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CLINICAL AND ANATOMICAL STRUCTURE OF LONG-BONE DEFECTS AS A COMPLICATION OF COMBAT TRAUMA: ANALYSIS OF DEFECT SIZE

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CLINICAL AND ANATOMICAL STRUCTURE OF LONG BONE DEFECTS AS A COMPLICATION OF COMBAT TRAUMA. ANALYSIS OF THE VOLUME OF THE DEFECT

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Introduction. Modern combat operations are accompanied by large-scale health consequences, one of the most common of which is damage to the long bones of the skeleton. One of the most common consequences is injury to the long bones.

The aim of the research is to determine a describe the clinical and anatomical structure of defects in the long bones of the skeleton depending on the volume (size of the defect).

Materials and research methods. The study is based on an analysis of 115 cases of long bone defects resulting from combat-related trauma.

Results and their discussion. As a result of the data analysis, it was established that in the total body of the study, long bone defects with a size of 5.0–9.99 cm (41.31%) are most often found in patients with mine-explosive injuries, and defects ≥ 20.0 cm in size (2.17%) are the least common. In shoulder injuries, defects with a size of 5.0–9.99 cm (80.00%) prevail. Most often, defects of forearm bones have a size of 5.0–9.99 cm (57.14%). 50.00% of hip defects also have a size of 5.0–9.99 cm. 35.48% of shin bone defects have a size of 10.00–14.99 cm, and 33.87% – 5.0–9.99 cm. In addition, defects larger than 20 cm were found in our study in 3.23% of shin bone injuries.

Conclusions:

1. The sizes of bone defects due to combat injuries are diverse. The largest proportion is in defects measuring 5.0–9.99 cm. 41.31% of defects have the smallest proportion with a size greater than 20 cm (2.17%).
2. The occurrence of bone defects obviously depends on the segment of the lesion, and in all groups of defects, as in the general array, lesions of the lower extremities predominate.
3. There is a tendency for bone defects to occur predominantly in the distal segments of both the upper and lower extremities, but this tendency is more pronounced in the lower extremities.
4. The size of the bone defect obviously depends on the segment of impact as the mechanism of implementation of the striking agent in combat casualties.

Keywords: defects, size, long bones, combat trauma, long-bone defects, bone loss, defect size, combat injuries, mine-blast trauma.

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КЛІНІКО-АНАТОМІЧНА СТРУКТУРА ДЕФЕКТІВ ДОВГИХ КІСТОК ЯК УСКЛАДНЕННЯ БОЙОВОЇ ТРАВМИ. АНАЛІЗ ОБСЯГУ ДЕФЕКТУ

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Стаття присвячена визначенню, аналізу та формуванню клініко-анатомічної структури дефектів довгих кісток скелета залежно від розміру дефекту. Це дослідження засноване на ретроспективному аналізі 115 випадків дефектів довгих кісток скелета, що виникли внаслідок отримання сучасної бойової травми. В результаті аналізу встановлено, що розміри дефектів кісток внаслідок бойових уражень є різноманітними. Найбільшу питому вагу мають дефекти розміром 5,0–9,99 см – 41,31%, найменшу, з розміром дефекту більше 20 см – 2,17%. Крім того, розміри дефекту кісток, вірогідно, залежать від сегмента враження як механізму реалізації вражаючого агента в постраждалих внаслідок бойових дій.

Ключові слова: дефекти, розмір, довгі кістки, бойова травма.

Introduction

Modern combat operations are accompanied by large-scale medical and sanitary consequences, one of the most common is damage to the long bones of the skeleton. This type of injury accounts for 56–60% of all combat-related injuries [1–4]. The results of treatment of victims with gunshot fractures of long bones remain suboptimal [5–9]. One of the most threatening complications of such injuries is the development of long-bone defects [10–14]. Unfortunately, the issue of assessing and verifying the size of defects as a component of the clinical and anatomical structure of defects of long bones as a whole remains insufficiently studied, which, in turn, prevents the formation of effective treatment measures. The above determines the relevance of this study.

The aim of the work is to determine and characterize the clinical and anatomical structure of defects of the long bones of the skeleton depending on the volume (size of the defect).

Materials and Methods

This study is based on the analysis of 115 cases of defects in the long bones of the skeleton, resulting from combat-related injuries. The sample size was sufficient for reliable statistical analysis regarding what is necessary and sufficient for conducting a full analysis and obtaining reliable results. Taking into account the uncertainty of the generally accepted classification of defects in long bones in sources of scientific information and the practical lack of consensus on this issue, it can be noted that, according to some scientists, large defects of long bones are considered to be defects of 2.5 cm or more in size [15–17]. Given the extent and character of combat injuries in combat trauma of long bones, we applied the following working classification of defect sizes: up to 4.99 cm, 5–9.99 cm, 10–14.99 cm, 15–19.99 cm and more than 20 cm. An analysis of the distribution of the study array was carried out based on the size of defects both in the general study array and in the arrays of each limb segment separately. An integral analysis of the distribution of defects in a comparative aspect based on the size (volume) of defects and limb segments was also carried out.

The analysis of the actual study material was carried out using methods of non-parametric and parametric statistics and elements of fractal analysis. The analysis was carried out in accordance with the criteria and requirements of evidence-based medicine using computer technologies.

The study complies with the requirements established by the Declaration of Helsinki, adopted in 1964 and revised by the 59th WMA General Assembly. The study complies with modern ethical standards and principles of conducting scientific research (Minutes of the meeting of the Ethics Committee No. 3 dated 30.07.2025, State Institution "Ukrainian Scientific and Practical Center for Emergency Medical Care and Disaster Medicine of the Ministry of Health of Ukraine"). Informed consent was obtained from all participants.

Research results and their discussion

Given the nature and purpose of this study, we divided the total study sample by defect size in accordance with our working classification. The results of this analysis are presented in Table 1.

Table 1

Analysis of the distribution of the total study array based on defect size

Defect size	Proportion, %	Rank
2.5–4.99	17.39	3
5.0–9.99	41.31	1
10.0–14.99	26.09	2
15.0–19.99	13.04	4
Over 20	2.17	5
Total	100.00	–

The data in Table 1 show the following: the largest proportion (first place) is occupied by bone defects measuring 5.0–9.99 cm in size with an indicator of 41.31%. In second place are victims with a defect in long bones measuring 10.00–14.99 cm (26.09%). Thus, in the general study population, victims with a defect volume of 5.0–14.99 cm have a proportion of 67.40%, that is, the vast majority. In third place are victims with a defect size of 2.5–4.99 cm – 17.39%. Defects measuring more than 15 cm occur only in 15.21%, and very large defects measuring more than 20 cm – only in 2.17%.

Summarizing the above, we can conclude that the greatest problem for providing medical care is patients with a defect volume of 5–14.99 cm. The ratio of the maximum and minimum values of the distribution indicators is 19.04, which indicates a high dissipation of the distribution and indirectly – the probability of this distribution.

In order to more thoroughly analyze and assess the defects of long bones in this study, we studied and analyzed the sizes of the defects depending on the anatomical segment. The data of such an analysis are given below.

The results of the distribution of the array of victims with a defect of the humerus are given in Table 2.

Table 2

Analysis of the distribution of the array of victims with a humerus defect

Defect size	Proportion, %	Rank
2.5–4.99	20.00	2
5.0–9.99	80.00	1
10.0–14.99	0	3
15.0–19.99	0	3
Over 20	0	3
Total	100.00	–

The data presented in Table 2 show the following: all defects of the humerus are less than 10 cm in size, and 80.00% of them are victims with defects of 5.0–9.99 cm. Thus, it can be noted that the humerus is characterized by defects of relatively moderate size. Defects of the humerus larger than 10 cm in statistically significant numbers were not identified.

Data on the sizes of defects of the forearm bones are given in Table 3.

When analyzing the data in Table 3, the following was found: all forearm bone defects in our study have a size of

Table 3

Analysis of the distribution of the array of victims with a forearm bone defect

Defect size	Proportion, %	Rank
2.5–4.99	42.86	2
5.0–9.99	57.14	1
10.0–14.99	0	3
15.0–19.99	0	3
Over 20	0	3
Total	100.00	–

less than 10 cm, which is due in particular to the size of the anatomical segment itself. It is noteworthy that defects with a size of 5–9.99 cm (first place) – 57.14% predominate to a certain extent. Defects of forearm bones with a size of more than 10 cm in our study were also not found in a statistically significant volume.

The results of the analysis of the size of the defect in the femur are given in Table 4.

Table 4

Analysis of the distribution of the array of victims with a femoral bone defect

Defect size	Proportion, %	Rank
2.5–4.99	22.22	2
5.0–9.99	50.00	1
10.0–14.99	11.11	4
15.0–19.99	16.67	3
Over 20	0	5
Total	100.00	–

The data presented in Table 4 allow us to note that by proportion 50% are defects with a size of 5.0–9.99 cm, in second place are defects of the thigh with a size of 2.5–4.99 cm (22.22%). Thus, defects of the femur with a size of up to 10 cm occur in 72.22% of victims of this group. Fractures from 15.00–19.99 occur in 16.67% of victims. It is also noteworthy that defects of more than 20 cm in a statistically significant volume did not occur in our study.

The results of distribution based on the size of defects of the bones of the lower leg are shown in Table 5.

The analysis of the data presented in Table 5 allows us to establish the following: the largest proportion consisted of patients with a defect size of 10–14.99 cm (35.48%), the second – with a defect size of 5–9.99 cm (33.87%). Thus, victims with a defect size of up to 10 cm constitute 46.77%

Table 5

Analysis of the distribution of the array of victims with a defect in the tibia bones

Defect size	Proportion, %	Rank
2.5–4.99	12.90	4
5.0–9.99	33.87	2
10.0–14.99	35.48	1
15.0–19.99	14.52	3
Over 20	3.23	5
Total	100.00	–

of the victims in this group by specific weight. There are also bone defects of more than 20 cm, which occupy the fifth rank in the distribution with a specific weight of 3.23%. The presence of such large defects, as proven by the analysis of cases, is associated with the impact of the damaging agent in mine-explosive trauma.

In order to determine the influence of the anatomical segment of the lesion on the defect size, we divided the study array into groups of defect size by the anatomical segment of the lesion. The data are presented in Table 6.

Comparative analysis of the data presented in Table 6 allows us to establish the following: most of the sizes up to 5 cm are found on the lower leg – 50%, in the second place – the hip (5.00%), in the third place – the forearm (18.75%). Overall, upper-limb defects accounted for 25%, nearly twice the proportion observed in the total sample. The ratio of the upper and lower limb in the group of defects up to 5 cm is 3.0, which is significantly different from the ratio in the general array – 6.7.

In the group of defects with a size of 5.0–9.99 cm. the size of the defect by specific weight also prevails with damage to the lower leg – 55.26% of this group. In the second place is also the hip – 23.68%. Both segments of the upper limb have a specific weight of 10.53%. Thus, the damage to the lower limb is 78.94% of the specific weight of this group, which is somewhat lower than the indicator of the general mass. The ratio of the upper and lower limbs in this group is 3.8, which is significantly lower than the indicator of the general mass.

In the groups of defects of more than 10 cm, damage to the upper limb with the occurrence of bone defects did not occur. Summarizing the above, we can conclude that bone defects occur more often when the distal segments of the limbs are affected, and for the upper limb, defects up to 5 cm are more typical, and for the lower limb in general, defects of 5–9.99 cm are typical.

Table 6

Integral analysis of the distribution of the study array in the group of lesion segments based on the defect size

Anato-mical segment	2.5–4.99		5.0–9.99		10.0–14.99		15.0–19.99		over 20		Total array
	*	rank	*	rank	*	rank	*	rank	*	rank	
Shoulder	6.25	4	10.53	3	0	3	0	3	0	2	5.43
Forearm	18.75	3	10.53	3	0	3	0	3	0	2	7.61
Hip	25.00	2	23.68	2	8.33	2	25.00	2	0	2	19.57
Shin	50.00	1	55.26	1	91.67	1	75.00	1	100.0	1	67.39
	100.0	–	100.0	–	100.0	–	100.0	–	100.0	–	100.0

Note: * proportion, %.

There is also an increase in the ratio of the distal segment to the proximal segment with an increase in the indicator of the "defect size" feature. In addition, it is worth noting that the lower leg has the first rank in terms of specific weight in all groups formed by the defect volume feature. The thigh has the second rank, which corresponds to the rank distribution in the general array. As the analysis of cases has shown, this nature of the distribution is due to the predominant mechanism of damage – mine-explosive, with the most intense impact on the lower extremities.

As a result of the polychoric analysis of the data in Table 6, it was established that there is a positive and moderately strong association ($\varphi 2 = 0.3107$; $C = 0.4869$), which was statistically significant ($\chi^2 = 28.58$).

Summarizing the above, it is worth noting that the occurrence of bone defects of a specific size depends on the segment of the lesion, which in turn is the implementation of the mechanism of influence of a high-intensity damaging agent, primarily of mine-explosive origin.

Conclusions

1. The sizes of bone defects due to combat injuries are diverse. The largest proportion (41.31%) consisted of defects measuring 5.0–9.99 cm, whereas the smallest proportion (2.17%) involved defects ≥ 20 cm. The occurrence of bone defects was significantly associated with the segment of the lesion, and in all groups of defects, as in the general array, lesions of the lower extremities prevail.
2. There is a tendency for the predominant occurrence of bone defects in the distal segments of both the upper and lower extremities, but this tendency is more pronounced in the lower extremities.
3. The size of the bone defect obviously depends on the segment of impact as the mechanism of implementation of the damaging agent in victims of combat operations.

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