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The Analysis of Trauma Character and Severity in Patients with Shoulder Girdle Combat Injuries

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Summary. Introduction. *According to various studies, limb injuries caused by combat trauma account for 44% to 70% of all injuries to musculoskeletal system.* ***Objective.*** *This study aims to analyze shoulder girdle injuries in patients with combat-related surgical trauma who underwent surgical treatment.* ***Materials and Methods.*** *A retrospective analysis was conducted on 733 patients with combat-related surgical trauma of the limbs, including 378 patients (51.6%) with upper limb injuries and 355 patients (48.4%) with lower limb injuries. All patients received inpatient treatment at the Department of Severe Skeletal Trauma of the State Institution «Institute of Traumatology and Orthopedics of the National Academy of Medical Sciences of Ukraine» from August 1, 2022, to December 31, 2024.* ***Results.*** *During this period, surgical treatment was performed in 63 patients with shoulder girdle combat-related surgical trauma, accounting for 8.6% of all limb injuries and 16.7% of upper limb injuries. The mean age of patients was 34.7±8.1 years. By injury type, gunshot wounds were observed in 35 patients (55.6%), mine-blast injuries in 13 patients (20.6%), other injuries in 8 patients (12.7%), shrapnel wounds in 4 patients (6.3%), and road traffic accident (RTA) injuries in 3 patients (4.8%). Fractures were classified into three groups: fractures and dislocations involving the clavicle in 28 patients (44.4%), scapular fractures in 17 patients (27.0%), and combined fractures of the clavicle and scapula in 18 patients (28.6%). Bone defects were observed in 43 patients (68.3%), with a mean defect length of 4,7±3,8 cm. Gunshot wounds to soft tissues involving shoulder girdle muscles and tendons were found in 54 patients (85.7%). Nerve injuries were diagnosed in 14 patients (22.2%). Major vascular injuries requiring surgical intervention, according to accompanying documentation, were found in 3 patients (4.8%).* ***Conclusions.*** *The analysis of combat-related shoulder girdle injuries demonstrated a high incidence of multi-structural injuries, particularly among working-age males (96.8%), requiring complex surgical interventions and prolonged rehabilitation. The most common injuries were fractures of the clavicle (44.4%) and scapula (27.0%), along with soft tissue injuries involving muscles (85.7%) and nerves (22.2%), which significantly complicate treatment and rehabilitation.*

Key words: *upper limb; gunshot fractures; combat trauma; scapula; clavicle; shoulder joint; multi-structural trauma; surgical treatment; reconstructive and restorative surgery.*

Introduction

With the onset of the armed conflict in eastern Ukraine, which subsequently escalated into a full-scale war between Ukraine and the russian federation, significant changes occurred in approaches to combat operations, the use of combat resources, weaponry, and methods of their application [1]. According to various studies, limb injuries resulting from combat trauma account for 44% to 70% of all musculoskeletal injuries, with bone fractures observed in 35% to 40% of cases [1–4]. Combat-related surgical injuries of the shoulder girdle have not been an exception, as the shoulder remains a vulnerable area of the body during gunfire and other combat operations. In civilian life, the frequency of injuries to this region is much lower: clavicle fractures are among the most common limb fractures, accounting for 2% to 10% of all fractures; acromioclavicular joint dislocations represent 9% of shoulder girdle injuries; scapular fractures are among the rarest injuries, comprising 0.4% to 1% of all fractures and 5% of shoulder girdle fractures [5–9]. Combat-related injuries differ significantly

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from civilian ones in terms of the nature of tissue damage, the extent of tissue destruction, and the level of contamination; they are often accompanied by tissue defects and carry a high risk of infectious complications. They are characterized by severe, multi-structural injuries that have no counterparts in civilian trauma. Such injuries, a typical phenomenon of wartime, require a fundamentally different approach to diagnosis and treatment. Nevertheless, both Ukrainian and international scientific literature provide critically limited information regarding the clinical and epidemiological structure of combat-related surgical injuries of the bones, joints, and soft tissues of the shoulder girdle [10]. Due to the challenging conditions of the active warfare, there is a shortage of reliable data on the incidence and characteristics of these injuries, complicating the planning of medical care and the development of personal protective equipment for military personnel during combat operations. Therefore, the analysis of the nature and severity of injuries in patients with combat-related surgical trauma of the shoulder girdle is an essential component of a comprehensive approach aimed at ensuring the most effective treatment and rehabilitation.

Objective. This work aims to analyze the nature and structure of shoulder girdle injuries in patients with combat-related surgical trauma who underwent surgical treatment.

Materials and Methods

A retrospective analysis was conducted on the surgical treatment of 733 patients with combat-related limb injuries: 378 patients (51.6%) with upper limb injuries and 355 patients (48.4%) with lower limb injuries. All patients received inpatient treatment at the Department of Severe Skeletal Trauma of the State Institution «Institute of Traumatology and Orthopedics of the National Academy of Medical Sciences of Ukraine» between August 1, 2022, and December 31, 2024. Inclusion criteria for the study were as follows: military personnel and civilians aged over 18 years, presence of combat-related shoulder girdle injuries involving fractures of the clavicle and/or scapula, and injuries caused by gunshot or mine-blast trauma confirmed by accompanying medical documentation. Exclusion criteria included: non-combat shoulder girdle injuries, shoulder girdle injuries not requiring surgical treatment, and patients younger than 18 or older than 60 years. The analysis of treatment considered the following data: duration of injury, timing of surgical interventions, type and name of injured structures, nature of surgical care provided, and level of specialized medical assistance. All patients underwent standard general clinical examinations, conventional radiography, spiral computed tomography (CT), electroneuromyography (ENMG), magnetic resonance imaging (MRI), and ultrasonography (US). Fractures of the clavicle and scapula were classified according to the AO/ASIF classification, 2018 edition [11]; nerve injuries were classified using Seddon's classification [12].

The study was approved by the Local Ethics Committee of the State Institution «Institute of Traumatology and Orthopedics of the National Academy of Medical Sciences of Ukraine» (protocol No. 3 dated May 29, 2025). Written informed consent was obtained from all patients prior to participation.

Statistical analysis was performed using Microsoft Excel (Microsoft Office 365) and STATISTICA 12.0 software. Descriptive statistics were used to characterize the data: results were presented as the mean ± standard deviation (M±SD) for normally distributed variables. Student's t-test was used for comparison of parametric data, and the Mann–Whitney U-test was applied for non-parametric comparisons. Quantitative data were presented as absolute values and percentages – n (%). Results were considered statistically significant at $p < 0.05$, with a confidence level of 95%.

Results

Between August 2022 and December 2024, surgical treatment was performed on 63 patients with combat-related surgical trauma of the shoulder girdle, accounting for 8.6% of all limb injuries and 16.7% of upper limb injuries. Most patients were males – 62 (98.4%), while only one was female (1.6%) ($p < 0.05$). Left shoulder girdle injuries were diagnosed in 34 patients (53.9%), while right shoulder girdle injuries were observed in 29 patients (46.1%) ($p < 0.05$). Regarding the type of injuries, gunshot wounds predominated, occurring in 35 patients (55.6%); mine-blast injuries were observed in 13 patients (20.6%); shrapnel wounds were identified in 4 patients (6.3%); road traffic accidents (RTAs) were the cause of injuries in 3 patients (4.8%); and other injuries accounted for 8 cases (12.7%) (Fig. 1).

By fracture localization within the shoulder girdle, patients were divided into three groups: fractures and dislocations of the clavicular joints (Group I) – 28 patients (44.4%); scapular fractures (Group II) – 17 patients (27.0%); and combined fractures of the clavicle and scapula (Group III) – 18 patients (28.6%) (Fig. 2).

Analyzing the data from the diagram illustrating

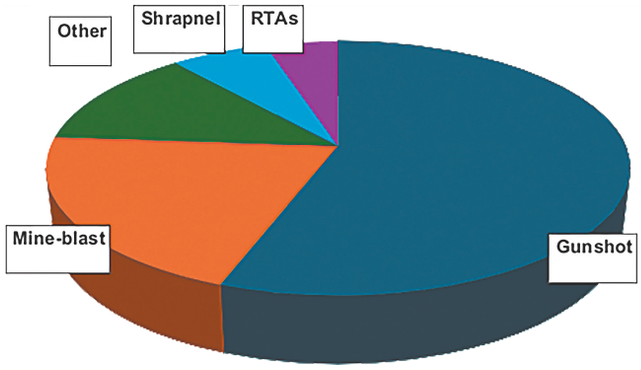

Fig. 1. Distribution of patients according to the type of traumatic factor.

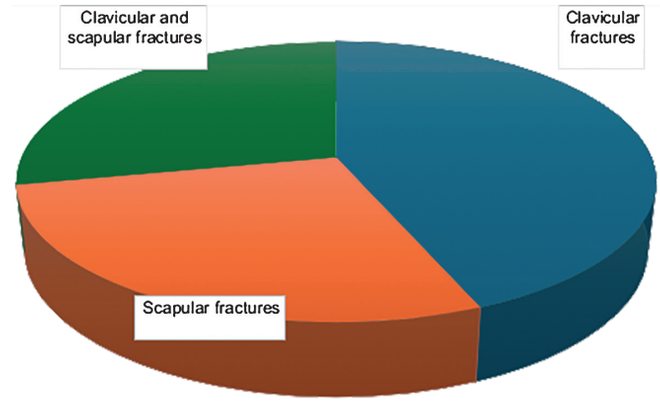

Fig. 2. Distribution of patients with combat-related surgical trauma of the shoulder girdle.

the distribution of patients with combat-related surgical trauma of the shoulder girdle by localization (Fig. 2), it can be noted that the largest proportion consisted of patients with fractures and dislocations of the clavicular joints (44.4%). A more detailed examination of patients in Group I (n=28) (Fig. 3A) showed the following distribution: acromioclavicular joint dislocations were observed in 9 patients (14.3%), including 3 patients (4.8%) with acute grade III dislocation according to the Rockwood classification and 6 patients (9.5%) with chronic acromioclavicular joint dislocation. According to the AO/ASIF classification of clavicle fractures: fractures of the distal (lateral) end segment (15.3) were diagnosed in 6 patients (9.5%), fractures of the diaphyseal segment (15.2) in 8 patients (12.7%), and fractures of the proximal (medial) end segment (15.1) in 5 patients (7.9%). Patients in Group II (n=17) were distributed as follows (Fig. 3B): fracture of the acromion process of the scapula (14A2) in 8 patients (12.7%), fracture of the coracoid process of the scapula (14A1) in 5 patients (7.9%), fracture of the glenoid fossa (14F) in 3 patients (4.8%), fracture of the scapular body (14B) in 7 patients (11.1%), and fracture of the scapular spine (14A3) in 9 patients (14.3%). Patients in Group III (n=18) were distributed as follows (Fig. 3C): fractures of the distal (lateral) end segment (15.3) were observed in 17 patients (27.0%), fractures of the diaphyseal segment (15.2) in 3 patients (4.8%), fracture of the coracoid process of the scapula (14A1) in 15 patients (23.8%), fracture of the acromion process of the scapula (14A2) in 8 patients (12.7%), fracture of the glenoid fossa (14F) in 4 patients (6.3%), fracture of the scapular body (14B) in 10 patients (15.9%), and fracture of the scapular spine (14A3) in 13 patients (20.6%).

Bone defects were observed in 43 patients (68.3%), with a mean defect length of 4.7±3.8 cm. In Group I, 14 patients (22.2%) had clavicle bone defects with a mean length of 1.7±0.8 cm. In Group II, 14 patients (22.2%) had bone defects with a mean length of 4.3±3.6 cm: in the coracoid process (n=1) – 1.1 cm, in the acromion process of the scapula (n=6) – 2.5±1.9 cm, in the scapular body (n=3) – 2.3±0.5 cm, and in the scapular spine (n=8) – 4.7±2.1 cm. Bone defects were identified in 15 patients (23.8%) in Group III, with the following measurements: clavicle (n=15) – 1.9±0.8 cm, coracoid process (n=3) – 1.9±0.9 cm,

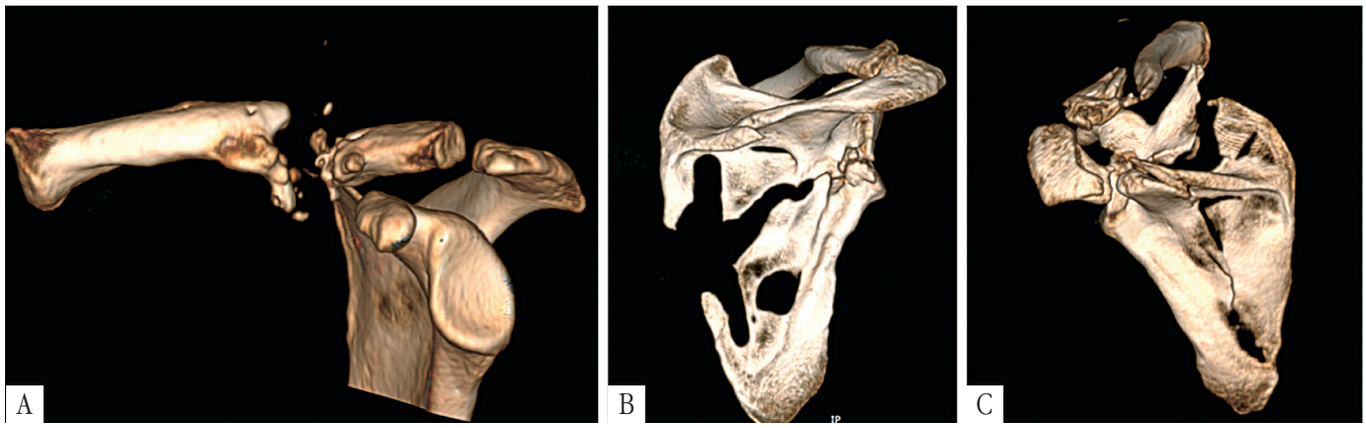

Fig. 3. A – Group I, clavicle fractures; B – Group II, scapular fractures; C – Group III, combined fractures of the clavicle and scapula.

acromion process of the scapula (n=5) – 2.5±0.9 cm, scapular body (n=15) – 2.9±1.1 cm, and scapular spine (n=9) – 3.8±2.3 cm.

The mean age of patients was 34.7±8.1 years (ranging from 21 to 53 years), with a mean age of 34.9±8.1 years among males and 24 years among females. Figure 4 shows age distribution of patients with combat-related surgical trauma of the shoulder girdle.

As shown in Figure 4, individuals with shoulder girdle injuries resulting from modern combat operations were predominantly of working age, between 20 and 49 years, accounting for 96.8% (n=61), which represents a significant medical, social, and economic issue for the country.

Gunshot wounds to the soft tissues with associated muscle and tendon damage (Fig. 5) were identified in 54 patients (85.7%). Muscle defects were distributed as follows: the deltoid muscle in 24 patients (38.1%), the supraspinatus muscle in 19 patients (30.2%), the infraspinatus muscle in 8 patients (12.7%), the teres minor muscle in 2 patients (3.2%), the trapezius muscle in 12 patients (19.1%), and the clavicular portion of the pectoralis major muscle in 5 patients (7.9%). For skin defects reconstruction, a latissimus dorsi musculocutaneous flap was used in 3 patients (4.8%), a dorsal scapular artery perforator flap (DSAP) in 1 patient (1.6%), and a local keystone perforator island flap in 1 patient (1.6%). Negative pressure wound treatment (NPWT) was applied as an intermediate stage before final closure of skin defects in 35 patients (55.6%).

Nerve injuries were identified in 14 patients (22.2%). Suprascapular nerve injuries classified as neurotmesis were found in 9 patients (14.3%), axillary nerve injuries classified as neurotmesis were diagnosed in 4 patients (6.3%), and 3 patients (4.8%) had axillary nerve injuries classified as axonotmesis. One patient (1.6%) sustained a brachial plexus injury in the subclavian region, predominantly affecting the median and ulnar nerves (Fig. 6).

Major vascular injuries requiring surgical intervention were recorded in 3 patients (4.8%), according to accompanying medical documentation. In 2 patients (3.2%), the axillary artery was injured; in 1 patient (1.6%), the axillary vein was injured. Two patients (3.2%) developed post-traumatic aneurysms of the axillary artery, requiring further surgical treatment (endovascular stenting).

Discussion

Combat-related injuries of the shoulder girdle involving fractures of the scapula and clavicle are of particular clinical interest because they differ significantly from peacetime injuries and therefore require alternative approaches to classification and diagnosis. A review of the literature reveals that shoulder girdle injuries with gunshot fractures of the clavicle and scapula are relatively common. According to O. Loskutov, among 1,809 wounded military personnel with gunshot wounds, gunshot fractures were present in 31.5% of cases, with fractures of the scapula and clavicle identified in 14.7% of patients [13]. Owens et al. reported clavicle

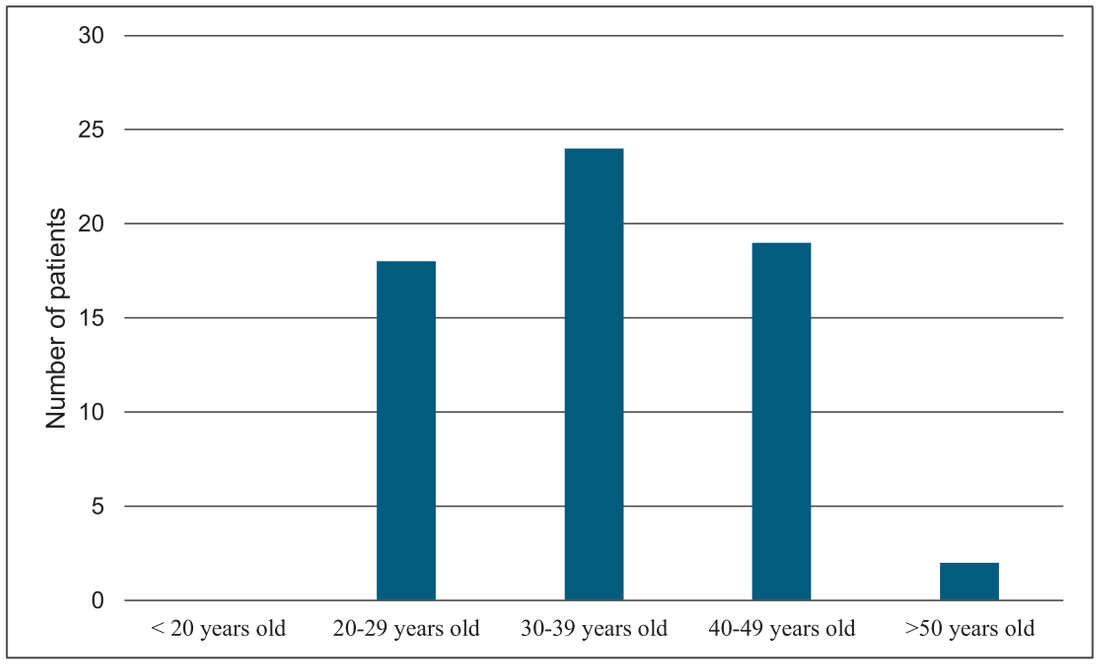

Fig. 4. Age distribution of patients with combat-related surgical trauma of the shoulder girdle.

Fig. 5. Gunshot wounds of the shoulder girdle.

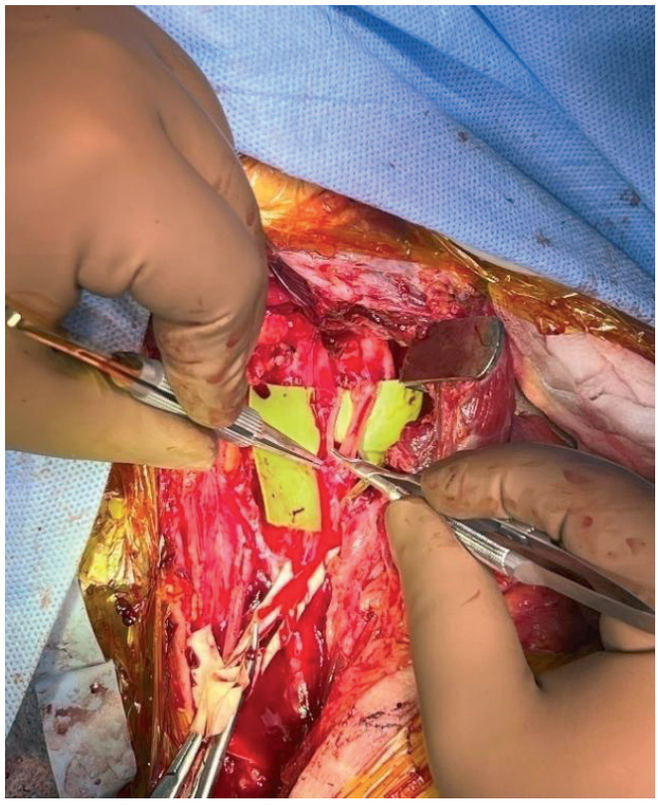

Fig. 6. Intraoperative image of a brachial plexus injury in the subclavian region, predominantly affecting the median and ulnar nerves.

fractures in 13 military personnel (6 open fractures [1.3%] and 7 closed fractures [1.5%]), accounting for 2.8% of upper limb injuries, while scapular fractures (4 closed [0.9%] and 28 open [6.1%]) were found in 32 military personnel, accounting for 6.9% of upper limb injuries among U.S. military personnel during the armed conflicts in Iraq and Afghanistan [14]. Similar data are reported by other researchers. Tahtabasi et al. described 8 cases (7.8%) of scapular fractures (6 open [5.8%] and 2 closed [1.9%]) sustained during the civil war in Somalia [15]. Roberts D.C. et al. inform about 44 scapular fractures (7.7%) among 572 upper limb fractures sustained by United Kingdom military personnel over 10 years of participation in combat operations in Iraq and Afghanistan. The authors emphasized that scapular fractures occur 20 times more frequently in military personnel compared to the civilian population. The use of personal protective equipment (body armor, helmets, ballistic eyewear) significantly influences the injury distribution, making limbs among the least protected anatomical regions [19]. However, the collection of comprehensive statistics in combat conditions is often challenging, which limits the accuracy of available epidemiological data.

Existing classifications of clavicle and scapula fractures are usually based on anatomical localization

and the number of fragments; however, most do not take into account the specific nature of combat injuries. The situation is further complicated by the multi-structural nature of these injuries, with simultaneous extensive damage to bone, muscle, tendon, joint, and nerve tissues. In our study, we used the AO/OTA fracture classification (2018 edition), which provides a two-level approach. The first level defines the anatomical location of the fracture, which is especially relevant in cases of multi-structural injuries. The second level further specifies each fracture location. Scapular fractures are designated as number 14 and classified as intra-articular segment fractures (F), with F0 including all fractures of the articular segment, F1 representing simple fractures with two major fragments, and F2 representing comminuted fractures of the articular segment. Fractures of the scapular body (B) are divided into B1 (simple fractures with two or fewer major fragments) and B2 (comminuted fractures with more than three fragments). Fractures of the scapular processes (P) include P1 (coracoid process fractures), P2 (acromion process fractures), and P3 (combined fractures of both processes) [8]. Clavicle fractures are designated as number 15 and are classified as fractures of the proximal (medial) segment (15.1), diaphyseal fractures (15.2), and distal (lateral) segment fractures (15.3) [16].

Bone tissue injuries with defect formation represent one of the most significant challenges in combat trauma. According to the literature, the frequency of bone defects in patients with combat-related limb injuries ranges from 5.95% to 76% [17, 1]. In our study, bone defects were identified in 68.3% of patients, with an average defect length of 4.7±3.8 cm. Bone defects resulting from combat trauma differ markedly from those sustained in peacetime due to higher contamination and associated soft tissue damage. This significantly complicates the recovery process and requires considerable surgical and resource expenditures.

According to S. Strafun et al., the need for soft tissue reconstruction in patients with gunshot injuries of the shoulder arose in 27.9% of cases, while shoulder muscle reconstruction was required in only 3.7% [4]. Muscle tissue is highly sensitive to the cavitation effects of the temporary pulsating cavity generated by high-velocity projectiles, resulting in extensive destruction not only of soft tissues but also of bone structures, with the introduction of foreign material and microbial contamination, complicating the healing process.

Injuries to the suprascapular and axillary nerves resulting from gunshot fractures of the scapula represent a serious complication, significantly impairing shoulder joint function. However, the available literature lacks reliable statistical data on the prevalence of such injuries, complicating the selection of reconstructive treatment strategies.

Vascular injuries are observed more frequently in modern conflicts compared to previous wars. This is due to improved evacuation procedures, timely application of tourniquets, and more effective prehospital care. According to the literature, injuries to major vessels account for 2.8–8% of combat-related injuries and remain an important cause of mortality both on the battlefield and during evacuation [18].

Gunshot wounds are characterized by severe tissue destruction, deep contamination, and frequent infectious complications, leading to prolonged healing times compared to other types of injuries. Our findings confirm that combat-related surgical trauma of the shoulder girdle is multi-structural in nature, involving damage to bones, soft tissues, tendons, nerves, and vessels, and requiring a multidisciplinary treatment approach.

Conclusions

Based on surgical treatment of 63 patients with combat-related injuries of the shoulder girdle, several key conclusions can be made:

1. Injury structure. Most patients (98.4%) were males, and injuries were almost equally distributed between the right (46.1%) and left (53.9%) shoulder girdles. Injuries were most often caused by gunshot wounds (55.6%) and mine-blast trauma (20.6%).

2. Types of injuries. The most common were fractures and dislocations of the clavicular joints (44.4%), fractures of the scapula (27.0%), and combined injuries of the clavicle and scapula (28.6%), confirming the multi-structural nature of shoulder girdle combat injuries.

3. Bone defects. Bone defects were identified in 68.3% of patients. The mean defect length was 4.7 ± 3.8 cm, indicating the severity of these injuries and the need for complex reconstructive treatment. The issue of bone defect reconstruction in combat-related injuries remains relevant and warrants further research.

4. Soft tissue and nerve injuries. Muscle injuries were observed in 85.7% of patients, most commonly affecting the deltoid, supraspinatus, and infraspinatus muscles. Peripheral nerve injuries were identified in 22.2% of patients, predominantly involving the suprascapular and axillary nerves, which significantly impacts functional treatment outcomes.

5. Vascular injuries. Injuries to major vessels (axillary artery and vein) were diagnosed in 4.8%

of patients, requiring urgent surgical intervention, including endovascular reconstruction in cases of post-traumatic aneurysms.

Conflict of Interest. The authors declare no conflict of interest.

Prospects for Further Research. In-depth study of the long-term outcomes of injuries and treatment results in patients with combat-related surgical trauma of the shoulder girdle is necessary.

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Аналіз характеру та тяжкості ушкоджень у пацієнтів із бойовою хірургічною травмою надпліччя

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Резюме. Актуальність. *Згідно з різними дослідженнями, ушкодження кінцівок, спричинені бойовими травмами, становлять від 44 до 70% від усіх травм опорно-рухового апарату.* ***Мета дослідження.*** *Проаналізувати ушкодження в пацієнтів із бойовою хірургічною травмою надпліччя, які отримали хірургічне лікування.* ***Матеріали і методи.*** *Проведено ретроспективний аналіз хірургічного лікування 733 пацієнтів із бойовою хірургічною травмою кінцівок: 378 пацієнтів (51,6%) з травмою верхньої та 355 (48,4%) з травмою нижньої кінцівки, які перебували на стаціонарному лікування у відділенні важкої поліструктурної травми ДУ «Інститут травматології та ортопедії НАМН України» з 01 серпня 2022 року по 31 грудня 2024 року.* ***Результати.*** *У період з серпня 2022 по грудень 2024 року проведено хірургічне лікування 63 пацієнтів з бойовою хірургічною травмою ділянки надпліччя, що становить 8,6% від усіх травм верхніх та нижніх кінцівок та 16,7% від травм верхніх кінцівок. Середній вік пацієнтів становив 34,7±8,1 років. За типом ушкоджень кульові поранення були в 35 пацієнтів (55,6%), мінно-вибухові поранення – у 13 пацієнтів (20,6%), інші ушкодження становили 8 випадків (12,7%), осколкові поранення – 4 пацієнта (6,3%), ДТП – 3 пацієнта (4,8%). За локалізацією переломів пацієнти були розподілені на 3 групи: переломи та вивихи суглобів ключиці – 28 пацієнтів (44,4%), переломи лопатки (II група) – 17 пацієнтів (27,0%) та комбіновані переломи ключиці та лопатки (III група) – 18 пацієнтів (28,6%). Дефекти кісткової тканини спостерігали в 43 пацієнтів (68,3%), середня довжина дефекту склала – 4,7±3,8 см. Вогнепальні рани м'яких тканин з пошкодженням м'язів та сухожилків були в 54 пацієнтів (85,7%). Пошкодження нервів були в 14 пацієнтів (22,2%). Ушкодження магістральних судин, що призвели до хірургічного лікування, згідно даних супроводжуючої документації, спостерігали у 3 пацієнтів (4,8%).* ***Висновки.*** *Аналіз бойової хірургічної травми ділянки надпліччя показав високу частоту поліструктурних ушкоджень, зокрема у чоловіків працездатного віку (96,8%), що потребують складного хірургічного втручання та тривалого відновлення. Найпоширенішими були переломи ключиці та лопатки (44,4% і 27,0% відповідно), а також ушкодження м'язів (85,7%) і нервів (22,2%), що значно ускладнюють лікування та реабілітацію пацієнтів.*

Ключові слова. *Верхня кінцівка, вогнепальні переломи, бойова травма, лопатка, ключиця, плечовий суглоб, хірургічне лікування, реконструктивно-відновні операції.*