Brief communications

Treatment of combat surgical trauma of the limbs in the conditions of modern war

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Among the total number of wounded who entered the Military Medical Clinical Center of the Western Region from February to September 2022, combat injury to the limbs was in 63.3%. Bullet wounds caused combat injury to the limbs in 10.4%, shrapnel and mine-explosive – in 68.1%, explosive injury – in 21.5%. At the second role of medical care, emergency surgical interventions were performed on the wounded, immobilization of bone fractures with an external fixation and anti-shock therapy. At the third and fourth roles – the treatment of the wounded consisted in the use of a multidisciplinary approach with the involvement of doctors of various specialties, first of all, general surgeons, traumatologists, vascular, plastic surgeons and anesthesiologists. The most frequent surgical intervention was repeated and secondary debridement of gunshot wounds, which was required by 93% of the wounded. The main pathogens that vegetated in wounds were Acinetobacter baumannii, Pseudomonas aeruginosa, Enterobacter aerogenes, Proteus vulgaris, Enterococcus faecalis with high levels of microbial contamination – 10^4–10^8/g in tissues. Various types of plastics were used to close soft tissue defects, according to the rule of the reconstruction ladder. After healing a soft tissue wound to determine the timing of replacing the method of fixing fractures with internal osteosynthesis, were analyzed clinical and laboratory parameters and assessed the risks of complications. The main causes of amputations of the limbs were common defects in soft tissue and bones, which were not subject to reconstruction with no prognosis for bone fusion and progression of the infectious-necrotic process.

Keywords: Combat injury, gunshot fracture, gunshot wound, plastic soft tissue defects.
Introduction
Combat trauma to the limbs in modern warfare is the most frequent injury in the wounded, often accompanied by a soft tissue defect with a high risk of infectious complications and the threat of limb loss. After analyzing the general structure of hostilities of different scales I.P. Khomenko with co-author. (2021) concluded that in the structure of combat sanitary losses, combat injury to the limbs ranges from 52.3 to 60.1% [1]. Among those wounded in the limb, soft tissue defects requiring plastic closure are present in 64.9-68.2% [2]. Already in the first days of Russia’s large-scale attack on Ukraine as a result of hostilities on the right side of the Dnieper in the city of Kiev, among the hospitalized victims, 43.7% had injured limbs and pelvis [3]. A significantly higher percentage of combat limb injuries, namely 82%, were observed by Owens BD et al., (2007) in Iraq and Afghanistan during the war years from 2001 to 2005. [4]. The frequency of early and late amputations with severe injuries of the limbs reaches 31% [5].

Material and methods
Among the total number of wounded who entered the Military Medical Clinical Center of the Western Region (MMCC WR) from February to September 2022, combat injury to the limbs was 63.3%. Of these, 17.8% had gunshot fractures (2.5% with bone defects), 34.5% had wounds to soft tissues only, 1.9% had injuries to the upper vessels with damage to the great vessels, 59.4% had multiple fractures, and 10.9% had combat trauma to the limbs combined with abdominal injuries. 5.8% were treated with amputation stumps, of which 4.3% of amputations were performed according to primary indications, and 1.5% – for secondary ones, after complications. The lower limbs were amputated in 74%, the upper limbs – in 26%, and in 3.5% – two or more. Bullet wounds caused combat injury to the limbs in 10.4%, shrapnel and mine-explosive – in 68.1%, explosive injury – in 21.5%.

Results
Medical care for the wounded with injuries to the limbs at the pre-hospital stage included anesthesia, stopping bleeding, fixing the wounded limb and transporting to the second role of medical care, where emergency surgical procedures were performed, immobilization of fractures with an external fixation (EF), full anti-shock therapy and preparing the wounded person for evacuation to the third and fourth role of medical care – to the military medical clinical center.

In the MMCC WR a multidisciplinary approach was used to treat patients with high-energy injuries of the extremities with polystructural damage to bones, blood vessels and soft tissue defects with the involvement of various specialties physicians, primarily general surgeons, traumatologists, vascular, plastic surgeons and anesthesiologists.. Comprehensive treatment of wounds began with repeated debridment, negative pressure therapy, the use of antibacterial drugs according to the sensitivity of microorganism. After preparing the wound, the soft tissue defects were restored by plastic surgery to create conditions for the use of modern methods of osteosynthesis of bone fractures.

The most serious were wounded with combined injuries to the chest, abdomen and limbs. At the second role of medical care, the treatment of such wounded was carried out according damage control technology, which allowed them to save their lives. In the MMCC WR, treatment was continued according damage control surgery and it consisted in the first treatment of life-threatening complications of the chest and abdomen wound. Internal osteosynthesis of the extremities bones fractures was performed after stabilization of the wounded condition and soft tissue wounds healing.

Discussion
The main causes of combat injury to the limbs were mine-fragmentation, mine-explosive and gunshot bullet wounds. After analyzing the injuries of the limbs during military conflicts, Owens BD et al. (2007), Belmont PJ et al. (2016), Perez KG et al. (2022) note that the mechanism of limb damage in 73-75% of the wounded is mine-explosive and mine-shrapnel injury [4,6,7], which correlates with our observations. Shrapnel wounds of mines, high-explosive shells and missile were multiple with different depths and areas of the wound surface. Bone damage during such injuries was characterized by multiple fragmentary fractures, often with a bone tissue defect. When directly hit in the immediate vicinity, explosive devices cause of the limb amputation with muscle damage, non-viable tissues and multiple lesions of other parts of the body. When a mine exploded under the vehicle, the shock pulse and axial pressure crushed the bones of the foot, usually heel, with bones fracture of the lower leg. Such mechanisms of combat injury create conditions for a complicated running of the wound process with the danger of limb loss.

In all evacuated wounded, bone fractures were fixed by an EF at previous roles, but in 1.8% it became necessary to correct it. Correction of applied EF was carried out in order to stabilize the fracture and fixing pins to prevent core...
osteomyelitis, and remounting it - to mobilize the joints. 93% of the wounded needed repeated and secondary debridement on the first day after admission. Repeated debridement – surgical procedure before the development of wound infection. The aim of it was to assess the viability of soft tissue and bone fragments, remove dead tissue with thorough hemostasis, cytologically and microbiologically determination of the wound contamination with sensitivity to antibacterial drugs. The assessment of the viability of the injured tissues was carried out according to clinical signs (color, consistency, capillary bleeding, the muscles to contract ability) and using photothermoscopy with the FLIR C2 device.

Pulse lavage and ultrasonic cavitation improved the quality of debridement and effectively reduced bacterial contamination of wounds. The main causative agents of wound infection in our patients were Acinetobacter baumannii, Pseudomonas aeruginosa, Enterobacter aerogenes, Proteus vulgaris, Enterococcus faecalis with a high level of microbial contamination – $10^4$-$10^8$/g tissue after admission. These results are different from those of the wounded who entered the MMCC WR in 2014-2015, and in which the wounds were contaminated by Staphylococci and Streptococci.

After debridment, antiseptics wound washing with pulse-lavage, the number of microbes per gram of tissue decreased by 2-3 levels. Only 1.5% of the wounded who entered MMCC WR had to perform a fasciotomy according to indications of complications of the wound process.

The method of treating wounds with negative pressure has proven itself well. Vacuum therapy reduced the volume of wounds, the release of wound secretions, improved microcirculation, stimulated the growth of granulation tissue and accelerated their preparation for plastic closure.

The choice of the method and timing of wounds plastic closure with open fragmentary fractures of the limbs depended on the location and anatomical features of the wound, the type of fracture, the nature of the displacement of fragments, the phase of the wound process and the general condition of the patient.

Split skin graft plastic is technically simple method and allow to close large wound surfaces, but the integuments created are not functionally suitable and make it difficult to perform internal osteosynthesis. Therefore, to create conditions for further surgical intervention on the bones, they tried to make the most of the intact integuments around the wounds. Most often, the wound edges were mobilized and moved to close the deep wound defect. V-Y plastic and keystone plastic have proven themselves well (Figures 1,2).

Figure 1. V-Y plastic procedure of the thigh soft tissue defect
Regional flaps plastic procedures were used in 7.7% of our patients (Figures 3, 4, 5).

Figure 2. The keystone flap plastic of the soft tissue defect with a gunshot fracture of the shoulder

Figure 3. The groin flap plastic in patient with tissue defect of the hand

Figure 4. The pedicled thoracodorsal artery myocutaneous flap plastic of the shoulder gunshot fracture with soft tissue defect
In 2 wounded with a defect in the calcaneus, a cement spacer with vancomycin was used, and the wound was closed in one with a sural flap, and in the other with local plastic.

It remains difficult to resolve the issue of the timing of replacing the method of EF with intramedullary or plate osteosynthesis. Despite the advantages of the EF, it has several disadvantages: it is a decrease in stable fixation over time, the risk of a spin infection, a significant frequency of fracture non-fusion. Given this, internal osteosynthesis has significant benefits. To determine the timing of the replacement of the fixation method with internal osteosynthesis, we were guided by the recommendations of the National Military Medical Clinical Center and took into account the size of the gunshot wound, the duration of its healing, the condition of the integuments of the surgical intervention site and limb, the presence of foreign bodies, concomitant pathology, structural bone changes, the condition of wounds after removed EF, evaluated the blood supply to tissues after surgical restoration of blood flow, the nature of microflora, dynamics patient temperature reaction, laboratory indicators of white and red blood cells and C-reactive protein.

The main causes of limb amputations were common soft tissue and bone defects that were not subject to reconstruction with no prognosis for bone fusion and progression of the infectious-necrotic process, despite intensive surgical and therapeutic treatment.

All wounded after inpatient treatment in the surgical department were rehabilitated in a specialized department of the MMCC WR and in medical institutions of the region to restore the functions of the affected organs, musculoskeletal system and social adaptation.

In conclusions, treatment of modern combat trauma of the limbs is a multidisciplinary problem and requires the involvement of various specialties physicians: surgeons, traumatologists, vascular, plastic surgeons and anesthesiologists. The primary aim is to save the life of the wounded, and then the limb with the restoration of its function. To do this, it is necessary to prevent wound infection, heal the wound and perform stable osteosynthesis of a gunshot fracture. Common defects in soft tissues and bone structures with no prognosis for bone fusion and progression of the infectious-necrotic process are indications for limb amputation.

**Limitations in study:** 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


