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TREATMENT OF COMBAT FIRE INJURIES CONSEQUENCES OF THE LOWER LIMBS' MAJOR VESSELS FOR THE PERIOD OF ATO AND JFO IN 2014-2019

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Gunshot wounds to blood vessels are severe injuries that are often combined with damage to other anatomical structures. Only 21 % had injuries to the main vessels and soft tissues, the rest had injuries to the bones and nerves. In 45.6 % the injuries were isolated, which makes 45.6 %, in 54.4 % – multiple, including injuries of the lower and upper extremities or both lower (22.8 %), head and neck injuries (1.8 %), chest organs (3.5 %), abdominal organs (3.5 %). In most cases, there were injuries of the femoral-popliteal segment, which is 78.9 %, less than the tibial segment 19.3 % and injuries of the femoral-popliteal and tibial segments by 1.8 %. All the wounded were of conscription age. The total of 565 operations were performed to 57 wounded, including 88 on the major vessels (15.6 %), amputations and reamputations – 15 (2.7 %), surgical treatment of the wound – 382 (67.6 %), others – 80 (14.1 %).

Key words: major vessels of lower extremities, gunshot wounds, amputation, shunting, surgical treatment of wound.

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ЛІКУВАННЯ НАСЛІДКІВ БОЙОВИХ ВОГНЕПАЛЬНИХ ПОРАНЕНЬ МАГІСТРАЛЬНИХ СУДИН НИЖНІХ КІНЦІВОК ЗА ПЕРІОД 2014-2019 РОКІВ ПРОВЕДЕННЯ АТО ТА ООС

Вогнепальні пошкодження судин є тяжкою травмою, котра часто поєднуються з ушкодженням інших анатомічних структур. У 21 % відмічалося поранення тільки магістральних судин та м'яких тканин, у решти було поєднане поранення з кістками та нервами. У 45,6 % поранення було ізольованим, що становить 45,6 %, у 54,4 % – множинним, включаючи поранення нижніх та верхніх кінцівок або обох нижніх (22,8 %), поранення голови та шиї (1,8 %), органів грудної клітки (3,5 %), органів черевної порожнин (3,5 %). В більшості випадків мало місце поранення стегново-підколінного сегменту, що становить 78,9 %, менше гомілкового сегменту 19,3 % та поранення стегново-підколінного та гомілкового сегментів в 1,8 %. Усі поранені були призивного віку. Всього у 57 пораненого було виконано 565 операцій, з них на магістральних судинах – 88 (15,6 %), ампутацій та реампутацій – 15 (2,7 %), хірургічна обробка рани – 382 (67,6 %), інших – 80 (14,1 %).

Ключові слова: магістральні судини нижніх кінцівок, вогнепальні поранення, ампутація, шунтування, хірургічна обробка рани

The work is a fragment of the research project "Application of domestic laser and electric welding technologies in the treatment of wounds and trophic disorders of soft tissues caused by combat injuries and the major vessels diseases" in cooperation with the National Research Fund of Ukraine, state registration No. 2020.01/0308.

Local armed conflicts today and the use of modern firearms have led to an increase in the number of victims of gunshot wounds, including damage to main vessels. Important in practical terms is the fact that the true area of tissue damage is mostly larger than the visible limits. According to various sources, gunshot wounds of vessels range from 2.8–8% [1, 5, 6]. The study of statistics on combat gunshot wounds of the major vessels of the lower extremities (CGWMVLE) in modern warfare is an urgent task of military angiosurgery.

The purpose of the work was to study the structure and nature of combat gunshot wounds of the lower extremities' major vessels and their treatment during the anti-terrorist operation (ATO) and the Joint Forces Operation (JFO) at the 4th stage of angiosurgical care.

Materials and methods. The study was carried out on the basis of the vascular surgery clinic of the National Military Medical Clinical Center "MMCH" (Kyiv). The study included 57 cases of patients' treatment at the National Military Medical Clinical Center of Kyiv in the period from 2014 to 2019 with BVPMSNK during the environmental protection in eastern Ukraine. In retrospective and prospective mode, the study of medical records of patients who were in the 4th stage of medical evacuation in the clinic was conducted. A comprehensive analysis with the characteristics of patients for CGWMVLE was also performed and the results in treated patients were studied.

Characteristics of study methods. To assess the results of CGWMVLE treatment, the general clinical methods of examination, clinical-laboratory and clinical-instrumental methods used in the work were studied. The following algorithm was based on the examination of a patient with CGWMVLE: the presence of complaints from the wounded; detailed collection of medical history; assessment of local status; the presence of concomitant injury; the presence of concomitant somatic pathology; laboratory diagnostics;

instrumental methods of examination (ultrasound scan of the major vessels of the lower extremities, aortoarteriography and phlebography of the lower extremities, computed tomography with vascular contrast).

At the stage of collecting the anamnesis of the disease, serious attention was paid to the study of the elapsed time from the moment of injury to the beginning of medical care, primarily interested in specialized medical care, namely its timeliness, rationality and qualification. An important point was the term of the imposed hemostatic tourniquet, i.e. the time elapsed from the stage of providing first aid in the battlefield to receiving specialized medical care, compliance with the rules of its operation.

When studying the local status of the limb with CGWMVLE attention was paid to: the presence of a wound canal; skin temperature; skin color; the presence of trophic changes (dryness, scanty hair, trophic ulcers, necrotic changes); preservation of sensitivity; state of motor function of the limb; the presence of arterial pulsation in different segments; the presence of limb edema; the presence of varicose veins (primary or secondary varicose veins).

Clinical and instrumental study methods. All patients with CGWMVLE underwent ultrasound scanning of major vessels (arteries or arteries and veins) of the lower extremities with a high-frequency sensor (5-10 MHz). USMVLE was performed using the "LOGIQ P7" device (General Electric, USA), Ultima PA (Ukraine) and Simens Medicaln Solutions (USA). During the study of the lower extremities' arteries assessed were: the state of the "intima-media"complex; the presence, location and length of the wall-occlusive process, the nature of the curve; characteristics of the distal bed, ways to compensate for arterial failure; the presence of pathological arterio-venous anastomoses; functioning of the anastomosis.

Aorto-arteriography was performed according to standard methods. Indications for the study were: suspected prosthetic thrombosis; arterio-venous fistula; arterial aneurysm. Multispiral computed phlebography (with contrast) was performed to the vast majority of wounded. The study was performed on a 64-slice multispiral computed tomograph "Optima", General Electric, manufactured in the USA, with an installed software package for image processing GE Advantage Workstation. X-ray examinations in these patients were extremely valuable (fig. 1).

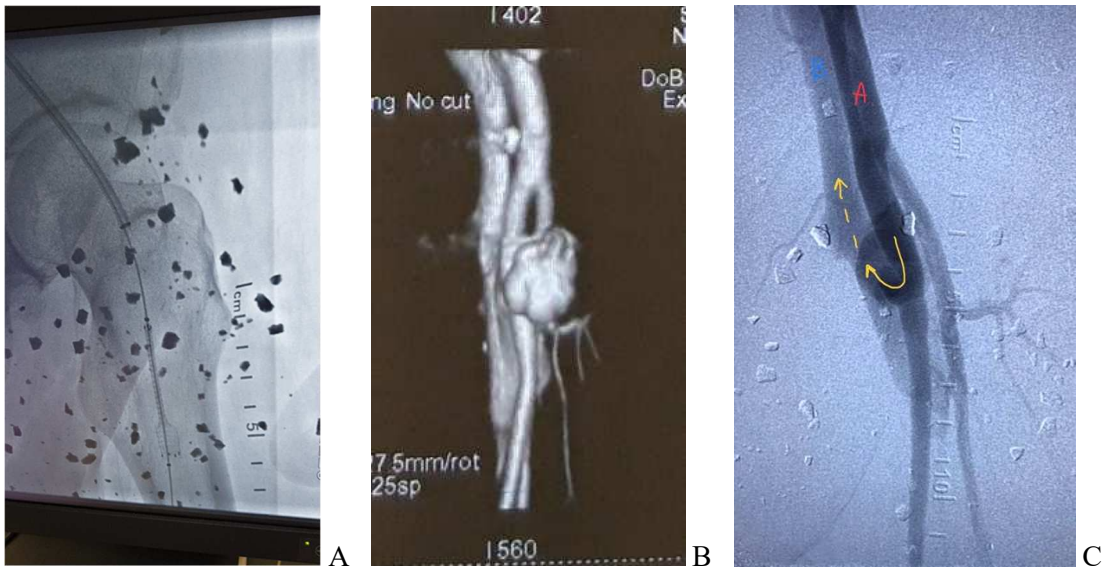


Fig.1. Mine explosion injury in a serviceman with CGWMVLE, where: a – X-ray imaging of fragments, b – functioning post-traumatic arteriovenous fistula between the common femoral artery and vein (MSCT with contrast), c – stent-graft stenting operation of AB-fistula.

The endpoints of the diagnostic algorithm were: determination of limb viability, stage of acute or chronic ischemia, degree, form and nature of venous insufficiency, especially development of postthrombotic disease, severity of concomitant and combined injuries, infectious complications and others. As a result, in each case, a unique algorithm of surgical tactics was developed, which ultimately permitted to develop appropriate standards for individual groups in CGWMVLE.

Results of the study and their discussion. General characteristics of the wounded. Analyzing the frequency of vascular injuries by years in the study, the following data were obtained: in 2014, 16 injuries of the main vessels were included (28 %); 2015 – 11 (19.3 %); 2016 – 16 (28 %); 2017 – 4 (7.1 %); 2018 – 7 (12.3 %); 2019 – 3 cases (5.3 % of all injured specific weight).

The study included patients under the age of 55, of whom: under 20 there were 6 soldiers, which made 10.6 %; from 21 to 30 years – 22 (38.6 %); from 31 to 40 years there were 17 (29.8 %); from 41 to 50 – 10 (17.5 %) and older than 50 years there were 2 servicemen (3.5 %).

Analyzing the age group of vascular injuries by years, the following data were obtained: (Table 1).

Table 1

The number of servicemen with CGWMVLE depending on their age in different time intervals

Age/year	2014	2015	2016	2017	2018	2019	total
Under 20	4	-	-	2	-	-	6
21–-30	11	2	6	-	3	-	22
31–40	1	7	3	2	2	2	17
41–50	-	2	5	-	2	1	10
Over 50	-	-	2	-	-	-	2

The analysis of wounds localization in anatomic sites revealed wounds exclusively of femoral-popliteal, shin segments and their combination. Thus, in 45 cases there were injuries of the femoral-popliteal segment (78.9 %), in 11 – shin (19.3 %) and in 1 case (1.8 %) there was a combination of injuries of the femoral-popliteal and tibial segments (table 2).

Table 2

Characteristics of the damaged vessel's type depending on the age group of wounded in CGWMVLE

Age/type of the damaged vessel	artery	artery and vein	vein	Total
Under 20	3	2	1	6
21–30	6	13	3	22
31–0	6	9	2	17
41–50	3	7	0	10
51–60	2	0	0	2

Analysis of the type of affected vessel revealed that in 20 cases (35.1 %) only the artery was injured, in 6 cases – a vein (10.5 %) and in 31 cases (54.4 %) – both an artery and a vein. Of these, at the age of 20 years, artery injuries were observed in 3 cases (50 %), in 1 case – a vein (16.7 %) and in 2 – artery and vein injuries (33.3 %). At the age of 21 to 30 years in 6 cases there was an isolated artery injury (27.3 %), in 3 – only a vein injury (13.6 %), and in 13 – artery and vein injuries (59.1 %). Between the ages of 31 and 40 there were 6 arterial injuries (35.3 %), 2 had vein injuries (11.8 %) and 9 – artery and vein injuries (52.9 %). From 41 to 50 years of age, artery injuries were noted in 3 servicemen (30 %) and in 7 wounds of both arteries and veins (70 %). In the age group from 51 years and older, there were 2 arterial injuries, which corresponds to 100 %.

Analyzing the frequency and characteristics of vascular damage in CGWMVLE concomitantly in 12 cases revealed injuries of the major vessels and soft tissues (21 %), in 19 cases – a combination of injury to bone (33.3 %), in 12 cases a combination with nerve damage (21, 1 %) and in 14 cases there was involvement of both bone and nerve (24.6 %).

The following data were obtained by analyzing the relationship of concomitant trauma by age. Under the age of 20, 2 servicemen had a combined bone injury (33.3 %), 1 had a nerve injury (16.7 %), 2 had a bone and nerve injury (33.3 %), and 1 case had a combined wound injury. main vessels and soft tissues (16.7 %). At the age of 21 to 30 years, 4 had combined bone injuries (18.1 %), 6 had nerve injuries (27.3 %), 6 had bone and nerve injuries (27.3 %), and 6 had injuries of vessels and soft tissues (27.3 %).

Between the ages of 31 and 40, 6 servicemen had a combined bone injury (35.3 %), 3 had a nerve injury (17.6 %), 5 had a bone and nerve injury (29.5 %), and 3 had injuries of major vessels. and soft tissues (17.6 %). In the age group from 41 to 50 years in 6 cases there was a combined bone injury (60 %), in 2 – nerve (20 %), in 1 – bone and nerve (10 %), in 1 case of blood vessels and soft tissues. (10 %). In servicemen aged 51 and older, 1 had a combined bone injury (50 %) and another had a vascular and soft tissue injury, corresponding to 50 % in their age group (Fig. 2).

In 26 cases the wound was isolated, which makes 45.6 %, in 31 – multiple (54.4 %), namely: 13 servicemen had a combination of injuries of the lower and upper extremities or both lower ones (22.8 %), in 1 case – head and neck (1.8 %), 2 – chest (3.5 %), 2 – abdominal organs (3.5 %), 13 had injuries to 3 or more anatomical areas (2.8 %).

Analyzing multiple injuries by age groups, the following data were obtained. At the age of 20 years, 2 wounded had an isolated injury (33.3 %), 1 had injuries to the upper or both lower extremities (16.7 %), 1 had chest injuries (16.7 %), 2 (33.3 %) – injuries of 3 or more anatomical zones. At the age of 21 to 30 years in 9 fighters the injury was isolated (40.9%), in 1 case – injuries of the chest (4.5 %) and abdominal

organs (4.5 %), in 5 injuries 3 and more anatomical areas (22.8 %), injuries of the upper or both lower extremities occurred in 6 cases (27.3 %). At the age of 31 to 40 years in 10 servicemen the wound was isolated (58.8 %), in 4 – wounds of both upper or lower extremities (23.5 %), in 1 – injuries of abdominal organs (5.9 %), in 2 – injury of 3 or more anatomical zones (11.8 %). In the age group from 41 to 50 years in 5 cases the injury was isolated (50.0 %), 2 cases were injuries of both upper or lower extremities (20.0 %) and injuries of 3 or more anatomical areas (20.0%).), in 1 case (10.0%) there was an injury of the abdominal cavity. At the age of 51 years and older in 1 case the injury was isolated, which corresponds to 50 % in its age category.

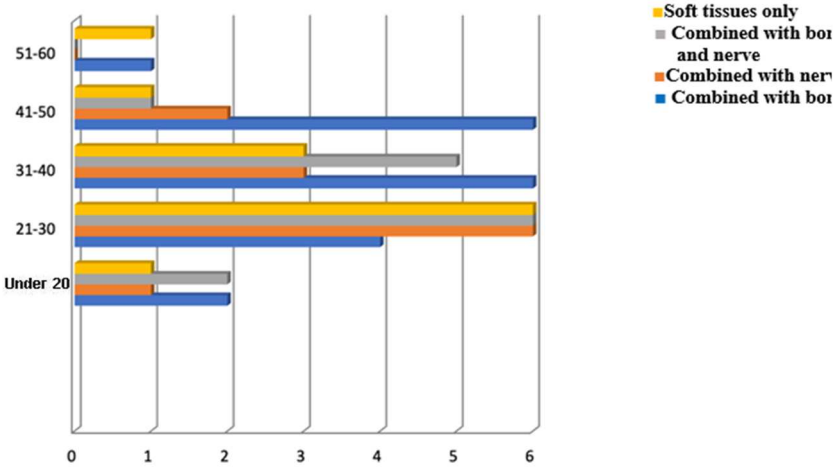


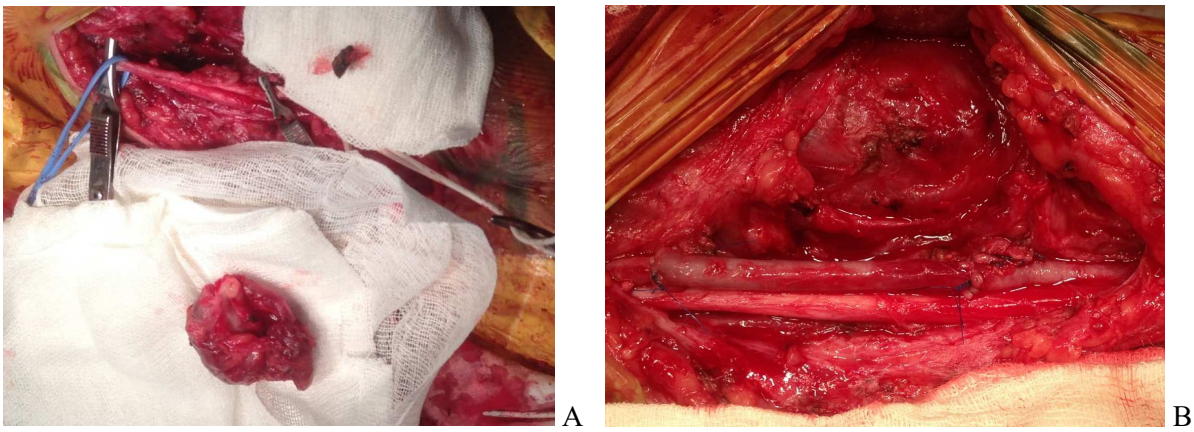
Fig. 2. Characteristics of concomitant injuries of other tissues depending on the age group of the wounded in CGWMVLE.

The total of 565 operations were performed on 57 wounded, including 88 on the major arteries (15.6 %), amputations and reamputations – 15 (2.7 %), surgical treatment of the wound – 382 (67.6 %), others - 80 (14.1 %). Among others, interventions on the perforating and major veins in cases of postthrombotic disease predominated.

With regard to operations on the major vessels were performed: vascular suture was applied in 14 cases (2.5 %), autovenous prosthetics – in 19 (3.4 %), alloprosthetics – in 16 (2.8 %), vascular ligation – in 21 (3.7 %), operations for arteriovenous fistula - in 3 (0.5%), with 1 of them performed stenting, operations for post-traumatic aneurysms – in 3 (0.5 %), thrombectomy – in 4 (0.7 %), revision of the main vessels – 3 (0.6 %), endovascular interventions (balloon dilatation) – in 1 (0.2 %), limb amputation – in (2.3 %) and 2 of these – reamputation (0.4 %), vein plastic surgery – 2 (0.4 %), a temporary shunt was imposed on 2 servicemen (0.4 %). Fasciotomy was performed in 16 cases (2.8 %).

All the wounded were regularly treated with surgical (SP) wounds under anesthesia (fig. 2), with the installation and replacement of the VAC system. The total of 382 SPs were performed in 51 wounded, which is (67.6 %). Autodermoplasty was performed in 8 (1.5 %).

Given that most of the injuries were concomitant and combined, surgical interventions were performed for injuries in other anatomical areas (fig. 3).



A B

Fig. 3. False aneurysm of the brachial artery, where: a – aneurysmectomy procedure, b – autovenous prosthesis of the brachial artery.

The usefulness of a temporary shunt was very high. An alternative access to provide proximal vascular control was access to retroperitoneal iliac vessels according to Pirogov. Synthetic vascular prostheses were used in case of too large diameter of the femoral artery or lack of time and autovein (fig. 4).

Given the high risk of bleeding during these and other surgeries, reliable hemostasis is extremely important. Therefore, surgical (including using domestic technology of electric welding of living tissues) and medical methods of reliable bleeding control were extremely important. In this sense, proceeded according to international protocols, in which there were 3 principles of Patient Blood Management.

Therefore, special attention has recently been paid to the use of tranexamic acid (TEA), which is by 26 times more active than aminocaproic acid and by 10 times more effective than ethamsylate. For the treatment of chronic anemia, ferric iron was used for intravenous administration of Sufer® – solution for intravenous injection; active substance: 1 ml of solution contains 20 mg of iron in the form of iron (III) hydroxide sucrose complex.


A

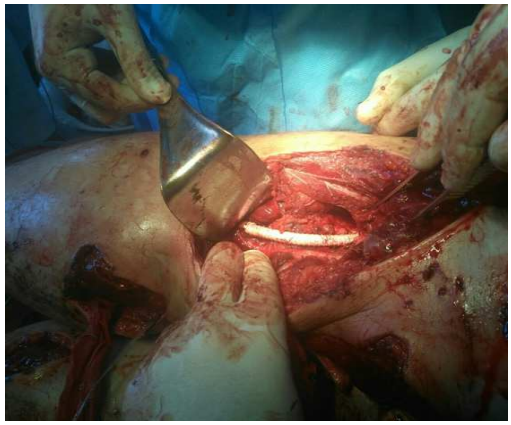

B

Fig. 4 Explosive injury: general type of injuries, ISD of wounds, allosthetics of the left popliteal artery (MMCC of the Northern region)

In order to prevent reperfusion syndrome, L-arginine was used, which was administered intravenously at the dose of 4.2 g, which also provided a powerful anti-inflammatory effect. A restrictive strategy of infusion therapy (according to Chappell D. et al.) using crystalloids and a multicomponent polyionic colloidal-hyperosmolar solution was used.

Hecoton as a colloidal plasma expander. The drug was administered in the volume of 5 ml/kg to prevent hemodynamic disorders before epidural anesthesia, then – before clipping the artery (at a dose of 3 ml / kg) and to prevent ischemia-reperfusion syndrome after declipation.

Conservative treatment consisted primarily of receiving adequate antibiotic therapy (with preliminary determination of sensitivity), anticoagulant therapy, anti-inflammatory and analgesic drugs, antisecretory drugs. Detoxification therapy, daily dressings, physical therapy, etc. were important. In order to prevent infectious complications, LEFLOCIN (levofloxacin) was most frequently used in the postoperative period – an antibacterial drug with a broad spectrum of action, fluoroquinolone series with a pronounced bactericidal effect. LEFLOCIN was administered to patients intravenously in 250–500 mg (50–100 ml) once a day for prevention of postoperative complications, for a course of 5–7 days. In particularly severe cases, the Ukrainian drug Grandazole was used – a combined antibacterial drug, which includes levofloxacin hemihydrate and ornidazole in vials for intravenous administration of 100 and 200 ml. TIVOREL (4.2 g of arginine hydrochloride +2.0 g of L-carnitine) was used in the group of wounded with chronic myocardial ischemia. Domestic products of xylate, reosorbilact, and sorbilact were involved in the complex of detoxification agents. Twenty-five patients with severe limb ischemia received the "Trio" treatment regimen: basic therapy + Reosorbilact 400 ml/day, Latren 400 ml/day, Tivortin 100 ml/day. When developing venous outflow disorders from the extremities, phlebo-lymphotonics (mainly cyclo-3-fort) were used, and in the remote period, oral anticoagulants (mainly rivaroxaban) were preferred.

Local and conservative treatment of wounds and trophic ulcers of arterial, venous, neurotrophic and mixed genesis. In 44 (86.3 %) wounded at the 4th stage of medical evacuation, trophic changes, mainly soft tissues of the extremities, persisted, which significantly complicated their treatment. Of course, correction of the main blood flow of both arteries and veins was the basis of success in healing these ulcers, but local treatment was also mega-important. In addition to the use of various bandages, vacuum devices, ultrasonic cavitation using low-frequency ultrasound, and laser radiation were actively used. The introduction of low-energy laser radiation into clinical practice, in our opinion, can significantly accelerate the process of wounds and ulcers repair. This is due to increased tissue oxygen utilization, decreased lipid peroxidation, increased phagocytic activity of leukocytes and activation of microcirculation in the affected tissues under its influence. It was important to use electrocoagulation using an electric welding machine in the ablation of failed perforating veins in the area of the ulcer of venous origin. To do this, a tool was created – a monopolar, which is used for this under ultrasound-controlled monitoring. At this, the method is safe and easy to perform, because the features of the electric welding probe-electrode ensured the preservation of healthy tissues outside the vessel wall. In the presence of extensive trophic changes on the shins of the wounded, it was decided to use remote from

trophic changes treatment methods. Thus, under the control of a video camera to perform high-frequency electric welding for ablation of perforating veins in the subfascial space. This device was successfully used in the treatment of 18 (35.3 %) wounded.

Gunshot wounds to blood vessels are a serious injury, which is often combined with damage to other anatomical structures [1, 8]. 21 % had injuries to the major vessels and soft tissues only, and the rest had injuries to the bones and nerves. In 45.6 % the injuries were isolated, which is 45.6 %, in 54.4 % – multiple, including injuries of the lower and upper extremities or both lower (22.8 %), head and neck injuries (1.8 %) , chest organs (3.5 %), abdominal organs (3.5 %).

In most cases, there were injuries of the femoral-popliteal segment [5, 7], which is by 78.9 % smaller than the tibial segment 19.3 % and injuries of the femoral-popliteal and tibial segments by 1.8 %. The total of 565 operations were performed on 57 wounded, including 88 on the major arteries (15.6 %), amputations and reamputations – 15 (2.7 %), surgical treatment of the wound – 382 (67.6 %), others – 80 (14.1 %). Among others, interventions on perforating and main veins in cases of postthrombotic disease prevailed [2, 4].

Conclusions

1. According to world statistics, modern wars differ in significantly higher rates of major vessels' gunshot wounds than those in the wars of the late XX – early XXI centuries (World War II, Korea and Vietnam) (12 % vs. 2.8 – 8 %), and the proportion of vessel gunshot wounds of the lower extremities is constantly growing.

2. Analyzing the statistics on the wounded with CGWMVLE at the IV stage of medical evacuation revealed the following: in 35.1 % of the wounded only the artery was damaged, in 10.55 % – only the vein in 54.4 % – the artery and vein were combined.

3. All wounded with CGWMVLE at the 4th stage of medical evacuation are mostly severe due to complications after the previous stages of evacuation and due to a combination of injuries in other arterial basins, other organs, which required multiple surgeries, sometimes with loss of limb.

4. The high level of surgical care at the 4th stage of medical evacuation in Ukraine, the completeness of modern medical support of mainly domestic manufacturers and the use of state-of-the-art technologies permit to avoid mortality in this category of wounded.

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