Review

Problematic issues of limb amputation in wounded with combat trauma

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Among the wounded with limb injuries admitted to the Military Medical Center of the Western region during the year of Russia’s full-scale war in Ukraine, 29% had a mine-blast injury, 47% had shrapnel wounds, 1.5%–thermal injuries, and 14.5%–traumatic injuries. Upper limbs were injured in 22%, lower – in 32%, 15% had two limbs injured, and 31% had combined combat trauma. In all hospitalized with multi-fracture fractures, limbs were fixed with external fixation devices. 2% of patients had vascular damage. All wounded had unhealed wounds with a soft tissue defect. The average age of patients was 30 years. There were no comorbid diseases in the wounded, and concomitant diseases that did not affect the course of injury were found in 10%. Amputations of limbs were performed in 6.5%. Traumatic separation of a limb segment or its destruction with crushed bone and non-viable soft tissues, nerve damage with significant defect, soft tissue and bone defect, as well as thermal ischemia of the limb for more than 6 hours with necrosis of its soft tissues, were indications for primary limb amputation in 3% of wounded and injured, which were in the nature of primary debridement. Progressive wound infection with the development of the septic condition of the wounded despite intensive treatment, total ischemic necrosis, and recrudescent arrosive bleeding from great vessels required a secondary limb amputation in 1.5%. In 1.5% of the wounded, staged operations were performed as re-amputations. Re-amputation had to be performed in 0.6% of patients with an inappropriate limb stump level, which complicated prosthetics. To reduce the number of amputations for secondary indications, a timely diagnosis is needed of compartment syndrome and rational treatment of soft tissue wounds and gunshot fractures with surgical and medical prevention of the infectious process.

Keywords: Amputation, war injury, limb, extremity.
Introduction

Combat limb injury is the most frequent injury in modern warfare and ranges from 52.3 to 60.1% [1] and 63.3%, according to the Military Medical Clinical Center of the Western Region. [2].

The main task of medical care to the wounded with combat trauma and limb injuries is to save their lives (life before limb), and if this is not possible, then amputation of the limb with the formation of a stump suitable for prosthetics [3].

During military conflicts in Afghanistan and Iraq, 70.5% of wounded US service members had severe injuries to their limbs, and the percentage of amputations was 7.4%. Amputations were performed three times more often on the lower extremities [4]. During the 2014–2016 antiterrorist operation in the East of Ukraine, the frequency of amputations among service members of the Armed Forces of Ukraine was 2.2%, excluding data from other law enforcement agencies [5].

Analysis of the results of surgical treatment of wounded with amputees showed a number of shortcomings that required repeated surgical interventions to eliminate complications and form a stump suitable for prosthetics. The most frequent complications were phantom pain, neuromas, osteophytes, heterotopic ostificates, and excess or lack of soft tissue stump.

Materials and Methods

During the year of Russia’s full-scale war in Ukraine from 02/24/2022 to 02/24/2023, patients with various types of combat trauma were under our supervision at the Military Medical Center of the Western Region: bullet, shrapnel wounds, blast trauma, burns, and combined trauma. According to the mechanism of injury, 29% of those wounded with limb injuries had mine-blast trauma, 47% had shrapnel wounds, 8% had gunshot bullet wounds, 1.5% – thermal lesions, and 14.5% – traumatic injuries. Upper limbs were injured in 22%, lower – in 32%, 15% had two limbs injured, and 31% had combined combat trauma. In all hospitalized with multi-fragment fractures, the limbs were fixed with external fixation devices. 2% of patients had vascular damage. All wounded had unhealed wounds with a soft tissue defect. The average age of patients is 30 years. There were no comorbid diseases in the wounded, and concomitant diseases that did not affect the course of injury were found in 10%. Limb amputations were performed in 6.5%.

Results

In the treatment of bullet, shrapnel and mine-blast wounds, the peculiarities of such wounds were taken into account. All wounds are primarily contaminated with germs; the wound canal or wound defect has a special structure with necrotic tissues and tissues of the zone of molecular concussion, in which secondary necrosis subsequently occurs. In addition, in the case of mine-blast wounds, a wave of compression from the energy of the explosion causes the separation of the limb segment, and the muscles are forcefully thrown up and out and detached from the bone (Umbrella effect). The intact structures then go down and cover and mask the damaged deep tissue. These features significantly affect the results of surgery.

In the case of mine-blast wounds and combined combat trauma, the best treatment tactics were staged treatment of the victim using technology damage control, which allowed for saving the lives of the wounded and preparing him for restorative and reconstructive surgical interventions.

Traumatic separation of the limb segment or its destruction with crushed bone and non-viable soft tissues, nerve damage with a significant defect, soft tissue and bone defect, as well as thermal ischemia of the limb for more than 6 hours with necrosis of its soft tissues, were indications for primary amputation of the limb in 3% of wounded and injured.

Among the existing scales that determine the need for amputation, the MESS scale is the most used [6]. This scale includes a point assessment of the severity of injuries to the following limb components: bone and soft tissue injury, severity of limb ischemia, traumatic shock and systolic blood pressure, and patient age. The MESS scale gives recommendations for the preservation or amputation of the injured limb. According to this scale, the assessment of the severity of damage is 0–6 points – preservation of the limb, 7 points or more – amputation. However, the criteria of this scale do not always help make the most correct choice. Other scales have similar disadvantages: LSI, PSI, NISSSA, and HFS-97 [7].
In addition to assessing the limb condition, when deciding on amputation, the general condition of the wounded person was taken into account (combined cavitary injuries, hemorrhagic shock, systemic diseases) and specifications (surgeon’s experience, level of medical care, tactical situation, resources).

**Discussion**

Primary amputations, which were performed at the second level of medical care, were in the nature of primary surgical debridement of the wound. Non-viable tissues and foreign bodies were removed in such a way as to maintain the maximum length of the limb with identification of vessels and nerves, thorough hemostasis, fasciotomy and stabilization of fractures by external fixation apparatus.

A hemostatic turnstile was applied at the basic level of medical care to save the life of the wounded in case of damage to the great vessels of the extremities. If this turnstile was more than 6 hours, then irreversible limb ischemia occurred with tissue necrosis. In these cases, there was no alternative to limb amputation. When the applied turnstile interfered with the debridement without removing it, a second turnstile was applied more proximally, and amputation was performed over the distal turnstile. After the initial amputation, the stump wound was left open.

It is a mistake to believe that limb amputation is a simple surgery and does not require certain techniques. The main mistakes in performing primary amputations were insufficient excision of necrotic tissues, inadequate treatment of nerves and blood vessels, and absence or inadequate fasciotomy.

Since in high-energy gunshot wounds, and especially in mine-blast trauma, the spread of non-viable tissues is much greater than their visualization during primary wound debridement, monitoring of the wound process with revision of the wound under anesthesia and, if necessary, repeated surgical treatments is necessary. Such surgical tactics, correction of homeostasis disorders and adequate antibacterial therapy made it possible to reduce the number of amputations of the limbs according to secondary indications or preserve the limb segment, which is more suitable for functional prosthetics.

The causes of amputations of the limbs, according to secondary indications, were late diagnosis of compartment syndrome with the development of myonecrosis, early suturing of secondary sutures on the wound at previous levels of medical care, followed by suppuration of wounds and the spread of the infectious process.

Progressive wound infection with the development of the septic state of the wounded despite intensive treatment, total ischemic necrosis, and repeated arching bleeding from great vessels required secondary amputations of the limb in 1.5%.

The decision on limb amputation for secondary indications was taken by a consultation of surgeons and anesthesiologists. The condition of the limb was documented and recorded in the photo. Before amputation, radiography was mandatory.

Often, a complex issue was the psychological preparation of the patient for amputation. The situation was aggravated by the unstable emotional state of the wounded. According to research by S. L. Mitchell et al. (2019), 19.4% of wounded with severe limb injuries had post-traumatic stress disorder, and 12.3% had depression [8].

Reasonable explanations to the patient that further treatment of the wounded segment of the limb threatened his life and that there was no way to restore limb function reached an understanding and agreement on amputation. Clinical examples of patients who had restored the function of an amputated limb after prosthetics convinced the wounded person to make a decision.

In 1.5% of the wounded, stage operations were in the nature of re-amputation. Re-amputation had to be performed in 0.6% of patients with an inappropriate stump level, which complicated prosthetics.

Late limb amputations were performed in cases where the limb was afunctional. The ideal characteristics of the stump suitable for prosthetics were its cylindrical shape, functional proximal joint, absence of neuroma and bone protrusions, and normal skin sensitivity without deformations of the integuments. We believe that the longer the segment is left on the upper limb, the better. On the lower leg, the best prosthetic length was about 22 centimeters from the floor, and on the thigh – 15 centimeters from the middle of the knee.

During the patient’s preparation for prosthetics, rehabilitation specialists conducted motor rehabilitation of an amputated limb to prevent contractures, restore muscle function and train walking on a prosthesis.
Prevention of heterotopic ossification of stumps and neuromas of main and cutaneous nerves, which worsen the quality of life of amputees and require repeated surgical operations, remains a problematic issue. The main reason for the formation of heterotopic ossification is considered to be traumatization of the periosteum and insufficient treatment of bone edges. Some foreign colleagues recommend myodesis to reduce the risk of heterotopic ossification during amputation of lower extremities \cite{9,10}. Today, there is no consensus among specialists regarding the use of effective technology to prevent neuromas, so this issue is being investigated. It will be the topic of our further reports.

In conclusions: High-energy bullet, shrapnel and mine-blast wounds destroy soft tissues and crush the bones of the limbs, forming significant defects or separation of the segment, which are indications for primary amputation of the limb. Primary amputation of the limb under such conditions has the nature of the primary surgical treatment of the wound, and the stump of the limb is formed at the next stage of the surgery. Reducing the number of amputations for secondary indications allows timely diagnosis of compartment syndrome and rational treatment of soft tissue wounds and gunshot fractures with surgical and medical prevention of the infectious process. The level of amputation should contribute to functional limb prosthetics.

**Study limitations:** This study has some limitations regarding restrictions of statistic data sharing.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**References**