UDC 616.137.83-004.6-089
DOI: 10.15587/2519-4798.2023.291217

X-RAY DIAGNOSTICS OF GUNSHOT WOUNDS OF MAIN VESSELS OF THE LIMBS: THEORETICAL ANALYSIS

Mykola Rudenko

The analysis of damage to the main vessels of the limbs was considered for the formation of further organizational and tactical instructions for the provision of emergency medical care at the stages of evacuation of the injured to specialized wartime departments. It was determined that with the help of MSCT-angiography, signs of damage to main vessels can be accurately diagnosed, and additional information about damage to bone structures, neighbouring organs and tissues can be obtained. It is emphasized that MSCT is an effective and accurate method in the assessment of clinically significant arterial injuries of the lower extremities in case of gunshot injury. It was noted that timely diagnosis of vessels gunshot wounds can contribute to the preservation of the functionality of the limbs and the life of patients, reducing the risk of bleeding, infections and other complications. It was noted that the correct medical decisions, in particular, the correct diagnosis of gunshot injuries to blood vessels will help doctors make informed decisions regarding emergency surgical care, the choice of treatment methods and preoperative preparation.

The aim. *The aim of the work is the theoretical substantiation of gunshot injuries of the main vessels of the limbs and the definition of practical diagnostic methods.*

Materials and methods: *analysis of theoretical sources, comparison, induction of isolated analytical data. The study was conducted based on the database of the State institution "National Institute of Cardiovascular Surgery named after M. M. Amosov of the National Academy of Medical Sciences of Ukraine".*

Results. *It was determined that with the help of MSCT-angiography, signs of damage to main vessels can be accurately diagnosed, and additional information about damage to bone structures, neighboring organs and tissues can be obtained.*

Conclusions. *Radiological diagnosis of gunshot injuries of the main vessels of the limbs demonstrates the importance of using radiological diagnostics in the detection and analysis of vascular injuries in gunshot injuries of the extremities. The study confirms the high efficiency of this method, its accuracy and reliability in determining the nature of damage. In addition, radiological diagnostics allows timely and accurate determination of the extent and nature of injuries, which is important for making informed clinical decisions and providing adequate medical care to the injured*

Keywords: *gunshot wounds, wound channel, main vessels, MSCT-angiography*

How to cite:
Rudenko, M. (2023). X-ray diagnostics of gunshot wounds of main vessels of the limbs: theoretical analysis. ScienceRise: Medical Science, 4 (55), 24–28. doi: http://doi.org/10.15587/2519-4798.2023.291217

1. Introduction

According to current studies, it has been determined that among all the wounded with gunshot wounds to the extremities, the frequency of damage to the main vessels reaches 12–25 % (20–30 %). As a rule, in 70–80 % of cases, a complete cross-section of the vessel is noted, in half of the cases, the vein of the same name is damaged. Vascular trauma is accompanied by combined gunshot fractures of the bones of the corresponding area in 40–60 % of cases, large injuries of soft tissues occur in 10–40 % of cases. The frequency of primary amputations of this category of wounded is up to 6.6 %, and the mortality rate is about 4.3 % [1].

It became known that among the wounded with gunshot fractures of the limbs, the frequency of amputations was 23.3 %, due to both the nature of bone damage and the degree of vascular injury, the impossibility of temporary shunting of the main vessels. When the popliteal artery is damaged, the unsuccessful outcome of reconstructive vascular operations reaches 60 %. The indication for limb amputation is, as a rule, the development of arterial thrombosis [2].

The aim of the work is the theoretical substantiation of gunshot injuries of the main vessels of the limbs and the definition of practical diagnostic methods.

2. Materials and methods

The theoretical and methodological analysis was carried out based on the repository of scientific texts of the State institution "National Institute of Cardiovascular

Surgery named after M. M. Amosov of the National Academy of Medical Sciences of Ukraine".

The research is built on the basis of the analysis of scientific and methodological literature for prospective further research on the formation of practical recommendations in the conducted research.

According to domestic and foreign research, one of the main methods of diagnosing damage to the vascular in gunshot wounds of the extremities is ultrasound examination (US) or duplex scanning with visualization of the injury zone and assessment of hemodynamic disturbances [3]. It should be noted that over the past two to three decades, foreign studies have discussed the widespread use of portable ultrasound devices and the advantages of ultrasound in the examination of patients with traumatic injuries of the vascular bed due to gunshot wounds to the extremities [4].

One study confirms data on the rather high informativeness of ultrasound research methods (dopplerography and duplex scanning) in the diagnosis of damage to main vessels in 150 patients with gunshot injuries to the extremities. MSCT-angiography was performed for patients in whom there were no signs of vessel damage during Doppler imaging (40 victims), in which 7 patients were found to have damage to the vascular bed. In this study, ultrasound Doppler had a fairly high sensitivity of 94 % and specificity of 82.5 % in the diagnosis of vascular damage, but it was inferior to MSCT-angiography [5].

3. Research results

As a result of the study of the theoretical aspect of scientific research on the subject of radiation diagnostics of gunshot injuries of the main vessels of the limbs, it was noted that the mobility and portability of ultrasound devices increase the possibility of their use at the first stages of diagnosis of limb injuries. The use of ultrasound expands the use of the diagnostic method in patients who have lost mobility (in a forced position), in some cases, ultrasound can replace more time-consuming radiological research methods. At the site of injury in accidents in patients with unstable hemodynamics, ultrasound can become the main and only method of diagnosing damage to the main vessels of the limbs [6].

In domestic and foreign publications, there are data that during radiological examination of victims, a significant number of combined injuries of main vessels and bones in gunshot wounds of the upper and lower extremities is noted – up to 50–55 %. In the process of studying two methods of visualizing the vascular in gunshot vascular injuries: selective catheter angiography and MSCT-angiography, it was noted that both methods had a specificity of 100 % based on clinical data. The sensitivity of MSCT-angiography and selective angiography was 74.5 and 76.6 %, respectively. Negative predictive values for MSCT-angiography and selective angiography were 84.6 and 85.7 %. The sensitivity of MSCT and selective angiography in detecting ongoing bleeding was about 75 % in all anatomical regions with penetrating gunshot trauma to the torso [6].

Studies comparing MSCT of the extremities with traditional selective angiography have shown that MSCT-angiography is more efficient in time and less invasive in the diagnosis of traumatic penetrating injuries of the main arteries. Thus, in the analysis of 62 arterial lesions in 55 of 87 patients with trauma of the upper or lower extremities, MSCT-angiography even on a 4-slice computer tomography showed a retrospective sensitivity of the method and a specificity of 99 and 87 % [7].

Traditionally, selective catheter angiography has been the diagnostic method of choice for the evaluation of gunshot vascular injuries. During the X-ray examination of 251 victims with limb injuries, the possibilities of MSCT-angiography and selective angiography were studied and compared. In 52 patients, MSCT and selective angiography were performed to visualize damage to the main arteries.

The authors claim that, having advantages, MSCT-angiography replaces selective angiography in the initial assessment of vascular injuries and can be an effective alternative to traditional angiography in the diagnosis of vascular injuries of extremities in gunshot trauma [4].

In the foreign literature, there is a report on the examination of 198 victims with penetrating wounds of the limbs, who underwent 232 MSCT-angiography, among which gunshot wounds accounted for 103 (52 %) cases, the structure of vascular injuries was studied. The arteries of the upper extremities were damaged in 39 (20 %) cases, the superficial femoral artery – in 37 (19 %) cases. 7 false aneurysms and 3 traumatic arteriovenous fistulas were diagnosed. Reconstructive vascular interventions were performed on the patients, and endovascular methods of treatment for false aneurysms were applied to 5 victims. Amputation was performed in 8 (4 %) cases. The mortality rate in this study was 4 % [8].

According to the results of another foreign study, in 80 victims with suspected damage to the vessels of the extremities, which were diagnosed by MSCT-angiography in 24 (30 %) cases, the results of the radiological examination were confirmed intraoperatively. MSCT-angiography becomes an effective method of visualization and assessment of damage to the vascular bed in gunshot wounds of the extremities and allows to abandon more invasive diagnostic methods, such as selective angiography [9].

In a retrospective analysis of the examination and treatment of 144 patients with gunshot wounds who underwent whole-body MSCT angiography, the possibilities and role of MSCT in the diagnosis of vascular trauma were studied. Thrombosis of the arteries of the upper and lower extremities was diagnosed in 17 % of cases; in 43 % – damage to bone structures; in 63 % – damage to parenchymal organs. The average time from the admission of the victim to the hospital to the performance of MSCT-angiography was 28 minutes. The duration of the whole body MSCT angiography itself was less than 2 minutes and was in total 116 seconds. Thus, MSCT-angiography is a fast, minimally invasive, and informative method of diagnosing gunshot injuries to vessels [10].

In a clinical study of 393 patients with penetrating gunshot injuries to the extremities with suspicion of vascular damage, MSCT angiography was performed in 114 (29 %) of the victims, which revealed damage to the vascular bed in all cases [11].

In a study of victims with gunshot wounds to the extremities who underwent MSCT angiography, the sensitivity and specificity was 100 % for the detection of clinically significant vascular injuries. Unlike MSCT angiography, selective angiography took 31 to 61 minutes per procedure. Thus, MSCT-angiography can replace selective angiography as the method of choice for the diagnosis of vascular injuries of the extremities in gunshot wounds [12].

Post-traumatic false aneurysms, the wall of which is connective tissue with thrombotic masses, can develop in cases of unrecognized gunshot vascular injuries.

During the Second World War, the frequency of aneurysm formation as a common complication of vascular trauma was 7.3 % of all injuries of main vessels. Most often, false traumatic aneurysms are formed because of gunshot shrapnel wounds. This is explained not only by the prevalence of shrapnel wounds over bullet wounds – 72.4 and 24.7 %, respectively, but also by the fact that shrapnel wounds are accompanied by extensive tissue damage adjacent to the wound channel, which creates conditions for the formation of false aneurysms [12].

Arterial aneurysms after gunshot injuries of main vessels are observed in approximately two-thirds of cases, arteriovenous – in one-third of cases. Among traumatic aneurysms, arterial aneurysms after gunshot wounds to the extremities were observed in 59.5 % of cases, arteriovenous aneurysms in 39.1 %, venous aneurysms in 1.6 %. Most often, traumatic aneurysms occur with gunshot injuries of the femoral, popliteal, brachial, axillary, and common carotid arteries [1].

During the analysis of the treatment of 40 patients who received gunshot wounds to the limbs with unrecognized early vascular damage on the first day after the injury, it was found that the diagnosis of post-traumatic vascular complications mainly occurred after 60 days. The most frequent complications after gunshot wounds discovered later were false aneurysm – 21 (52.5 %), arteriovenous fistula – 14 (35 %), occlusion (thrombosis) – 5 (12.5 %). The superficial femoral artery was most often damaged – in 11 cases [13].

In the literature, there are isolated reports of clinical observations of the diagnosis and treatment of false aneurysms, AB fistulas after gunshot injuries to the limbs of a wide variety of anatomical localization (superficial femoral artery, iliac vessels, axillary, subclavian artery). In all cases, radiographic imaging methods of the vascular bed were used: ultrasound dopplerography, MSCT-angiography. Selective angiography was used as a method that clarifies and moves to the stage of endovascular treatment: implantation of a graft-stent to disconnect the AB shunt or exclude a false aneurysm from the blood flow [14].

The issues of timely diagnosis of gunshot injuries of main vessels remain relevant and debatable even now. One of the main tasks of military field surgery is the active introduction of specialized methods of diagnosis and treatment to the system of providing primary surgical care to the wounded. The nature of gunshot injuries in combat gunshot trauma, the complicated course of the wound process, the critical condition, and the forced position of the wounded force us to look for modern approaches to improving the quality and optimization of radiological research methods in the diagnosis and treatment of gunshot injuries to the main vessels. There is still no single algorithm for radiographic examination of victims with suspected gunshot damage to the vascular bed [4].

It is difficult to reach a unanimous answer, since the data found in the literature are relatively contradictory about the advantages and informativeness of one or another method of radiodiagnosis (ultrasound studies, MSCT-angiography, selective catheter angiography) in the visualization of vascular injuries in gunshot combat trauma.

Undisputed defining criteria and advantages for methods of radiological diagnosis of vascular injuries should be speed (rule of the "golden hour"), minimal invasiveness and informativeness for a victim with large gunshot injuries.

The scientific literature increasingly provides data and claims that the advent of multi-slice technologies (use of 64- and 128-slice computed tomography) allows to abandon the traditional selective catheter angiography in patients with gunshot vascular injuries in favour of the use of MSCT – angiography [7].

Study limitations. Our research is limited by a rather low base of literary data on the study topic.

Prospects for further research. In further investigations, a comprehensive study of wounds of main vessels on animals will be conducted.

5. Conclusions

It was determined that with the help of MSCT-angiography, signs of damage to main vessels can be accurately diagnosed, and additional information about damage to bone structures, neighbouring organs and tissues can be obtained. Studies have shown that MSCT is an effective and accurate method in the assessment of clinically significant arterial injuries of the lower extremities in gunshot trauma.

Conflict of interests

The authors declare that they have no conflict of interest in relation to this research, including financial, personal, authorship or other nature, which could affect the research and its results presented in this article.

Funding

The study was conducted without financial support.

Data availability

The manuscript has no associated data.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the currrent work.

References

1. Zarutskyi, Ya. L., Zaporozhan, V. M., Bilyi, V. Ya., Denysenko, V. M., Aslanian, S. A.; Zarutskyi, Ya. L., Zaporozhan, V. M. (Eds.) (2016). Voienno-polova khirurhiia. Odesa: ONMedU, 415.

2. Kashtalian, M. A., Herasymenko, O. S., Tertyshnyi, S. V., Yenin, R. V., Dkhauadi, F. (2017). Novi napriamky v likuvanni vohnepalnykh ran. Problemy viiskovoi okhorony zdorovia, 48, 360–366.

3. Rushai, A. K., Skiba, V. V., Borzykh, N. A., Kozlov, V. V., Hryb, A. M. (2017). Features of the treatment of the comminuted gunshot fractures of the extremities at an early hospital stage. Odeskyi medychnyi zhurnal, 3, 56–59.

4. Fox, C. J., Patel, B., Clouse, W. D. (2011). Update on Wartime Vascular Injury. Perspectives in Vascular Surgery and Endovascular Therapy, 23 (1), 13–25. doi: https://doi.org/10.1177/1531003511400625

5. Wani, M. L., Sheikh, M. T., Nayeem-ul-Hassan, Irshad, I., Ahangar, A. G., Ganie, F. A. et al. (2014). Evaluating peripheral vascular injuries: is color Doppler enough for diagnosis? International Cardiovascular Research Journal, 8 (1), 15–17.

6. Bozlar, U., Ogur, T., Norton, P. T., Khaja, M. S., All, J., Hagspiel, K. D. (2013). CT Angiography of the Upper Extremity Arterial System: Part 1 – Anatomy, Technique, and Use in Trauma Patients. American Journal of Roentgenology, 201 (4), 745–752. doi: https://doi.org/10.2214/ajr.13.11207

7. Gakhal, M. S., Sartip, K. A. (2009). CT Angiography Signs of Lower Extremity Vascular Trauma. American Journal of Roentgenology, 193 (1), W49–W57. doi: https://doi.org/10.2214/ajr.08.2011

8. Ramdass, M., Harnarayan, P. (2017). A decade of major vascular trauma: Lessons learned from gang and civilian warfare. The Annals of The Royal College of Surgeons of England, 99 (1), 70–75. doi: https://doi.org/10.1308/rcsann.2016.0296

9. Adibi, A., Krishnam, M. S., Dissanayake, S., Plotnik, A. N., Mohajer, K., Arellano, C., Ruehm, S. G. (2014). Computed tomography angiography of lower extremities in the emergency room for evaluation of patients with gunshot wounds. European Radiology, 24 (7), 1586–1593. doi: https://doi.org/10.1007/s00330-014-3174-1

10. Halvorson, J. J., Anz, A., Langfitt, M., Deonanan, J. K., Scott, A., Teasdall, R. D., Carroll, E. A. (2011). Vascular Injury Associated With Extremity Trauma: Initial Diagnosis and Management. American Academy of Orthopaedic Surgeon, 19 (8), 495–504. doi: https://doi.org/10.5435/00124635-201108000-00005

11. Gurien, L. A., Kerwin, A. J., Yorkgitis, B. K., Renkosik, J., Allmon, J. C., Habib, J. H., Dennis, J. W. (2018). Reassessing the utility of CT angiograms in penetrating injuries to the extremities. Surgery, 163 (2), 419–422. doi: https://doi.org/10.1016/j.surg.2017.09.019

12. Polishchuk, M. Ye., Starcha, V. I., Slynko, Ye. I., Zavalniuk, A. Kh. (2005). Vohnepalni ushkodzhennia tsentralnoi nervovoi systemy. Ternopil: TDMU: Ukrmedknyha, 184.

13. Alam, H. B., DiMusto, P. D. (2015). Management of Lower Extremity Vascular Trauma. Current Trauma Reports, 1 (1), 61–68. doi: https://doi.org/10.1007/s40719-014-0007-2

14. Michaud, K., Grabherr, S., Lesta, M. del M., Augsburger, M., Doenz, F., Mangin, P. (2012). Ruptured pseudo-aneurysm of a femoral artery in a drug abuser revealed by post-mortem CT angiography. International Journal of Legal Medicine, 127 (4), 819–823. doi: https://doi.org/10.1007/s00414-012-0803-6

Received date 06.06.2023
Accepted date 24.07.2023
Published date 31.07.2023

Mykola Rudenko, PhD, Leading Researcher, Department of Innovative and Cardiosurgical Technologies, Amosov National Institute of Cardiovascular Surgery of National Academy of Medical Sciences, Amosova str., 6, Kyiv, Ukraine, 03038
E-mail: civid@ukr.net