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MÜASİR MÜHARİBƏ ŞƏRAİTİNDƏ DÖYÜŞ TRAVMALARININ DİAQNOSTİKASINDA GÖRÜNTÜLƏMƏ METODLARININ ROLU

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Xülasə. Ukraynadakı hibrid müharibədə tibbi təxliyə zamanı müasir döyüş travması ilə yaralanan 965 xəstədə radioloji müayinə üsullarının retrospektiv təhlili aparılmışdır. Bunlardan 198-i (20,5%) döyüş zonasındakı mobil xəstəxanada (1-ci qrup), 73-ü (7,6%) cəbhə xəttindəki tibb müəssisələrində (2-ci qrup) və 964-ü (71,9%) Kiyev Mərkəzi Hərbi Klinik Xəstəxanasında (3-cü qrup) radioloji diaqnostikadan keçmişdir.

Tədqiqat göstərmişdir ki, yaralılara tibbi yardımın hər üç mərhələsində ultrasəs müayinəsi üsulundan daha çox yaralının müayinəsində istifadə edilmişdir ($p < 0,001$). II Qrupda rentgenoloji müayinə MRT müayinəsinə nisbətən daha çox istifadə edilmişdir ($p < 0,001$). Təxliyə edilən yaralılara ixtisaslı tibbi yardım göstərmək üçün rentgen angiografiyası yalnız III Səviyyədə (mərkəzi xəstəxana) aparılmışdır.

Açar sözlər: şüa diaqnostikası, döyüş travması, hibrid müharibə

Keywords: radiological diagnosis, combat trauma, hybrid war

Ключевые слова: лучевая диагностика, боевая травма, гибридная война

THE ROLE OF IMAGING METHODS IN THE DIAGNOSIS OF COMBAT TRAUMA IN MODERN WARFARE

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A retrospective analysis of radiological examination data was conducted on 965 patients wounded with modern combat trauma during medical evacuation in the hybrid war in Ukraine. Of these, 198 (20.5%) underwent radiological diagnostics at a mobile hospital in the combat zone (Group 1), 73 (7.6%) at frontline medical facilities (Group 2), and 964 (71.9%) at the Kyiv Central Military Clinical Hospital (Group 3).

It can be concluded that ultrasound was significantly ($P < 0.001$) the most commonly used imaging method at all three stages of medical care for the wounded. In Group II, X-rays were used significantly ($P < 0.001$) more frequently than MRI. X-ray angiography was performed only at Level III (the central hospital) for providing qualified medical care to the evacuated wounded.

The nature and characteristics of any war are determined not so much by the methods as by the means of waging it. Modern, next-

generation weapons possess high kinetic energy projectiles, which lead to multifactorial impacts and serious complications [1]. In modern

warfare, where FPV drones are used, cluster munition drops and anti-personnel mine explosions cause combined and multiple injuries. Currently, the proportion of shrapnel wounds involving multiple anatomical locations is approximately 81% [2].

The increase in the structure of combat trauma of multiple and combined wounds has led to significant difficulties in providing surgical care to the wounded and carrying out medical evacuation measures [3]. In this regard, in the organization of medical care in modern warfare, there is a shift from the “golden hour” doctrine to the doctrine of prolonged support and observation in combat trauma treatment tactics [4, 5].

Thus, surgical care is moving closer to the combat zone, where visualization techniques for the wounded play a crucial role in modern warfare. The effectiveness of medical support for armed forces is determined, to a certain extent, by the ratio of battlefield deaths to survivors in medical facilities. Consequently, the more sophisticated the technical equipment at all levels of medical care, from the battlefield to central hospitals, the greater the number of wounded, especially those in critical condition, who can be fully examined [6].

The experience of NATO and Ukrainian combat operations has led to the development of a doctrine for distinct levels of medical care with clearly defined scopes. With the full use of air power, any level can be organized where tactical requirements dictate, reinforced by mobile forward groups. Thus, surgical care can be brought closer to the combat zone to meet the three modern requirements of military medicine: preserving life, sight, and limbs [7].

Despite differences in the definition of forces and resources, the level of care (emergency, primary, specialized) in the Ukrainian and American armed forces depends on the tactical situation. Therefore, to effectively diagnose, limit the necessary imaging equipment during medical triage, reduce the diagnostic period, and ensure timely treatment of combat-injured patients, we used the recommendations of the Joint Trauma System clinical protocols (JTS CPG – ID: 01) [8].

Objective: to study was to examine the role of imaging studies at different levels of medical care for the wounded in modern warfare.

Materials and methods. An analysis of the use of visualization methods for diagnosing combat trauma at different levels of medical care was conducted for 965 wounded: 198 of them underwent visualization research in the region where military operations were conducted (Group I), 73 wounded were treated in medical institutions in front-line zones (Group II), and 694 evacuated wounded received care at the Main Military Clinical Hospital of Kyiv (Group III). The age of the wounded ranged from 18 to 61 years and averaged 35 ± 8 years.

To assess differences between quantitative indicators in the compared groups, the Student's t-test and the χ^2 test were used. Differences were considered statistically significant at $p < 0.05$.

Results and discussion. To ensure the fastest and most effective communication between clinicians and radiologists, we used the international injury mechanism algorithm based on NATO experience [9, 10]. When preparing a full report, the following were taken into account: the injury mechanism (explosion of ammunition, bullet wound, fall, burn); a complete description of the injury (location, nature of damage, use of protective equipment, gear); assessment of vital signs and the types of imaging methods used (X-ray, ultrasound, computed tomography, magnetic resonance imaging, and X-ray angiography).

During the study, we conducted a retrospective analysis of the volume, nature, location, mechanism of injury, characteristics of combat trauma, and the sequence of surgical care for 965 wounded at various levels of medical care. All wounded were divided into three groups based on imaging studies, type of surgical care, and technical equipment at each level, from brigade stabilization centers to the Main Military Clinical Hospital.

The table, the proportion of visualization methods in group I was $20.5 \pm 1.3\%$, in group II – $7.6 \pm 0.9\%$, and in group III – $71.9 \pm 1.4\%$, respectively. The total number of visualization methods performed in group III was significantly higher than in groups I and II ($p < 0.001$), and in group I it was higher than in group II ($p < 0.001$).

Table presents the frequency of using different imaging modalities depending on the level of medical care provided to the wounded due to combat trauma. In Group 1 (mobile hospital in the combat region), digital radiography was used in 72 cases ($4.1 \pm 0.7\%$), ultrasound in

Table. Results of the analysis of data on the distribution of visualization methods by groups

Groups of wounded taking into account the level of medical care provided	Digital radiography	Ultrasound	Multidetector computed tomography	Magnetic resonance imaging	X-ray angiography	Total
	1	2	3	4	5	
I group	72 4,1±0,7%	236 13,4±0,8% P 2-1 <0,001 P 2-3 <0,001	6 0,3±0,1%	0	0	314 17,8%
II group	49 2,8±0,4% P1-4<0,001	113 6,4±0,6% P 2-1 <0,001 P 2-3 <0,001 P 2-4 <0,001	62 3,5±0,4% P 3-4 <0,001	7 0,4±0,2%	0	231 13,1%
III group	208 11,8±0,8% P2-4<0,001 P2-5<0,001	683 38,7±1,2% P 2-1 <0,001 P 2-3 <0,001 P 2-4 <0,001 P 2- 5 <0,001	190 10,8±0,7% P3-4<0,001 P3-5<0,001	105 6,0±0,6% P4-5<0,001	32 1,8±0,1%	1218 69,1%
Total	329 18,7%	1032 58,5%	258 14,6%	112 6,4%	32 1,8%	1763

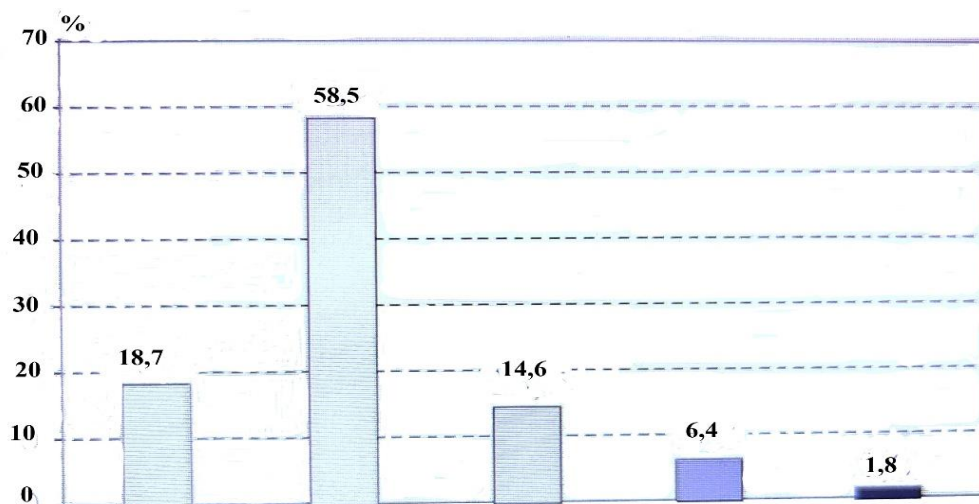
236 cases (13.4±0.8%), and multidetector computed tomography in 6 cases (0.3±0.1%). Magnetic resonance imaging and X-ray angiography were not available at the first level of medical care. In this group, ultrasound was used with a high degree of reliability ($p<0.001$) more often than digital radiography and multidetector computed tomography.

In Group II (in frontline medical institutions), digital radiography was used in 49 (2.8±0.4%) cases, ultrasound in 113 (6.4±0.6%), multidetector computed tomography in 62 (3.5±0.4%), and magnetic resonance imaging in 7 (0.4±0.2%) cases, respectively. At the second level of medical care, ultrasound was also used more frequently than other methods ($p<0.001$). In this group, X-ray methods were used more frequently than magnetic resonance imaging with high reliability ($p<0.001$).

In Group III (Main Military Clinical Hospital), digital radiography was used in 208 (11.8±0.8%) cases, ultrasound in 683 (38.7±1.2%), multidetector computed tomo-

graphy in 190 (10.8±0.7%), magnetic resonance imaging in 105 (6.0±0.6%), and X-ray angiography in 32 (1.8±0.1%) cases, respectively. In this group, ultrasound was used with high reliability ($p<0.001$) more often than all other imaging methods, and digital radiography and CT more often ($P<0.001$) than magnetic resonance imaging and X-ray angiography.

Figure presents the percentage of each imaging method used at various levels of medical care. The overall share of digital radiography was 18.7%, ultrasound 58.7%, multidetector computed tomography 14.6%, magnetic resonance imaging 6.4%, and X-ray angiography 1.8%, respectively. As Figure 1 shows, ultrasound was significantly more commonly used at all levels of medical care for triaging and supporting the diagnostic workup of the wounded. X-ray and computed tomography were second in the diagnostic workup for combat trauma. Magnetic resonance imaging and X-ray angiography were used less frequently.



Figure

The overall distribution of imaging methods for combat trauma diagnostics (n = 1763): digital radiography (18.7%); ultrasound diagnostics (58.7%); multidetector computed tomography (14.6%); magnetic resonance imaging (6.4%); X-ray angiography (1.8%)

Discussion

The study of the extent, nature of the injury, and the specifics of the organization of radiation diagnostics in victims of modern combat trauma using a systems approach and statistical analysis methods is a significant scientific problem, since it facilitates the accumulation, systematization, and analysis of data on the clinical diagnostic parameters of the course of the wound process in this category of patients. Important characteristics for the diagnosis of modern combat trauma in hybrid warfare victims include those influencing the course of the post-traumatic period: age, gender, circumstances of injury, ballistic parameters of injury and diagnostic capability, appropriateness, consistency of use of radiodiagnostic methods, and continuity in the diagnosis and treatment of the wounded and injured during medical evacuation [11].

In the context of hybrid warfare, it is important to obtain data useful for predicting the need for modern radiological care: an integrated coefficient for the need for medical imaging methods and specific coefficients for individual methods, which can be calculated for one as well as for one hundred wounded/injured

during combat operations [12].

Hybrid warfare creates conditions in which the number of wounded requiring full radiological diagnostic support, and consequently the technological capabilities of the various levels of medical care, significantly exceeds their capacity. Therefore, it becomes necessary to group specialized surgical and radiological care according to the urgency of their implementation. The increasing need for radiation diagnostics per wounded patient at Level III medical care is explained by the increased volume of qualified surgical care, technical equipment, and training of medical personnel [13].

Our proposed parameters for the need for radiological diagnostic methods for modern combat injuries allow us to predict the required number of their applications for casualties in hybrid warfare and the massive influx of wounded due to modern combat injuries. They thus facilitate the coordination of the capabilities of each level of medical care with the identified needs during medical evacuation. Our research revealed that modern combat injuries are most often diagnosed using ultrasound, which was used in 58.7% of wounded patients during medical evacuation, where qualified, specialized, and highly specialized surgical care was provided.

Conclusions

At all stages of medical care for the wounded in hybrid warfare, ultrasound remains

the most commonly used imaging method ($P < 0.001$). Digital radiography ranks second, and CT is third in frequency of use. Only at

Level III do evacuated wounded have access to qualified medical care using all imaging methods, including X-ray angiography.

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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РОЛЬ ВИЗУАЛИЗИРУЮЩИХ МЕТОДОВ В ДИАГНОСТИКЕ БОЕВОЙ ТРАВМЫ В УСЛОВИЯХ СОВРЕМЕННОЙ ВОЙНЫ

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Резюме. Проведен ретроспективный анализ данных о выполненных лучевых исследованиях у 965 раненых в результате современной боевой травмы в гибридной войне в Украине на этапах

медицинской эвакуации. 198 (20,5%) из них прошли лучевую диагностику в мобильном госпитале в регионе ведения боевых действий (I группа), 73 (7,6%) раненных – в медицинских учреждениях прифронтовой зоны (II группа), 964 (71,9%) раненных – в центральном военном клиническом госпитале Киева (III группа).

Результаты исследования показали, что на всех трех этапах оказания медицинской помощи раненные, которые были обследованы методом визуализации УЗИ достоверно ($p < 0,001$) преобладала. Во II группе рентгеновские методы использовались достоверно ($p < 0,001$) чаще, чем МРТ. Рентгеновская ангиография выполнялась только на III уровне (в центральном госпитале) оказания квалифицированной медицинской помощи эвакуированным раненым.

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