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ÜRƏYİN VƏ DÖŞ QƏFƏSİNİN İRİ DAMARLARININ DÖYÜŞ XƏSARƏTLƏRİ NƏTİCƏSİNDƏ ZƏDƏLƏNMƏSİNİN ŞÜA DİAQNOSTİKASI

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Xülasə. Məqalədə döyüş əməliyyatları zamanı ürəyin və döş qəfəsinin iri damarlarının zədələnməsinin şüa diaqnostikası metodları vasitəsilə tədqiqinin nəticələri təqdim edilib. Tədqiqata 38 xəstə cəlb edilmiş və ümumilikdə 46 zədələnmə (31 ürək, 13 aorta və 2 ağciyər arteriyası) – 7 küt və 39 qəlpə yarası qeydə alınmışdır. Göstərilmişdir ki, hemoperikard 27 (58,7±7,3%), psevdoanevrizma 11 (23,9±6,3%) halda ($p<0,001$) qeydə alınıb.

Qəlpələrin diaqnostikasında rentgenoqrafiyanın həssaslığı 97,2%, spesifikliyi 66,7%, dəqiqliyi 94,9%; ultrasonoqrafiyanın həssaslığı 94,3%, spesifikliyi – 75,0%, dəqiqliyi – 92,3%, təşkil edib. Hemoperikardin diaqnostikasında ultrasonoqrafiyanın həssaslığı 96,0%, spesifikliyi – 50,0%, dəqiqliyi – 92,6%, təşkil edib.

Əldə edilmiş məlumatlara görə, döş qəfəsinin daxilinə nüfuz edən travmanın ağırlaşmalarının qiymətləndirilməsində ultrasəs müayinəsinin məhdud istifadəsinə baxmayaraq, bu metod ürəyin qəlpə yaralarının və perikard boşluğunda qan toplanmasının diaqnostikasında kifayət qədər həssaslığa və dəqiqliyə malikdir. Qəlpə ilə yaralanmaların diaqnostikasında rentgenoqrafiya və ultrasəs arasında ciddi fərqlər aşkar edilməmişdir.

Açar sözlər: şüa diaqnostikası, döyüş travması, döş qəfəsinin iri damarları

Ключевые слова: лучевая диагностика, боевая травма, крупные сосуды грудной клетки

Key words: radiological diagnosis, combat trauma, large chest vessels

RADIOLOGICAL DIAGNOSIS OF DAMAGE TO THE HEART AND LARGE CHEST VESSELS IN COMBAT TRAUMA

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This article presents the results of a radiological diagnostic study on injuries to the heart and major chest vessels sustained during combat operations. The study involved 38 patients, recording a total of 46 injuries (31 heart injuries, 13 aortic injuries, and 2 pulmonary artery injuries), of which 7 were blunt injuries and 39 were shrapnel wounds. It was shown that hemopericardium was registered in 27 (58.7±7.3%) cases, pseudoaneurysm – in 11 (23.9±6.3%) cases ($P<0.001$).

In the diagnosis of metal fragments, the sensitivity of radiography was 97.2%, specificity – 66.7%,

accuracy - 94.9%; the sensitivity of ultrasound was 94.3%, specificity - 75.0%, accuracy - 92.3%. The sensitivity of ultrasound in the diagnosis of hemopericardium was 96.0%, specificity - 50.0%, accuracy - 92.6%.

According to the data obtained, despite the limited use of ultrasound in assessing complications of penetrating chest trauma, the method has sufficient sensitivity and accuracy in diagnosing shrapnel wounds of the heart and blood effusion in the pericardial cavity. No significant differences were found between radiography and ultrasound in the diagnosis of metal fragments.

Penetrating gunshot wounds to the chest always present serious problems in providing care. According to the literature, about 90% of patients with penetrating thoracic injuries die before reaching the hospital. Factors that affect survival include the presence of cardiac tamponade, right ventricular injury, and single versus multiple chamber injury. It should be noted that the development of tamponade in some cases allows one to gain time for choosing treatment tactics for patients with gunshot wounds of the heart. The success of thoracotomy for all patients with penetrating wounds to approach 15% [1, 2]. According to M.J.Seamon et al. (2015) in cases of penetrating chest trauma, overall survival approaches 21% in patients with signs of life. Overall survival was 8% in patients without signs of life on presentation [3].

The incidence of injury to the major thoracic vessels is unknown. In most cases, dissection of the pulmonary artery or pulmonary vein is rapidly fatal, which explains the limited clinical data on these injuries. Because pulmonary artery pressures are often low, the most common manifestations of injury may be hemothorax or a presumed pseudoaneurysm on CT angiography. The most common chest CT findings in patients with non-fatal gunshot wounds to the chest are metal debris near or on the wall of the heart or great vessels [4].

Cardiovascular injuries are the second most common cause of death after central nervous system injuries. Cardiac trauma is divided into two broad categories: nonpenetrating or blunt cardiac injuries and penetrating cardiac injuries. Blunt cardiac injuries are more common and occur due to crush. Penetrating cardiac injuries are more common due to gunshot wounds and carry higher mortality. In gunshot wounds to chest a bullet can cause direct injury to the cardiac structures and result in tamponade, structural cardiac defects, or valve or aortic injury [5, 6].

Penetrating cardiac injuries carry a grave

prognosis. The most common presentation is with hemopericardium and pericardial tamponade [7]. In rare cases of gunshot wounds to the chest, when the bullet ricochets and lodges in the pericardium, it may not damage the adjacent cardiac structures. In such cases, multimodality imaging can help localize the bullet, assess the nature of the damage. Some patients may not have symptoms of foreign bodies in the heart. The right ventricle is most commonly involved, followed by the left ventricle, right atrium, and left atrium [8].

In patients with gunshot wounds to the chest, ricocheting bullets can cause cardiac injury. A chest X-ray allows you to determine the silhouette of metallic foreign bodies, in particular bullets, with a clarification of the direction of their tip. In gunshot wounds to the chest, where the bullet ricochets into the pericardium without damaging other cardiac structures, echocardiography is the best method to determine the exact location of the foreign body and minimal pericardial effusion. Echocardiography may be particularly useful when CT scanning does not accurately visualize the object due to projectile artifact [9].

Accurate determination of the location of the foreign body is of paramount importance for choosing the most rational method of treatment. The evaluation should begin with advanced life support protocols during trauma. If the patient remains stable, imaging should be continued to determine the specific location of the bullet or fragment to determine individual treatment. Computed tomography remains the best imaging modality in hemodynamically stable patients with thoracic trauma, allowing rapid and accurate examination of the entire chest [10-11].

The purpose of the study is a comparative assessment of the capabilities of radiological methods investigation in the diagnosis of injuries to the heart and thoracic large vessels resulting from combat trauma.

Material and methods. The analysis of the results of ultrasonography and radiography in

diagnosis of injury to the heart, thoracic aorta and pulmonary artery in 42 wounded during combat operations diagnosed by CT contrast was performed. The types of injury were established on the basis of CT-contrast, which is currently the main method of assessing injuries to the chest organs. The age of patients varied within 28-46 years (average 38 ± 4 years). Ultrasonography was performed on the RADMIR Ultima PA Expert ultrasound device using a convex sensor in the frequency mode of 2-5 MHz.

Statistical analysis was performed using the nonparametric Mann-Whitney method. If the p value < 0.05 , the difference between the compared groups was considered statistically significant. The sensitivity, specificity and accuracy of radiation research methods in the diagnosis of various types of damage to the heart, thoracic aorta and pulmonary artery were determined.

Results and discussion. Among the 42 wounded, 46 injuries were recorded: of these, isolated damage to the heart – in 27 (58.7%), thoracic aorta – in 9 (14.0%), pulmonary artery – in 2 (18.6%). Combined shrapnel damage to the heart and thoracic aorta was recorded in 4 wounded (Table 1). In all 39 ($84.8 \pm 5.3\%$) cases, penetrating injuries to the heart, aorta, and pulmonary artery were caused by shrapnels. As can be seen from the table, in all cases penetrating injuries to the heart and thoracic aorta were registered statistically significantly ($P < 0.001$) more often than blunt ones. Metal shrapnel in all types of radiological diagnostics were defined as luminous inclusions with the appearance of a dorsal track (Fig. 1).

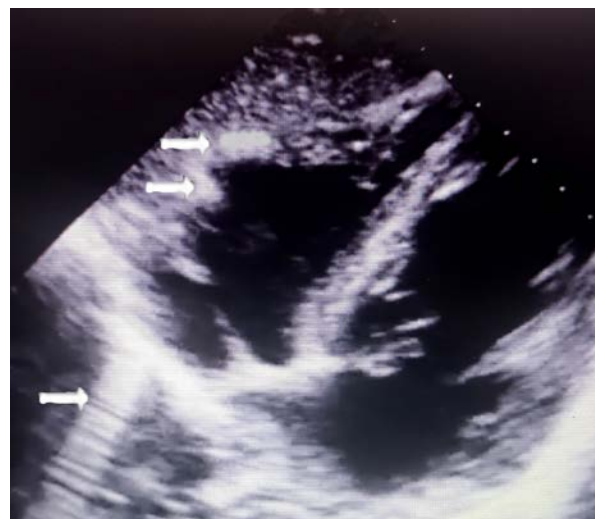


Fig. 1. Two-dimensional subcostal echocardiographic image of a metallic foreign body (metal shrapnel). The upper and middle arrows show the shrapnel, the lower arrow - the dorsal track.

The following types of injuries were identified: hemopericardium, intimal flap, dissection, pseudoaneurysm formation, rupture. Of all 46 cases of injury, hemopericardium was recorded in 27 ($58.7 \pm 7.3\%$) cases; intimal flap of the thoracic aorta – in 2 ($4.3 \pm 3.0\%$), pulmonary artery – in 1 ($2.2 \pm 2.2\%$) case, dissection – in 3 ($6.5 \pm 3.6\%$) and 1 ($2.2 \pm 2.2\%$) cases, respectively. Pseudoaneurysm of the heart was recorded in 3 ($6.5 \pm 3.6\%$) cases, of the thoracic aorta – in 8 ($17.4 \pm 5.6\%$) cases, respectively. In 1 case ($2.2 \pm 2.2\%$), a rupture of the interventricular septum of the heart was recorded (table 2).

Table 1. Distribution of cases of injury to the heart, thoracic aorta, and pulmonary artery in blunt and penetrating combat trauma

Localization	Nature of injury (n = 46)		Total
	Blunt	Penetrating	
The heart	6 ($13.0 \pm 5.0\%$)	25 ($54.3 \pm 7.3\%$) $P < 0.001$	31
Thoracic aorta	1 ($2.2 \pm 2.2\%$) -	12 ($26.1 \pm 6.5\%$) $P < 0.001$	13
Pulmonary artery	-	2 ($4.3 \pm 3.0\%$)	2
Total	7 ($15.2 \pm 5.3\%$)	39 ($84.8 \pm 5.3\%$) $P < 0.001$	46

Table 2. Types of combat injuries to the heart, thoracic aorta, pulmonary artery

Type injuries	The heart	Thoracic aorta	Pulmonary artery	Total
	1	2	3	
Hemo-pericardium	27 (58,7±7,3%)	-	-	27 (58,7±7,3%) P* <0,001
Intimal flap	-	2 (4,3±3,0%)	1 (2,2±2,2%)	3 (6,5±3,6%)
Dissection	-	3 (6,5±3,6%)	1 (2,2±2,2%)	4 (8,7±4,1%)
Pseudoaneurysm	3 (6,5±3,6%)	8 (17,4±5,6%)	-	11 (23,9±6,3%) P** <0,05
Rupture	1 (2,2±2,2%)	-	-	1 (2,2±2,2%)
Total	31 (67,4±6,9%) P 1-2 <0,001	13 (28,3±6,6%) P 2-3 <0,001	2 (4,3±3,0%)	46

Note: P – comparison of heart and thoracic aorta; P* – comparison of hemopericardium and pseudoaneurysm; P** – comparison of pseudoaneurysm and dissection.

As can be seen from the table, the damages of the heart were registered significantly more frequently ($P < 0.001$) then, the thoracic aorta, and damages of the thoracic aorta were more frequent ($P < 0.001$) then, the pulmonary artery. The hemopericardium was registered signi-

ficantly more frequently ($p < 0.001$) then, the pseudoaneurysm, and the pseudoaneurysm more frequently ($p < 0.05$) then, the dissection. Penetrating damage to the heart by metal fragments in all cases was accompanied by the development of hemopericardium (Fig. 2-4).



Fig. 2. Two-dimensional apical 4-chamber view of pericardial effusion in a patient with a gunshot wound. From top to bottom, arrows show pericardial effusion, a metallic foreign body on lateral wall of the left ventricle.



Fig. 3. Two-dimensional subcostal 4-chamber view of massive pericardial effusion with cardiac tamponade in a patient with a gunshot wound. From top to bottom, arrows show pericardial effusion along the anterior wall of the right ventricle, a metallic foreign body, reverberation from it, a significantly compressed left ventricular cavity, effusion along the posterolateral wall of the left ventricle.

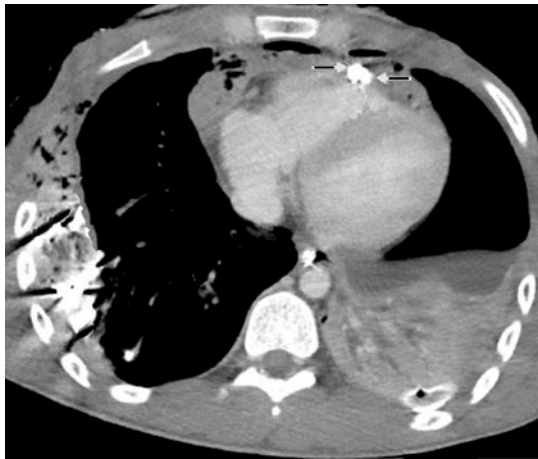


Fig. 4. Oblique CT view of a metallic foreign body (arrows) on the anterior surface of the right ventricle

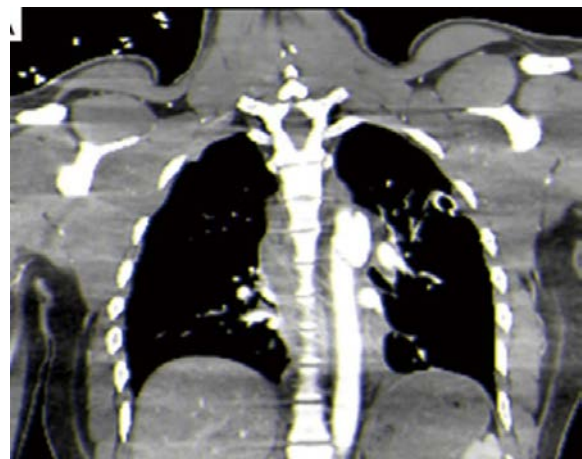


Fig. 5. CT image of blunt trauma to the thoracic aorta in a patient with a gunshot wound to the chest. Coronal view of the aortic pseudoaneurysm

The most common anatomic site of injury in blunt thoracic aortic injury occurs at the aortic isthmus, on the medial aspect of the descending thoracic aorta, distal to the origin of the left subclavian artery. This is where the relatively mobile aortic arch transitions to the relatively fixed descending aorta (Fig. 5).

Table 3 presents the results of radiography and USG in the diagnosis of shrapnel, which was detected by CT. In 35 cases, the results of radiography were true positive (TP), in 1 case false negative (FN), in 2 cases true negative (TN), in 1 case false positive (FP). The sensitivity of radiography was 97,2%, the

specificity was 66,7%, and the accuracy was 94,9%. In 33 cases, the results of USG were TP, in 2 cases FN, in 3 cases TN and in 1 case FP. The sensitivity of USG was 94,3%, specificity – 75,0%, accuracy – 92,3%, respectively (Table 3).

Table 4 presents the results of USG in the diagnosis of hemopericardium, which was detected by CT. In 34 cases, the results of USG was true positive (TP), in 1 case false negative (FN), in 1 case true negative (TN) and in 1 case false positive (FP). The sensitivity of USG was 97,1%, the specificity was 50,0% and the accuracy was 94,6% (Table 4).

Table 3. Results of radiography and USG in identifying of shrapnels

Shrapnels on the heart wall, thoracic aorta and pulmonary artery identifying by contrast-enhanced CT (n=39)							
X-ray				USG			
Yes		No		Yes		No	
36		3		35		4	
TP	FN	TN	FP	TP	FN	TN	FP
35	1	2	1	33	2	3	1
Sensitivity		97,2%		Sensitivity		94,3%	
Specificity		66,7%		Specificity		75,0%	
Accuracy		94,9%		Accuracy		92,3%	

Note: TP – true positive, FN – false negative, TN – true negative, FP – false positive.

Table 4. Results of USG in identifying of hemopericardium

Hemopericardium identifying by contrast-enhanced CT (n=27)			
Yes		No	
25		2	
TP	FN	TN	FP
24	1	1	1
Sensitivity		96,0%	
Specificity		50,0%	
Accuracy		92,6%	

Note: TP – true positive, FN – false negative, TN – true negative, FP – false positive.

Discussion. Thoracic trauma accounts for approximately 25% of all trauma-related deaths. Gunshot wounds are the second most common cause of fatal traumatic injuries. In modern warfare, a significant proportion of large vessel damage occurs due to shrapnel and blast wounds [12]. Blunt thoracic aortic injury are the second most common cause of early trauma-related deaths following traumatic brain injuries and this accounts for approximately 1.5% of all thoracic trauma [13].

The location of retained projectile fragments in the chest organs is a key factor in determining the management plan. When associated with direct cardiac injury, shrapnels can be found on the heart walls, partially or totally embedded in the myocardium, within the pericardial cavity or lodged in proximity to the great vessels [10]. In our studies, the sensitivity of ultrasonography in diagnosing of metal shrapnels reached 94.3%, and the accuracy was 92.3%.

High-velocity penetrating chest injuries with shrapnels are accompanied by the development of hemopericardium and hemothorax. On multidetector computed tomography, they appear as high values (50-90 units) of Hounsfield. In our studies, the sensitivity of ultrasonography in diagnosing of

hemopericardium reached 97,1%, and the accuracy was 94,6%.

In rare cases, when the interventricular septum is ruptured as a result of gunshot wounds, it is possible to deliver the patient to the cardiac surgery department within a few hours and perform surgical intervention. In our studies, rupture of the interventricular septum in gunshot wounds was recorded only in one case, but the patient died a few hours later.

The results of our studies confirm the high role of ultrasonography in the assessment of complications of blunt and penetrating chest trauma and demonstrate sufficient sensitivity and accuracy in the diagnosis of shrapnels on the walls of the heart, hemopericardium and pseudoaneurysm.

Conclusion

1. Despite the limited use of ultrasound in assessing complications of penetrating chest trauma, the method has sufficient sensitivity, specificity and accuracy in diagnosing shrapnel lesions of the heart and blood effusion in the pericardial cavity.

2. There are no significant differences between radiography and ultrasound in the diagnosis of shrapnel.

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ЛУЧЕВАЯ ДИАГНОСТИКА ПОВРЕЖДЕНИЙ СЕРДЦА И КРУПНЫХ СОСУДОВ ГРУДНОЙ КЛЕТКИ ПРИ БОЕВОЙ ТРАВМЕ

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Резюме. В статье представлены результаты лучевой диагностики при повреждении крупных сосудов сердца и грудной клетки в ходе боевых действий. В исследование включены 38 больных, всего зарегистрировано 46 ранений (31 сердце, 13 аорты и 2 легочные артерии), 7 тупых и 39 осколочных ранений. Показано, что гемоперикард зарегистрирован в 27 (58,7±7,3%) случаях, псевдоаневризма – в 11 (23,9±6,3%) случаях ($p < 0,001$).

При диагностике металлических осколков чувствительность рентгенографии составила 97,2%, специфичность – 66,7%, точность – 94,9%; чувствительность УЗИ составила 94,3%, специфичность – 75,0%, точность – 92,3%. Чувствительность УЗИ в диагностике гемоперикарда составила 96,0%, специфичность – 50,0%, точность – 92,6%.

Согласно полученным данным, несмотря на ограниченное применение УЗИ при оценке осложнений проникающей травмы грудной клетки, метод обладает достаточной чувствительностью и точностью при диагностике осколочных ранений сердца и выпота крови в полости перикарда. Существенных различий между рентгенографией и ультразвуком в диагностике металлических осколков не обнаружено.

Conflict of interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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