Efficacy of the Military Tactical Emergency Tourniquet for Lower Extremity Arterial Occlusion Compared with the Combat Application Tourniquet

A Randomized Crossover Study

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ABSTRACT

Introduction: Extremity bleeding and subsequent hemorrhagic shock is one of the main causes of preventable battlefield death, leading to mass-fielding of modern tourniquets, such as the Combat Application Tourniquet (CAT; Composite Resources). Numerous look-alike tourniquets, such as the Military Tactical Emergency Tourniquet (MTET; SZCTKlink), flood commercial markets, offering visually near-identical tourniquets for drastically reduced prices. We examined the performance of the MTET compared with that of the CAT. **Methods:** We undertook a randomized crossover trial to observe self-applied tourniquets to the lower extremity by combat medics, comparing the CAT to the MTET in application time and success rates, proven by loss of distal pulse assessed by Doppler ultrasound in <1 minute. **Results:** All 50 participants (100%) successfully applied the CAT versus 40 participants (80%) using the MTET (p = .0001). Median application time for the CAT (29.03 seconds; range, 18.63 to 59.50 seconds) was significantly less than those of successful MTET applications (35.27 seconds; range, 17.00 to 58.90 seconds) or failed MTET applications (72.26 seconds; range, 62.84 to 83.96 seconds) (p = .0012). Of 10 MTET failures, three (30%) were from application time >1 minute and seven (70%) from tourniquet mechanical failure. **Conclusion:** The MTET performed worse than the CAT did in all observed areas. Despite identical appearance, look-alike tourniquets should not be assumed to be equivalent in quality or functionality to robustly tested tourniquets.

KEYWORDS: *education; hemorrhage; bleeding control*

Introduction

Hemorrhage control is a central intervention of prehospital medicine, initially from findings of disproportionate preventable deaths and now as the opening focus in military care guidelines, including recommendations from the Committee on Tactical Combat Casualty Care (CoTCCC) and Joint Trauma System.[1–4] Development and implementation of modern tourniquets generally center on vasculature constriction through circumferential limb pressure, which is then amplified through mechanical advantage by a secondary mechanism, such as a windlass or ratcheting lever. One of the earliest modern tourniquets, the CAT, fielded throughout American and international forces, is recommended by CoTCCC and is often used as the prototype for comparison with newer, untested models.[2,5–9]

The current CAT design centers on a single-looped hook-and-loop fastening strap, which is further tightened by turning a thick plastic windlass rod. Repeated studies have demonstrated effective measured occlusion by the CAT in simulated injuries.[5,6,8] Still, over the past two decades, numerous tourniquets have entered the commercial market, many using some variation of the Spanish windlass, with varying degrees of success, and others using different mechanisms. More recently, however, several companies abandoned attempts to devise a novel tourniquet and instead directly replicated the well-known design of the CAT.[10–12] These primarily appear to come from international companies but are sold on the Internet and marketed in English to potential American customers.[11,12] Many of these are nearly identical to the CAT in terms of both the mechanism of action and general appearance but with no clear evidence of efficacy or product quality.

The MTET is a CAT look-alike, both in general appearance and mechanical design. It is sold individually at online retailers for approximately half the cost of the CAT ($16.99 vs. $30), and a three-pack can be purchased for $23.59, or less than one-third the cost of the three CAT devices (Figure 1). The MTET has thousands of reviews on the Amazon website and is listed as "Amazon's Choice" in the tourniquet category. The manufacturer of MTET has little public company information to be found through online searches but is listed as a registered trademark of the Tianke Electronics.[13] The company offers a wide range of products, including electronics cables, record players, smartphones, socks, and dog whistles.[13]

Visual similarities (Figure 2), substantail price markdowns, and the advertised equivalency of imitation tourniquets such as the MTET offer a compelling inexpensive alternative for budget-concerned military units and prehospital providers. The market for imitation tourniquets has increased substantially (to include the MTET, introduced within the past three years), and military budgets have become tighter. Although imitation devices offer a budget-friendly option, they remain largely untested compared with the robust body of studies into the efficacy of CoTCCC-recommended tourniquets.[2]

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FIGURE 1 *Internet advertisement and purchasing information for the Military Tactical Emergency Tourniquet.*

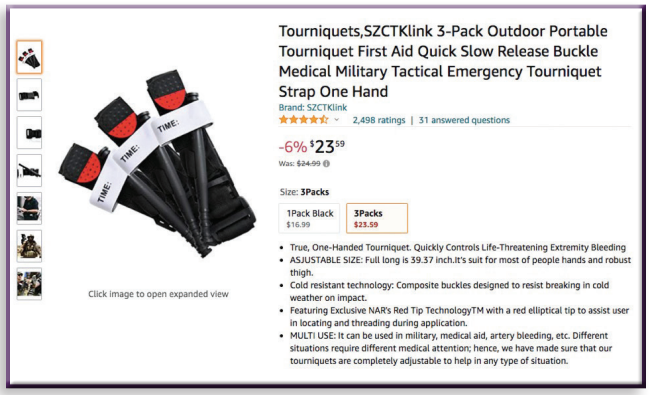


FIGURE 2 *Within each image section, the side-by-side comparison shows the Combat Application Tourniquet (CAT)* **(ON THE LEFT)**, *and the Military Tactical Emergency Tourniquet (MTET)* **(ON THE RIGHT)**.

Given the lack of evidence for the MTET, despite its near-identical appearance and dimensions, we developed and executed a prospective randomized crossover study to evaluate and compare self-application success rates of the MTET with those of the CAT in a military population.

Methods

Investigators solicited volunteers from a population of US Army Combat Medics (military occupational specialty 68W) serving as instructors at the Combat Medic Specialist Training Program at Joint Base San Antonio–Fort Sam Houston, Texas, to undergo study execution on June 2 and 9, 2021. Potential volunteers were excluded when they had known injuries to the lower limbs or physical profile limitations that would hinder their ability to apply a tourniquet. All volunteers provided basic demographics and were measured for thigh circumference at the approximate site of planned tourniquet placement over standardized physical training shorts. After locating the dorsalis pedis artery via Doppler ultrasound, investigating team members annotated the location with a skin marker to confirm pulse location prior to attempted tourniquet placement.

Although all volunteers had received multiple iterations of tourniquet instruction, given their military medical professional training, investigators provided brief instruction on proper tourniquet self-application, including the goal of distal arterial flow cessation and expectations of discomfort and skin color changes. After being given a short, standardized scenario, investigators placed volunteers into one of four cohorts for tourniquet application and instructed them to place either an MTET or a CAT at mid-thigh level on the designated lower extremity while in a seated position, without disclosing the identity of the tourniquet provided. Three device lots were used for the CATs (Nos. 101K116, 120E599, and 210B200). There were no lot numbers found for the MTETs used. Cohort groups were (1) CAT on left thigh first, (2) CAT on right thigh first, (3) MTET on left thigh first, and (4) MTET on right thigh first.

Volunteers were randomized to cohorts for tourniquet and limb on first iteration and then used the other tourniquet on the contralateral limb for a second iteration. Time began once volunteers received the tourniquet. Once volunteers applied the tourniquet to their satisfaction, investigators checked the previously marked dorsalis pedis artery for flow with a Doppler ultrasound. Volunteers were encouraged to secure the windlass rod to complete tourniquet applications properly within 60 seconds of being given the tourniquet, but otherwise were not provided explicit criteria for successful application. Once volunteers removed their hands from the tourniquet device and verbalized completion, cessation of arterial flow was sonographically ensured for 5 seconds over the previously identified site. If arterial flow was sonographically verified to be halted for 5 seconds, timing was stopped, and the time was recorded. Failure was defined as an inability to occlude dorsalis pedis arterial flow for a 5-second period within 1 minute of initial application. Volunteers could continue tourniquet application attempts beyond 1 minute and have their times recorded if they felt initial attempts were unsuccessful or if arterial flow continued on Doppler, but they were reminded that times would still be annotated as a failed attempt.

We performed all statistical analysis using Microsoft Excel (version 10) and JMP Statistical Discovery from SAS (version 13.2). We reported descriptive statistics to include numbers and percentages for nominal variables and median values with ranges for scale variables. The Kruskal-Wallis test was applied to examine time data, and a Fisher's exact test was used to analyze the tourniquet application success rates.

Results

Fifty medics were solicited as a convenience sample for participation, each self-applying a tourniquet twice for a total of 100 observed applications. Volunteer data are summarized in Table 1.

TABLE 1 *Volunteer Demographics*

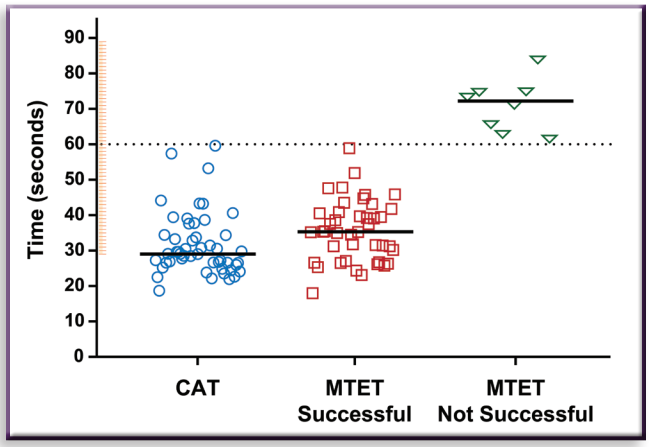
Gender	**Number (%)**
Male	43 (86%)
Female	7 (14%)
Measurements	**Median (Range)**
Age	33 (25–45)
Height (cm)	175 (152–193)
Weight (lbs)	189 (116–263)
Thigh Circumference (cm)	53 (43–65)

All 50 participants (100%) successfully applied the CAT in under 1 minute, with a complete cessation of dorsalis pedis arterial flow confirmed by Doppler ultrasound (Table 2). In contrast, 40 participants (80%) applied the MTET successfully with a higher median time (Figure 3). All MTET failures exceeded the 1-minute time limit. Additionally, mechanical reasons for MTET failure included bent windlass rod, ripped stitching, and/or a deformed buckle (Figure 4).

TABLE 2 *CAT vs MTET Performance*

	CAT (n = 50)	MTET, success (n = 40)	MTET, failure (n = 10)	*p*-value
Time (seconds; median, range)	29.03 (18.63–59.50)	35.27 (17.00–58.90)	72.26 (62.84–3.96)	0.0012
Reason for Failure	N/A	N/A	7 (70%) Mechanical and Time 3 (30%) Time	N/A

FIGURE 3 *Scatterplot of application times and medians* **(BLACK LINES)** *for* **(LEFT TO RIGHT)** *the CAT, MTET successful application, and MTET failed application.*



CAT, Combat Application Tourniquet; MTET, Military Tactical Emergency Tourniquet

Post-investigation analysis found that the MTET demonstrated significantly longer application times ($p < .0012$) and lower rates of successful application ($p = .0001$). Failure of MTET application was not significantly correlated with user thigh circumference ($p = .9428$).

Discussion

This study demonstrated that the MTET, a mass-produced, readily available, and popular CAT look-alike tourniquet, proved to be less successful than the CAT in application time and to have lower rates of success for extremity arterial occlusion when self-applied by experienced US Army combat medics. Furthermore, while the CAT did not show any mechanical defects in all observed single-use applications, the MTET demonstrated a 14% mechanical failure rate on self-application. MTET failure did not show any statistical correlation to user thigh circumference.

Emergency-use limb tourniquets are devices intended to stop arterial blood flow. [AU: Per a reviewer, "references 15 and 16 are not sources for a definition of 'tourniquet.' I don't believe you need references for this sentence, so I recommend simply deleting the two reference numbers and renumbering references accordingly."] Suboptimal tourniquet pressures do not halt the arterial flow but can impede venous return, leading to venous congestion, ongoing or resumptive bleeding, shock, compartment syndrome, and death.[14] A critical requirement for CoTCCC consideration is ≥3.81cm width, given that tourniquet width demonstrates an inverse relationship with the pressure necessary for arterial occlusion.[2,15] The CAT and MTET both meet recommendations for tourniquet width, and this identical characteristic may deceive purchasers into further considering the MTET to be an inexpensive alternative to the CAT.

FIGURE 4 *Findings of mechanical failure points in the windlass* **(RIGHT)**, *buckle* **(TOP LEFT)**, *and stitching* **(BOTTOM LEFT)** *of the MTET after user self-application.*

MTET, Military Tactical Emergency Tourniquet

Actions have been taken by producers to impede the marketing of counterfeit tourniquets. This includes a 2019 federal lawsuit by Composite Resources, the manufacturer of the CAT, against Recon Medical, a China-based CAT look-alike manufacturer, for their tourniquet model.[12,16] In December 2021, Recon Medical was handed a permanent injunction against further tourniquet production for intentionally deceiving consumers into believing their tourniquet was identical to the CAT.[16] However, as evidenced by the search of Amazon retailers in this study, a copycat market remains for other overseas manufacturers.

The ability to produce a product such as the MTET, which is substantially less expensive but visually nearly identical to the CAT, leads to suspicion of material inadequacy, engineering shortcuts, and production flaws. There is no listed patent or in-depth product description for the MTET at the time of this study to provide a material comparison of the devices tested. However, given the significant difference in observed mechanical failure rates between the CAT and MTET (0% vs. 14%), obvious concerns arise.

Continued employment of the CAT as one of several CoTCCC-recommended tourniquet devices currently used by the US Military is largely because of its documented success in laboratory testing and battlefield conditions.[2,17] The CAT, as well as other CoTCCC-recommended devices, such as the SOF Tactical Tourniquet–Wide and the Tactical Mechanical Tourniquet, have been repeatedly tested, compared, and reviewed by expert panels for inclusion in the treatment of prehospital extremity hemorrhage. With the continued use of Internet mass markets such as Amazon.com and other online retailers, previously unknown companies can establish commercial advantage through several means, including low prices, paid-for search engine result placement, and customer feedback metrics. This allows for improved product placement not only to laypersons but also to military personnel searching for less expensive alternatives to CoTCCC-recommended devices in challenging economic times.

This study had several limitations, primarily that volunteers were more familiar with the CAT than the MTET, given their positions as experienced medics and combat medic instructors routinely using the CAT for instruction. Furthermore, we could not completely blind participants from seeing which device they were given at the time of application. These facts may have had an effect on time measurements. However, in comparison with numerous other studies comparing tourniquets, given the identical appearance and mechanisms of the MTET, these facts are likely to have had minimal effect on the outcomes of this study. All tourniquets were stored in watertight containers prior to use, were used within 1 month of receiving them from suppliers, and were used only once, in accordance with manufacture and military recommendations. These ideal conditions may differ from those on the battlefield or when a tourniquet is attempted to be reused. Finally, all testing was performed in a controlled classroom-style setting and thus did not perfectly duplicate the stressful nature of battlefield medicine.

Conclusion

Tested and proven emergency-use limb tourniquets are being imitated and sold by little-known companies across mass markets for a fraction of the cost of CoTCCC-recommended devices, leading to the presence of rarely tested tourniquets made of potentially inadequate materials. Our findings demonstrate that copycat tourniquets cannot be assumed to be equivalent in quality or functionality to robustly tested tourniquets.

Disclaimer

The view(s) expressed herein are those of the author(s) and do not reflect the official policy or position of Brooke Army Medical Center, Madigan Army Medical Center, the US Army Medical Department, the US Army Office of the Surgeon General, the Department of the Army, the Department of the Air Force, or the Department of Defense or the US Government.

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Ethics

The Brooke Army Medical Center institutional review board reviewed and approved protocol C.2021.061.

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We have no relevant disclosures to report.

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Author Contributions

DKS and BMC conceived the study concept. DKS organized and observed volunteer participation and data collection. DKS and BMC analyzed the data. DKS and BMC wrote the first draft and read, provided critical revisions to, and approved the final manuscript.

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