

Endovascular treatment of post-thrombotic syndrome of the lower extremities caused by combat trauma. Clinical case

Y. M. Susak¹, K. K. Karpenko²

¹ Bogomolets National Medical University, Kyiv

² National Military Medical Clinical Centre «Main Military Clinical Hospital», Kyiv

✉ Kostiantyn Karpenko: zushpre@gmail.com

Y. M. Susak, <http://orcid.org/0000-0002-5102-485X>

K. K. Karpenko, <http://orcid.org/0000-0002-9737-4484>

In the course of Russia's military invasion of Ukraine, gunshot shrapnel wounds of the lower extremities that result in damage to major blood vessels have become a common phenomenon. Their incidence is consistent with the general data on combat-related vascular injuries. Vascular gunshot injuries can cause significant changes to the normal anatomy and hemodynamics of the extremity as a result of the bullet or shrapnel travelling through the wound channel. Combat trauma of the vascular bundle, either as a primary factor or in combination with other lesions, often causes a serious condition in the wounded that requires urgent surgical intervention]. Injury to the major blood vessels of the lower limbs carries the risk of critical ischemia, which can lead to higher mortality rates, poor limb recovery, and disability. This clinical case demonstrates the endovascular management of a disabling combat-related vascular injury. The treatment involves the use of modern imaging techniques and minimally invasive surgical procedures. This case highlights the progression of the pathological process after a gunshot shrapnel wound to the soft tissues and major blood vessels. It also shows a change in the normal anatomy of the major blood vessels and the subsequent development of regional hemodynamic disorders of the lower limb after injury.

In January 2023, a 51-year-old male received a gunshot wound to the soft tissues of the pelvis and right lower limb, as well as a gunshot fracture of the right femur. Immediate post-evacuation therapy included the management of life-threatening bleeding by ligating the deep femoral artery and providing external fixation of the gunshot femur fracture. Following the healing of the wounds and the removal of the external fixation device, the injured individual experienced a progressive and notable swelling of the lower limb over a period of 3 months. Subsequently, trophic ulcers appeared on the lower leg. In September 2023, the patient was admitted to the National Military Medical Clinical Centre in Kyiv after developing clinical signs of the post-thrombotic syndrome. However, further examination revealed the presence of an AV fistula. Consequently, a simultaneous endovascular reconstructive intervention was performed on the arteries and veins of the patient's lower extremity.

CONCLUSIONS. A gunshot wound to the major blood vessels can contribute to pathological changes in the normal anatomical structure, resulting in arterial collateral blood circulation or narrowing of blood vessels that can lead to regional hemodynamic disorders. The clinical case exemplifies the importance of using modern imaging techniques for a comprehensive examination of the vascular system and the possibility of minimally invasive treatment for patients with gunshot injuries to the major blood vessels.

KEYWORDS

gunshot wound, AV fistulae, venous stenting, arterial embolization, combat trauma, endovascular intervention, post-thrombotic syndrome.

ARTICLE • Received 2023-10-19 • Received in revised form 2023-11-14

© 2023 Authors. Published under the CC BY-ND 4.0 license

This case demonstrates the endovascular management of a disabling combat-related vascular injury [4, 9]. The treatment involves the use of modern imaging techniques and minimally invasive surgical procedures. This case highlights the progression of the pathological

process after a gunshot shrapnel wound to the soft tissues and major blood vessels. It also shows a change in the normal anatomy of the major blood vessels and the subsequent development of regional hemodynamic disorders of the lower limb after injury.

Patient information

A 51-year-old male presented with severe edema and trophic changes in the right lower limb (Fig. 1).

At the time of the patient's visit, the circumference of the diseased limb in the upper third of the thigh was 100 cm, and the healthy limb was 68 cm.

Primary concerns and symptoms of the patient. Initially, the patient reported an enlargement of the right lower limb, a feeling of heaviness, and cramps in the limb. Later, he began to notice a change in the skin colour of the lower leg, trophic changes, and the appearance of ulcers. Trophic ulcers did not heal for a long time, and lymphorrhea was pronounced at the time of admission. The dimensions of the diseased limb hindered the patient's mobility and reduced his ability to self-care.

Medical, family, and psychosocial history, including relevant genetic information. The patient has a concomitant diagnosis of type 2 diabetes, of moderate severity, and is medically subcompensated. He is also overweight, with a body mass index of 30.9. Smokes.

Relevant past interventions and their outcomes. In January 2023, during the invasion of Russian troops into Ukraine, the patient received a combat injury to the soft tissues of the pelvis and right lower limb, as well as a fracture of the right femur. During evacuation, it was found that the patient had multiple gunshot shrapnel wounds to the pelvis and the right lower limb, as well as a gunshot shrapnel fracture of the right femur that resulted in damage to the major blood vessels of the lower limb. Immediate post-evacuation therapy included the management of life-threatening bleeding by ligating the deep femoral artery and providing external fixation of the gunshot femur fracture. After the stabilization, the patient was immediately taken to one of the nearest forward military hospitals, where revision of the wounds was performed, metal fragments were removed, the proximal parts of the deep femoral artery were ligated, and an external fixation device was applied to the femur. Since May 2023, the patient has observed a progressive worsening of symptoms, including an enlargement of the right lower limb, a change in the skin colour of the lower leg, and a feeling of heaviness and cramps in the calf muscles. In September 2023, he sought medical attention after the appearance of trophic ulcers and lymphorrhea.

Diagnostic Assessment. The examination revealed the signs of marked venous hypertension and lymphostasis. The patient was admitted to the National Military Medical Clinical Centre. A diagnosis was made based on general clinical blood tests, ultrasound of blood vessels in the pelvis and lower

extremities (Fig. 2), multispiral computed tomography (CT) with a contrast of organs in the pelvis and lower extremities (Fig. 3), and angiography of the right limb and pelvis.

The ultrasound examination revealed an arteriovenous discharge of blood into the femoral vein, a mixed type of blood flow in the common femoral vein (CFA), a collateral type of blood flow in the basin of the previously (January 2023) proximally ligated deep femoral artery (DFA), and the consequences of previous deep vein thrombosis.

A functional arteriovenous (AV) fistula and critical stenosis of the right common iliac vein, as well as varicosity of the suprapubic venous collaterals, were confirmed on CT with contrast.

We collected and analysed data on combined arteriovenous (AV) pathology. To accurately identify



Figure 1. On admission, patient S. had edema and trophic ulcers on the right lower limb. The scars were visualized on the thigh after placement of the external fixation device and in the groin area after revision of the blood vessels during the management of life-threatening bleeding

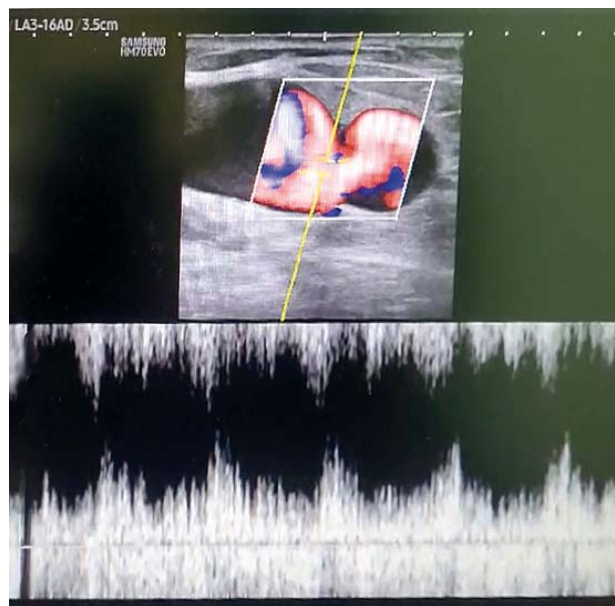


Figure 2. Ultrasound imaging of mixed blood flow in the arteriovenous fistula

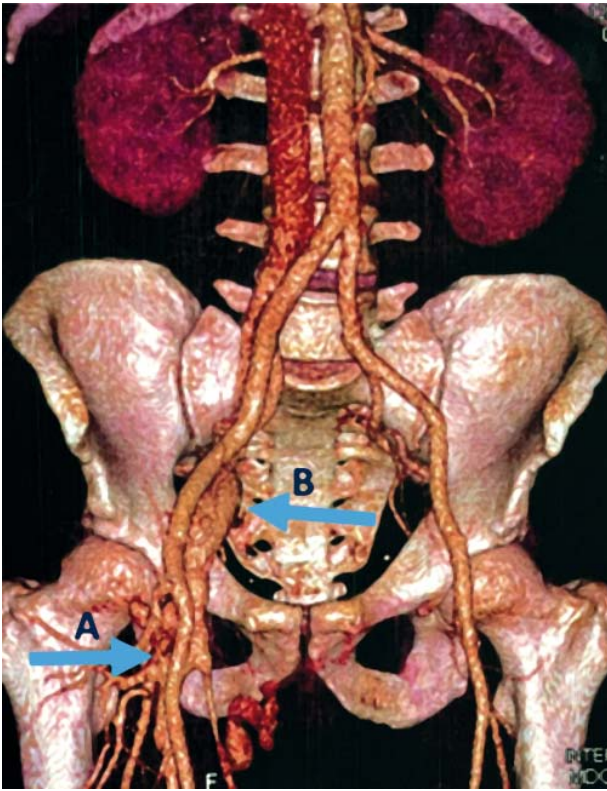


Figure 3. 3D vascular reconstruction and MSCT verification. A – Previously ligated deep femoral artery. B – Stenosis of the common iliac vein. The presence of arterio-venous discharge was indicated by contrasting the venous system in the arterial phase of the study

the source of AV discharge and assess the narrowing of the right common iliac vein, we conducted angiography and phlebography using digital subtraction and «Pseudo perfusion» techniques.

During the selective angiography procedure, we observed the retrograde filling of the basin of the previously ligated DFA. This occurred due to the compensatory development of a collateral network of blood vessels from the inlet of the superficial femoral artery (SFA), the AV fistula between the DFA, and the common femoral vein. A critical stenosis (90 %) of the common iliac vein on the right side was also confirmed (Fig. 4).

Diagnostic challenges. The primary challenge in establishing the cause of venous hypertension was to determine how the AV fistula between the deep femoral artery and the femoral vein began to function if it was known that the deep femoral artery had been ligated. Additionally, it was crucial to reveal the extent of damage to the venous system of the right lower limb, as precise knowledge of vascular dimensions is essential for successful endovascular intervention.

Diagnosis. A functioning arteriovenous fistula between the deep femoral artery and the common femoral vein, critical stenosis (90 %) of the common iliac vein. CEAP (C6, S, E, Ad, Po CIV, LIII).

Intervention. Taking into account the anatomical changes and intense cicatricial deformation caused

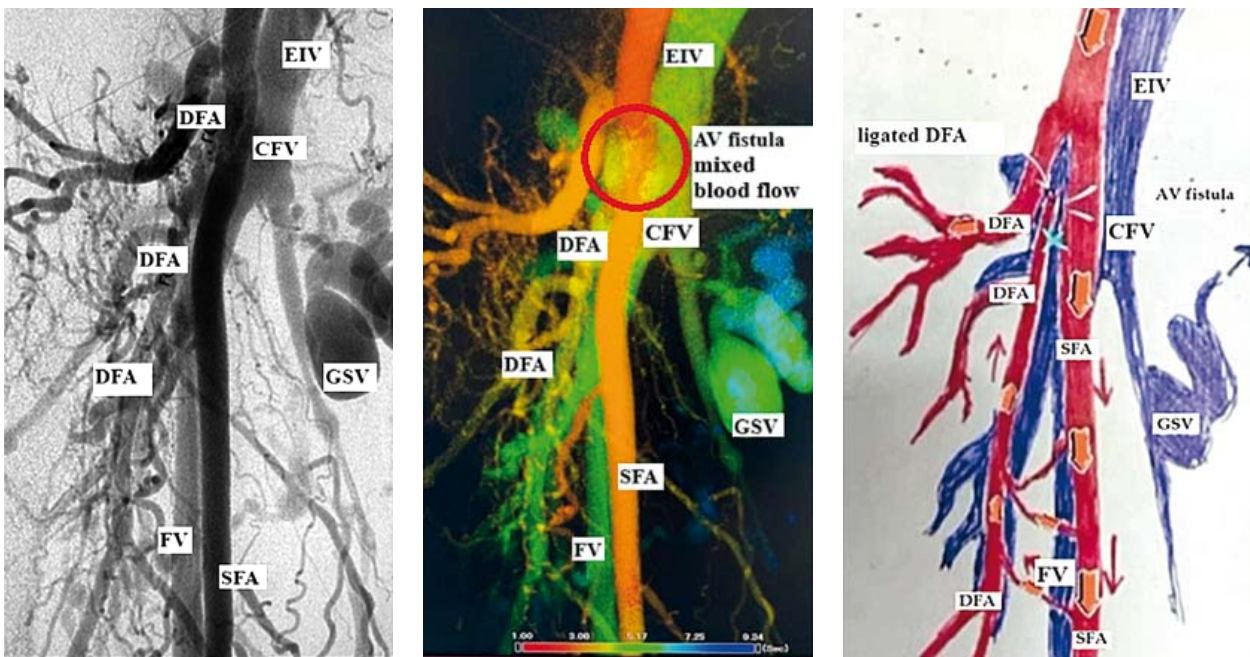


Figure 4. From left to right: angiography with visualization of the arteriovenous (AV) fistula and the network of collateral circulation with SFA-DFA. «Pseudo perfusion» mode with visualization of time intervals of blood circulation. A schematic drawing of pathological blood circulation in the functioning of the AV fistula. The abbreviations are used according to the Foundational Model of Anatomy Ontology (FMA): DFA – deep femoral artery, SFA – superficial femoral artery, FV – femoral vein, GSV – great saphenous vein, CFV – common femoral vein, EIV – external iliac vein



Figure 5. **Combined arterial 4Fr, 5Fr, and 11Fr venous accesses**

by the gunshot wound and surgical intervention, we decided to perform an endovascular intervention consisting of embolization of the AV fistula and stenting of the stenosed iliac vein. We chose a combined femoral approach, which included the

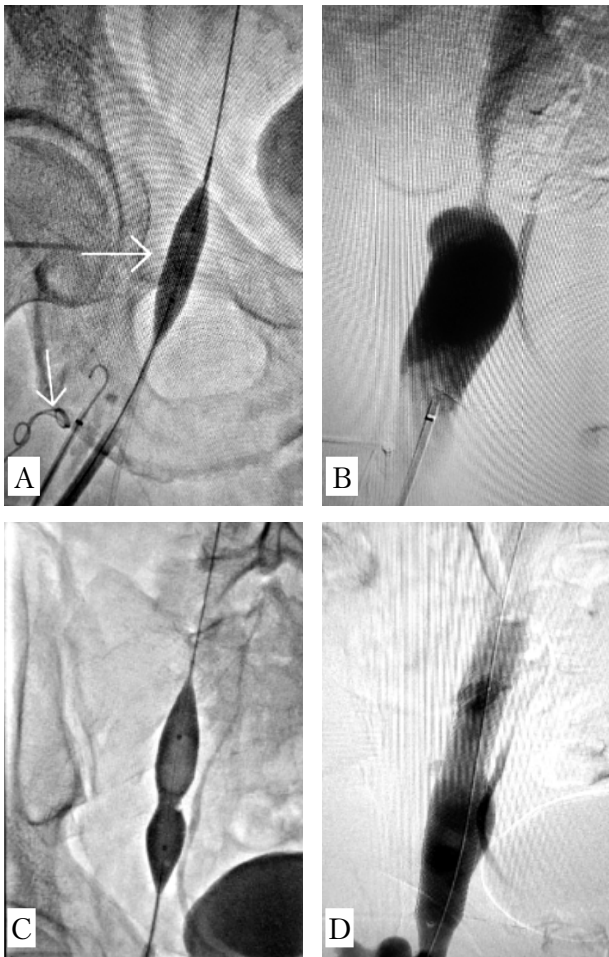


Figure 6. **Stages of intervention: Procedure of balloon occlusion and spiral embolization (A; arrows indicate embolization spirals and balloon occlusion of AV fistula); Critical stenosis of the common iliac vein (B); Balloon dilatation of a critical narrowing of the common iliac vein (C); Common iliac venous stenting (D)**

installation of an antegrade 4 Fr introducer into the common femoral artery to monitor the functioning of the AV fistula through developed SFA-DFA collaterals, a retrograde 5 Fr introducer into the distal parts of the deep femoral artery for spiral embolization, and also a retrogradely installed 11 Fr introducer into femoral vein tributaries for iliac vein stenting. The retrograde introducers were placed under both ultrasound and X-ray control (Fig. 5).

After establishing access to the arteries and veins, the initial procedure included using a balloon to occlude the functioning AV fistula. This was done to prevent the migration of embolization coils, given the large diameter of the AV fistula. During the subsequent phase, we used spirals with Teflon villi to embolize the AV fistula until the cessation of blood flow through it. After occlusion of the pathological discharge of blood, dilatation and stenting of the iliac vein were performed under intubation anaesthesia (Fig. 6, 7).

After venous stenting, the patient was prescribed clopidogrel 75 mg once a day for 6 months and rivaroxaban 15 mg twice a day for 1 month, then 20 mg for 12 months, and painkillers.

Follow-up and Outcomes. During the first 5 days after the intervention, in the conditions of inpatient treatment, elastic bandages were used for compression. A discharge-compression jersey of the third compression class was worn during the day, while a second-class compression jersey was worn at night. Local treatment of trophic ulcers using laser therapy (exposure of trophic ulcers to laser radiation) was also administered. After 5 days of inpatient treatment, complete epithelialization of trophic ulcers took place (Fig. 8).

On the 7th day after hospitalization, the patient was discharged from the hospital in a satisfactory

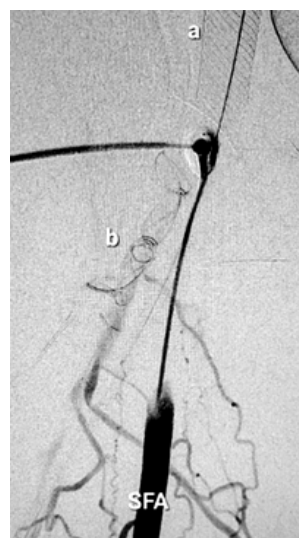


Figure 7. **Final angiographic result after intervention (performed through antegrade 4Fr access) a – common iliac venous stent; b – embolization spirals in the deep femoral artery (DFA). When contrast is injected into the superficial femoral artery, there is no contrast of the femoral vein through DFA collaterals, and the fistula does not function**



Figure 8. Epithelialization of trophic ulcers against the background of laser therapy at the beginning of treatment after venous stenting (A; the moment of laser exposure), after 5 days (B), and after 30 days (C)

medical condition. The swelling of the lower limb decreased from 96 cm to 76 cm in the upper third of the thigh (Fig. 9). After 1 month, the diameter of the limb was 66 cm, which was equal to the diameter of the opposite limb.

Adverse and unanticipated events. The treatment at the inpatient facility and a 3-month follow-up were uneventful.

Clinical discussion. A gunshot wound to the major blood vessels can contribute to pathological changes in the normal anatomical structure, resulting in arterial collateral blood circulation or narrowing of blood vessels that can lead to regional hemodynamic disorders [7].

In cases like this, performing an endovascular intervention requires a series of coordinated actions [3]. Venous stenting is not feasible due to the existing abnormal blood supply, and embolization of the collateral network of the deep femoral artery requires preliminary balloon occlusion of the VA fistula to prevent pulmonary embolism. The application of low-traumatic surgical techniques can significantly reduce the duration of hospital stays for patients in such cases. We believe that endovascular interventions should be the preferred approach for diagnosis and possible further treatment in patients with injuries to the major blood vessels and after surgical operations. However, this type of operation requires complex imaging diagnostics, including ultrasound and computed tomography, as well as invasive angiographic techniques. The



Figure 9. From left to right: the dynamics of changes in swelling of the lower limb before the start of treatment, on the third day, and 1 month after the surgical treatment

experience of specialists and equipment for endovascular treatment of patients with combat trauma is also important [1]. These requirements somewhat limit the prevalence of endovascular interventions in patients with combat trauma.

Patients with gunshot wounds to the major blood vessels may exhibit clinical signs of arterial or venous insufficiency [6, 8]. It is crucial to conduct a thorough assessment during the later stages of therapy or recovery in medical care centres, even after successful emergency surgical interventions [2, 5].

Conclusions

This case demonstrates the variability of compensatory anatomical changes in the major blood vessels in patients after gunshot wounds, which can cause a «pathological circle». The combined gunshot injury to the major blood vessels and bone fractures of the lower extremities dramatically increase the risk of developing deep vein thrombosis and intensifying hemodynamic disturbances.

After urgent surgical interventions for gunshot wounds to the major blood vessels and critical bleeding, in all subsequent stages of recovery, patients are recommended to undergo additional examinations — an ultrasound examination of blood vessels — and, if pathological signs are suspected, a CT-scan with contrast. Taking into account the anatomical changes and significant scar deformation because of a gunshot wound and as a result of surgical treatment, we consider endovascular intervention a good alternative to repeated surgical interventions to correct hemodynamic disorders.

We suppose that endovascular methods have an advantage over open surgical methods in this category of patients, given the distance of access and the possibility of performing percutaneous interventions in several sessions.

In our opinion, patients who suffer combat trauma or injuries are more likely to successfully undergo percutaneous interventions. However, it requires further research.

Take-away message. In patients with gunshot wounds of the major blood vessels, if they show any signs of arterial or venous insufficiency, it is important to conduct a detailed examination during the later stages of therapy or recovery in medical care centres. This examination should be carried out even after successful emergency surgical interventions.

Patient Perspective. After being discharged from the hospital, the patient fully restored his physical activity level and showed no clinical manifestations or signs of post-thrombotic syndrome.

DECLARATION OF INTERESTS

The authors declare that they have no conflicts of interest.

Funding: The authors did not receive any additional financial support.

ETHICS APPROVAL AND WRITTEN INFORMED CONSENTS STATEMENTS

All procedures performed in the study and involving human participants were carried out in accordance with the ethical standards of the institutional and/or national research committee, the 1964 Helsinki Declaration and its later amendments, or comparable ethical standards. Written informed consent was obtained from each individual participant included in the study.

AUTHORS CONTRIBUTIONS

The authors have contributed equally to conception and design, treatment of patients in the clinic, acquisition and interpretation of data, drafting the article.

REFERENCES

1. Humeniuk KV, Hangal II, Karpenko KK. Providing of a highly specialized medical care for servicemen of the Armed Forces of Ukraine by roentgen-endovascular interventional methods. *Zaporozhye Medical Journal*. 2021;23(3):375-380. <https://doi.org/10.14739/2310-1210.2021.3.223139>.
2. Patel JA, White J, White PW, Rich NM, Rasmussen TE. A contemporary, 7-year analysis of vascular injury from the war in Afghanistan. *Journal of Vascular Surgery*. 2018;68(6):1872-1879. doi: 10.1016/j.jvs.2018.04.038.
3. Rogovsky VM, Gybalo RV, Lurin IA, Sivash YY, Oklei DV, Taraban IA. A Case of Surgical Treatment of a Gunshot Wound to the Left Scapular Region With Damage to the Distal Axillary and Proximal Brachial Arteries. *World J Surg*. 2022 Jul;46(7):1625-1628. doi: 10.1007/s00268-022-06577-y. Epub 2022 Apr 28. PMID: 35484404.
4. Schoenfeld AJ, Dunn JC, Bader J, Belmont PJ. The nature and extent of war injuries sustained by combat specialty personnel killed and wounded in Afghanistan and Iraq, 2003-2011. *The Journal of Trauma and Acute Care Surgery*. 2013;75(2):287-291. doi: 10.1097/ta.0b013e31829a0970.
5. Scott D, Arthurs ZM, Stannard A, Monroe HM, Clouse WD, Rasmussen TE. Patient-based outcomes and quality of life after salvageable wartime extremity vascular injury. *Journal of Vascular Surgery*. 2014;59(1):173-179.e1. doi: 10.1016/j.jvs.2013.07.103.
6. Sharrock AE, Remick KN, Midwinter M, Rickard RF. Combat vascular injury: Influence of mechanism of injury on outcome. *Injury International Journal of the Care of the Injured*. 2019;50(1):125-130. doi: 10.1016/j.injury.2018.06.037.
7. Tsema IeV, Bepalenko AA, Dinets AV, Koval BM, Mishalov VG. Study of damaging factors of contemporary war, leading to the limb loss. *Novosti Khirurgii*. 2018;26(3):321-331. doi: 10.18484/2305-0047.2018.3.321.
8. Vuoncino M, Hoo AJS, Patel JA, White PW, Rasmussen TE, White J. Epidemiology of Upper extremity vascular injury in contemporary combat. *Annals of Vascular Surgery*. 2020;62:98-103. doi: 10.1016/j.avsg.2019.04.014.
9. White J, Stannard A, Burkhardt G, Eastridge BJ, Blackburne LH, Rasmussen TE. The epidemiology of vascular injury in the wars in Iraq and Afghanistan. *Annals of Surgery*. 2011;253(6):1184-1189. doi: 10.1097/sla.0b013e31820752e3.

Ендоваскулярне лікування посттромботичного захворювання нижніх кінцівок внаслідок бойової травми. Клінічний випадок

Я. М. Сусак ¹, К. К. Карпенко ²

¹ Національний медичний університет імені О. О. Богомольця, Київ

² Національний військово-медичний клінічний центр «Головний військовий клінічний госпіталь», Київ

Під час російського військового вторгнення в Україну кількість вогнепальних осколкових поранень нижніх кінцівок з ураженням магістральних судин порівняннн із загальними даними щодо бойових уражень судин. Існують різні шляхи проходження крізь рановий канал кулі або осколка при вогнепальних ушкодженнях кровоносних судин. Такі ушкодження змінюють анатомію та гемодинаміку кінцівки. Бойова травма судинного пучка як основна причина або в поєднанні з іншими ураженнями часто призводить до тяжкого стану пораненого, що потребує термінового хірургічного втручання. Пошкодження магістральних судин нижніх кінцівок асоціюється з ризиком критичної ішемії, що супроводжується підвищенням ризику поганого відновлення кінцівки, інвалідності, а також летального наслідку. У наведеному клінічному випадку описано методику ендоваскулярного лікування хворого з бойовим ураженням судин, що інвалідизує, застосування сучасних візуалізаційних та малоінвазивних хірургічних методів, розвиток патологічного процесу після вогнепального осколкового поранення м'яких тканин і магістральних судин, зміну нормальної анатомії магістральних судин, розвиток регіональних гемодинамічних розладів нижньої кінцівки після травми.

У січні 2023 р. 51-річний чоловік отримав вогнепальне поранення м'яких тканин таза, правої нижньої кінцівки та вогнепальний перелом правої стегнової кістки. Початкове лікування після евакуації передбачало зупинку небезпечної для життя кровотечі шляхом перев'язки глибокої стегнової артерії, та зовнішню фіксацію вогнепального перелому стегнової кістки. Після загоєння ран і зняття апарату зовнішньої фіксації протягом наступних 3 місяців у потерпілого виник значний набряк нижньої кінцівки, згодом — трофічні виразки на гомілці. Хворого госпіталізували у вересні 2023 р. до Національного військово-медичного клінічного центру «Головний військовий клінічний госпіталь» з клінікою посттромботичної хвороби, однак діагностовано артеріо-венозну фістулу. Проведено одночасне ендоваскулярне реконструктивне втручання на артеріях і венах нижньої кінцівки.

Після вогнепального поранення магістральних судин відбуваються патологічні зміни в їхній анатомії, часто формуються артеріальний колатеральний кровообіг або стенозуювальні зміни судин, що призводить до регіональних розладів гемодинаміки. Наведений клінічний випадок демонструє важливу роль використання сучасних методів візуалізації для повноцінної діагностики судинної системи та можливості малоінвазивного лікування в пацієнтів після вогнепальних поранень магістральних судин.

Ключові слова: вогнепальне поранення, артеріо-венозна фістула, венозне стентування, артеріальна емболізація, бойова травма, ендоваскулярне втручання, посттромботична хвороба.

FOR CITATION

■ Susak YM, Karpenko KK. Endovascular treatment of post-thrombotic syndrome of the lower extremities caused by combat trauma. Clinical case. General Surgery (Ukraine). 2023;3-4:61-67. <http://doi.org/10.30978/GS-2023-3-61>.