

## OPEN

# Who needs a tourniquet? And who does not? Lessons learned from a review of tourniquet use in the Russo-Ukrainian war

Frank Butler, MD, FFAO, FUHM, John B. Holcomb, MD, FACS, Warren Dorlac, MD, FACS, Jennifer Gurney, MD, FACS, Kenji Inaba, MD, FACS, Lenworth Jacobs, MD, MPH, FACS, Bob Mabry, MD, FACEP, Mike Meoli, AS, Harold Montgomery, BBA, Mel Otten, MD, FACEP, Stacy Shackelford, MD, FACS, Matthew D. Tadlock, MD, FACS, Justin Wilson, EMTP, Kostiantyn Humeniuk, MD, Oleksandr Linchevskyy, MD, PhD, and Oleksandr Danyliuk, MD, Pensacola, Florida

<b>BACKGROUND:</b>	Extremity tourniquets have proven to be lifesaving in both civilian and military settings and should continue to be used by first responders for trauma patients with life-threatening extremity bleeding. This is especially true in combat scenarios in which both the casualty and the first responder may be confronted by the imminent threat of death from hostile fire as the extremity hemorrhage is being treated. Not every extremity wound, however, needs a tourniquet. One of the most important aspects of controlling life-threatening extremity bleeding with tourniquets is to recognize what magnitude of bleeding requires this intervention and what magnitude of bleeding does not. Multiple studies, both military and civilian, have shown that tourniquets are often applied when they are not medically indicated. Overuse of extremity tourniquets has not caused excess morbidity in either the recent conflicts in Iraq and Afghanistan or in the US urban civilian setting. In the presence of prolonged evacuation, however, applying a tourniquet when it is not medically indicated changes tourniquet application from being a lifesaving intervention to one that may cause an avoidable amputation and the development of an array of metabolic derangements and acute kidney injury collectively called prolonged tourniquet application syndrome.
<b>METHODS:</b>	The recent literature was reviewed for papers that documented the complications of tourniquet use resulting from the prolonged casualty evacuation times being seen in the current Russo-Ukrainian war. The literature was also reviewed for the incidence of tourniquet application that was found to not be medically indicated, in both the US civilian setting and from Ukraine. Finally, an in-person meeting of the US/Ukraine Tourniquet Working Group was held in Warsaw, Poland, in December of 2023.
<b>RESULTS:</b>	Unnecessary loss of extremities and life-threatening episodes of prolonged tourniquet application syndrome are currently occurring in Ukrainian combat forces because of nonindicated tourniquet use combined with the prolonged evacuation time seen in the Russo-Ukrainian war. Specific numbers of the complications experienced as a result of tourniquet use by Ukrainian forces in the current conflict are treated as classified information and are not available, but multiple sources from the Ukrainian military medical personnel and from the US advisors providing medical assistance to Ukraine have all agreed that the problem is substantial.
<b>CONCLUSION:</b>	Unnecessary tourniquet morbidity might also occur in US forces in a variety of potential future combat scenarios in which evacuation to surgical care is delayed. Prehospital trauma training programs, including but not limited to tactical combat casualty care, place insufficient emphasis on the need to avoid leaving tourniquets in place when they are not medically indicated. This aspect of training should receive emphasis in future Tactical Combat Casualty Care (TCCC) and civilian first responder curriculum development. An interim ad hoc training solution on this topic is available at the websites noted in this articles. Additional training modalities may follow in the near future. ( <i>J Trauma Acute Care Surg.</i> 2024;97: S45–S54.)
<b>LEVEL OF EVIDENCE:</b>	Therapeutic/Care Management; Level V.
<b>KEY WORDS:</b>	Tourniquet; prolonged tourniquet application syndrome; tourniquet ischemia; amputation; hemostasis.

Submitted: April 25, 2024, Revised: April 30, 2024, Accepted: May 6, 2024, Published online: July 12, 2024.

From the Defense Health Agency Joint Trauma System (F.B., J.G., H.M., S.S., J.W.); University of Alabama at Birmingham (J.B.H.), Birmingham, Alabama; Medical Center of the Rockies (W.D.), University of Colorado Health; Los Angeles County + University of Southern California (K.I.); Trauma Institute (L.J.), Hartford Hospital, Connecticut; Texas A+M Health (B.M.); NAEMT TCCC Affiliate Faculty for TCCC Training Centers in Ukraine (M.M.); University of Cincinnati Medical Center (M.O.); Uniformed Services University (M.D.T.); Department of Surgery (M.D.T.), Naval Medical Center, San Diego, California; Medical Forces of the Armed Forces of Ukraine (K.H.); and Surgeon of the Medical Forces of the Armed Forces of Ukraine (O.L., O.D.).

Address for correspondence: Frank Butler, MD, Defense Health Agency Joint Trauma System, 4575 Lavallet Lane, Pensacola, FL 32504; email: fkb064@yahoo.com.

Written work prepared by employees of the Federal Government as part of their official duties is, under the U.S. Copyright Act, a “work of the United States Government” for which copyright protection under Title 17 of the United States Code is not available. As such, copyright does not extend to the contributions of employees of the Federal Government.

DOI: 10.1097/TA.0000000000004395

*J Trauma Acute Care Surg*  
Volume 97, Number 2, Supplement

Prehospital tourniquet use was strongly discouraged in both the military and the civilian sectors in the United States as recently as the early 1990s. There were several successful uses of tourniquets to stop severe extremity bleeding during the Battle of Mogadishu on October 3, 1993,<sup>1</sup> but those incidents were insufficient to reverse the prevailing antitourniquet doctrine at the time.

A review of battlefield trauma care conducted in 1992 through 1996 by the Navy SEAL Biomedical Research Program noted that exsanguination from extremity bleeding had been a leading cause of preventable death in US troops in Vietnam.<sup>2,3</sup> This research effort further noted that tourniquets were commonly used by orthopedic surgeons for short periods of time to reduce bleeding during extremity surgery.<sup>4</sup> Based on these observations, the original 1996 Tactical Combat Casualty Care (TCCC) paper called for tourniquets to be used aggressively to stop life-threatening extremity hemorrhage and noted that ischemic damage to extremities was rare if tourniquets were left on for periods less than an hour.<sup>4</sup>



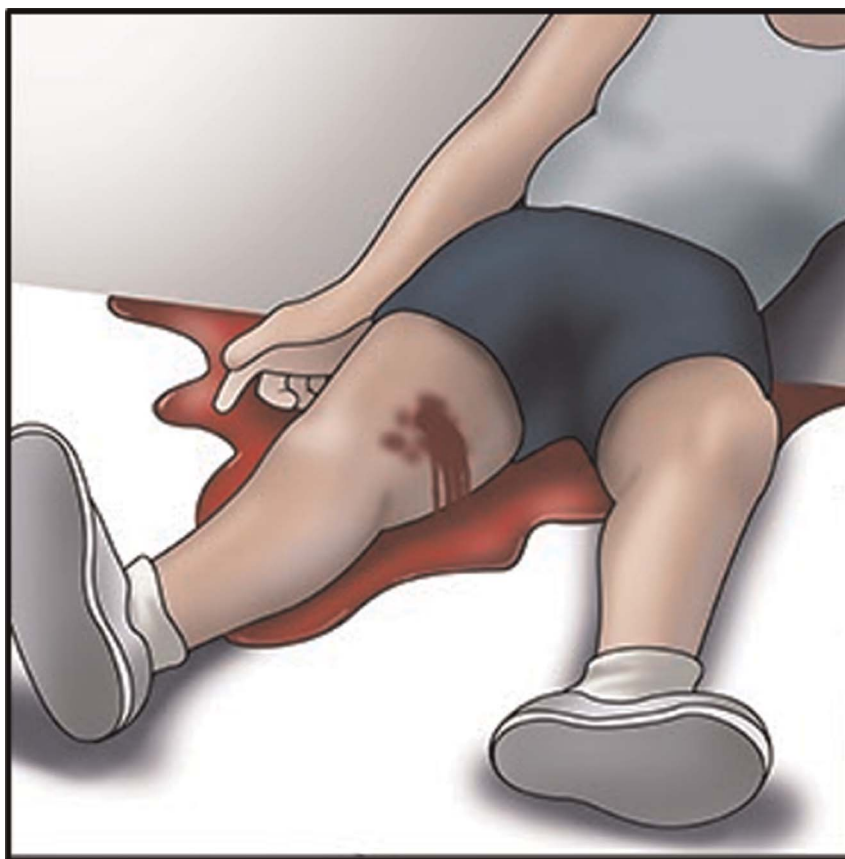
**Figure 1.** Femoral artery bleeding in an animal model. Photo courtesy of COL (retired) John Holcomb.

This recommendation to use prehospital tourniquets when indicated in combat actions was widely discussed but infrequently incorporated into military combat trauma standards during the 5-year interval between the TCCC paper's publication and the start of the conflict in Afghanistan.<sup>5</sup> Most American troops did not carry or use tourniquets in 2001 when that war began.

Furthermore, in the early years of the recent conflicts in Iraq and Afghanistan, there was no Joint Trauma System to provide expert oversight of trauma care for US combat forces, nor was there an ongoing performance improvement effort seeking opportunities to improve the care provided to wounded US troops. There was also no Department of Defense Trauma



**Figure 2.** Superficial forearm laceration. Photo, TCCC Curriculum 2018.



**Figure 3.** Life-threatening extremity bleeding. Image Courtesy American College of Surgeons.

Registry to gather the documentation of combat casualty care needed to better inform clinical decisions and create best-practice trauma care guidelines.

The first systematic preventable death analysis of fatalities sustained in combat in Iraq and Afghanistan was requested by the US Special Operations Command in 2004 and carried out by the US Army Institute of Surgical Research.<sup>6</sup> Holcomb and colleagues<sup>6</sup> found that, of 12 potentially preventable deaths among the 82 Special Operations fatalities sustained through November of 2004, 3 could likely have been prevented by the application of an effective tourniquet and 5 others might also have been saved by recommended TCCC interventions. These findings resulted in an expedited fielding of TCCC training and equipment, including tourniquets, to Special Operations forces and, shortly thereafter, to the rest of the US military. In a few short years, tourniquets became commonplace among US forces on the battlefield.<sup>5,7-9</sup>

### Recognition of Life-threatening Extremity Bleeding

As the military increased its use of tourniquets in the conflicts in Afghanistan and Iraq, it was recognized that the term *life-threatening extremity bleeding* needed to be illustrated for TCCC students. When a standardized TCCC training presentation was created in 2004 for the Special Operations TCCC Transition Initiative,<sup>10</sup> the training material included an animal model of spurting arterial blood (thus demonstrating life-threatening

bleeding) (Fig. 1) and a photo of a long forearm laceration without significant hemorrhage to illustrate bleeding that did not require a tourniquet (Fig. 2).

In 2013, the Hartford Consensus group, led by Hartford, Connecticut, trauma surgeon, Dr. Lenworth Jacobs, took a strong advocacy position for tourniquet use in the civilian sector. This program soon evolved into the very successful international Stop the Bleed effort, and the need to have additional illustrations of life-threatening bleeding incorporated into the tourniquet training was recognized. Illustrations such as the one shown in Figure 3 were created by graphic artists to meet this need and were included in the initial Stop the Bleed training material.<sup>11</sup>

In addition, the 2015 Hartford Consensus Compendium included a written description of how to recognize life-threatening extremity bleeding and the need for a tourniquet:

- There is pulsatile or steady bleeding from the wound.
- Blood is pooling on the ground.
- The overlying clothes are soaked with blood.
- Bandages or makeshift bandages used to cover the wound are ineffective and steadily becoming soaked with blood.
- There is a traumatic amputation of the arm or leg.
- There was prior bleeding, and the patient is now in shock (unconscious, confused, pale).<sup>11</sup>

There is not, however, a major focus in either the present TCCC curriculum or the Stop the Bleed training material on teaching students in those courses to reliably differentiate

extremity bleeding that is life-threatening from that which is not. There is also no requirement for the student to demonstrate in end-of-course testing with the use of objective measures that he or she has acquired the ability to reliably identify non-life-threatening bleeding. If bleeding is noted to be minor or minimal, the use of a tourniquet can be avoided, or if the tourniquet was applied during a Care Under Fire situation, the first responder can remove it when the wound is reassessed and simply cover the wound with a dressing.

## Tourniquets in Afghanistan and Iraq

Tourniquet use in Iraq and Afghanistan was well-documented to have saved many lives in those conflicts.<sup>5,7,9,12–15</sup> These two combat theaters matured quickly, and evacuation time for casualties to reach surgical care was generally 2 hours or less. By 2009, evacuation time in Iraq was typically an hour or less, and Secretary of Defense Robert Gates mandated that operations in Afghanistan be planned such that casualties in that theater would also be able to reach surgical care within 1 hour after the approval of the evacuation mission.<sup>16</sup> With these relatively short evacuation times to surgical care, complications from tourniquet use were infrequent, and amputations caused by tourniquet-related limb ischemia were not seen in US casualties during those conflicts.<sup>5,9</sup>

## Civilian Tourniquet Use in the United States

Although some Emergency Medical Services (EMS) programs led by ex-military physicians were early adopters of prehospital tourniquets,<sup>17</sup> prehospital tourniquet use for trauma victims was adopted more slowly in the US civilian sector. By 2009, when tourniquets were commonplace on the battlefield, Goodwin and colleagues<sup>18</sup> noted that there had been zero tourniquet uses reported in the National EMS Information System database for the years 2008 and 2009.<sup>19</sup> Thanks to the success of the Hartford Consensus and the Stop the Bleed programs,<sup>20–23</sup> prehospital extremity tourniquet use has since become increasingly prevalent in the US civilian sector and has been well documented to save lives without causing excess morbidity.<sup>17,24–32</sup> A recent meta-analysis of 7 studies with 1,692 tourniquet applications in the US and Canadian civilian settings found that prehospital tourniquet application did not cause a significant increase in the risk of amputation.<sup>33</sup>

## Prehospital Tourniquets Are Often Not Medically Indicated

A number of recent reports from the US civilian sector have also found, however, that tourniquets are often applied when they are not medically indicated, which is to say that the bleeding seen in the injured extremity was not severe enough to threaten the life of the trauma victim.<sup>17,34–38</sup> The application of tourniquets when they were not medically indicated has been observed in both EMS and non-EMS first responders. The incidence of nonmedically indicated tourniquets in civilian settings ranges from 10.5% in one report<sup>17</sup> to 100% in one small case series.<sup>37</sup>

As with military operations in Iraq and Afghanistan, however, relatively short prehospital transport times in US urban civilian settings largely prevented tourniquet complications, both with medically indicated and nonindicated prehospital tourniquets.

Tourniquets that are found not to be medically indicated are removed shortly after the patient arrives at the trauma center.

## Tourniquet Use in the Present Ukraine Conflict

The Ukrainian military was an early adopter of TCCC, and at present, there are 10 National Association of Emergency Medical Technicians–approved TCCC training centers throughout the country. The TCCC training materials on the Deployed Medicine website are translated into Ukrainian and posted on a sister website at <https://tccc.org.ua/en>. Thus, in theory, Ukrainian service members receive the same training on tourniquet use that US service members do.

Nonmedically indicated tourniquets are a common occurrence in Ukraine. A report from the earlier phase of the Russo-Ukrainian war by vascular surgeon LTC Vladyslav Yatsun found that 75% of tourniquets applied to casualties treated by that author were not medically indicated.<sup>39</sup>

When the Russia military commenced its full-scale invasion of Ukraine on February 24, 2022, the ensuing conflict was unlike the recent combat actions in Southwest Asia. Because of both the lack of air superiority and the new addition of drones as an element of ground combat, rapid helicopter evacuation of wounded Ukrainian troops from the point of injury to a medical treatment facility with a surgical capability was not feasible.<sup>40–44</sup> Evacuation was often delayed until the cover of darkness and carried out by ground vehicle, with the mean evacuation time being 21 hours in one article.<sup>42</sup>

While short tourniquet application times are typically not associated with adverse effects, longer tourniquet times clearly are.<sup>40,41,43,45</sup> One report from the Russo-Ukrainian war noted tourniquet application on an extremity that had no wound at all.<sup>40</sup> Another casualty described in that article had a tourniquet applied to a leg about which personnel at the medical treatment facility stated that it was unclear whether the leg had sustained a vascular injury. The tourniquet was in place for more than 10 hours, and the leg had to be amputated. The casualty suffered prolonged tourniquet application syndrome (PTAS) with acute kidney injury that required hemodialysis. There was no mention of the casualty's tourniquet ever being reassessed prior to arrival at the treating medical facility.<sup>40</sup>

The much longer evacuation times for casualties in the present Russo-Ukrainian war have been reported to be the cause of many extremity amputations because of prolonged tourniquet ischemia and many instances of severe PTAS.<sup>41,43</sup>

A recent article by Samarskiy et al.<sup>46</sup> reported on tourniquet use in the Russo-Ukrainian War from 2014 to 2022, a period that includes the early phase of the large-scale Russian invasion of Ukraine. There were 2,496 casualties who sustained limb injuries and had tourniquets applied. Lower extremity wounds comprised 84.4% of this total. Tourniquets used early in the study period were largely Esmarch's tourniquets. These were later superseded by the Combat Application, Sich, and Dnipro tourniquets. The reported duration of tourniquet application was 50 to 380 minutes with a mean application time of 205.9 minutes. There were 92 limb amputations reported during the study period (3.7%), and the amputations were noted to be “mainly due to extensive necrosis.” The duration of tourniquet application in those casualties who underwent amputation of the injured extremity ranged from 210 to 380 minutes. The



authors note that 78 of the amputations involved tourniquet use of more than 6 hours. There were also 11 cases of PTAS encountered.<sup>46</sup> The authors do not comment on the incidence of tourniquet application that occurred in instances where the casualty's bleeding was minor and tourniquets were not medically indicated.

Because of operational security concerns and the lack of a combat trauma registry in the Ukrainian military, there are no published reports that document the total number of amputations performed in Ukraine, but unpublished data compiled by a US government Medical Assist Team in 2024 and ongoing contact with Ukrainian medical personnel have indicated that there have been many amputations due to tourniquet ischemia and many cases of PTAS.<sup>40,41,43</sup> These reports did not delineate how many of the amputations were necessitated by the extremity wounds themselves and how many were caused by tourniquet ischemia.

Other recent conflicts have also produced prolonged evacuation times. A report from the French military on combat actions in the Sahelian strip in Africa also noted tourniquet morbidity as a result of prolonged evacuation times.<sup>47</sup> This case series consisted of 11 casualties with 14 extremity injuries requiring tourniquet application. The mean tourniquet application time was 268 minutes with a range from 180 to 360 minutes. Complications included rhabdomyolysis, compartment syndrome, and limb amputations. Two of the casualties died, but the other nine survived their wounds.<sup>47</sup>

In 2015, after a leg amputation in a casualty with an 8-hour tourniquet application time in Africa, the TCCC Guidelines were changed to recommend reassessment of applied tourniquets as soon as feasible but no later than 2 hours after injury.<sup>45</sup> When reassessments are performed, and bleeding from the extremity wound is found to be minor or minimal, the tourniquet is not needed and may be released. If the extremity bleeding is judged to be potentially life-threatening, then attempted conversion from a tourniquet to other means of hemorrhage control (primarily hemostatic dressings and strong, direct pressure) is indicated.<sup>43,45,48,49</sup> In either case, the wound must be frequently reassessed to ensure that bleeding has not recurred.

While a precise temporal threshold for ischemic damage to extremities with tourniquets applied has not been established, tourniquets that remain in place for longer than 2 hours may be associated with PTAS, compartment syndrome, and possibly amputation of the limb. If the tourniquet application time exceeds 6 hours, the PTAS is likely to be severe and require extremity fasciotomy, aggressive crystalloid resuscitation, treatment of electrolyte derangements, and renal replacement therapy — challenging interventions in any austere forward deployed environment. In this instance, tourniquet removal should take place in a medical treatment facility with intensive care and laboratory support to guide the treatment of the medical consequences of PTAS.<sup>43,45</sup>

The Ukrainian military is aggressively pursuing performance improvement in the area of recognition of life-threatening bleeding and ensuring that all tourniquets are, in fact, medically indicated. Also, in August 2023, the Chief of Medical Forces in Ukraine, Colonel Kostiantyn Humeniuk, was successful in an effort to change a Ukrainian law to allow soldiers, not just combat medics, who have had the appropriate training to remove, adjust, or convert tourniquets if required.

Another point that requires emphasis is that one impact of the relatively short evacuation times for US casualties in Iraq and Afghanistan has been that TCCC training typically focused on short

duration (20–40 minutes) casualty management scenarios.<sup>50,51</sup> As a result, casualty reassessment was rarely adequately trained and was not typically a tested feature of the training. The lack of appropriate focus on casualty reassessment during TCCC training was likely another factor that contributed to reassessments not being reliably conducted on the battlefields in Ukraine. This is an opportunity to improve in TCCC training, and reassessment must address all aspects of TCCC, not just tourniquets.

## Implications for Tourniquet Use in US Forces in Future Combat Actions

The need to ensure that tourniquets are released from extremities when reassessment finds that the bleeding is minor and a tourniquet is not needed is by no means limited to the present Russo-Ukrainian war. The US military is currently reviewing what aspects of battlefield trauma care might need to be revised in prolonged casualty care scenarios should the US find itself in a ground conflict with a near-peer country with long evacuation times for casualties.<sup>52</sup> With the ubiquity of low-cost, First-Person View drones on the Ukrainian battlefield posing a near-constant threat to both tanks and personnel,<sup>53</sup> any future conflict in which US forces are fighting with a technologically sophisticated enemy will likely find that both point-of-injury care and attempted rotary wing evacuation of casualties will be met with drone attacks, thus prolonging the time to surgical care.

The US Navy is currently using a more widely dispersed ship configuration in an operational concept called Distributed Maritime Operations. Naval forces using this concept will often have smaller combatant vessels a significant time/distance away from larger warships with surgical capability.<sup>54–56</sup> Shipboard casualties sustained in surface warfare combat actions can thus expect to encounter delays of several to many hours before reaching surgical care.<sup>57</sup> The potential for prolonged evacuation times may also be encountered in immature theaters of conflict such as Gaza,<sup>58</sup> urban warfare,<sup>1</sup> and far-forward special operations missions.

All Navy personnel are required to have TCCC training,<sup>59</sup> but the task of tourniquet reassessment is not presently taught to all crewmembers. Understanding the need to avoid nonmedically indicated tourniquet use will be critical as the US Navy prepares for near-peer conflict in the maritime domain.

## Recognition of Non-Life-threatening Extremity Hemorrhage

One of the most important aspects of controlling life threatening extremity bleeding with tourniquets is to recognize what magnitude of bleeding requires this intervention. The short transport times and minimal morbidity associated with tourniquet use in Iraq, Afghanistan, and the US civilian sector have caused this point not to receive major emphasis previously.

In addition, having one's self or one's comrades wounded in combat often prompts an emergency response, a desire to be perceived as addressing the needs of the wounded. As described in Mabry's 2006 article:

*“Longmire addressed the question of the general distribution of tourniquets, because it was ‘‘so frequently urged by nonprofessional persons on the occasion of war. . . who seem to think that every gunshot wound is accompanied with serious loss of blood that life is endangered from this cause alone . . . although rarely*

*fatal solely from hemorrhage, almost every wound is attended with a slight oozing and loss of blood. But to many uneducated and excited men this bleeding would at once be interpreted as showing the need for a tourniquet.”<sup>60,61</sup>*

The tourniquet overuse evidence from both the civilian and the Ukrainian combat settings combined with the Ukrainian tourniquet morbidity experience has now shown us that there is a

clear opportunity, and a pressing need, for first responder training to better prepare students to differentiate life-threatening extremity bleeding, which requires a tourniquet, from minor or minimal bleeding, which does not.

The tourniquet patient presented by Holcomb and his co-authors in their 2023 article, and shown in Figure 4, lost his arm as a result of 11.5 hours of tourniquet ischemia. When the casualty was seen at the medical treatment facility, his arm wound was



**Figure 4.** A tourniquet that was not medically indicated. The application time was 11.5 hours, and the arm had to be amputated. Image courtesy of Dr. John Holcomb.

described as “minor shrapnel injury of the soft tissues of the back surface of the right forearm.” There was no life-threatening hemorrhage, and no symptoms of shock were reported.<sup>43</sup>

The US DoD Ukrainian Medical Assistance team addressed the issue of nonmedically indicated tourniquets during a meeting in Warsaw, Poland, in December of 2023. One of the steps that can be undertaken immediately and with minimal resources is an ad hoc block of instruction that presents TCCC students with examples of extremity wounds and requires them to decide whether a tourniquet is indicated based on the amount of bleeding observed (Fig. 5 and 6).<sup>62</sup>

As examples of bleeding that does require tourniquet application, Figure 5 illustrates instances of life-threatening extremity bleeding, while Figure 6 provides examples of minor extremity bleeding that does not require tourniquet application. A caveat in tourniquet reassessment is that, when a casualty is in shock, bleeding that is initially severe may slow to the point where it appears to be minor. If shock is present, tourniquet release will also further lower the blood pressure and should be avoided until after resuscitation is initiated. The potential for the bleeding rate of a specific wound to vary over time highlights the need for frequent reassessment of wound sites.

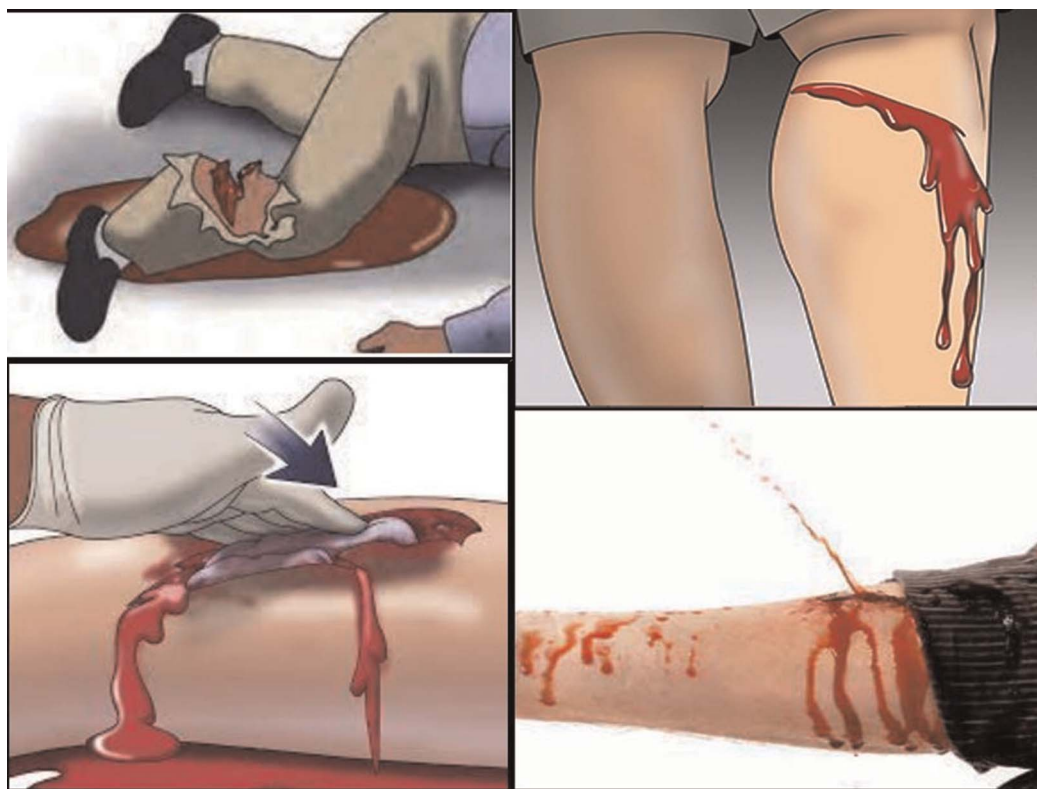
If a tourniquet has been applied to an extremity, a mandatory reassessment of whether the extremity wound(s) merit the continued use of a tourniquet should occur as soon as feasible and no later than 2 hours after injury.<sup>45</sup> An updated version of the “Tourniquet Yes or No” presentation<sup>62</sup> will be made available in the near future at the websites listed below:

- Deployed Medicine
- TCCC.Org.UA (TCCC Curriculum Material Translated into Ukrainian)
- National Association of Emergency Medical Technicians
- Joint Trauma System
- Journal of Special Operations Medicine

Arrangements are also being made to translate both this article and the presentation mentioned previously into Ukrainian. This training module is meant to supplement the material in the approved TCCC curricula. Both combat leaders and medical leaders in the Ukrainian military as well as other militaries who may be faced with combat conditions that may cause evacuation delays beyond 2 hours will need to be made aware of this new training opportunity and ensure that it is trained and executed by battlefield first responders.

## CONCLUSION AND RECOMMENDATIONS FROM THE MULTIDISCIPLINARY AND MULTINATIONAL REVIEW OF CURRENT TOURNIQUET USE IN THE RUSSO-UKRAINIAN WAR

1. Tourniquets are lifesaving and should continue to be used aggressively in the presence of life-threatening extremity bleeding, especially in combat scenarios in which both the casualty and the first responder are confronted by the imminent threat of death from hostile fire.
2. However, not every extremity wound needs a tourniquet.



**Figure 5.** Extremity bleeding that does require a tourniquet. The bottom right image is from the Department of Defense. The other three photos are courtesy of the American College of Surgeons.





**Figure 6.** Extremity bleeding that does not require a tourniquet. Photos courtesy of (clockwise from top left) Mr. Mike Meoli, *Journal of the American Academy of Orthopedic Surgeons*, Dr. Oleksandr Linchevskyy, Dr. Andy Fisher, and Dr. Warren Dorlac.

3. Multiple studies, both military and civilian, have shown that tourniquets are often applied when they are not medically indicated.
4. Overuse of extremity tourniquets has not caused excess morbidity in either the recent conflicts in Iraq and Afghanistan or in civilian settings.
5. The application of a tourniquet when it is not medically indicated and when evacuation of the casualty is prolonged places the casualty at unnecessary risk of limb amputation and potentially life-threatening PTAS.
6. This unnecessary loss of extremities and life-threatening episodes of PTAS are currently occurring in Ukrainian combat forces.
7. Needless loss of extremities and episodes of PTAS might also occur in US forces in a variety of future combat scenarios during which evacuation to surgical care is delayed.
8. In wounded extremities with only minimal or minor bleeding, tourniquets are not needed and a simple dressing will suffice, although casualties in shock require close monitoring to ensure that bleeding does not increase as the casualty is fluid resuscitated.
9. Reassessment of the need for a tourniquet on an injured extremity should be performed as soon as feasible but not later than 2 hours after tourniquet placement.
10. Early reassessment also enables tourniquets that are found to be indicated to be moved to a location just proximal to the bleeding site, thus reducing both the amount of extremity tissue at risk of ischemic damage and the magnitude of PTAS that may be sustained if evacuation to surgical care is delayed.
11. If the bleeding is judged to be potentially life-threatening in a delayed evacuation setting, convert the tourniquet to other means of bleeding control, such as hemostatic dressings applied with strong, direct pressure as soon as feasible. If attempted conversion of the tourniquet is not successful at controlling the bleeding, reapply the tourniquet.
12. Sites of current or previous tourniquet application should be frequently reassessed until the casualty arrives at the medical treatment facility, especially during periods of fluid resuscitation.
13. Current prehospital trauma training programs place insufficient emphasis on not using tourniquets for extremities with only minor bleeding and removing previously applied tourniquets when they are found not to be medically indicated on reassessment. This aspect of training should be reinforced in future TCCC and civilian first responder curriculum development.
14. An interim, ad hoc training solution on this topic is available at the websites indicated in this article. Additional training modalities may follow.
15. Training on how to distinguish life-threatening extremity bleeding from bleeding that is minimal or minor should be received by all persons who might be called upon to manage casualties with applied tourniquets when evacuation to surgical care may be delayed.

#### AUTHORSHIP

F.B., J.B.H., and W.D. contributed in the conception and study design. F.B. and J.B.H. contributed in the literature review. F.B., J.B.H., and W.D. contributed in the data acquisition. F.B., J.B.H., W.D., J.G., K.I., L.J., B.M.,



M.M., H.M., M.O. S.S., M.D.T., J.W., K.H., O.L., and O.D. contributed in the data analysis and interpretation. F.B., J.B.H., W.D., J.G., K.I., L.J., B.M., M.M., H.M., M.O., S.S., M.D.T., J.W., K.H., O.L., and O.D. contributed in the drafting of the manuscript. F.B., J.B.H., W.D., J.G., K.I., L.J., B.M., M.M., H.M., M.O., S.S., M.D.T., J.W., K.H., O.L., and O.D. contributed in the critical revision.

## DISCLOSURE

Conflicts of Interest: Author Disclosure forms have been supplied and are provided as Supplemental Digital Content (<http://links.lww.com/TA/D884>). 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, or Navy or the Department of Defense.

## REFERENCES

- Mabry RL, Holcomb JB, Baker AM, Cloonan CC, Uhorchak JM, Perkins DE, et al. United States Army rangers in Somalia: an analysis of combat casualties on an urban battlefield. *J Trauma*. 2000;49:515–528; discussion 528–9.
- Bellamy RF. The causes of death in conventional land warfare: implications for combat casualty care research. *Mil Med*. 1984;149:55–62.
- Maughon JS. An inquiry into the nature of wounds resulting in killed in action in Vietnam. *Mil Med*. 1970;135:8–13.
- Butler FK Jr, Hagmann J, Butler EG. Tactical combat casualty care in special operations. *Mil Med*. 1996;161(Suppl):3–16.
- Butler FK Jr. Military history of increasing survival: the U.S. military experience with tourniquets and hemostatic dressings in the Afghanistan and Iraq conflicts. *J Spec Oper Med*. 2015;15(4):149–152.
- Holcomb JB, McMullin NR, Pearse L, Caruso J, Wade CE, Oetjen-Gerdes L, et al. Causes of death in U.S. Special operations forces in the global war on terrorism: 2001–2004. *Ann Surg*. 2007;245:986–991.
- Butler FK. Two decades of saving lives on the battlefield: tactical combat casualty care turns 20. *Mil Med*. 2017;182:e1563–e1568.
- Kragh JF Jr, Walters TJ, Westmoreland T, Miller RM, Mabry RL, Kotwal RS, et al. Tragedy into drama: an American history of tourniquet use in the current war. *J Spec Oper Med*. 2013 Fall;13(3):5–25.
- Kragh JF Jr, Walters TJ, Baer DG, Fox CJ, Wade CE, Salinas J, et al. Practical use of emergency tourniquets to stop bleeding in major limb trauma. *J Trauma*. 2008;64(2 Suppl):S38–S49 discussion S49–50.
- Butler F, Holcomb J. The tactical combat casualty care transition initiative. *Army Med Dept J*. 2005;33–37.
- Holcomb JB, Butler FK Jr, Rhee P. Hemorrhage control devices: tourniquets and hemostatic dressings. *J Spec Oper Med*. 2015 Winter;15(4):153–156.
- Eastridge BJ, Mabry R, Seguin P, Cantrell J, Tops T, Uribe P, et al. Prehospital death on the battlefield: implications for the future of combat casualty care. *J Trauma Acute Care Surg*. 2012;73:S431–S437.
- Kotwal RS, Montgomery HR, Kotwal BM, Champion HR, Butler FK Jr, Mabry RL, et al. Eliminating preventable death on the battlefield. *Arch Surg*. 2011;146:1350–1358.
- Kragh JF Jr, Walters TJ, Baer DJ, Fox CJ, Wade CE, Salinas J, et al. Survival with emergency tourniquet use to stop bleeding in major limb trauma. *Ann Surg*. 2009;249:1–7.
- Beekley AC, Sebesta JA, Blackburn LH, Herbert GS, Kauvar DS, Baer DG, et al. Prehospital tourniquet use in Operation Iraqi Freedom: effect on hemorrhage control and outcomes. *J Trauma*. 2008;64(2 Suppl):S28–S37; discussion S37.
- Kotwal RS, Howard JT, Orman JA, Tarpey BW, Bailey JA, Champion HR, et al. The effect of a golden hour policy on the morbidity and mortality of combat casualties. *JAMA Surg*. 2016;151:15–24.
- Scerbo MH, Mumm JP, Gates K, Love JD, Wade CE, Holcomb JB, et al. Safety and appropriateness of tourniquets in 105 civilians. *Prehosp Emerg Care*. 2016;20:712–722.
- Goodwin T, Moore KN, Pasley JD, Troncoso R, Levy MJ, Goolsby C. From the battlefield to main street: tourniquet acceptance, use, and translation from the military to civilian settings. *J Trauma Acute Care Surg*. 2019;87: S35–S39.
- Butler FK, O'Connor KO, Butler J. *Tell Them Yourself—It's Not Your Day to Die*. Tampa, FL: Breakaway Media; 2024.
- Levy M, Jacobs L. A call to action to develop programs for bystanders to control severe bleeding. *JAMA Surg*. 2016;151:1103–1104.
- Jacobs LM Jr. Joint Committee to Create a National Policy to Enhance Survivability From Intentional Mass Casualty Shooting Events. The Hartford Consensus IV: a call for increased national resilience. *Comm Med*. 2016;80: 239–244.
- Jacobs LM, Wade DS, McSwain NE, Butler FK, Fabbri WP, Eastman AL, et al. The Hartford consensus: THREAT, a medical disaster preparedness concept. *J Am Coll Surg*. 2013;217:947–953.
- Jacobs LM, McSwain NE Jr, Rotondo MF, Wade D, Fabbri W, Eastman AL, et al. Improving survival from active shooter events: the Hartford consensus. *J Trauma Acute Care Surg*. 2013;74:1399–1400.
- Hashmi ZG, Hu PJ, Jansen JO, Butler FK, Kerby JD, Holcomb JB. Characteristics and outcomes of prehospital tourniquet use for trauma in the United States. *Prehosp Emerg Care*. 2023;27:31–37.
- Jerome JE, Pons PT, Haukoos JS, Manson J, Gravitz S. Tourniquet application by urban police officers: the Aurora, Colorado experience. *J Spec Oper Med*. 2021 Spring;21:71–76.
- Henry R, Matsushima K, Ghafil C, Henry RN, Theeuwens H, Golden AC, et al. Increased use of prehospital tourniquet and patient survival: Los Angeles countywide study. *J Am Coll Surg*. 2021;233:233–239.e2.
- Hawk AJ. How hemorrhage control became common sense. *J Trauma Acute Care Surg*. 2018;85(1S Suppl 2):S13–S17.
- Teixeira PGR, Brown CVR, Emigh B, Long M, Foreman M, Eastridge B, et al. Civilian prehospital tourniquet use is associated with improved survival in patients with peripheral vascular injury. *J Am Coll Surg*. 2018;226: 769–776.e1.
- Scerbo MH, Holcomb JB, Taub E, Gates K, Love JD, Wade CE, et al. The trauma center is too late: major limb trauma without a pre-hospital tourniquet has increased death from hemorrhagic shock. *J Trauma Acute Care Surg*. 2017;83:1165–1172.
- Leonard J, Zietlow J, Morris D, Berns K, Eyer S, Martinson K, et al. A multi-institutional study of hemostatic gauze and tourniquets in rural civilian trauma. *J Trauma Acute Care Surg*. 2016;81:441–444.
- Zietlow JM, Zietlow SP, Morris DS, Berns KS, Jenkins DH. Prehospital use of hemostatic bandages and tourniquets: translation from military experience to implementation in civilian trauma care. *J Spec Oper Med*. 2015;15:48–53.
- Snyder DT, Schoelles K. Efficacy of prehospital application of tourniquets and hemostatic dressings to control traumatic external hemorrhage. DOT HS 811 999b. Washington, DC: National Highway Traffic Safety Administration, May 2014. Available at: [www.ems.gov/assets/Prehospital\\_Applications\\_Of\\_Tourniquet\\_And\\_Hemostatic\\_Dressings.pdf](https://www.ems.gov/assets/Prehospital_Applications_Of_Tourniquet_And_Hemostatic_Dressings.pdf). Accessed June 25, 2024.
- Ko Y-C, Tsai T-Y, Wu C-K, Lin K-W, Hsieh M-J, Matsuyama T, et al. Effectiveness and safety of tourniquet utilization for civilian vascular extremity trauma in the pre-hospital settings: a systematic review and meta-analysis. *World J Emerg Surg*. 2024;19:10.
- Legare T, Schroll R, Hunt JP, Duchesne J, Marr A, Schoen J, et al. Prehospital tourniquets placed on limbs without major vascular injuries: has the pendulum swung too far? *Am Surg*. 2022;88:2103–2107.
- Mokhtari AK, Mikdad S, Luckhurst C, Hwabjire J, Fawley J, Parks JJ, et al. Prehospital extremity tourniquet placements-performance evaluation of non-EMS placement of a lifesaving device. *Eur J Trauma Emerg Surg*. 2022;48: 4255–4265.
- Mikdad S, Mokhtari AK, Luckhurst CM, Breen KA, Liu B, Kaafarani HMA, et al. Implications of the national stop the bleed campaign: the swinging pendulum of prehospital tourniquet application in civilian limb trauma. *J Trauma Acute Care Surg*. 2021;91:352–360.
- Duignan KM, Lamb LC, DiFiori MM, Quinlavin J, Feeney JM. Tourniquet use in the prehospital setting: are they being used appropriately? *Am J Disaster Med*. 2018;13:37–43.
- Ode G, Studnek J, Seymour R, Bosse MJ, Hsu JR. Emergency tourniquets for civilians: can military lessons in extremity hemorrhage be translated? *J Trauma Acute Care Surg*. 2015;79:586–591.
- Yatsun V. Application of hemostatic tourniquet on wounded extremities in modern “trench” warfare: the view of a vascular surgeon. *Mil Med*. 2024; 189:332–336.
- Patterson JL, Bryan RT, Turconi M, Leiner A, Plackett TP, Rhodes LL, et al. Life over limb: why not both? Revisiting tourniquet practices based on lessons learned from the war in Ukraine. *J Spec Oper Med*. 2024; V057-2PCH.
- Stevens RA, Baker MS, Zubach OB, Samotowka M. Misuse of tourniquets in Ukraine may be costing more lives and limbs than they save. *Mil Med*. 2024;usad503.

42. Walravens S, Zharkova A, De Weggheleire A, Burton M, Cabrol J-C, Lee JS. Characteristics of medical evacuation by train in Ukraine, 2022. *JAMA Netw Open*. 2023;6:e2319726.
43. Holcomb JB, Dorlac WC, Drew BG, Butler FK, Gurney JM, et al. Rethinking limb tourniquet conversion in the prehospital environment. *J Trauma Acute Care Surg*. 2023;95:e54–e60.
44. Quinn J, Panasenko SI, Leshchenko Y, Gumeniuk K, Onderková A, Stewart D, et al. Prehospital lessons from the war in Ukraine: damage control resuscitation and surgery experiences from point of injury to role 2. *Mil Med*. 2024;189:17–29.
45. Shackelford SA, Butler FK Jr., Kragh JF Jr., Stevens RA, Seery JM. Optimizing the use of limb tourniquets in tactical combat casualty care: TCCC guidelines change 14-02. *J Spec Oper Med*. 2015;15:17–31.
46. Samarskiy IM, Khoroshun EM, Vorokhta Y. The use of tourniquets in the Russo-Ukrainian war. *J Spec Oper Med*. 2024;CB00-GYYX.
47. Sabate-Ferris A, Pfister G, Boddaert G, Daban J-L, de Rudnicki S, Caubere A, et al. Prolonged tactical tourniquet application for extremity combat injuries during war against terrorism in the Sahelian strip. *Eur J Trauma Emerg Surg*. 2022;48:3847–3854.
48. Standifird CH, Kaisler S, Triplett H, Lauria MJ, Fisher AD, Harrell AJ 4th, et al. Implementing tourniquet conversion guidelines for civilian EMS and prehospital organizations: a case report and review. *Wilderness Environ Med*. 2024;35(2):223–233.
49. Drew B, Bird D, Matteucci M, Keenan S. Tourniquet conversion: a recommended approach in the prolonged field care setting. *J Spec Oper Med*. 2015;15:81–85.
50. Schmitz CC, Chipman JG, Yoshida K, Vogel RI, Sainfort F, Beilman G, Clinton J, Cooper J, Reihisen T, Sweet RM. Reliability and validity of a test designed to assess combat medics' readiness to perform life-saving procedures. *Mil Med*. 2014;179:42–48.
51. Hemman EA, Gillingham D, Allison N, Adams R. Evaluation of a combat medic skills validation test. *Mil Med*. 2007;172:843–851.
52. Keenan S, Riesberg JC. Prolonged field care: beyond the “golden hour”. *Wilderness Environ Med*. 2017;28(2S):S135–S139.
53. Detsch J. Ukraine's cheap drones are decimating Russia's tanks. Foreign policy. April 9, 2024. Available at: <https://foreignpolicy.com/2024/04/09/drones-russia-tanks-ukraine-war-fpv-artillery/#:~:text=In%20the%20third%20year%20of,have%20gotten%20plenty%20of%20practice>. Accessed April 15, 2024.
54. Tadlock MD, Kitchen LK, Brower JJ, Tripp MS. Maritime applications of prolonged casualty care: a series introduction. *J Spec Oper Med*. 2024;GOPF-AS10.
55. Tadlock MD, Edson TD, Cancio JM, Flieger DM, Wickard AS. War at sea: burn care challenges—past. *Present Future Eur Burn J*. 2023;4:605–630.
56. Tadlock MD, Gurney J, Tripp MS, Cancio LC, Sise MJ, Bandle J, et al. Between the devil and the deep blue sea: a review of 25 modern naval mass casualty incidents with implications for future distributed maritime operations. *J Trauma Acute Care Surg*. 2021;91(Suppl. S2):S46–S55.
57. Butler FK, Burkholder T, Chernenko M, Chimiak J, Chung J, Cubano M, et al. Tactical combat casualty care maritime scenario — shipboard missile strike. *J Spec Oper Med*. 2022;22:9–28.
58. Almog O: Lessons learned from the 2023 Hamas-Israel war — first week summary. Tel HaShomer, Israel: Israeli Defense Forces Medical Corps Headquarters October 28, 2023.
59. Office of the Chief of Naval Operations Instruction 1500.86. [https://www.secnav.navy.mil/doni/Directives/01000 Military Personnel Support/01-500 Military Training and Education Services/1500.86.pdf](https://www.secnav.navy.mil/doni/Directives/01000%20Military%20Personnel%20Support/01-500%20Military%20Training%20and%20Education%20Services/1500.86.pdf). Accessed 25 June 2024.
60. Mabry RL. Tourniquet use on the battlefield. *Mil Med*. 2006;171:352–356.
61. Longmire T. Treatment of gunshot wounds. In: *Combat Injuries: Their History, Characteristic Features, Complications, and General Treatment, with Statistics Concerning Them as They Have Been Met with in Warfare*. London, England: Longmans, Green and Co; 1895:770–772.
62. Butler F, Holcomb J: Who needs a tourniquet? And who does not. U.S. DoD Ukrainian Medical Assistance Team Meeting; December 16, 2023; Warsaw, Poland.