

**Khramtsov D. M., Salenko D. S. Evolution of hemostatic tourniquet and emergency care for massive bleeding from limb vessels. Journal of Education, Health and Sport. 2024;63: 289-294. eISSN 2391-8306. <https://dx.doi.org/10.12775/JEHS.2024.63.021>
<https://apcz.umk.pl/JEHS/article/view/57396>
<https://zenodo.org/records/14569621>**

The journal has had 40 points in Ministry of Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Education and Science of 05.01.2024 No. 32318. Has a Journal's Unique Identifier: 201159. Scientific disciplines assigned: Physical culture sciences (Field of medical and health sciences); Health Sciences (Field of medical and health sciences). Punkty Ministerialne z 2019 - aktualny rok 40 punktów. Załącznik do komunikatu Ministra Edukacji i Nauki z dnia 05.01.2024 Lp. 32318. Posiada Unikatowy Identyfikator Czasopisma: 201159. Przypisane dyscypliny naukowe: Nauki o kulturze fizycznej (Dziedzina nauk medycznych i nauk o zdrowiu); Nauki o zdrowiu (Dziedzina nauk medycznych i nauk o zdrowiu).
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The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 28.06.2024. Revised: 02.07.2024. Accepted: 12.07.2024. Published: 31.07.2024.

Evolution of hemostatic tourniquet and emergency care for massive bleeding from limb vessels

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Abstract

The review is devoted to the problem of providing emergency care for injuries of limb vessels using tourniquets. The development of various types of tourniquets in the historical aspect, the risk of complications with improper use of tourniquets are analyzed. Aspects of training medical personnel in emergency situations, humanitarian disasters, and large-scale war are discussed.

Keywords: emergency medicine; tourniquets; complications; prevention; training

A hemostatic tourniquet is a device that, due to mechanical compression, prevents the passage of blood through the vessels of the limb [1]. The use of tourniquets has been known since ancient times. The soldiers of Alexander the Great used primitive tourniquets for wounds during his military campaigns. Sushruta was familiar with tourniquets, who used a leather tourniquet in the 6th century BC to stop bleeding during amputation [2, 3]. In ancient Rome, tourniquets made of leather and bronze were widely used [4] (Fig. 1a). The practice of tourniquets was eventually forgotten until Hans von Hersdorff, the founder of the Prussian school of military medicine, described the use of a tourniquet in amputation surgery in 1517. Somewhat later, Ambroise Paré recommended to use a thick ribbon as a tourniquet [2, 5]. In

1593, Fabricius Hildanus improved the twisting tourniquet by describing the use of a stick to twist the constricting bandage in a circle [5].



Fig. 1 Types of harnesses (a – ancient Roman harness, 2nd century AD, b – Petit tourniquet, c – Esmarch tourniquet (USSR), d -Israel military tourniquet, e – combat application tourniquet Gen. 7, f - Smart Tactical Application Tourniquet (S.T.A.T.)

However, these models were primarily intended to provide hemostasis during amputation. Injury to a large vessel in the limb remained fatal. It was not until 1674 that Étienne J. Morel, a French army surgeon who is often credited with the first unambiguous statement of the use of a tourniquet on the battlefield, described a tourniquet used during the Siege of

Besançon [2]. This tourniquet consisted of a leather strap that went through a wooden bar (with holes at each end) and a stick that was inserted into the loop of the strap. The device was improved by the famous French surgeon Jean-Louis Petit, who in 1718 proposed a screw tourniquet of his own design, calling it the “*touriquet à vis*” [6]. The popularization of this model of tourniquet was facilitated by the successes of the French surgical school, but for the needs of military medicine, improvised fabric tourniquets or leather straps were mainly used to stop bleeding. This was true of most military conflicts of the 18th and 19th centuries.

A real revolution was created by the flat rubber bandage, proposed by Johann Friedrich August von Esmarch, professor of surgery at the University of Kiel, during the Franco-Prussian War [2, 7]. Later, Harvey Cushing invented a pneumatic tourniquet, which allowed to avoid neurological complications [2]. But in military medicine, the main means of stopping bleeding from the limb remained the Esmarch rubber tourniquet [7-9].

However, as further experience has shown, the risk of serious complications increases with improper tourniquet use. This applies to incorrect application of the tourniquet, its excessive duration on the limb, concealing the presence of the tourniquet with clothing or a blanket, etc. [10].

The Esmarch rubber tourniquet has been modified in different countries of the world [2, 7, 9]. In the USSR, it took the form of a narrow thick rubber band with perforation and a plastic protrusion for fixation (previously with a metal chain), in Israel - a wide (6.5 cm) rubber bandage (Fig. 1 c, d).

In the early 2000s, new types of emergency tourniquets [2, 11, 12] were introduced, suitable for providing emergency care to others and self-application (Table 1). They differ in the mechanism for providing sufficient compression and the width of the tape (Fig. 1e. 1f. In addition to tourniquets for stopping bleeding from the vessels of the limb, there are so-called junctional tourniquets that can control bleeding from the inguinal and axillary vessels.

With the beginning of the large-scale invasion of Russia, emergency medicine specialists faced a serious problem - how to ensure medical care and provide the necessary training to the population. Replacing the Esmarch tourniquet in the individual first-aid kits of military personnel with the CAT and its modifications allowed to reduce mortality significantly [13-15]. Successes in standardizing the parameters of tourniquets allowed to reduce the use of home-made unreliable devices, a significant number of which were supplied to the troops and mobile groups of paramedics. At the same time, the best results were obtained when using a silicone ring autotransfusion tourniquet and various modifications of the CAT.

Table 1 Characteristics of tourniquets used during the Russian-Ukrainian War (2014-2024)

Tourniquet	Mechanism	CoTCCC certification	Strap width, cm	Producer
CAT Gen 7	Windglass	+	3.8	North American Rescue, USA
SAM-XT	Windglass/buckle	+	3.7	SAM Medical, USA
SOF TTW	Windglass	+	3.8	Tactical medical solutions, USA
TX 3	Windglass	+	3.7	RevMed, USA
RMT	Windglass	+	3.8	MedInc., USA
Sich	Windglass	-	3.8	Ukraine
Dnipro	Windglass	-	3.8	Ukraine

Tourniquets used in military medicine can be successfully used by the civilian population in areas of increased criminal activity, during accidents at work or in transport, or active military operations. The main difference is that the soldier typically has to apply the tourniquet under fire as a self-help procedure, realizing that evacuation from the battlefield after injury may be delayed.

Recent field trials show that wider straps are more effective and less painful than tourniquets with thinner straps [14, 15]. The concept of limb occlusion pressure is also gaining popularity over the misconception that greater applied force leads to greater effectiveness. In addition, studies of failed cases show that the correct devices must be combined with training that facilitates realistic expectations and correct actions by the user [16-18]. In Odesa, since the beginning of the large-scale invasion, professionals from both government and commercial medical care structures have received training in emergency care, including the use of tourniquets.

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