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QARIN BOŞLUĞUNUN İRİ ARTERİYALARININ DÖYÜŞ XƏSARƏTLƏRİ NƏTİCƏSİNDƏ ZƏDƏLƏNMƏSİNİN DİAQNOSTİKASINDA ULTRASƏS MÜAYİNƏSİNİN TƏTBİQİ

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Xülasə. Məqalədə döyüş əməliyyatları zamanı qarın boşluğunun iri arterial damarlarının zədələnməsinin diaqnostikasında ultrasəs müayinəsinin nəticələri təqdim olunur. Döyüş zamanı yaralanmış 43 xəstə üzərində müşahidə aparılmışdır. Göstərilmişdir ki, aortanın zədələnməsi 43 xəstədən 29 (67,4%), böyrək arteriyalarının zədələnməsi – 6 (14,0%), qalça arteriyalarının zədələnməsi – 8 (18,6%) nəfərdə qeydə alınmışdır. Aorta zədələnməsinin diaqnostikasında ultrasəsin həssaslığı 96,2%, spesifikliyi 66,7%, dəqiqliyi 93,1%, böyrək və galça arteriyaların zədələnməsi üzrə müvafiq olaraq 75,0%, 50,0% və 71,4% təşkil edib.

Müəlliflərin fikrincə, aortanın döyüş xəsarətlərinin diaqnostikasında ultrasəs yüksək həssaslığa, spesifikliyə və dəqiqliyə malikdir. Qarın aortasının şaxələrinin döyüş xəsarətlərinin diaqnostikasında ultrasəs müayinəsi məqbul həssaslığa malikdir.

Açar sözlər: qarın boşluğunun iri arteriyaları, ultrasonografiya, döyüş xəsarətləri

Ключевые слова: крупные артерии брюшной полости, ультрасонография, боевые травмы

Key words: large abdominal arteries, ultrasonography, combat injuries

ULTRASONOGRAPHY IN DIAGNOSTICS OF LARGE ARTERIES DAMAGES OF ABDOMINAL CAVITY IN COMBAT INJURIES

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The article presents the results of ultrasound examination in diagnostics of damage to large abdominal arterial vessels during combat operations in 43 patients. It is shown that aortic damage was registered in 29 (67.4%), renal arteries - in 6 (14.0%), iliac arteries - in 8 (18.6%) patients. The sensitivity of ultrasound examination in diagnostics of aortic injury was 96.2%, specificity - 66.7%, accuracy - 93.1%, for renal and iliac artery injury - 75.0%, 50.0% and 71.4%, respectively.

According to the authors, in diagnostics of combat injuries of the aorta, ultrasound has high sensitivity, specificity and accuracy. Ultrasound examination in diagnostics of combat injuries of the branches of the abdominal aorta has acceptable sensitivity.

Gunshot wounds are the second most common cause of traumatic injuries leading to death [1]. The mechanisms of vascular injury in polytrauma can be blunt, penetrating, or combined [2]. Vascular injuries in modern armed conflicts occur five times more often than in previous wars. According to American surgeons, the incidence of vascular injury during the Iraq War was 12%, which was 1-3% higher than during the Korean and Vietnam Wars [3]. Victims with injuries to the vessels of the chest and neck often die from blood loss and shock in the coming hours. With injuries to the vessels of the abdominal cavity, the survival rate is comparatively higher [4].

The determining factor for the successful outcome of surgical treatment is the timely evacuation of the wounded to specialized vascular departments, and this should be preceded by high-quality and rational radiological diagnostics. It is one of the complex areas of modern military surgery and angiology in combat injuries to the main vessels [5].

Ultrasound examination of the abdomen, pelvis, FAST protocol allows to accurately determine clinically significant intra-abdominal bleeding in patients with severe pelvic fractures [6]. Previously published works have shown the clinical use of ultrasound to identify injuries to the abdominal aorta and its large branches, to perform ultrasound-guided catheterization, as well as to assess hemodynamic parameters, angioarchitecture of internal organs in case of injuries [7–9].

Experience with the results of radiographic examinations of wounded patients who died as a result of blood loss and shock in NATO hospitals has shown their low diagnostic efficiency. Currently, among the numerous imaging methods, the most effective with high throughput is computed tomography with contrast. [10, 11].

In combat injuries of internal organs and vessels, damage by explosive fragments or bone fragments causes bleeding, hemorrhage in the abdominal cavity and the risk of fragment embolization, which has an unfavorable prognosis. For this reason, contrast-enhanced CT is the “gold standard” for identifying emboli and vascular injury [12]. Due to the detailed interpretation of the most common vascular injuries, multidetector contrast-enhanced CT is an

invaluable method for assessing the severity of injury [13].

In the visual assessment of vascular injury to the abdominal cavity and pelvis, the effectiveness of emergency ultrasound has been proven in blunt abdominal trauma, but the role of the FAST protocol in penetrating abdominal and pelvic trauma is controversial [14].

The purpose of the study is evaluation the capabilities of duplex ultrasonography in the diagnosis of damage to large arterial vessels of the abdominal cavity in combat trauma.

Material and methods. The analysis of ultrasound results in diagnostics of damages of large arterial vessels of the abdominal cavity in 43 wounded during combat operations diagnosed by CT contrast was performed. The types of vascular damages were established on the basis of CT angiography results, which is currently the main method of assessing the condition of the vessels of the abdominal organs. The age of patients varied within 29-48 years (average 37 ± 5 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. The sensitivity, specificity, and accuracy of radiography and ultrasonography in diagnosing various types of chest injuries were determined.

Results and discussion. The presence and type of damage to large abdominal vessels was determined based on CT with contrast. In this case, damage to parenchymatous and hollow organs was simultaneously determined, and fragments were visualized (Fig. 1).

As can be seen from Table 1, according to the results of CT with contrast, aortic damage was recorded in 29 cases ($67.4 \pm 7.1\%$), renal arteries – in 6 cases ($14.0 \pm 5.3\%$), iliac arteries – in 8 cases ($18.6 \pm 5.9\%$). The following types of damage were identified: intimal flap, dissection, pseudoaneurysm formation. In CT, among all 43 cases, intimal flap was recorded in 8 cases ($18.6 \pm 5.9\%$), dissection – in 16 cases ($37.2 \pm 7.4\%$), pseudoaneurysm – in 19 cases ($44.2 \pm 7.6\%$), respectively. As can be seen from the table, intimal flap was registered significantly less frequently than dissection ($P < 0.05$) and pseudoaneurysm ($P < 0.01$). In addition, damage to the abdominal aorta was registered significantly more frequently than renal ($P^* < 0.001$) and iliac ($P^{**} < 0.001$) arteries.

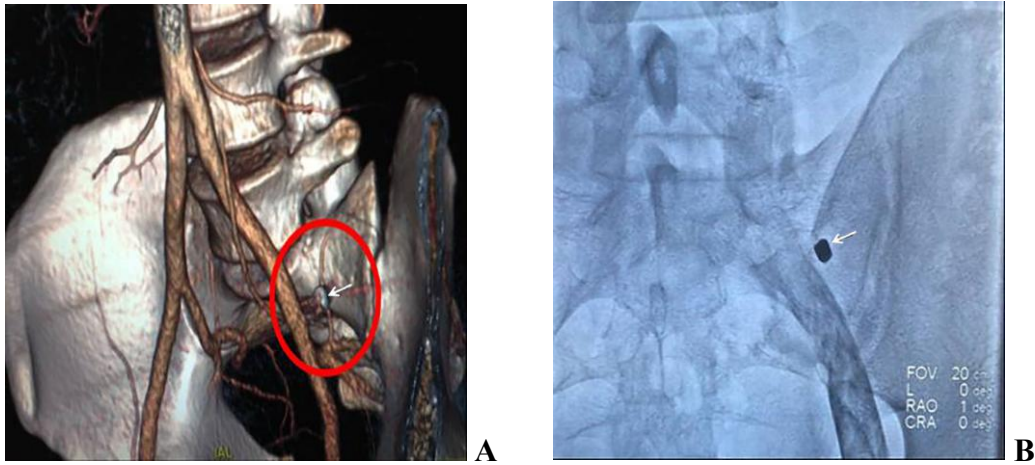


Fig. 1. Penetrating gunshot wound to the abdomen, CT angiography (A) and X-ray angiography (B) demonstrate a metallic fragment (arrow) at the bifurcation of the left common iliac vein.

Table 1. Types of combat injuries to the abdominal aorta, renal and iliac arteries in combat trauma

Major abdominal arteries	Type of Injury			Total
	Intimal flap	Dissection	Pseudoaneurysm	
Abdominal aorta	6 (14,0±5,3%)	9 (20,9±6,2%)	14 (32,6±7,1%) P<0,05	29 (67,4±7,1%) P* <0,001 P** <0,001
Renal artery	1 (2,3±2,3%)	3 (7,0±3,9%)	2 (4,6±3,2%)	6 (14,0±5,3%)
Iliac artery	1 (2,3±2,3%)	4 (9,3±4,4%)	3 (7,0±3,9%)	8 (18,6±5,9%)
Total	8 (18,6±5,9%)	16 (37,2±7,4%) P<0,05	19 (44,2±7,6%) P<0,01	43

Note: US: Ultrasound, CT: Computed tomography; P – comparison with intimal flap; P* - comparison of abdominal aorta with renal arteries; P** - comparison of abdominal aorta with iliac arteries.

Table 2 presents the results of USG in diagnostics of damages of large abdominal arteries, which were revealed by CT with contrast. In 38 cases the results of USG were true positive (TP), in 4 cases false negative

(FN), in 3 cases true negative (TN), in 2 cases false positive (FP). The sensitivity of USG was 89.5%, specificity - 60.0%, accuracy - 86.0%, respectively (Table 2).

Table 2. Results of USG in diagnosing injuries of large abdominal vessels

Trauma of major abdominal arterial vessels diagnosed by contrast-enhanced CT (n=43)			
Yes		No	
38		5	
TP	FN	TN	FP
34	4	3	2
Sensitivity		89,5%	
Specificity		60,0%	
Accuracy		86,0%	

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

The diagnosis of arterial damage by the intimal flap type was based on the visualization of a thin hyperechoic linear structure floating (dangling) with its distal end in the lumen of the vessel. It can cause turbulence or uneven flow in color Doppler examination, as well as thrombosis in the form of a hyperechoic mass in the lumen of the vessel with the absence of color signals (Fig. 2).



Fig. 2. Echogram of the abdominal aorta in a patient with combat trauma. The arrow shows the intimal flap – the distal segment of the torn intima.

Table 3 presents the results of USG in diagnostics of abdominal aortic injuries, which were revealed by CT with contrast. In

25 cases the results of USG 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 USG was 96.2%, specificity - 65.7%, accuracy - 93.1%, respectively (Table 3).

Dissection of the arterial wall is determined by ultrasonography as a hyperechoic mobile segment of the intima, dividing the vessel into true and false lumens. The true lumen expands during the systolic phase and contracts during the diastolic phase of blood flow. The false lumen, on the contrary, decreases during systole and expands during diastole. The blood flow velocity in the true lumen is higher than in the false lumen (Fig. 3).

Pseudoaneurysm is defined by B-mode ultrasonography as a localized bulge without involvement of the inner layer of the vessel wall. In color Doppler mode, vortex motion of the wall can be observed during systole (Fig. 4).

Table 4 presents the results of USG in diagnostics of injuries of the branches of the abdominal aorta – renal and iliac arteries. In 9 cases the results of USG were true positive (TP), in 3 cases false negative (FN), in 1 case – true negative (TN), in 1 case – false positive (FP). The sensitivity of USG was 75.0%, specificity – 50.0%, accuracy – 71.4%, respectively (Table 4).

Table 3. Results of USG in diagnosing injuries of abdominal aorta

Trauma of abdominal aorta diagnosed by contrast-enhanced CT (n=29)			
Yes		NO	
26		3	
TP	FN	TN	FP
25	1	2	1
Sensitivity		96,2%	
Specificity		66,7%	
Accuracy		93,1%	

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

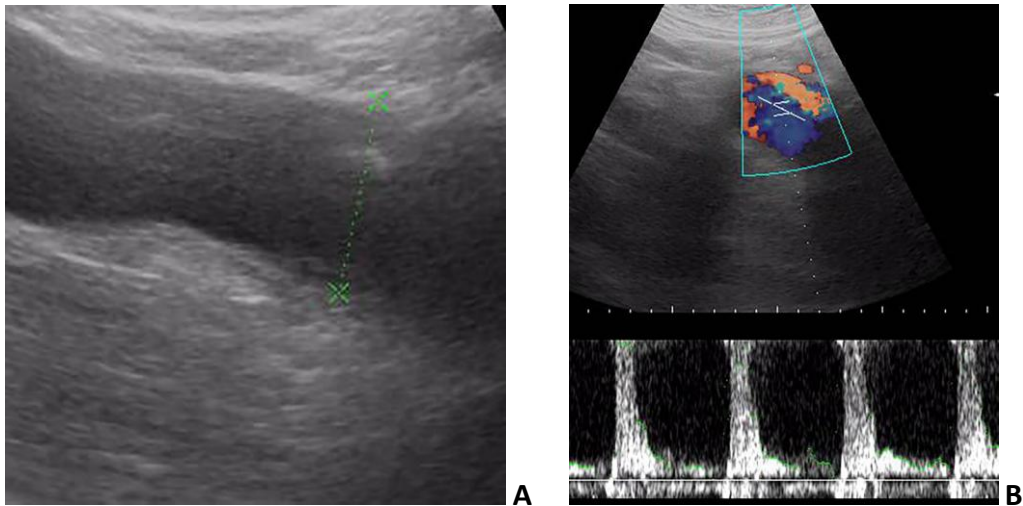


Fig. 3. Echogram of the abdominal aorta in a patient with a combat injury. A – in B mode, dissection of the anterior wall of the aorta is determined. B – in triplex mode, the false channel of the abdominal aorta is colored red, the true channel is colored blue. The control volume is located in the true channel and three-phase blood flow is recorded.



Fig. 4. Large pseudoaneurysm of the posterior wall of the abdominal aorta (arrows). Blood enters the false channel through the intimal defect and bulges the posterior wall of the aorta.

Table 3. Results of USG in diagnosing injuries of renal and iliac arteries

Renal and iliac artery injury diagnosed by CT (n=14)			
Yes		No	
12		2	
TP	FN	TN	FP
9	3	1	1
Sensitivity		75,0%	
Specificity		50,0%	
Accuracy		71,4%	

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

Discussion. 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 [15]. In the vast majority of cases, damage to the abdominal aorta occurs due to penetrating trauma. In blunt trauma, the incidence of aortic injury does not exceed 1%. The close proximity of the abdominal aorta increases the risk of its damage during fractures of the lumbar vertebral bodies. Most often, with traumatic injury to the abdominal aorta, the infrarenal (67%) and adrenal (33%) sections are affected. In 25% of cases, damage to the thoracic aorta extends to the lower thoracic region [16].

Currently, CT with contrast is the main method of non-invasive diagnostics of injuries to abdominal organs, large trunk and visceral vessels [17]. The effectiveness of ultrasound using the FAST protocol is a generally recognized method for the primary diagnosis of free blood in the abdominal cavity as a result of rupture of internal organs. We studied the possibility of the method in diagnosing injuries to large vessels of the abdominal cavity. As is known, in case of injuries to arterial vessels, the following types

of changes are distinguished: rupture of the intima with the appearance of a flap, dissection with the formation of an intramural hematoma, rupture with a transverse incision and the formation of an arteriovenous fistula [18].

Ultrasonography using Doppler modes allows visualization of the vessel lumen and recording numerous flow parameters in different phases of the cardiac cycle [19]. Among the various types of vascular wall damage, intimal rupture with flap formation is very rare [20]. The results of our studies showed that dissection of wall layers and pseudoaneurysms in combat trauma were significantly more common than intimal flap formation. In addition, aortic injuries were also recorded significantly more often than renal and iliac arteries.

Conclusions

1. Despite the limited use of ultrasonography in assessing complications of abdominal ballistic trauma, the method has sufficient sensitivity, specificity and accuracy in the diagnosis of abdominal aorta injuries.

2. In diagnosing injuries to the branches of the abdominal aorta, ultrasonography has diagnostic sensitivity acceptable for practice.

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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ВОЗМОЖНОСТИ УЛЬТРАСОНОГРАФИИ В ДИАГНОСТИКЕ ПОВРЕЖДЕНИЙ КРУПНЫХ АРТЕРИЙ БРЮШНОЙ ПОЛОСТИ ПРИ БОЕВЫХ ТРАВМАХ

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Резюме. В статье представлены результаты ультразвукового исследования при диагностике повреждений крупных абдоминальных артериальных сосудов во время боевых действий. Под наблюдением находились 43 больных получивших повреждения крупных абдоминальных артерий при боевых действиях. Показано, что повреждение аорты зарегистрировано у 29 (67,4%), почечных артерий – у 6 (14,0%), подвздошных артерий – у 8 (18,6%) больных. Чувствительность ультразвукового исследования в диагностике травмы аорты составила - 96,2%, специфичность – 66,7%, точность – 93,1%, при травме почечной и подвздошной артерий – 75,0%, 50,0% и 71,4%, соответственно.

По мнению авторов, в диагностике боевых травм аорты УЗИ обладает высокой чувствительностью, специфичностью и точностью. Ультразвуковое исследование в диагностике боевых травм ветвей брюшной аорты обладает приемлемой чувствительностью.

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