

COMMENTARY

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Misuse of Tourniquets in Ukraine may be Costing More Lives and Limbs than they Save

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ABSTRACT Hands-on training and social media sites have heavily emphasized the use of tourniquets to treat limb injuries during the Ukraine war. Tourniquet overuse or misuse can lead to significant tragedy—limb loss, physiologic complications, and even death. Casualty evacuation in Ukraine often exceeds 6 hours, and the liberal use of limb tourniquets may have unintentionally increased morbidity. Tourniquet application was appropriate in 24.6% of the wounded with tourniquets in one recent publication by a Ukrainian vascular surgeon. The longer a limb tourniquet is in place raises the risk of compartment syndrome, vascular thrombosis, rhabdomyolysis, and irreversible myonecrosis resulting in major tissue loss and often necessitating limb amputation. If bleeding is controlled with a tourniquet, attempts to remove the tourniquet as early as possible to avoid the negative consequences are essential. Training in tourniquet use without explaining possible limb loss and other complications resulting from tourniquets left *in situ* more than 2 hours makes use risky. Tourniquets should be loosened at one hour if the tactical situation allows, and the injury assessed to determine if major bleeding persists or to determine if other methods of hemostasis would be effective. Ukraine must improve the training so that everyone becomes aware of the risks of prolonged or improper tourniquet use. This tourniquet training information must be transmitted to military medical leaders, Ukrainian military medics, civilian volunteers, volunteers in Ukraine, and NATO trainers in allied countries conducting medical training for Ukrainian soldiers. A trauma registry and tracking through echelons of care can enhance performance improvement through timely feedback.

The training of Ukrainian soldiers and civilian volunteers to stop life-threatening bleeding has strongly emphasized limb tourniquets (Fig. 1). However, tourniquet training and use in the West which reflects much of the U.S. DoD Tactical Combat Casualty Care (TCCC), upon which the civilian “Stop-the-Bleed” courses and Ukrainian guidelines are based.

These relate to recent U.S. and NATO experience in the Middle East.^{1,2} There were two important differences on those battlefields:

1. U.S. and NATO forces have embedded and well-trained combat medics and medical officers as integral parts of combat arms battalions (infantry, artillery, and armor), and
2. Allied forces in the Middle East had control of the air. This meant that most tactical casualty evacuation (CASEVAC) was conducted by rotary wing assets (helicopters) and was rapid, often less than 60 minutes from the time that the CASEVAC was called until the wounded soldier was treated by a NATO military surgeon.

Therefore, if a tourniquet was placed under fire, it was assessed and potentially removed by a military surgeon within 1-2 hours, and often no harm was done even if wrongly placed or not needed for hemorrhage control.

This is not the same in the current war in Ukraine. The Ukrainians do not have control of the air due to Russian anti-air assets, and CASEVAC from the point of wounding to reaching the first military surgeon at a Role 1 (no surgical capability) stabilization point (Stabpunkt) often takes >6 hours and sometimes a day or more (personal communication with Dr. K and Dr. Z—from Zbroini syly Ukrayiny = ZSU—Ukrainian Military Forces—name

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FIGURE 1. Ukrainian civilian medics and military medics get training in tourniquet application Ismael, Ukraine.

and military title is confidential).³ CASEVAC is often conducted by ground transportation over poor roads, and sometimes on foot, even by civilian volunteers and vehicles—and is often delayed due to enemy fires (personal communication with doctor from ZSU, name and military title is confidential).

Additionally, many Ukrainian infantry battalions do not have adequate numbers of trained imbedded combat medics. This means that most limb tourniquets are placed either by the wounded soldier himself, or one of his comrades. Most of these soldiers have had some TCCC training; however, it was based upon our guidelines (see above) and many soldiers are afraid to release (convert) the tourniquet to another form of hemorrhage control, despite recent Ukrainian military guidance concerning tourniquet conversion.⁴

The longer that a limb tourniquet is left *in situ* fully tightened increases the risk of compartment syndrome, thrombosis of vessels, rhabdomyolysis, and irreversible myonecrosis. This can result in major tissue loss and limb amputation. The Ukrainian experience with prolonged CASEVAC appears to show many cases of limb amputation for injuries where either a tourniquet was not necessary, was placed unnecessarily proximal, or was left on too long—resulting in myonecrosis and a cascade of problems. This situation of prolonged tourniquet use apparently has resulted in a numerous limbs lost and degradation of renal function due to rhabdomyolysis from compartment syndrome causing acute renal failure, often requiring hemodialysis (personal communication with Dr.s K and Z from ZSU—and Dr. V. Pirsiki). There is contrary literature to suggest that longer tourniquet times have not necessarily resulted in amputation.⁵

Some Ukrainian hospitals receiving casualties from the front have had their hemodialysis capabilities overwhelmed due to large numbers of wounded soldiers with “prolonged tourniquet syndrome.” Two large casualty receiving hospitals in southern Ukraine report receiving 2-3 new patients per week with what they describe as “prolonged tourniquet

syndrome”—often requiring amputation of the limb(s), sometimes hemodialysis due to rhabdomyolysis-related acute renal failure, with case-fatality rates in patients requiring hemodialysis >30% (personal communication with Dr. V. Pirsiki).

We believe that Ukrainian military, volunteer civilian, and NATO military trainers do not realize the high risk of limb loss and other negative consequences due to inappropriate use or prolonged tourniquet application. Nor do they see these consequences as the casualty is moved through and up the care chain, as there is no Ukrainian version of the U.S. joint trauma registry, and no regular review of complications. Casualty data are not published by the Ukrainian Ministry of Defense or Ministry of Health due to security concerns.⁶

Ukrainian hands-on training and social media sites have over-emphasized the use of proximal placement of tourniquets without explaining possible limb loss and other complications resulting from tourniquets left *in situ* more than 2 hours. Yatsun reported that only 25% of limb tourniquets placed during combat operations in Ukraine were appropriate, the remainder were more appropriately managed with pressure dressings.⁷

Those of us with experience in combat zones in the Middle East are not surprised by reports of tourniquets being placed under fire for wounds that are not resulting in life-threatening hemorrhage. In our experience in the Middle East conflicts, tourniquets placed during Care Under Fire are often not removed until the wounded soldier is under the care of a military surgeon at a Role 2 or Role 3 facility, but this is often less than 60 minutes (personal experience, author Stevens). Irreversible damage is less likely if the limb tourniquets are removed within 2 hours.² This explains the paucity of published reports of limb loss due to use of tourniquets in U.S. and NATO forces. However, in Ukraine, with CASEVAC times often exceeding 6 hours, the liberal use of limb tourniquets has apparently resulted in tragedy.

History often repeats itself: “*Trying to prevent tourniquet misuse the US Seventh Army Surgeon (WWII) directed that the*

*'sole indication' for applying a tourniquet should be 'active spurting hemorrhage from a major artery' and that medics in the field or at battalion aid stations should note the presence of a tourniquet on a patient in capital letters."*⁸

During WWII, the evacuation times from the point of wounding to reaching a military surgeon were often prolonged, as on the Ukrainian battlefield today. This situation resulted in many limbs lost to prolonged tourniquet use. Most tourniquets placed under fire are probably not necessary to control life-threatening hemorrhage. Leaving them in place can result in compartment syndrome, vascular thrombosis, myonecrosis, shock, and/or acute renal failure—hence further attention and assessment of the affected limb, the need for the tourniquet to stop bleeding, and consideration of alternative methods to stop bleeding is essential.

A tourniquet which is placed too proximal can result in unnecessary loss of limb length. Placing them in the appropriate location—just proximal to the bleeding point—will save limb length. Tourniquet removal/tourniquet conversion to a different technique to control bleeding if necessary at the earliest possible time is essential to limb salvage and prevention of negative metabolic consequences such as renal failure due to muscle necrosis.

Use of pressure dressings, wound packing, and hemostatic dressings to control non-life-threatening hemorrhage in lieu of tourniquets—unless essential—is critical and casualty care education needs to be directed to this end.

OUR RECOMMENDATIONS

1. As soon as "safely feasible" all limb tourniquets must be removed and the limb reassessed for active bleeding, aspirationally within 60 minutes of initial tourniquet placement—realizing that most tourniquets applied during the "Care Under Fire" phase of TCCC are not necessary to control life-threatening hemorrhage.⁵
 2. If the limb tourniquet is necessary to control life-threatening limb hemorrhage, re-tighten the windlass or re-inflate the pneumatic tourniquet and identify this patient as an absolute priority for evacuation to a higher level of medical care.
 3. Use alternative forms of hemorrhage control if possible. Most tourniquets placed under fire may be transitioned to a hemostatic dressing with tourniquet release (tourniquet conversion or TC), or at least moved to immediately proximal to the injury site (tourniquet replacement or TR).
 4. Develop "YouTube" or other source videos to train commanders, soldiers, medics, and civilian volunteers about the risk of unnecessary tourniquets and tourniquets placed too proximally. Provide additional training to explain and promote TC and TR.
 5. Distribute widely on social medical sites with help of government communication specialists.
 6. Exceptions to tourniquet conversion/removal:
- a. Traumatic limb amputations (but in this case, the tourniquet must be placed just above the amputated stump).
 - b. A hopelessly mangled extremity that is not salvageable. This requires the type of clinical judgement that a trained combat medic or medical officer on the battlefield would provide. Possibly, a substitute could be videos or photos of non-salvageable extremity wounds that could be incorporated into the above-mentioned smart phone application (app).
7. The Ukrainian Military Medical Service must develop their own tourniquet guidelines based upon the realities of their war. Following U.S./NATO TCCC tourniquet guidelines may have led to many unnecessary limb amputations in Ukraine.
 8. Increase the number of medical officers and trained combat medics on the battlefield. Commission nurses as junior officers (currently in the Ukrainian military, nurses are non-commissioned officers) to help supervise and train enlisted medics assigned to combat arms battalions.
 9. Consider increasing the number of Role 2 forward surgical teams and moving them closer to the battlefield, e.g., to the "Stabilization Points."
 10. The Ukrainian military medical service should implement a trauma registry with a system to track and analyze combat wounds and treatment to learn from their experience. They need to utilize this system to track all injured patients from the first Role 2 or 3 encounters—where there is surgical support—and provide feedback as the patient is tracked through the system of higher levels of care.
 11. U.S. and NATO military medical planners and the DoD Committee on TCCC take note of these recent battlefield lessons. If the U.S. and/or NATO become involved in a conflict with a near-peer adversary, allied control of the air is not guaranteed. This means CASEVAC will be conducted by ground, and that CASEVAC times will be prolonged. If limb tourniquets are applied under these circumstances, limbs might be unnecessarily lost, unless TCCC tourniquet guidance and military medical training is updated based upon Ukrainian battlefield experience.⁷

Ukrainian military medical leaders must improve the training of leaders, soldiers, military medics, and civilian volunteers so that they become aware of the risks of prolonged or improper tourniquet use. All must avoid leaving tourniquets on more than 2 hours and avoid the negative consequences of placing tourniquets more proximal than necessary. This information must be transmitted to Ukrainian Forces and to NATO trainers in allied countries and to volunteers in Ukraine conducting medical training for Ukrainian soldiers. Social media can be employed to help disseminate this information.

Ukrainians can also work toward increasing the number of trained combat medics with actual medical experience and position doctors (medical officers) and nurses within combat

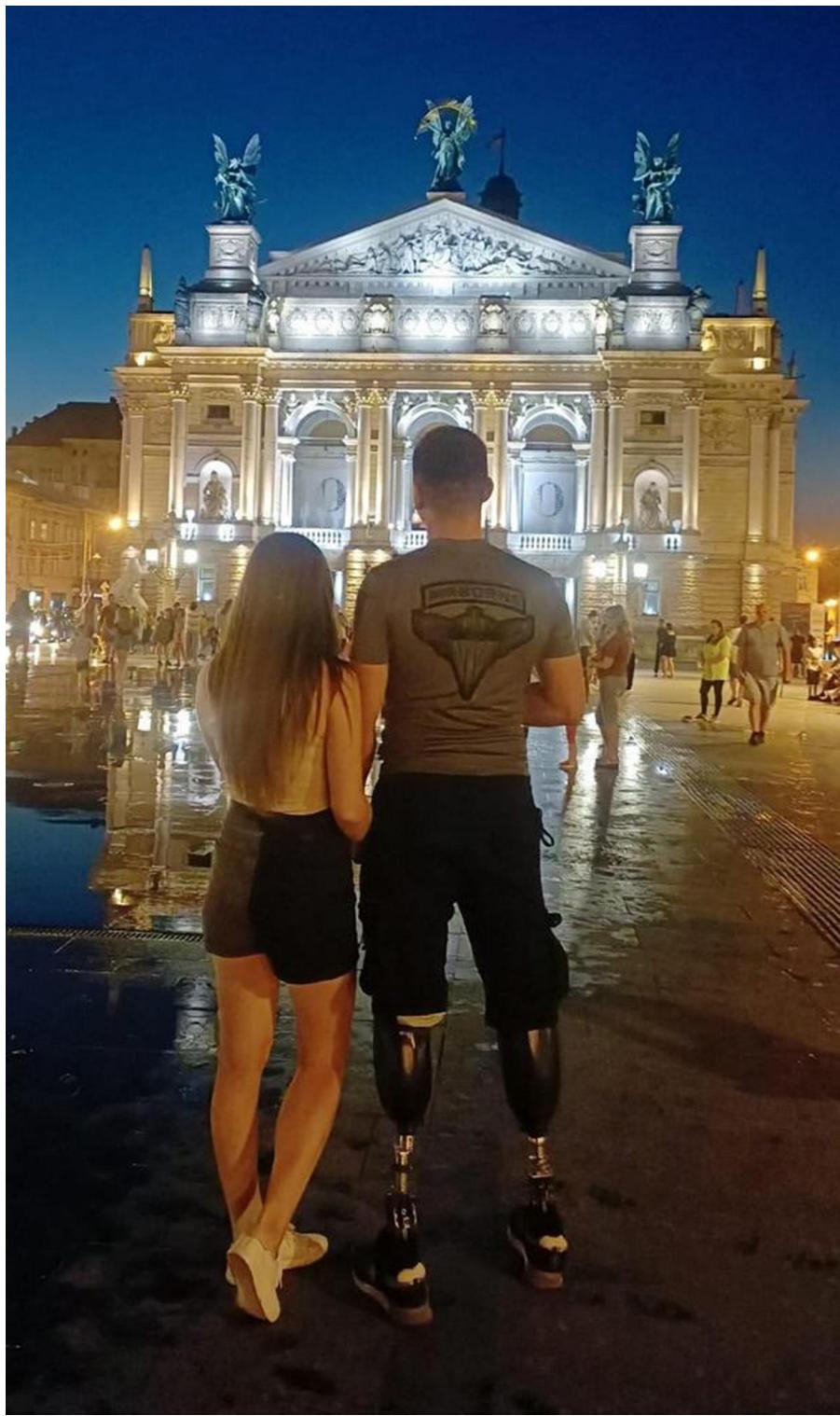


FIGURE 2. Wounded Ukrainian soldier in recovery—gazes at his future.

arms battalions to provide training and supervision for combat medics, as is common in NATO militaries. A former U.S. Navy Surgeon General has stated: “*No Marine has ever taken a hill without a [US Navy] corpsman by his side.*”⁹ Providing more trained medical manpower on the battlefield in Ukraine

could save more Ukrainian lives and limbs. This change would come at a large manpower cost to Ukraine; however, it would help to ensure that more wounded soldiers survive battlefield wounds and survive the war with intact limbs to help rebuild their country after victory.

A Theater Trauma Registry and system for recording the findings, tracking the injured patient through the all roles of medical care, military and civilian, and providing feedback to the providers closer to the front is essential. This could be done with a web-based system and teleconferencing, as is seen with the U.S. military's Joint Tracking System. Joint Tracking System is a performance improvement organization which employs a systematic approach to determine the acute and long-term outcomes of all casualties, the quality of care, improvements in prevention and treatment and logistical implications.¹⁰ A registry with feedback will immensely improve outcomes by making performance improvement measure recommendations to ensure the appropriate evaluation and treatment of injured military across the continuum of care. Loss of a limb is very difficult to recover from (Fig. 2), and we must be careful not to increase the numbers of limbs lost by failing to properly replace and promote the timely removal of tourniquets.

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