions for user preferences making it difficult to assess. In nearly all studies, user preference is also skewed in that most users had previous exposure to one or more of the tourniquets through previous training. For this review, we scaled user preferences as High, Upper, Middle, Lower, Low, or none recorded. Scores were also weighted depending on the number of users in the study.

TABLE 8 *User Preference Scoring*

5	High User Preference >50% (n >20).
4	Upper User Preference >50% (n <20).
3	Middle User Preference 26–49%.
2	Lower User Preference <25% (n <20).
1	Low User Preference <25% (n >20).
0	None Recorded.

Logistics – The primary focus of logistics is the individual unit cost of a tourniquet device. Devices were scored according to their commercial and government-services agency (GSA) established costs. Commercial prices were generally based on the price on the primary vendors website as of 06 AUG 2019. Additional scores were included if the device has an established national stock number (NSN) in the logistics system.

TABLE 9 *Logistics Scoring*

5	YES – NSN in DOD Logistics System.
0	NO – NSN not in DOD Logistics System.
5	Very Low Cost <$15.
4	Low Cost $16–30.
3	Mid Cost $31–45.
2	High Cost $46–100.
1	Very High Cost >$100.

Pain – Pain was not included in the assessment criteria. Several studies considered tourniquet devices to fail in testing due to recipient discomfort. It is established that virtually all successful tourniquet applications will most likely involve significant pain in conscious casualties. As such, tourniquet pain is often inevitable and is a different problem set than hemorrhage control. Tourniquet pain should be addressed by the analgesia recommendations in the TCCC Guidelines. Additionally, other studies have indicated that tourniquet pain is an inadequate measure of effectiveness in training.[16]

The omission of pain as criteria should not be confused with potential twisting or damage of tissue due to the shape, structure or mechanism of a tourniquet if the device cannot even be tolerated during a simple training application.

Scoring – There is a maximum possible score of 50.

Non-Pneumatic Tourniquets Recommended by CoTCCC

Combat Application Tourniquet, Generation 6 (CAT6) – SCORE: 41.74.

The CAT6 was in production and fielded from September 2009 to August 2015 and likely has the most combat uses of all limb tourniquets. The CAT6 has been involved in the most limb tourniquet studies since 2011 as both a comparison anchor for other tourniquets as well as studies of real-world combat usage. Though no longer in production, there possibly remains a significant quantity of CAT6 tourniquets fielded in individual first aid kits and deployment stocks throughout the services.

FIGURE 2 *Combat Application Tourniquet, Generation 6.*

Courtesy North American Rescue, LLC.

https://www.narescue.com/all-products/massive-hemorrhage/combat-application-tourniquet-c-a-t.html

TABLE 10 *CAT6 Occlusion Efficacy*

Total Score	Score	Occlusion Efficacy	n =	Citation
8.95	10	99% effectiveness.	180	17
	9	96% mean effectiveness in bleeding control 10 tests per tourniquet.	10	18
	9	100% occlusion.	10	19
	10	100% effectiveness of unexposed CATs.	50	20
	6	82% effectiveness of exposed CATs to 18 months on a metal roof in San Antonio, TX.	50	20
	10	100% occlusion.	20	21
	9	100% occlusion.	10	22
	10	100% occlusion after prolonged heat exposure (15–unexposed/15–exposed).	30	23
	10	100% occlusion on 15 forearm and 15 calf application.	30	14
	10	96% occlusion after 120 seconds of application on 15 forearm and 15 calf applications.	30	14
	10	100% effectiveness over improvised on HapMed Tourniquet Trainer.	20	24
	6	86% occlusion on arm applications.	46	25
	4	78% occlusion on leg applications.	46	25
	10	100% occlusion on pediatric upper extremities.	60	26
	8	93% occlusion on pediatric lower extremities.	60	26
	8	Leg and arm applications – >90% success with no breakage or deformities reported.	44	27
	10	99.6% Effectiveness assessing single vs double-routing.	240	28
	10	95.2% Effectiveness for unexposed tourniquets.	400	29
	10	97% occlusion.	22	30
	10	100% occlusion.	20	31

TABLE 11 *CAT6 Time of Application*

Total Score	Score	Time (Speed) of Application	n =	Citation
4.64	5	Application time – mean 21 seconds (19–23).	100	20
	4	30 seconds mean time to occlusion.	10	22
	5	Application time – mean 31 seconds.	20	22
	4	Application time – mean 31 seconds.	10	18
	3	Application time – mean 69 seconds.	10	19
	5	Arm application – mean 15 seconds.	46	25
	5	Leg application – mean 18 seconds.	46	12
	5	Leg application time – mean 58.68 seconds (±22.96).	40	27
	5	Arm application time – mean 52.5 seconds (±28.8).	40	27
	5	33.8 seconds mean application time.	22	30
	5	Application time – 28.60 seconds mean.	20	31

TABLE 12 *CAT6 Simplicity of Application*

Total Score	Part Score	Score	Ease of Use	n =	Citation
8.55	3.83	3	Ease of use score of 53% Easy, 29% Neutral, 12% Very Easy, 5% Difficult, 1% Very Difficult – Likert scale with a range of 5 numbers: 1: very difficult, 2: difficult, 3: neutral, 4: easy, and 5: very easy.	100	18
		2	CAT6 was either 29% Easy or 53% Neutral.	10	18
		4	100% Rated as Easy to apply to calf.	16	14
		4	94% Rated as Easy / 6% Rated as Difficult to apply to forearm.	16	14
		5	Application technique simplicity 100% Easy – 5.0 ± 0.2 out of 5.	23	25
		5	Ease of Use rated overall 97.12%.	22	30
	Part Score	**Score**	**Steps to Complete**	**n =**	**Citation**
	4.71	4	One-Handed – 7 steps.	n/a	32
		5	Two-Handed – 6 steps.	n/a	32
		5	59% of CATs required 3 turns to be effective.	166	33
		5	2.35 turns (Range 2–4) mean to occlusion.	20	21
		5	Median 2 turns (min 1–4 max) on calf application.	15	14
		5	Median 1 turn (min 0–3 max) on forearm application.	15	28
		4	Mean 4.00 turns to occlusion.	20	31

TABLE 13 *CAT6 Pressures*

Total Score	Score	Pressures	n =	Citation
4.29	5	322.91mmHg mean combined pressures of all studies.	92	Combined
	4	205mmHg in mean tourniquet pressure.	10	18
	4	202mmHg mean pressure.	10	22
	4	Strap occlusion pressures of 318mmHg (median), 260mmHg (minimum) – 536mmHg (maximum).	12	34
	4	Calf application – pressures at occlusion, completion, and 120 seconds after completion 382 ± 100, 510 ± 108, 424 ± 92mmHg.	15	14
	4	Forearm application – pressures at occlusion, completion, and 120 seconds after completion 301 ± 100, 352 ± 112, 310 ± 98mmHg.	15	14
	5	Occlusion completion pressure mean 360mmHg (147–745mmHg). Three CAT thigh and 9 CAT arm completion pressures were >500mmHg.	61	35

TABLE 14 *CAT6 Specifications*

Total Score	Score	Specifications		Scoring
5	1	Width – ≥1.5 inches (critical requirement).	1.5 inches	1 – Yes / –1 – No
	1	Length – ≥37.50 inches or provide 35 inches circumferential (critical requirement).	37.5 inches	1 – Yes / –1 – No
	1	Locking Mechanism/Method.	Yes	1 – Yes / 0 – No
	1	Time Recording.	Yes	1 – Yes / 0 – No
	1	Weight – <8 ounces (critical for JFAK inclusion).	2.7 oz	1 – Yes / –1 – No

TABLE 15 *CAT6 Complications and Safety*

Total Score	Score	Complications and Safety	n =	Citation
3.25	3	Unexposed CAT6 had 100% effectiveness (50 of 50 tests), whereas exposed devices had 82% effectiveness (41 of 50 tests; p = .003).	50	20
	5	Wet tourniquets neither prolonged application nor did they increase failure rates.	46	25
	5	Heat exposure was not associated with tourniquet damage, inability to gain hemorrhage control, or inability to stop the distal pulse.	30	23
	3	CAT6 was the only tourniquet to experience a mechanical failure. The failure occurred when the windlass was tightened before adequate tension was applied to the main strap.	40	27
	1	Occlusion pressure decrease over 1 minute after occlusion of 44 ± 33mmHg with 17 of 61 applications requiring adjustment.	61	35
	4	1 of 15 calf applications and 0 of 15 forearm applications lost occlusion after 120 seconds from initial occlusion.	30	14
	2	12% of tourniquets worn on plate carrier and exposed to Afghanistan elements broke on testing.	400	29
	3	14/166 exposed versus 0/166 Unexposed broke and had decreased efficacy.	166	33

TABLE 16 *CAT6 Usage*

Total Score	Score	Usage	Citation
3.40	4	70% efficacy reported in 104 combat prehospital applications.	36
	4	152 documented uses in combat.	10
	4	71 documented uses in combat.	37
	5	98% effectiveness (n = 61) reported in civilian multi-institutional study between 2009 and 2014.	38
	0	No user preferences recorded.	

TABLE 17 *CAT6 Logistics*

Total Score	Score	Logistics	
N/A	5	NSN in DoD System.	Same as CAT7
	3	GSA Cost per Unit.	No longer sold as CAT6
	3	Commercial Cost per Unit.	No longer sold as CAT6

Combat Application Tourniquet, Generation 7 (CAT7) – SCORE: 44.00.

The CAT7 has been in production and fielded since September 2015. There are enough changes to assess The CAT7 as a different tourniquet. It should be noted that the modifications developed into the CAT7 are generally the result of findings in studies of the CAT5 and CAT6, as well as feedback from the field.

FIGURE 3 *Combat Application Tourniquet, Generation 7.*

https://www.narescue.com/all-products/massive-hemorrhage/combat-application-tourniquet-c-a-t.html

TABLE 18 *CAT7 Occlusion Efficacy*

Total Score	Score	Occlusion Efficacy	n =	Citation
8.60	10	92% effectiveness using ultrasound to determine popliteal occlusion.	24	39
	10	98.7% effectiveness.	80	40
	4	73% effectiveness.	78	41
	9	97% mean effectiveness in bleeding control 10 tests per tourniquet.	10	18
	10	97.27% combined success rate of arm and leg (110 applications to 55 individuals – 1 arm application and 1 leg with application Doppler confirmation for 1 minute). 3 total failures categorized as User Error (2– tourniquet too loose before twisting, 1–could not apply within 5 minutes.	110	42

TABLE 19 *CAT7 Time of Application*

Total Score	Score	Time (Speed) of Application	n =	Citation
4.86	5	Median time to reach complete arterial occlusion was 37.5 (interquartile range [IQR], 27–52) seconds.	24	39
	5	Time to effective occlusion 27 seconds (11–90).	78	41
	4	Application time – 62 seconds (± 18) to control bleeding.	80	40
	5	43.6 seconds (± 18.2) on 53 arm applications.	53	42
	5	40.4 seconds (± 13.0) on 53 leg applications.	53	42
	5	Application time – 56 seconds (41–71).	24	43
	5	Application time – mean 32 seconds.	10	18

TABLE 20 *CAT7 Simplicity of Application*

Total Score	Part Score	Score	Ease of Use	n =	Citation
8.50	3.83	3	50% rated CAT7 easier to use.	24	39
		5	Difficulty assessment mean 2.3 (Easy) out of 10.	78	41
		4	Mean ease-of-use score was 5 (Easy) ± 0 out of 5.	4	40
		5	Ease of use score of (n = 100) 41% Easy, 33% Very Easy, 17% Neutral, 9% Difficult, 0% Very Difficult.	100	18
		2	37% rated as easy.	110	42
		4	Rated as either easy (41%) or very easy (33%).	10	18
	Part Score	**Score**	**Steps to Complete**	**n =**	**Citation**
	4.66	5	One-Handed – 5 steps.	n/a	44
		5	Two-Handed – 5 steps.	n/a	44
		4	Mean of 3.1 ± 1 turns.	80	40

TABLE 21 *CAT7 Pressures*

Total Score	Score	Pressures	n =	Citation
4.71	5	216.67mmHg mean combined pressures of all studies.	412	Combined
	4	343mmHg ± 116mmHg; p = .0024.	80	40
	5	Interface pressure immediately after occlusion to arm – 189mmHg (± 51).	55	42
	5	Interface pressure immediately after occlusion to leg – 199mmHg (± 37).	55	42
	5	Maximal pressure median – 217mmHg	78	41
	5	Applied pressure, 147mmHg (0–217).	24	43
	4	205mmHg mean tourniquet pressure.	10	18

TABLE 22 *CAT7 Specifications*

Total Score	Score	Specifications		Scoring
5	1	Width – ≥1.5 inches (critical requirement).	1.5 inches	1 – Yes / –1 – No
	1	Length – ≥37.50 inches or provide 35 inches circumferential (critical requirement).	37.50 inches	1 – Yes / –1 – No
	1	Locking Mechanism/Method.	Yes	1 – Yes / 0 – No
	1	Time Recording.	Yes	1 – Yes / 0 – No
	1	Weight – <8 ounces (critical for JFAK inclusion).	2.7 oz	1 – Yes / –1 – No

TABLE 23 *CAT7 Complications and Safety*

Total Score	Score	Complications and Safety	n =	Citation
5	5	No documented complications or safety problems identified in medical literature.	n/a	n/a

TABLE 24 *CAT7 Usage*

Total Score	Score	Usage	Citation
3	2	No combat usage reports.	
	2	No civilian usage reports.	
	5	Ranked 51.9% as preferred tourniquet for arm application (n = 55).	42
	3	Ranked 41.5% as preferred tourniquet for leg application (n = 55).	42

TABLE 25 *CAT7 Logistics*

Total Score	Score	Logistics	
4.33	5	NSN in DoD System.	6515-01-521-7976
	4	GSA Cost per Unit.	$19.60
	4	Commercial Cost per Unit.	$29.99

Special Operations Forces Tactical Tourniquet – Wide (SOFTT-W), Generation 3 – SCORE: 41.39.

The SOFTT-Wide (Generation 3) is a windlass (metal) tourniquet using a hook and buckle interface with a single-piece aluminum windlass rod. It includes a quick-connect snap-lock clasp to preclude rethreading of the strap. It has a retention clip to lock the windlass once applied. The SOFTT-Wide is a wider version based on the original SOFTT design.

FIGURE 4 *Special Operations Forces Tactical Tourniquet – Wide, Generation 3.*

https://www.tacmedsolutions.com/products/hemorrhage-control

TABLE 26 *SOFTT-W Occlusion Efficacy*

Total Score	Score	Occlusion Efficacy	n =	Citation
8.09	9	100% occlusion.	10	13
	10	98% effectiveness of unexposed SOFTT-W.	50	20
	8	90% effectiveness exposed to 18 months on a metal roof in San Antonio, TX.	50	20
	10	100% initial occlusion on 16 forearm and 16 calf applications.	32	14
	7	94% of forearm applications–maintained occlusion after 120 seconds from initial occlusion.	16	14
	3	74% of calf applications–maintained occlusion after 120 seconds from initial occlusion.	16	14
	10	100% occlusion after prolonged heat exposure (15–unexposed/ 15–exposed).	30	23
	10	100% effectiveness in all four positions on thigh (medial, lateral, anterior, and posterior).	80	45
	8	>90% success with no breakage or deformities reported on leg and arm application.	44	27
	4	73.8% occlusion.	22	30
	10	100% occlusion.	20	31

TABLE 27 *SOFTT-W Time of Application*

Total Score	Score	Time (Speed) of Application	n =	Citation
4.50	5	Mean application time 29 seconds (26–29).	100	20
	2	Mean application time 83 seconds.	10	19
	5	Leg application time – mean 58.6 (±22.96).	40	27
	5	Arm application time – mean 52.5 seconds (±8 seconds 28.8).	40	27
	5	45.0 seconds mean application time.	22	30
	5	39.60 seconds mean application time.	20	31

TABLE 28 *SOFTT-W Simplicity of Application*

Total Score	Part Score	Score	Ease of Use	n =	Citation
8.13	3.33	2	31% Rated as Easy / 56% Rated as Challenging / 13% Rated as Difficult to apply to calf.	16	14
		3	62% Rated as Easy / 13% Rated as Challenging / 25% Rated as Difficult to apply to forearm.	16	14
		5	Ease of Use overall 78.96%.	22	30
	Part Score	**Score**	**Steps to Complete**	**n =**	**Citation**
	4.8	5	Looped (one-handed) – 5 steps.	n/a	46
		4	Routed (two-handed) – 7 steps	n/a	46
		5	Median 3 turns (min 2–4 max) on calf application.	16	14
		5	Median 2 turns (min 2–3 max) on forearm application.	16	14
		5	Mean 3.30 turns to occlusion.	20	31

TABLE 29 *SOFTT-W Pressures*

Total Score	Score	Pressures	n =	Citation
4.33	5	203mmHg mean pressure.	90	27
	4	Calf application pressures at occlusion, completion, and 120 seconds after completion 381 ± 81, 457 ± 103, 407 ± 88mmHg.	16	14
	4	Forearm application pressures at occlusion, completion, and 120 seconds after completion 321 ± 70, 397 ± 102, 346 ± 91mmHg.	16	14

TABLE 30 *SOFTT-W Specifications*

Total Score	Score	Specifications		Scoring
5	1	Width – ≥1.5 inches (critical requirement).	1.5 inches	1 – Yes / –1 – No
	1	Length – ≥37.50 inches or provide 35 inches circumferential (critical requirement).	44.75 inches	1 – Yes / –1 – No
	1	Locking Mechanism/Method.	YES	1 – Yes / 0 – No
	1	Time Recording.	YES	1 – Yes / 0 – No
	1	Weight – <8 ounces (critical for JFAK inclusion).	4 oz	1 – Yes / –1 – No

TABLE 31 *SOFTT-W Complications and Safety*

Total Score	Score	Complications and Safety	n =	Citation
4.0	3	Unexposed SOFTT-W devices had 98% effectiveness (49 of 50 tests); whereas exposed devices had 90% effectiveness (45 of 50; all p = .204).	50	20
	5	Heat exposure was not associated with tourniquet damage, inability to gain hemorrhage control, or inability to stop the distal pulse.	30	23

TABLE 32 *SOFTT-W Usage*

Total Score	Score	Usage	Citation
3.0	4	5 uses in combat documented in medical literature.	10
	2	No civilian usage documented in medical literature.	n/a

TABLE 33 *SOFTT-W Logistics*

Total Score	Score	Logistics	
4.33	5	NSN in DoD System.	6515-01-587-9943
	4	GSA Cost per Unit.	$22.99
	4	Commercial Cost per Unit.	$29.93

Tactical Mechanical Tourniquet (TMT) – SCORE: 40.31.

The TMT is a windlass (composite) tourniquet using Velcro adhesion to strap with a single-routed buckle and/or hooking link.

FIGURE 5 *Tactical Mechanical Tourniquet.*

https://combatmedical.com/product/tmt-tourniquet/

TABLE 34 *TMT Occlusion Efficacy*

Total Score	Score	Occlusion Efficacy	n =	Citation
8.29	4	71% effectiveness using ultrasound to determine popliteal occlusion; It should be noted that this study identified "pain not tolerated" deemed as a tourniquet failure.	24	39
	10	100% occlusion of the popliteal artery.	24	47
	8	90.91% combined success rate of arm and leg –1 arm application and 1 leg with application Doppler confirmation for 1 minute).	110	42
	8	95% occlusion.	20	21
	9	100% occlusion.	10	19
	10	100% occlusion of arm (40 applications) and leg (40 applications) within 5 minutes; maintaining occlusion for 1 full minute. 5 of 40 arm and 8 of 40 leg applications had re-bleeding occur requiring further tightening/ adjustment to regain occlusion.	80	48
	9	100% occlusion effectiveness achieved and maintained on 5 leg applications and 5 arm applications.	10	7

TABLE 35 *TMT Time of Application*

Total Score	Score	Time (Speed) of Application	n =	Citation
4.10	5	Median time to reach complete arterial occlusion was 35 (IQR, 29–42) seconds.	24	39
	2	67.6 seconds (± 30.5) on 50 arm applications; initial strap tension 35.9 seconds (± 15.0); tighten and secure 31.7 seconds (± 23.6).	50	42
	5	48.0 seconds (± 13.2) on 49 leg applications; initial strap tension 23.2 seconds (± 7.1); tighten and secure 24.8 seconds (± 9.2). The hooked clasp enables it to be routed quickly with no rethread requirements.	49	42
	5	Application time – 16 seconds (12–20).	24	47
	3	Application time – 66 seconds.	10	19
	5	Application time – mean 40 seconds	20	21
	4	Dry/Light applications – 55.8 ± 17.9 seconds	10	48
	4	Wet/Dark applications – 89.1 ± 35.05 seconds.	10	48
	4	Leg application time – 53.6 (± 10.9) seconds.	5	7
	4	Arm application time – 30.0 (± 4.8) seconds.	5	14

TABLE 36 *TMT Simplicity of Application*

Total Score	Part Score	Score	Ease of Use	n =	Citation
7.17	2.50	3	50% Rated TMT Easier to use.	24	39
		2	24% Rated as Easy.	110	42
	Part Score	Score	Steps to Complete	n =	Citation
	4.66	5	One-Handed – 5 steps.	n/a	49
		4	One-Handed – 7 steps including sub-steps.	n/a	49
		5	Two-Handed – 6 steps.	n/a	49
		4	Two-Handed – 7 steps including sub-steps.	n/a	49
		5	3.8 turns to occlusion (3–4).	24	47
		5	2 turns to occlusion.	20	21

TABLE 37 *TMT Pressures*

Total Score	Score	Pressures	n =	Citation
4.43	5	193.83mmHg mean combined pressures of all studies	250	Combined
	5	Interface pressure immediately after occlusion to arm – 180mmHg (± 54).	110	42
	5	Interface pressure immediately after occlusion to leg – 211mmHg (± 50).	110	42
	4	Leg contact pressure mean 198mmHg.	10	48
	4	Arm contact pressure mean 220mmHg.	10	48
	4	Contact pressure on HapMed Leg Tourniquet Trainer mean of 205mmHg.	5	7
	4	Contact pressure on HapMed Arm Tourniquet Trainer mean of 160mmHg.	5	7

TABLE 38 *TMT Specifications*

Total Score	Score	Specifications		Scoring
5	1	Width – ≥1.5 inches (critical requirement).	2.0 inches	1 – Yes / –1 – No
	1	Length – ≥37.50 inches or provide 35 inches circumferential (critical requirement).	38.68 inches	1 – Yes / –1 – No
	1	Locking Mechanism/Method.	Yes	1 – Yes / 0 – No
	1	Time Recording.	Yes	1 – Yes / 0 – No
	1	Weight – <8 ounces (critical for JFAK inclusion).	2.9 oz	1 – Yes / –1 – No

TABLE 39 *TMT Complications and Safety*

Total Score	Score	Complications and Safety	n =	Citation
5	5	No Reported Failures/Problems.	n/a	n/a
	5	No Reported/Known Safety Issues.	n/a	n/a

TABLE 40 *TMT Usage*

Total Score	Score	Usage	Citation
2	2	No combat usages documented in medical literature.	n/a
	2	No civilian usages documented in medical literature.	n/a
	1	Ranked 9.3% as preferred tourniquet for arm application (n = 55).	42
	3	Ranked 28.3% as preferred tourniquet for leg application (n = 55).	42

TABLE 41 *TMT Logistics*

Total Score	Score	Logistics	
4.33	5	NSN in DoD System.	6515-01-656-6191
	4	GSA Cost per Unit.	$19.85
	4	Commercial Cost per Unit.	$29.95

M2 Design – Ratcheting Tourniquets including Ratcheting Medical Tourniquet-Tactical (RMT-T) and TX2 and TX3 Tourniquets – SCORE: 41.83.

Ratcheting mechanism with single loop self-locking buckle. Includes M2 ratchet-based tourniquets RMT-Tactical, TX-2 and TX-3 which are MILSPEC compliant. This review does not include or recommend other non-military versions of the RMT.

FIGURE 6 *Ratcheting Medical Tourniquet – Tactical.*

https://www.ratchetingbuckles.com/ratchet-buckles-ladder-straps/ratcheting-medical-tourniquet-tactical/

FIGURE 7 *TX2 and TX3.*

https://www.revmedx.com/tx-tourniquets/

TABLE 42 *M2/RMT-T/TX2/TX3 Occlusion Efficacy*

Total Score	Score	Occlusion Efficacy	n =	Citation
9.29	8	94.55% combined success rate of arm and leg applications (110 applications to 55 individuals – 1 arm application and 1 leg with application Doppler confirmation for 1 minute). 6 total failures categorized 2 as User Error (same as CAT7), 1 as over 300mmHg pressure and 3 as "Discomfort."	110	42
	10	100% effectiveness of unexposed RMT.	50	20
	10	96% effectiveness exposed to 18 months on a metal roof in San Antonio, TX.	50	20
	9	100% occlusion.	10	19
	10	100% occlusion after prolonged heat exposure (15–unexposed/ 15–exposed).	30	23
	8	Leg and arm application – >90% success with no breakage or deformities reported.	44	27
	10	100% occlusion.	20	31

TABLE 43 *M2/RMT-T/TX2/TX3 Time of Application*

Total Score	Score	Time (Speed) of Application	n =	Citation
4.71	5	44.2 seconds (± 22.3) on 53 arm applications; initial strap tension 28.8 seconds (± 17.0); tighten and secure 15.4 seconds (± 12.3).	53	42
	5	47.4 seconds (± 17.9) on 50 leg applications; initial strap tension 30.7 seconds (± 10.5); tighten and secure 16.7 seconds (± 13.8).	50	42
	5	Application time – mean 24 seconds (22–35).	100	20
	3	Application time – 69 seconds	10	19
	5	Leg application time – mean 58.68 seconds (±22.96).	40	27
	5	Arm application time – mean 52.5 seconds (±28.8).	40	27
	5	Application time – 29.27 seconds.	20	31

TABLE 44 *M2/RMT-T/TX2/TX3 Simplicity of Application*

Total Score	Part Score	Score	Ease of Use	n =	Citation
8.17	4.33	5	100% Rated as Easy to apply to Calf.	16	14
		5	100% Rated as Easy to apply to Forearm.	16	14
		3	57% Rated as Easy.	110	42
	Part Score	**Score**	**Steps to Complete**	**n =**	**Citation**
	3.83	5	RMT 4 steps.	n/a	50
		5	TX2/TX3 4 steps.	n/a	51
		4	Median 6.5 clicks (min 4 – 9 max) on calf application.	16	14
		5	Median 3 clicks (min 0–5 max) on forearm application.	16	14
		2	RMT-CBT – mean 12.30 clicks.	20	31
		2	RMT-TAC – mean 14.80 clicks.	20	31

TABLE 45 *M2/RMT-T/TX2/TX3 Pressures*

Total Score	Score	Pressures	n =	Citation
4.75	5	263.2mmHg mean combined pressures of all studies.	322	Combined
	5	Interface pressure immediately after occlusion to arm – 172mmHg (± 62).	110	42
	5	Interface pressure immediately after occlusion to leg – 200mmHg (± 45).	110	42
	4	Strap occlusion pressures of 328mmHg (median), 160mmHg (minimum), 472mmHg (maximum).	12	34

TABLE 46 *M2/RMT-T/TX2/TX3 Specifications*

Total Score	Score	Specifications		Scoring
4	1	Width – ≥1.5 inches (critical requirement).	1.5 inches and 2 inches	1 – Yes / –1 – No
	1	Length – ≥37.50 inches or provide 35 inches circumferential (critical requirement).	38.5 inches	1 – Yes / –1 – No
	1	Locking Mechanism/ Method.	YES	1 – Yes / 0 – No
	0	Time Recording.	NO	1 – Yes / 0 – No
	1	Weight – <8 ounces (critical for JFAK inclusion).	4.2 oz	1 – Yes / –1 – No

TABLE 47 *M2/RMT-T/TX2/TX3 Complications and Safety*

Total Score	Score	Complications and Safety	n =	Citation
4.50	4	Unexposed RMT devices had 100% effectiveness (50 of 50 tests), whereas exposed devices had 96% effectiveness (48 of 50 tests; all p = .495).	50	20
	5	Heat exposure was not associated with tourniquet damage, inability to gain hemorrhage control, or inability to stop the distal pulse.	30	23

TABLE 48 *M2/RMT-T/TX2/TX3 Usage*

Total Score	Score	Usage	Citation
2.75	3	2 uses in combat documented in medical literature.	37
	2	No civilian usage documented in medical literature.	n/a
	3	Ranked 38.9% as preferred tourniquet for arm application (n = 55).	42
	3	Ranked 30.2% as preferred tourniquet for leg application (n = 55).	42

TABLE 49 *M2/RMT-T/TX2/TX3 Logistics*

Total Score	Score	Logistics	
3.67	5	NSN in DoD System.	6515-01-527-3841 (RMT-T) 6515-01-667-6027 (TX2) 6515-01-667-6208 (TX3)
	3	GSA Cost per Unit.	RMT-T $30.16 TX2 – $36.45 TX3 – $37.95
	3	Commercial Cost per Unit.	RMT-T $35.95 TX2 – $38.95 TX3 – $38.95

SAM Extremity Tourniquet (SAM-XT) – SCORE: 40.80.

The SAM-XT is a windlass (composite) tourniquet using Velcro adhesion to strap with single routed tension-locking buckle.

FIGURE 8 *SAM Extremity Tourniquet.*

http://www.sammedical.com/products/sam-xt

TABLE 50 *SAM-XT Occlusion Efficacy*

Total Score	Score	Occlusion Efficacy	n =	Citation
8.20	10	97.5% effectiveness.	80	40
	9	100% occlusion with untrained firefighters to assess mentored application.	12	52
	8	94% occlusion self-applied thigh application by Law Enforcement Officers.	32	53
	10	100% occlusion medical-trained individuals using 911-dispatch mentoring.	31	54
	4	73% occlusion on HapMed Leg Tourniquet Trainers simulators by IDF Cadets.	60	55

TABLE 51 *SAM-XT Time of Application*

Total Score	Score	Time (Speed) of Application	n =	Citation
3.60	2	Application time – 70 seconds (± 30) to control bleeding.	80	40
	3	Application time – 140 seconds with untrained firefighters to assess mentored application.	12	52
	4	Application time – 86 seconds median through 911 dispatch over-the-phone mentoring.	31	54
	5	Application time – >45 seconds for 94% of participant.	32	53
	4	Application time – 9–15 seconds upper arm.	10	56

It should be noted that two of the studies of the SAM-XT involved users who were either untrained on the device or were tele-mentored on how to apply the tourniquet. As such, these studies resulted in extended application times. In contrast, for the two other studies involving the SAM-XT, the applications times for the SAMXT and CAT7 were not statistically different.

TABLE 52 *SAM-XT Simplicity of Application*

Total Score	Part Score	Score	Ease of Use	n =	Citation
9	4.0	4	Mean ease-of-use score was 5 (Easy) ± 0 out of 5.	4	40
		4	Ease of use reported >70% as easy with "click" of tourniquet.	12	52
	Part Score	**Score**	**Steps to Complete**	**n =**	**Citation**
	5.0	5	5 steps.	n/a	57
		5	Mean of 2.9 ± 1 turns to occlusion.	80	40

TABLE 53 *SAM-XT Pressures*

Total Score	Score	Pressures	n =	Citation
5	5	Mean of 186.07mmHg (± 62.957).	60	55
	5	320mmHg (± 102).	80	40
	5	287mmHg (220–424).	31	54

TABLE 54 *SAM-XT Specifications*

Total Score	Score	Specifications		Scoring
5	1	Width – ≥1.5 inches (critical requirement)	1.5 inches	1 – Yes / –1 – No
	1	Length – ≥37.50 inches or provide 35 inches circumferential (critical requirement).	35 inches circumferential	1 – Yes / –1 – No
	1	Locking Mechanism/ Method.	Yes	1 – Yes / 0 – No
	1	Time Recording.	Yes	1 – Yes / 0 – No
	1	Weight – <8 ounces (critical for JFAK inclusion).	3.8 oz	1 – Yes / –1 – No

TABLE 55 *SAM-XT Complications and Safety*

Total Score	Score	Complications and Safety	n =	Citation
5	5	No reported complications in medical literature.	n/a	n/a
	5	No reported safety issues in medical literature.	n/a	n/a

The manufacturer conducted a self-imposed recall of the SAM-XT in May 2018. Based on internal testing, results indicated a possible failure of the stitches securing the buckle to the nylon belt could occur, posing a potential risk when used on a human patient to stop arterial blood flow. No injuries, deaths, or training failures were reported from field users.[58]

TABLE 56 *SAM-XT Usage*

Total Score	Score	Usage	Citation
1.33	2	No combat usage documented in medical literature.	n/a
	2	No civilian usage documented in medical literature.	n/a
	0	No user preferences documented in medical literature.	n/a

TABLE 57 *SAM-XT Logistics*

Total Score	Score	Logistics	
3.67	5	NSN in DoD System.	6515-01-670-2240
	3	GSA Cost per Unit.	$37.46
	3	Commercial Cost per Unit.	$37.95

Pneumatic Tourniquets Recommended by CoTCCC

Pneumatic tourniquets are not recommended for inclusion in the Joint First Aid Kit (JFAK) or as the initial tourniquet for application in care under fire. However, pneumatic tourniquets are recommended as considerations for medics and providers in tactical field care, evacuation platforms and Role I/II/III teams. The primary consideration for the use of pneumatic tourniquets is for replacement of previously applied tourniquets, tourniquet conversion, or prolonged application. Speed and simplicity of application are less concerning as these devices would be used in more secure situations when tourniquet replacement or conversion would be considered. As noted in the TCCC Guidelines and previous tourniquet guidelines[11] high and tight tourniquets placed in Care Under Fire should be replaced with more appropriately placed tourniquets when time and the tactical situation permits. In this situation, the application of prehospital pneumatic tourniquets could be considered if available.

Delfi Emergency and Military Tourniquet (EMT) – SCORE: 38.00.

This is a pneumatic tourniquet similar to blood pressure cuff looped through a locking clamp. The EMT was one of the original tourniquets recommended by CoTCCC in 2005. As a pneumatic, it has less consideration for the application in the combat environment due to the assumption that it could be easily punctured or damaged. As such, it has not been commonly carried by prehospital providers.

FIGURE 9 *Delfi Emergency and Military Tourniquet*

http://www.delfimedical.com/emergency-military-tourniquet/

TABLE 58 *Delfi EMT Occlusion Efficacy*

Total Score	Score	Occlusion Efficacy	n =	Citation
9.33	10	100% occlusion.	30	18
	9	100% occlusion.	10	19
	9	100% occlusion.	10	22
	8	Leg and arm application – >90% success with no breakage or deformities reported.	44	27
	10	100% occlusion.	20	31
	10	Leg applications with 100% occlusion.	30	1

TABLE 59 *Delfi EMT Time of Application*

Total Score	Score	Time (Speed) of Application	n =	Citation
4.67	5	47 seconds mean application time.	30	18
	4	Application time 59.1 seconds (± 8.9).	10	19
	4	38 seconds mean time to occlusion.	10	22
	5	Leg application time – mean 58.68 seconds (±22.96).	40	27
	5	Arm application time – mean 52.5 seconds (±28.8).	40	27
	5	Application time – 22.23 seconds.	20	31

TABLE 60 *Delfi EMT Simplicity of Application*

Total Score	Part Score	Score	Ease of Use	n =	Citation
5.67	1	1	No documented ease of use ratings in medical literature.	n/a	n/a
	Part Score	Score	Steps to Complete	n =	Citation
	4.66	5	Looped – 3 steps.	n/a	59
		5	Routed – 4 steps.	n/a	59
		4	Mean of 35 pumps.	30	60

TABLE 61 *Delfi EMT Pressures*

Total Score	Score	Pressures	n =	Citation
4.67	5	164mmHg mean combined pressures of all studies.	58	combined
	5	Mean 147mmHg – EMT tended to require slightly less pressure to achieve occlusion on the HapMed Leg Tourniquet Trainer.	48	27
	4	160mmHg mean pressure.	10	22

TABLE 62 *Delfi EMT Specifications*

Total Score	Score	Specifications		Scoring
4	1	Width – ≥1.5 inches (critical requirement).	3.5 inches	1 – Yes / –1 – No
	1	Length – ≥37.50 inches or provide 35 inches circumferential (critical requirement).	40.3 inches	1 – Yes / –1 – No
	1	Locking Mechanism/Method.	Yes	1 – Yes / 0 – No
	0	Time Recording.	No	1 – Yes / 0 – No
	1	Weight – <8 ounces (critical for JFAK inclusion).	7.8 oz	1 – Yes / –1 – No

TABLE 63 *Delfi EMT Complications and Safety*

Total Score	Score	Complications and Safety	n =	Citation
5	5	No reported complications in medical literature.	n/a	n/a
	5	No reported safety issues in medical literature.	n/a	n/a

TABLE 64 *Delfi EMT Usage*

Total Score	Score	Usage	Citation
2.33	5	Combat Usage: 106 (92%) of 115 device applications effective with 9 (8%) being ineffective.	61
	2	No civilian usage documented in medical literature.	n/a
	0	No user preferences documented in medical literature.	n/a

TABLE 65 *Delfi EMT Logistics*

Total Score	Score	Logistics	
2.33	5	NSN in DoD System.	6515-01-580-1645
	1	GSA Cost per Unit.	$426.54
	1	Commercial Cost per Unit.	$475.00

Tactical Pneumatic Tourniquet 2 Inches (TPT2) – SCORE: 34.62).

The TPT2 is a pneumatic tourniquet designed with an inner and outer cover which join in a Y-shape with the pneumatic bladder housed within the inner cover. It is secured with Velcro and a slider buckle and then inflated similar to a blood pressure cuff.

FIGURE 10 *Tactical Pneumatic Tourniquet, 2 inches.*

http://www.alphapointe.org/category/alphapointe-news/

TABLE 66 *TPT2 Occlusion Efficacy*

Total Score	Score	Occlusion Efficacy	n =	Citation
8.83	10	100% occlusion of the popliteal artery.	24	47
	9	100% occlusion.	10	19
	10	100% occlusion.	30	60
	9	100% occlusion.	10	22
	10	100% occlusion of Arm (40 applications) and Leg (40 Applications) within 5 minutes; maintaining occlusion for 1 full minute. 2 of 40 Arm and 2 of 40 Leg applications had re-bleeding occur requiring further tightening / adjustment to regain occlusion.	80	48
	5	80% occlusion effectiveness achieved and maintained on 5 leg applications and 5 arm applications (2 failed to maintain occlusion due to leaks in the air bladders).	10	7

TABLE 67 *TPT2 Time of Application*

Total Score	Score	Time (Speed) of Application	n =	Citation
3.25	5	Application time 11 seconds (7–12).	24	47
	3	Application time 87.6 seconds (± 19.6).	10	19
	4	35 seconds mean time to stop occlusion.	10	22
	2	90 seconds mean application time.	30	60
	4	Dry/Light applications – 55.3 seconds (± 15.4).	10	48
	0	Wet/Dark applications – 91.8 seconds (± 58.1).	10	48
	4	Leg application time – 56.2 seconds (± 12.5).	5	7
	4	Arm application time – 37.3 seconds (± 5.3).	5	7

TABLE 68 *TPT2 Simplicity of Application*

Total Score	Part Score	Score	Ease of Use	n =	Citation
4	1	1	No documented ease of use ratings in medical literature.	n/a	n/a
	Part Score	Score	Steps to Complete	n =	Citation
	3	4	7 Steps to apply.	n/a	62
		4	Pumps to occlusion 30.5 (25–32).	24	47
		1	Mean of 51 pumps.	30	60

TABLE 69 *TPT2 Pressures*

Total Score	Score	Pressures	n =	Citation
4.20	5	189.6mmHg mean combined pressures of all studies.	34	combined
	4	183mmHg mean pressure.	10	22
	4	Mean leg contact pressure 215mmHg.	10	48
	4	Mean arm contact pressure 215mmHg.		48
	4	TPT2 contact pressure on HapMed Leg Tourniquet Trainer [n = 4] mean of 210mmHg [and HapMed Arm Tourniquet Trainer [n = 4] mean of 125mmHg.	8	7

TABLE 70 *TPT2 Specifications*

Total Score	Score	Specifications		Scoring
5	1	Width – ≥1.5 inches (critical requirement).	2 inches	1 – Yes / –1 – No
	1	Length – ≥37.50 inches or provide 35 inches circumferential (critical requirement).	39.75 inches	1 – Yes / –1 – No
	1	Locking Mechanism/ Method.	Yes	1 – Yes / 0 – No
	1	Time Recording.	Yes	1 – Yes / 0 – No
	1	Weight – <8 ounces (critical for JFAK inclusion).	5.02 oz	1 – Yes / –1 – No

TABLE 71 *TPT2 Complications and Safety*

Total Score	Score	Complications and Safety	n =	Citation
5	5	No reported complications in medical literature.	n/a	n/a
	5	No reported safety issues in medical literature.	n/a	n/a

TABLE 72 *TPT2 Usage*

Total Score	Score	Usage	Citation
1.33	2	No combat usage documented in medical literature.	n/a
	2	No civilian usage documented in medical literature.	n/a
	0	No user preferences documented in medical literature.	n/a

TABLE 73 *TPT2 Logistics*

Total Score	Score	Logistics	
	5	NSN in DoD System.	6515-01-656-4831
	2	GSA Cost per Unit.	$55.69
	2	Commercial Cost per Unit.	$60.00

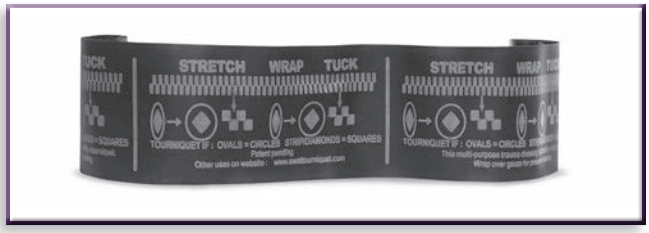
Tourniquets Not Currently Recommended by CoTCCC

The following tourniquet devices are not currently recommended by the CoTCCC as military tourniquets. These devices either have limited data for review or have data that scored too low to be considered for recommendation. Lack of comparative data is the critical consideration for lack of inclusion of some of these tourniquets in the current recommendations.

Stretch-Wrap-And-Tuck Tourniquet (SWAT-T) – SCORE: 28.47.

The SWAT-T is an elastic band applied with circumferential stretching and wrapping to around a limb to create compression.

FIGURE 11 *Stretch-Wrap-And-Tuck-Tourniquet.*



http://www.swat-t.com/products.html

TABLE 74 *SWAT-T Occlusion Efficacy*

Total Score	Score	Occlusion Efficacy	n =	Citation
4.80	10	100% occlusion on 16 forearm and 16 calf applications.	32	14
	10	100% occlusion after 120 seconds of application on 16 forearm and 16 calf applications.	32	14
	0	Average of 47% success rate in four experimental conditions and deemed not eligible to move on to Phase IIb.	40	27
	4	77% mid-thigh Doppler success rate observed when properly stretched.	150	63
	0	30% occlusion success. Failed to obtain occlusion for 70% of tests.	20	31

TABLE 75 *SWAT-T Time of Application*

Total Score	Score	Time (Speed) of Application	n =	Citation
1.67	0	Required, on average, 173.08 seconds (+82.14) to apply.	40	27
	0	Required on the average 149 seconds to apply.	20	31
	5	Average application times were <40 seconds for all locations (31 ± 6 seconds male, 34 ± 13 seconds female; p = .02).	150	63

TABLE 76 *SWAT-T Simplicity of Application*

Total Score	Part Score	Score	Ease of Use	n =	Citation
6.73	2.33	4	75% Rated as Easy / 25% Rated as Challenging to apply to calf.	16	14
		4	88% Rated as Easy / 12% Rated as Challenging to apply to forearm.	16	14
		1	The SWAT were the most difficult for the volunteers to apply and tended to require multiple adjustments and reapplications to achieve occlusion.	40	27
		2	Applications were rated Easy (101/67%), Challenging (37/25%), Difficult (12/8%).	150	63
		1	Reported 16 instances in which the volunteer had to reapply the tourniquet to achieve occlusion, contributing to longer application times.	48	27
		2	If occlusion was obtained, securing the tourniquet was very difficult and would come unsecured with little effort.	20	31
	Part Score	Score	Steps to Complete	n =	Citation
	4.40	4	One-Handed – 7 Steps.	n/a	64
		5	Two-Handed – 4 Steps.	n/a	64
		4	Median 5.25 wraps (minimum 3.5 – 6.5 maximum) on calf application.	16	14
		4	Median 6 wraps (minimum 4.5 – 7.5 maximum) on forearm application.	16	14
		5	4.50 wraps (mean).	20	31

TABLE 77 *SWAT-T Pressures*

Total Score	Score	Pressures	n =	Citation
4.60	5	258mmHg mean combined pressures of all studies.	199	combined
	5	190mmHg mean – tended to require slightly less pressure to achieve occlusion on the HapMed Leg Tourniquet Trainer.	48	27
	4	Calf application pressures at occlusion, completion, and 120 seconds after completion 212 ± 46, 294 ± 59, 287 ± 57mmHg	16	14
	4	Forearm application (n = 15) pressures at occlusion, completion, and 120 seconds after completion 181 ± 34, 308 ± 70, 302 ± 70mmHg	16	14
	5	Occlusion completion pressure mean 290mmHg (136–449)	61	35

TABLE 78 *SWAT-T Specifications*

Total Score	Score	Specifications		Scoring
3	1	Width – ≥1.5 inches (critical requirement).	3.95 inches	1 – Yes / –1 – No
	1	Length – ≥37.50 inches or provide 35 inches circumferential (critical requirement).	54.40 inches	1 – Yes / –1 – No
	0	Locking Mechanism/ Method.	No	1 – Yes / 0 – No
	0	Time Recording.	No	1 – Yes / 0 – No
	1	Weight – <8 ounces (critical for JFAK inclusion).	3.79 oz	1 – Yes / –1 – No

TABLE 79 *SWAT-T Complications and Safety*

Total Score	Score	Complications and Safety	n =	Citation
3.0	4	Occlusion pressure decrease over 1 minute after occlusion of 6mmHg (± 8) with 5 of 61 applications requiring adjustment.	61	35
	2	SWAT had a combination of breakages, including two critical failures where the device material ripped during application. The physical requirement for application was difficult for several of the volunteers and made applying and securing the device unobtainable.	48	27

TABLE 80 *SWAT-T Usage*

Total Score	Score	Usage	Citation
1.33	2	No combat usage documented in medical literature.	n/a
	2	No civilian usage documented in medical literature.	n/a
	0	No user preferences documented in medical literature.	n/a

TABLE 81 *SWAT-T Logistics*

Total Score	Score	Logistics	
3.33	0	NSN in DoD System.	NONE
	5	GSA Cost per Unit.	$11.52
	5	Commercial Cost per Unit.	$17.95

Special Operations Forces Tactical Tourniquet (SOFTT) – SCORE: 34.17.

The original SOFTT is a windlass (metal) tourniquet with a strap and single-routed gripping buckle. Based on reviewed data, it was recommended that the original SOFTT be removed from the CoTCCC-recommended tourniquets list. In contrast, the SOFTT-Wide is CoTCCC-recommended and based on available data seems to be the device predominantly fielded since circa 2012. Only two studies in 2015 by Heldenberg et al.[25] and in 2013 by Savage et al.[30] involved the SOFTT whereas all others were circa 2005 to 2007. Compression pressure data were scored only 1 point as there was no pressure data on the SOFTT found in the medical literature. Further, the SOFTT is only 1 inch wide which does not meet the 1.5 inches minimum width requirements established by the tourniquet working group and previous consensus.[6,7,65,66]

FIGURE 12 *Special Operations Forces Tactical Tourniquet.*

https://www.tacmedsolutions.com/products/hemorrhage-control

Combat uses of the SOFTT have been reported as 4 uses in 2011[37] and 70 used SOFTTs recovered during a period from 2010 to 2012.[10] There is also evidence of 66% effectiveness (n = 62) of combat applied SOFTT device in 2008.[61]

TABLE 82 *SOFTT Occlusion Efficacy*

Total Score	Score	Occlusion Efficacy	n =	Citation
4.33	6	Arm application 80% occlusion success.	46	25
	4	Leg application 77% occlusion success.	46	25
	4	72.7% occlusion.	22	30
	2	Arm applications with 68.18% occlusion.	25	67
	0	Leg applications with 48.0% occlusion.	25	67
	10	Leg and arm applications with 100% occlusion.	30	1

TABLE 83 *SOFTT Time of Application*

Total Score	Score	Time (Speed) of Application	n =	Citation
4	5	Arm application at mean 21 seconds.	46	25
	5	Leg application at mean 26 seconds.	46	25
	5	48.2 seconds mean application time	22	30
	0	Arm applications with mean time of 129.6 seconds (± 74.5).	25	67
	5	Leg applications with mean time of 56.3 seconds (± 25.2).	25	67

TABLE 84 *SOFTT Simplicity of Application*

Total Score	Part Score	Score	Ease of Use	n =	Citation
10	5	5	Application technique simplicity 80% Easy – 4.0 ± 0.8 out of 5.	46	25
		5	Ease of Use overall 73.6%.	22	30
	Part Score	Score	Steps to Complete	n =	Citation
	5	5	One Handed – 5 Steps.	n/a	68
		5	Two-Handed – 6 Steps.	n/a	68

TABLE 85 *SOFTT Specifications*

Total Score	Score	Specifications	Scoring
3	–1	Width – ≥1.5 inches (critical requirement).	1 – Yes / –1 – No
	1	Length – ≥37.50 inches or provide 35 inches circumferential (critical requirement).	1 – Yes / –1 – No
	1	Locking Mechanism/Method.	1 – Yes / 0 – No
	1	Time Recording.	1 – Yes / 0 – No
	1	Weight – <8 ounces (critical for JFAK inclusion).	1 – Yes / –1 – No

Israeli Emergency Silicon Tourniquet (IEST) – SCORE: 33.90.

The IEST is a silicon-based elastic-type band applied with circumferential stretching and wrapping around the limb to achieve occlusion pressure. There is one (1) study on the IEST in the literature searched from 2011 to 2018. The single study by Glick et al. reported a 91% occlusion effectiveness (n = 78); application time of mean 33 seconds to effective occlusion (5–74); a maximal pressure median of 261mmHg; and a difficulty assessment mean of 2.8 (easy) of a possible 10.[41] The IEST is 2.5 inches wide, 78 inches long, and weighs 4.3 oz but does not have a locking or recording mechanism. The documented combat usage was reported in 2002 as a combination of commercial silicon and improvised tourniquets with no significant difference between the two.[69] 78% of the tourniquet applications (n = 110) were effective with 94% effectiveness to upper limbs and 71% effectiveness to lower limbs.[69] The IEST was determined by the working group to have insufficient study data to make recommendations at this time.

FIGURE 13 *Israeli Emergency Silicone Tourniquet/*

https://israelifirstaid.com/6-5-feet-2-m-2-5-inches-6-5-cm-emergency-silicone-tourniquet/

Mechanical Advantage Tourniquet (MAT) – SCORE: 29.33.

The MAT is a C-shaped plastic and hooked strap applied around the limb with an integrated mechanical tightening system. The most recent publication in medical literature including the MAT was in 2009 as a case report in which the MAT was applied a short distance above the knee, but successful hemostasis was achieved only when it was moved proximally to the mid-thigh. No compression pressure data were found in medical literature and only one study reported application times of mean 60.7 seconds (± 31.0) for arm applications (n = 25) and 46.6 seconds (± 12.0) for leg applications (n = 25).[67] Based on available data, the MAT was not included in the current CoTCCC-recommended tourniquets list.

FIGURE 14 *Mechanical Advantage Tourniquet.*

http://www.pyng.com/products/matcombat/

TABLE 86 *MAT Occlusion Efficacy*

Total Score	Score	Occlusion Efficacy	n =	Citation
4.50	8	92.0% occlusion on arm applications.	25	67
	2	69.5% occlusion on leg applications.	25	67
	5	88% effectiveness in phase I tests.	16	1
	3	75% success rates led to the no further testing of the MAT in phase II tests.	12	1

Military Emergency Tourniquet (MET) and Response TK (RTK) – SCORE: 28.40.

The MET and RTK are open-loop windlass (aluminum) tourniquets using Velcro adhesion to strap with a single-routed buckle. The MET scored a 5.50 out of 10 for occlusion efficacy with only three studies found in literature (Table 87). No compression pressure data were found in medical literature. Based on available data, the Military Emergency Tourniquet (MET) was not included in the current CoTCCC-recommended tourniquets list. The MET was mentioned as one of the most difficult tourniquets for the volunteers to apply and tended to require multiple adjustments and reapplications to achieve occlusion.[27]

FIGURE 15 *Military Emergency Tourniquet.*

https://buyh&h.com/products/military-emergency-tourniquet-met-gen-iii

TABLE 87 *MET/RTK Occlusion Efficacy*

Total Score	Score	Occlusion Efficacy	n =	Citation
5.50	6	Failed to achieve a >80% success rate in four experimental conditions.	40	27
	10	100% occlusion.	20	31
	6	84.0% occlusion on arm applications.	25	67
	0	33.3% occlusion on leg applications.	25	67

TABLE 88 *MET/RTK Time of Application*

Total Score	Score	Time (Speed) of Application	n =	Citation
2.40	0	Mean time of 117.75 seconds (±64.69) on leg applications.	40	27
	5	Mean time of 52.5 seconds (±28.8) on arm applications.	40	27
	2	Mean 61.40 seconds application time.	20	31
	0	Arm applications mean time of 100.9 seconds (± 43.5).	25	67
	5	Leg applications with mean time of 54.1 seconds (± 23.8).	25	67

Rapid Application Tourniquet System (RATS) – SCORE: 34.00.

The RATS is a narrow elastic band applied with circumferential stretching around the limb to achieve occlusion. There is one (1) study on the RATS in the literature searched from 2011 to 2018. The single study by Gibson et al. reported a 95% occlusion effectiveness (n = 20) and a mean application time of 99 seconds.[21] There is no numerical compression pressure data reported in studies. The RATS is 0.5 inch wide, which does not meet the 1.5 inches minimum width requirements established by the tourniquet working group and previous consensus.[6,7,66] The one study reports an occlusion pressure of 190mmHg within the optimal range. There is no combat or civilian usage documented in medical literature. The RATS was determined by the working group to have insufficient study data to make recommendations at this time

FIGURE 16 *Rapid Application Tourniquet System.*

https://ratsmedical.com/collections/products/products/rats-gen-2-black

TK4 / Tourni-Quik / TK4L – SCORE: 21.17.

The TK4/Tourni-Quik/TK4L is a 2-inch band applied with circumferential stretching and wrapping around limb with hooks for pulling tension and securing to achieve occlusion. Only one study found in medical literature reports occlusion and application times and there was no data found on occlusion pressures. Arterial occlusion is reported as 80% on arm applications and 54.1% on leg applications and mean application times of 72.8 seconds (± 33.9) for the arm and 65.3 seconds (± 32.5) for leg applications.[67] The TK4 was dropped from a previous study as it broke on initial application and safety concerns prevented further testing.[31] The instructions for the TK4 specifically mention "DO NOT let go of the strap while winding; this will result in the hook and strap unraveling and may cause injury."[64] The USMC fielded the TK4 for a period, but it was replaced with the CAT in 2009. Based on available data, the TK4/Tourni-Quik/TK4-L was not included in the current CoTCCC-recommended tourniquets list.

FIGURE 17 *TK4 / TK4L.*

https://www.rescue-essentials.com/tourni-kwik-4-tk4-compression-strap/

Tourniquets with total scores <20.00.

The McMillan Tourniquet, NATO Tourniquet, Ramsey's Red-Pull Tourniquet, London Bridge Ratchet Tourniquet (LBRT), and the USGI Self-Applied Tourniquet System (SATS) scored less than 20 out of 50 points in this tourniquet review primarily resulting from poor performance in studies and lack of data.

- The McMillan Tourniquet arterial occlusion efficacy was reported with only 25% on leg applications and 27.2% on arm applications[67] and does not meet the minimum width requirement of 1.5 inches.
- The NATO Tourniquet arterial occlusion efficacy was reported with only 8.3% on leg applications and 21.7% on arm applications.[67]
- Ramsey's Red-Pull Tourniquet was reported to have failed to achieve occlusion in 90% of tests and was eliminated from future testing.[31]
- The London Bridge Ratchet Tourniquet has a width of 1 inch and weight of 9.17 ounces and does not meet the basic specifications of a military tourniquet. The LBRT has a single reported combat usage in which hemorrhage was controlled but the casualty had severe tourniquet pain resulting from extreme compression pressures.[6]

Based on available data, these tourniquets were not included in the current CoTCCC-recommended tourniquets list.

Tourniquets without published data at this time.

Recon Medical Tourniquet – The Recon Medical Tourniquet is a Windlass (aluminum) tourniquet using Velcro adhesion to strap with single routed buckle and finger-hole for pulling tight. There was no study performance data found in medical literature on the RECON Tourniquet. The RECON Tourniquet meets the basic specifications required and functions along the same principles as the CAT and TMT. The RECON Tourniquet certainly warrants further review and consideration for military application when more data is available.

FIGURE 18 *RECON tourniquet.*

https://www.reconmedical.com/tourniquets/recon-medical-tourniquet-gen-4-black/

OMNA Tourniquet

The OMNA Tourniquet is a ratchet-based tourniquet specifically designed as a surf-board leash attachment. There was no study performance data found in medical literature on the OMNA Tourniquet. The OMNA Tourniquet meets the basic specifications required and functions along the same principles as the RMT and TX2. The configuration has less of a military application but potentially meets the niche demand of the surfing community. Documented shark attacks on surfers have marked the importance of tourniquet application[70] and the OMNA Tourniquet has been suggested as a potential choice.[71]

FIGURE 19 *OMNA tourniquet.*

https://www.omnainc.com/collections/maritime-tourniquets

STAT Tourniquet

The STAT Tourniquet is a zip-tie like device with finger hole for pulling tightly to a locking point and has an integrated time recorder. There was no study performance data found in medical literature on the STAT Tourniquet. With a width of only 1 inch and length or 31.8 inches, the STAT Tourniquet does not meet the basic specifications required for military tourniquet application.

FIGURE 20 *STAT tourniquet.*

https://www.statmeddevices.com/product-page/s-t-a-t-tourniquet

Tourniquets Not Evaluated at This Time

Several tourniquets, such as belt tourniquets, that were not included in this review were considered to be extreme contingency devices for unique, special, or low-visibility operations in which a normal JFAK/IFAK might not be carried based on the mission. Such missions apply to an extremely small percentage of military personnel and it was determined that such a review and recommendations be conducted separately.

Warning on Fake Tourniquets

In the course of data collection, many devices were being sold online as tourniquets. In the wake of the Stop the Bleed campaign and shooting incidents across the nation, tourniquet awareness is increasing among citizenry. While this awareness is a monumental achievement in emergency medicine, it also allows the emergence of individuals concerned more with making money than saving lives. It is highly recommended that any person or organization purchasing tourniquets conduct a query of tourniquet performance data before purchasing tourniquets and risking lives. It would be regrettable for someone with good life-saving intentions to purchase a tourniquet that is a substandard device or an untested counterfeit copy of a recommended device.

Recommendations

It is recommended the Committee on TCCC publish a revised list of "CoTCCC-Recommended Tourniquets" based on the scoring of reviewed tourniquet devices in Table 89.

It is recommended that the CoTCCC conduct annual review of all recommended devices for continued efficacy or removal or inclusion of additional devices.

It is recommended that the CoTCCC publish a preferred features of military tourniquets document that specifies a refined and scoped list of preferred features for future development.

It is recommended that the CoTCCC publish a military tourniquet research requirements document to reference for future studies.

It is recommended that the Defense Health Agency (DHA) through the Joint Trauma System (JTS) develop and implement a DoD-wide problem reporting network for TCCC-based devices and products.

There is not a recommendation for wording changes to the current Tactical Combat Casualty Care Guidelines (01 AUG 2019).

Disclaimer

The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Departments of the Army, Air Force, Navy or the Department of Defense.

The recommendations of the CoTCCC are recommended clinical practice guidelines for the battlefield based on evidence, best practices, lessons learned, and subject-matter expertise consensus but are not considered DoD policy.

Financial Disclosure

The authors have no financial disclosure related to the tourniquets reviewed.

Dr Cain is a medical consultant for North American Rescue. MAJ Fisher is RAPTOR course trainer affiliated with Combat Medical Systems. Dr Goolsby has a patent pending and method of use for a device that was not part of this review.

TABLE 89 *Tourniquet Scoring Chart*

	Occlusion	Time	Simplicity	Pressure	Specifications	Safety	Usage /User Preference	Logistics	TOTAL SCORE (Max 50)
Recommended Limb Tourniquets for JFAK/IFAK/Aidbag									
CAT Gen 6	8.95	4.64	8.55	4.29	5	3.25	3.40	3.67	41.74
CAT Gen 7	8.60	4.86	8.50	4.71	5	5	3	4.33	44.00
SOFTT-Wide Gen 3	8.09	4.50	8.13	4.33	5	4	3	4.33	41.39
TMT	8.29	4.10	7.17	4.43	5	5	2	4.33	40.31
RMT-T/TX2	9.29	4.71	8.17	4.75	4	4.50	2.75	3.67	41.83
SAM-XT	8.20	3.60	9	5	5	5	1.33	3.67	40.80
Recommended Pneumatic Limb Tourniquets for Medics, Role I/II Teams & TACEVAC Platforms for TQ Replacement, Conversion or Prolonged Application									
Delfi EMT	9.33	4.67	5.67	4.67	4	5	2.33	2.33	38.00
TPT2	8.83	3.25	4.00	4.20	5	5	1.33	2.33	34.62
NOT Currently Recommended Limb Tourniquets based on existing data									
IEST	8	5	5	5	3	5	1.33	1.67	33.9
SWAT-T	4.80	1.67	6.73	4.60	3	3	1.33	3	28.13
RATS	8	0	10	1	3	5	1.33	2.67	34.00
TPT3	6.67	3.50	1	4	5	5	1.33	0.67	27.17
SOFTT	4.33	4	10	1	3	5	2.50	4.33	34.17
MAT	4.50	5	4	1	5	4.50	1.33	4	29.33
MET/RTK	5.50	2.40	6.50	1	4	4	1.33	3.67	28.40
TK4/TK4L/TQ	3.50	2	4	1	3	1.33	1.33	5	21.17
McMillan	0	1	1	1	1	5	1.33	0	10.33
NATO TQ	0	1	1	1	3	5	1.33	1.33	13.67
Ramsey's	0	0	0	0	0	0	0	0	0

GREEN = Meets Criteria Requirements; AMBER = Acceptable Criteria Requirements with caveats or concerns; RED = Does not meet Criteria Requirements

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