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Clinical and Morphological Characteristics of Gunshot Wound of Soft Tissues

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ABSTRACT

The forensic examination of a gunshot wound is considered to be one of the most complex kinds of forensic examinations. Currently, the gunshot injuries are often caused by grave crimes associated with the use of hand and often non-typical fire arms for military actions and criminal purposes. The forensic examination results of the gunshot injuries make it possible to answer the questions concerning determination of distance and sequence of shots, formation of wound, time limitation, lifetime nature, character and severity of bodily injuries, as well as identification of causes of death. To expand diagnostic opportunities of the histologic study, the immunohistochemical and semi-quantitative methods are used as they allow for identifying in the tissues the substances that cannot be identified by standard study methods, as well as objectifying the results obtained. This article provides the clinical and anatomical characteristics of the gunshot injuries.

Keywords: gunshot injury, forensic examination, thanatogenesis, cause of death, immunohistochemical study, morphometry.

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INTRODUCTION

The forensic examination of the gunshot injuries is of important practical meaning for investigation and uncovering of crime, as well as in court proceedings on criminal and civil cases [1].

The forensic examination of the gunshot injuries make it possible to answer the questions of the criminal procedure concerning determination of distance and sequence of shots, formation of wound, time limitation, lifetime nature, character and severity of bodily injuries, as well as identification of causes of death. Often an expert has to determine the time limitation and lifetime nature of the gunshot injuries. In this case, to expand diagnostic opportunities of the histologic study, the immunohistochemical and semi-quantitative methods are becoming more commonly used as they allow for identifying in the tissues the substances that cannot be identified by standard study methods, as well as objectifying the results obtained [3].

Today, the classic methods of the histologic study are used for diagnostics and lifetime nature of the gunshot injuries. At the same time, the molecular biology and morphometry methods are becoming more common in the modern morphology [2,8,9].

The forensic examination of a gunshot wound is considered to be one of the most complex kinds of forensic examinations. Currently, the gunshot injuries are often caused by grave crimes associated with the use of hand and often non-typical fire arms for military actions and criminal purposes [6].

Establishing the sequence particular injuries in their series causing and finding out the thanatogenetic importance of each of such injuries still remain the critical issues [4].

Treatment and forecast course of the gunshot wound are the traditional surgical problem. At the same time, establishing the thanatogenetic importance of any gunshot injuries is relevant for extreme medicine and poorly studied until now. A number of authors offer various methods for diagnostics and treatment of the gunshot injuries, their link to forecast not always remains clear [11].

It is known that in the primary surgical debridement of the gunshot wounds the excision site of necrotizing tissues spreads further than the visible necrosis and haemorrhages that requires detailed morphological substantiation [15].

Identification, research, extraction and further laboratory study of the gunshot injury materials of the human body with the establishment of their lifetime nature and time limitation constitute one of the critical stages of the forensic examination [10].

The objective of the research was to specify additional laboratory criteria and develop an algorithm for determining the lifetime nature of the gunshot injuries of soft tissues for the purposes of the forensic examination, and to determine their time limitation in the forensic medicine and military surgery, as well as to substantiate the thanatogenesis criteria of the gunshot injuries in the clinical and morphological aspect.

A range of **tasks of the research** was rather wide, namely:

- to specify the forensic and histological criteria of time limitation, lifetime nature of the gunshot injuries of soft tissues for the purposes of the forensic medicine;
- to find out the immunohistochemical criteria of the lifetime nature of the gunshot injuries of soft tissues;
- to develop additional laboratory methods for the gunshot injuries of soft tissues;
- to develop a laboratory diagnostics algorithm for the gunshot injuries of soft tissues;
- to determine the thanatogenesis in case of death from various gunshot injuries;
- to substantiate a scope of the primary surgical debridement of soft tissues on the basis of morphological criteria in case of the gunshot injuries considering the analysis of morphological peculiarities of the zone of molecular contusion.

STUDY METHODS

In the course of this work, the results of the forensic post-mortem examination were used with the morphological

method, namely sectional and histological, thanatogenetic analysis and method of establishment of the death rate. In addition, the statistical study methods were used.

RESULTS AND DISCUSSION

In the course of study of epidemiological aspect of injuries caused by fire arms in Astrakhan region for 2009-2018, the reduction in mortality rates was established. Among the killed, there prevailed the men at the age of 30-39 years old who had been injured by brush gun at point blank range as a result of the attempted suicide [7].

When studying the thanatogenesis, the entire material of the suffered from the gunshot injury was divided into four groups by time intervals (periods): the period of 1 day (to 24 hours), 2-3 days, 4-7 days, more than 7 days. The thanatogenetic analysis found out that the combined type of the thanatogenesis prevailed that had been represented by a combination of the brain, heart and lung components. The combination of the brain, heart and lung components was manifested by lung oedema, irregular blood filling of veins and capillaries, cardiac myocyte fragmentation, as well as emptying of many vessels, bleeding from ghost cells and emphysema-like expanded alveolar cavities. This type of the thanatogenesis was manifested by the brain component, oedema (both pericytial and destructive), bleeding around the brain and brain matter, severe destruction of the brain matter, as well as cranial bones damage.

The brain type of the thanatogenesis manifested by the brain oedema (both pericytial and destructive), bleeding around the brain and brain matter, severe destruction of the brain matter, as well as cranial bones damage. In this group, the described type of the thanatogenesis is explained by localization of damages or profuse blood loss causing the brain oedema. At this rate of the thanatogenesis, the peracute death rate dominated. The heart component was represented by the cardiac myocyte fragmentation, emptying of arterial, capillary and vein lumina, presence of ghost cells in a lumen.

The appearance of the heart component of the thanatogenesis might be related to the underlying pathology of the cardiac muscle. The lung component was manifested by lung oedema, irregular blood filling of veins and capillaries, cardiac myocyte fragmentation, as well as emptying of many vessels, bleeding from ghost cells and emphysema-like expanded alveolar cavities [4].

In the course of study of the death rate according to methodology developed by us, the following results were obtained that demonstrated the prevailing peracute death rate with the agonal period not exceeding 15-30 minutes [13,14].

As it was stated above, the molecular biology and morphometry methods are becoming more common in the modern morphology [12].

In the course of study of the soft tissue damages caused by fire arms during the lifetime, we have obtained and analysed the results. To establish the lifetime nature of the gunshot injuries, we used the immunohistochemical marker, fibrinogen. Fibrinogen is a colourless protein dissolved in blood plasma and is a fibrin predecessor, penetrates into tissues immediately after vessel damage and is a lifetime marker. The plasma agents appear too early even in the minor gunshot wound, as a result, opening them in tissues can serve as a lifetime marker of such damages.

Therefore, our study allows for using this method to establish the lifetime nature of the gunshot injuries without conventional signs, as well as specify the death rate in the gunshot injuries. It also provides for confirming the lifetime or post-mortem nature of the gunshot injury in case of doubtful or unreliable evidence of conventional methods [5].

We have conducted the comparative study of results using the morphometric technique for establishing the time limitation of injuries in case of the gunshot wound with the help of the layer-by-layer histostereometry of the injured zones in the canal depth of the gunshot wound.

We sampled the material in the course of the forensic post-mortem examination after the gunshot injury down the wound canal considering the wound canal site where the zones of necrosis and molecular contusion entered. As a control group, we used the material received from examination of stab wounds that was similar to the time limitation of death. The study groups were formed by three periods (no more than 30 minutes, about 3 and 7 days).

All quantitative data were recorded in the form of the database and subjected to statistical processing with due regard to individual and group dispersions using the electronic table MS Exel-10.0

As a result of the morphometric analysis, the comparisons of indicators of the gunshot and stab wound canals and the average values obtained from calculation, as well as deviations, are reliable according to the obtained error in mean values (m)

In the control group with the time limitation of no more than 30 minutes, the lymphocyte count in the zone of necrosis prevails over the similar zone of the gunshot injury. In the control group, the lymphocyte count is considerably reduced in the zone of reactive changes in contrast to the zone of molecular contusion. In this time interval, the neutrophil count in the zone of necrosis in the control group considerably exceeds the indicators in the gunshot injury. When comparing the macrophage indicators in the relevant sites, we have got insignificant differences both in stab and gunshot injuries.

With the time limitation of about 3 days, we have found out that the lymphocytes prevail in the zone of necrosis in the control group as distinguished from the gunshot injury. At this time point, the neutrophils prevail in the zone of necrosis in the gunshot injury as compared with the control group. The macrophage count at this time point of injury does not significantly differ.

With the time limitation of injury of about 7 days, we have identified that the indicators insignificantly differ in the study zones both in the control group and in the gunshot injury.

Table 1. Comparison of morphometry results in the gunshot and stab injuries

Study subjects	Stab injuries, 400x	Gunshot injuries, 400x
Lymphocytes, time limitation of injury to 30 minutes		
Necrosis	21±2.4 m=0.8	10±2.0 m=0.6
Zone of reactive changes/ Zone of molecular contusion	14±2.2 m=0.7	22±5.1 m=1.6

Neutrophils, time limitation of injury to 30 minutes		
Necrosis	8±7.6 m=1.0	4±1.5 m=0.5
Zone of reactive changes/ Zone of molecular contusion	3±3.3 m=0.3	5±1.5 m=0.5
Macrophages, time limitation of injury to 30 minutes		
Necrosis	3±3.4 m=0.4	1±0.4 m=0.1
Zone of reactive changes/ Zone of molecular contusion	2±1.5 m=0.2	2±0.7 m=0.2
Injured area, time limitation of injury to 30 minutes		
Necrosis	1±0.1 m=0	1±0.1 m=0
Zone of reactive changes/ Zone of molecular contusion	1±0.1 m=0	1±0.1 m=0
Lymphocytes, time limitation of injury of about 3 days		
Necrosis	25±7.5 m=2.4	13±3.3 m=1.0
Zone of reactive changes/ Zone of molecular contusion	23±3.3 m=1.0	11±2.4 m=0.8
Neutrophils, time limitation of injury of about 3 days		
Necrosis	10±2.8 m=0.9	18±4.7 m=1.5
Zone of reactive changes/ Zone of molecular contusion	8±2.1 m=0.7	12±3.0 m=1.0
Macrophages, time limitation of injury of about 3 days		
Necrosis	10±3.1 m=1.0	7±1.9 m=0.6
Zone of reactive changes/ Zone of molecular contusion	9±2.8 m=0.9	6±1.8 m=0.6
Injured area, time limitation of injury of about 3 days		
Necrosis	1±0.1 m=0	1±0.1 m=0.1
Zone of reactive changes/ Zone of molecular contusion	1±0.1 m=0	1±0.2 m=0.1
Lymphocytes, time limitation of injury of about 7 days		
Necrosis	12±3.1 m=1.0	13±3.1 m=1.0
Zone of reactive changes/ Zone of molecular contusion	9±2.1 m=0.7	10±2.1 m=0.7
Neutrophils, time limitation of injury of about 7 days		
Necrosis	6±1.9 m=0.6	6±2.0 m=0.6
Zone of reactive changes/ Zone of molecular contusion	3±1.6 m=0.4	3±1.5 m=0.3
Macrophages, time limitation of injury of about 7 days		
Necrosis	13±2.7 m=0.8	15±2.7 m=0.8
Zone of reactive changes/ Zone of molecular contusion	11±1.8 m=0.6	11±1.8 m=0.6
Injured area, time limitation of injury of about 7 days		
Necrosis	1±0.1 m=0	1±0.1 m=0
Zone of reactive changes/ Zone of molecular contusion	1±0.2 m=0.1	1±0.2 m=0.1

Therefore, with the time limitation of no more than 30 minutes in the gunshot injuries, the inflammatory response slows down in the zone of reactive changes when compared with the control group. At later time points of injury, the inflammatory response levels up.

These differences can be associated both with specific shot factors, particularly, thermal effect, and with more profound changes in microcirculation and cell migration in the gunshot injuries as compared with the stab ones.

When studying the issue of the thanatogenesis in case of death from various gunshot injuries, it is reasonable to use the methods of thanatogenetic (semiquantitative) analysis that will make it possible to judge on the kind of death, death rate and other thanatogenetic issues on the basis of the available morphological study, as well as to specify the conclusions on the time limitation of the gunshot injuries based on the same data.

CONCLUSION

The issue of study of the gunshot injury is of course relevant, and it is necessary to improve efficiency, quality and evidentiality of the forensic examinations in the conditions of the peace time. The information obtained demonstrates the relevance of the problem and requires its further study.

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