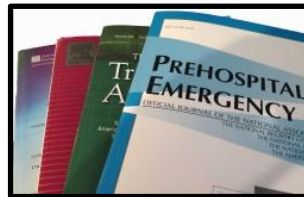


International Prehospital Medicine Institute



IPHMI Literature Review

Keeping You Up to Date with Current EMS Literature and Studies

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In this special edition review, three articles were recently published discussing tourniquet use for patients injured in the war in Ukraine. The first article is a descriptive article of the experience in Ukraine. The next two articles are important commentaries and reviews of the medical limitations encountered by the Ukrainians as well as a review of important concepts regarding tourniquet use that apply to all settings, not just the military.

The IPHMI Editorial team.

1. **The Use of Tourniquets in the Russo-Ukrainian War.** Samarskyi IM, Khoroshun EM, Vorokhta YM *J Spec Oper Med* 2024;23, Spring Edition, 67-70.
 2. **Misuse of Tourniquets in Ukraine may be Costing More Lives and Limbs than They Save.** Stevens RA, Baker MS, Zubach OB, Samotowka M. *Mil Med* 2024; published on-line ahead of print
 3. **Life Over Limb. Why Not Both? Revisiting Tourniquet Practices Based on Lessons Learned From the War in Ukraine.** Patterson JL, Bryan RT, Turconi M, et al. *J Spec Oper Med* 2024;23:Spring:18-25.
1. **The Use of Tourniquets in the Russo-Ukrainian War.** Samarskyi IM, Khoroshun EM, Vorokhta YM *J Spec Oper Med* 2024;23, Spring Edition, published on-line ahead of print

After the US military experience in the Middle East, the application of tourniquets for life threatening limb hemorrhage has become an accepted intervention for both the military combat and the civilian tactical and Emergency Medical Service (EMS) settings.

This article reviews the use of tourniquets during the Russo-Ukrainian war. Data were retrospectively collected for the period of 2014-2022 which covers the time period before and after the large scale invasion of Ukraine by Russian forces. These data were obtained from records of patients that reached military aid hospitals and did not include patients that received definitive care or died without reaching a military field hospital. The data included limbs treated with tourniquets and the number, type and duration of use per limb. It also included outcomes such as reconstruction, amputations and functional state of limbs.

The majority of tourniquets (50% to 60%) were applied during medical evacuation at the front line. Thirty to 40% of the cases had the tourniquet placed within 2 and 5km from the combat line. An additional 5%-10% were treated at the base of local civil or field hospitals. Prior to 2022, the primary tourniquet used was an elastic, Esmarch-like device. Beginning in 2022, the Combat Application Tourniquet (CAT) was instituted.

There were 2,496 patients with limb injuries requiring the use of tourniquets. Lower extremity injuries accounted for 2,107(84%) of all patients. A single tourniquet was used in 1,538 (61.6%) of the cases, 533 (21.4%) had two tourniquets, and 425 (17%) had three tourniquets. The duration of

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tourniquet applications ranged from 50 to 380 minutes with a mean application time of 206 minutes. These long application times were attributed to difficult evacuation due to heavy fire.

Casualty outcomes included 57 fatalities (3.7%) due to massive blood loss, 27 (1.1%) due to infection, sepsis or co-morbidities and 13 patients (0.5%) who died from multiple organ failure. Of the surviving 2,437 patients, amputations were done in 92 (3.7%). These amputations were performed to treat multi-fragment explosive injuries that had no possibility of reconstruction as well as those patients with prolonged application time (greater than 6 hours) and extensive tissue necrosis.

In patients who had tourniquets applied but did not require amputation, 938 cases of neuropathy were identified, with 679 of these resolving within 24 months post injury. Unresolved neuropathy was attributed to the primary limb injury in 147 cases.

The authors suggest naming the ischemic changes and compartment syndrome that result from prolonged tourniquet use as “tourniquet syndrome”. They suggest that a broader discussion of care for patients with long term tourniquet use should be considered.

2. Misuse of Tourniquets in Ukraine may be Costing More Lives and Limbs than They Save. Stevens RA, Baker MS, Zubach OB, Samotowka M. *Mil Med* 2024; published on-line ahead of print

While the control of life-threatening limb bleeding has been an important part of training for Ukrainian soldiers, there are a number of important differences between their overall capabilities and the U.S./NATO forces which have resulted in significant morbidity and mortality for the Ukrainians.

- US and NATO forces have embedded and well trained combat medics and medical officers as integral parts of combat arms battalions.
- Allied forces in the Middle East had control of the airspace that allowed for tactical casualty evacuation to be conducted by helicopters, generally resulting in times of less than 60 minutes from the time that a helicopter was called until the soldier was treated by a military surgeon.

In the Ukraine, the Ukrainians do not have control of the air and it can take from 6 hours to more than a day for the patients to get to the first military surgeon. In addition, many Ukrainian infantry battalions do not have adequate numbers of trained, embedded combat medics. This results in soldiers with some TCCC training providing care to their comrades and in some cases themselves. However, given the limited medical training and experience, they are often reluctant to consider tourniquet re-assessment and conversion to alternate methods of hemorrhage control.

The dangers of prolonged tourniquet use including compartment syndrome, thrombosis of the vessel, rhabdomyolysis and irreversible myonecrosis resulting in major tissue loss and amputations. Many limb amputations in Ukraine have been for injuries where a tourniquet was not necessary in the first place, was placed unnecessarily high on the limb, or left on for prolonged periods of time. One report quoted in this commentary said that appropriate indications for tourniquet placement were found in only 25% of cases, with the remainder of the wounds being more appropriately managed with pressure dressings.” The renal complications that occur from rhabdomyolysis have resulted in Ukrainian hospitals that receive the wounded having their hemodialysis capabilities overwhelmed by patients with prolonged tourniquet syndrome.

The authors also describe a similarity between the Ukrainian experience and World War II with both conflicts having long evacuation times and tourniquets that should have “transitioned” to another form of bleeding control to limit complications.

Based on their review of the Ukrainian experience, the authors made the following 11 recommendations with the first 6 having applicability not just to combat situations but all trauma cases including civilian injuries:

International Prehospital Medicine Institute

1. As soon as “safely feasible” given the situation, all limb tourniquets must be removed and the limb reassessed for active bleeding, ideally within 60 minutes of the initial tourniquet placement. They noted that most tourniquets applied during the “Care Under Fire” phase of combat or tactical situations are not necessary to control life-threatening hemorrhage.
2. If, after removing or loosening the limb tourniquet it remains 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 to help minimize the total tourniquet application time.
3. Whenever possible, use alternative forms of hemorrhage control. Most tourniquets placed under fire may be transitioned to a hemostatic dressing with tourniquet release (tourniquet conversion or TC), or at least moved to a location 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 on the injured limb. Provide additional training to explain and promote TC and TR.
5. Distribute educational materials widely on social media sites with the 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 a 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 Department of Defense (DoD) Committee on Tactical Combat Casualty Care (TCCC) must take note of these recent battle-field 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, in which case 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.

The authors closed with a call for improved training of leaders, soldiers, military medics and civilian volunteers with an emphasis on tourniquets being in place for no more than two hours and avoiding placing them more proximally than necessary. They also stressed the importance of a sophisticated trauma registry to provide data back to the front on patient outcomes to provide guidance to their care.

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3. Life Over Limb. Why Not Both? Revisiting Tourniquet Practices Based on Lessons Learned From the War in Ukraine. Patterson JL, Bryan RT, Turconi M, et al. *J Spec Oper Med* 2024;23:Spring:18-25.

Current tourniquet guidelines are based on the U.S./NATO supported military operations in which transportation times after injury rarely went beyond an hour. Prolonged and inappropriate tourniquet use can present threats to life and limb. The history that the guidelines are based on is significantly different than what the Ukrainian Military is currently facing. The tactical realities of the Ukraine-Russian conflict involve high attrition warfare and contested airspace.

The intent of this paper was to discuss the risks of directly implementing medical care guidelines outside of the systems in which they were validated. The authors present 7 cases that were initially cared for at or near the point of injury. All cases involved injured patients that had tourniquets applied and in place from 2 hours to 16 hours to unknown. All cases, except one, involved bleeding that was not life-threatening and prolonged application of the tourniquet resulting in amputation, compartment syndrome, rhabdomyolysis, and kidney injury.

The authors note that while lives are saved from vascular injury to limbs with the use of tourniquets, medical personnel in Ukraine report high rates of complications associated with tourniquet application. Three major factors that have impacted Ukrainian tourniquet practices include prolonged evacuation time, rigid protocolization of concepts, and systemic differences in the definition, training and availability of field medics.

Discussion and Commentary:

All three of these papers discuss the issues and limitations of providing care in the Ukraine-Russian war. They point out that lack of control of the airspace contributes significantly to prolonged evacuation times in combat situations. NATO's experience in the Gulf Wars where they had control of the skies had most patients being evacuated to definitive care within an hour; the injured in Ukraine may not make it to definitive care until 4 hours after the injury and frequently more than 12 hours later.

The U.S./NATO evidence for the safety of tourniquets finds exceedingly low rates of application times over 150 minutes. High rates of morbidity occur when times exceed this time frame. Since 2001, only one US serviceman lost a limb after prolonged tourniquet application (8 hours).

Tourniquet time principles are as follows:

- Up to 2 hours of application time is safe
- The rate of complications increases after 2 hours
- After more than 6 hours there are high rates of irreversible complications.

Recent evidence suggests the risk of major limb threatening complications may increase as soon as 4 hours after application.

The Ukrainian medical system heavily uses standardized protocols. Up through 2023, Ukrainian law stated that tourniquet conversion should only be performed by medical workers or specialists who have received appropriate training. Recently, the Ministry of health has changed their stance regarding conversion stating that "as soon as the situation allows, a re-evaluation of the need to use the tourniquet and a decision on its conversion should be made".

Trauma specialists have been well aware of the risks involved in using tourniquets. As a result of the Ukraine experience, experts in the field have come together to revisit tourniquet conversion through proposed changes to existing guidelines and increased training requirements on tourniquet need, conversion and replacement.

Our recent civilian EMS experience in the U.S. with short transport/evacuation times led to a de-emphasis on conversion of tourniquets to other methods of bleeding control. It was also pointed out that the skills needed for conversion need to be in the hands of the people that are responsible for the care of these patients beyond the 2-hour safe zone for tourniquets. EMS providers of all levels that are

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likely to find themselves caring for these patients must be able to make these assessments and have the skills to make the decisions to give their patients their best chance for optimal outcomes.

These concerns will likely not change how most of EMS providers in civilian urban/suburban EMS care for hemorrhaging patients, but rural EMS responders with prolonged evacuation/transport times will have similar issues.

Finally, it is important for all public safety responders (police, fire and EMS) to remember the following points about hemorrhage control and tourniquet application:

- Tourniquets should be applied only for life-threatening limb hemorrhage
 - Most other, non-life-threatening bleeding can be controlled with the application of direct pressure with or without a hemostatic wound packing
- If a tourniquet has been applied for 2 hours, the continued need for it should be reassessed by loosening the tourniquet and evaluating the bleeding.
 - If the bleeding can be controlled by other means, they should be implemented.
 - If the bleeding cannot be controlled, the tourniquet should be tightened again.
 - Assure that tourniquet placement is just proximal to the wound.