

## TREATMENT OF THE WAR WOUNDS OF THE HAND

*Jefta Kozarski, Srđan Cvetanović, Milomir Gačević, Svetlana Vesanović*

*Clinic for Plastic Surgery and Burns, Military Medical Academy, Belgrade*

*E-mail: kozarski@eunet.rs*

**Summary.** *The significance of war injuries of the hand is the direct consequence of the incidence of these wounds and the resulting disability. According to the World War II data, the incidence of hand injuries was approximately 7% of all war injuries. Inadequate management and surgical treatment produce severe disability. Due to highly specialized anatomic structure characterized by a high ratio of skin surface and the volume of deeper tissue structures and complex functional mechanisms it possesses, the hand is an organ which injury requires specific diagnostic and surgical measures. Since war injuries of the hand are mostly complex and associated with tissue (cutaneous) defects, it is essential that a surgeon has good knowledge of the reconstruction methods in wound closure in the reparatory phase, as well as of appropriate atraumatic technique in the reconstruction of tendons, nerves, bones in the reconstruction phase. This paper aims to presenting surgical management of war injuries of the hand according to the principles of war surgery and to establish the place of plastic surgery in the management of war injuries of the hand.*

**Key words:** *Hand, war wound, surgery, treatment*

### Introduction

Modern weapons use the projectiles of different initial velocity, size and shape. The bullets of low initial speed (up to 500 m/s) cause wounds with small entrance point, channel with relatively scarce tissue defect and small wound exit on the skin surface. High speed projectiles (above 600 m/s) cause extensive tissue defects on their course through the tissue. Wound entrances are small, channels are with extensive tissue or organ damage and large wound exit. Around 40% of these wounds are associated with tissue defect. Fragments of the explosive devices are irregular and, in the moment of explosion, may reach even 3000 m/s. War wounds caused by these are almost always associated with the defect of tissue, tendons, nerves, bone and joint injuries, with irregular "pockets" filled with secondary bone defect projectiles. These injuries are most commonly multilobular and associated with blast injury, but can also be penetrating. On their course through the tissue, projectiles create three zones of tissue defects. The zone of "direct traumatic necrosis" is situated in the immediate vicinity to the wound channel and clear clinical signs of tissue necrosis are present here. The next zone, situated laterally to the zone of direct tissue necrosis, is the zone of "massive tissue convulsion". In such tissue, irreversible circulatory changes develop immediately after injury, as the result of blood vessels defects or their thrombosis. Several hours after injury, the tissue develops clinical signs of necrosis. The most lateral zone is the so called «zone of molecular tissue convulsion», with functional circulatory irregularities after wounding. The blood vessels in this zone first become involved

with spasm, then vasodilatation occurs as well as increased permeability of the capillaries, which results in oedema. The tissue of the zone remains alive. Due to its pathomorphologic characteristics, wounds inflicted by firearms or explosive devices are susceptible to infection, especially anaerobic (1). The characteristic of warfare during the civil war in former Yugoslavia is the use of explosive devices (mines, mortar and Howitzer grenades, etc.), absence of large tank or aviation movements, absence of bombing, and insignificant use of flammable substances, which contributed to a reduced number of thermic injuries.

### Methods

Management of the wounds with tissue defects was done in accordance with the principles of war surgery doctrine. Since the wounds had been primarily contaminated with polymorphic bacteria, all the patients received antitetanus and antibacterial treatment. We applied single doses of antitetanus vaccine and human antitetanus immunoglobuline, and antibiotic therapy: crystalline penicillin 4 x 10.000.000 IU, Amikacin 3 x 500 mg and Metronidazole 3 x 500 mg during the first three days. After that, crystalline penicillin was replaced with Longaceph 2 x 1 g. Administration of these antibiotics prolonged latency in infection development (from 6 to 8 hours), considered optimal for primary surgical treatment of war wound, but it cannot replace surgical management of the wound. The key factor for infection development is the presence of devitalized tissue within the wound, and surgical treatment is the fundamental

method of war wound treatment and prevention of infection.

Surgical treatment of war wounds of the hand involve:

1. Primary surgical management
2. Additional surgical management (if required)
3. Delayed wound closure
4. Secondary reconstructive procedures on damaged deep structures

Primary surgical management of the injured hand is performed within 24 hours of wounding using «economical debridement» of devitalized tissue in accordance with war surgery principles all the way to clinically vital tissue. There are indications for hemostasis of metacarpal and digital blood vessels, as well as reconstruction of injured ulnar or radial arteries. It is not mandatory to remove each and every small foreign body from the injured hand. Dislocated bone fragments are repositioned and periosteal fragments are removed. Injured tendons and nerves, after primary work-up, were marked and left for secondary reconstruction procedures. If the expected surgical treatment of an injured finger is long and poor functional outcome is predicted, we believe that finger amputation is a better solution. After debridement, the hand is immobilized in plaster of Paris in neutral position. In accordance with war surgery doctrine, osteosynthesis of the phalanges and metacarpal bones is not allowed, but we used Kurschner wires in some cases for internal immobilization. With primary surgical management and excision of devitalized tissue, we intended to treat the wound adequately, determine its extent and structure of the tissue defects of the hand and plan surgical treatment. Primary management of the wound is basic for surgical treatment and prevention of infection, and provides appropriate conditions for delayed wound closure in the preparatory phase and for subsequent reconstruction procedures. Subsequent tissue necrosis, after primary wound management, caused by pathophysiological mechanisms of wounding and found on «secondary check-up», occurs in around 30% of the cases. In the phase of reparation, the most optimal reconstruction procedure should be selected, depending on the general patient status and structure, size and site of the wound, as well as planned secondary reconstruction of deeper tissue structures. In order to better systematize wounds and to better select reconstruction methods and future surgical treatment plan, we utilized our own classification of war wounds with different tissue defects, which determined reconstruction and further treatment (2). We utilized additional surgical treatment as primary delayed (on 3<sup>rd</sup> or 7<sup>th</sup> day) or secondary (7 days after wounding) (3), and after that the wound was closed. For wound closure we used partial thickness skin grafts as primary or final reconstruction procedure. Different flap types were used: local skin flap, fasciocutaneous, fascial, muscle flap, arterial, reverse, regional, direct distant or free microvascular flaps (4). During the phase of reparation, we performed final reposition of fractured bones. K-wire osteosynthesis of

the phalanges or metacarpal bones was then allowed, thanks to primary surgical debridement and adequate therapy with escalated doses of antibiotics and small surface of the hand (2.5% TBS). Injured tendons and neural elements were left for secondary reconstruction. The hand was then immobilized in plaster in neutral position, or not if the injured bone was fixated with K-wire. Reconstruction of deep hand structures with complex tissue defects (tendons, nerves, bones, joints) was performed two months after wound closure. For injured tendon reconstruction we commonly used tendon grafts, and for injured nerves additional neuroraphy was done or we used nerve grafts. For injured bones we used bone grafts and for joints we utilized capsulotomy or arthrodesis.

## Results

At the Clinic for Plastic Surgery and Burns, Military Medical Academy, 37.6% of the wounded had war wounds with tissue defects caused by firearms. War wounds caused by explosion were recorded in 55.2%, while in 7.1% some thermal agent was the cause. More than half of the wounds treated at the Military Medical Academy were associated with defects of various tissues. War wounds with tissue defects were most common on the extremities (72.3%; upper, 35.8%), while in 16.6% the hand was affected. In 13.4% of the wounded we found multilocular injuries (the consequence of the civil war characteristics). Head and neck injuries were found in 7.2%, abdominal injuries in 6.4%, and urogenital region in 0.7% (5). Complex tissue defects with injuries of the skeleton were observed in 55% of our patients. Phalanx injuries were detected in 12.44%, while metacarpal bones were injured in 10.97%. Direct suture was used to close soft tissue defects in 12.68% and skin grafts were used as either primary or final reconstructive procedure in 40.86%. We made use of various flaps: local – cutaneous (fasciocutaneous, fascial, arterial, reverse) in 9.89%, regional in 16.78%, distant direct in 9.89% or free microvascular ones in 2.37% of the wounded. Finger amputations or surgical management of the explosion-caused hand amputation were performed in 7.52% (6). Reconstructive surgical procedures on deep structures in the treatment of war wounds with complex tissue defects (tendons, bones, joints) were performed two months after the treatment of soft tissue defects. Tendon graft was most commonly used in the reconstruction of injured tendons; additional neuroraphy or nerve graft was used in nerve reconstruction, while bone structures were reconstructed with bone grafts or with free fibular graft (7). Transpositional tendoplastics were utilized after tendon, bone and nerve reconstructions in order to improve hand function. Various prosthetic devices were used for amputated hands.

War wounds of the hand were found in 16.6%. Injuries of bone structures, phalanges in 12.44% and metacarpal bones in 10.76% are the second most common, after the injuries to tibia and fibula. Surgical treatment

of war wounds of the hand involves primary or secondary excision of devitalized tissue, delayed wound closure and secondary reconstruction of deep structures. Adequate primary excision of devitalized tissue, enabling delayed closure, is the foundation of appropriate surgical treatment. Appropriate closure is the foundation of secondary reconstruction of deep structures.

## Conclusion

War wounds of the hand with tissue defects make up more than one third of all war wounds. Complex hand

injuries almost always cause a degree of permanent disability, since the hand is a specific, highly organized organ and injuries of several tissue structures (tendon, nerve, bone, joints) can compromise its functionality. Plastic and reconstruction surgery has a very prominent role in the surgical management of war wounds of the hand, during primary and primary delayed surgical treatment, in wound closure later on, and in the phase of reconstruction of deep tissue defects.

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## TREATMAN RATNIH RANA ŠAKE

*Jefta Kozarski, Srđan Cvetanović, Milomir Gačević, Svetlana Vesanović*

*Vojnomedicinska akademija, Klinika-za plastičnu hirurgiju i opekotine, Beograd  
E-mail: kozarski@eunet.rs*

Kratak sadržaj: *Značaj zbrinjavanja ratnih povreda šake proističe iz njihove učestalosti i invaliditeta do kojih rane dovode. Prema podacima iz II svetskog rata učestalost ratnih povreda šake iznosi oko 7% svih ratnih povreda. Neadekvatno zbrinjavanje i hirurško lečenje dovodi do teškog invaliditeta. Zbog visoko specijalizovane anatomske strukture koji se karakteriše velikim odnosom površine kože u odnosu na zapreminu ostalih dubokih tkivnih struktura i kompleksnog funkcionalnog mehanizma koje poseduje, šaka predstavlja organ čije povrede zahtevaju specifične dijagnostičke i hirurške mere. Obzirom na činjenicu da su ratne povrede šake pretežno kompleksne i praćene defektima tkiva (prvenstveno kože) od esencijalnog značaja je da hirurg vlada rekonstruktivnim metodama zatvaranja rane u reparatornoj fazi, kao i atraumatskom tehnikom tokom rekonstrukcije tetiva, nerava i kosti u rekonstruktivnoj fazi. Cilj ovog rada je da se prikaže hirurško zbrinjavanje ratnih povreda šake po principima ratno hirurške doktrine i odredi mesto plastične hirurgije u zbrinjavanju ratnih povreda šake.*

Ključne reči: *šaka, ratna rana, hirurgija, tretman*