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RELATIONSHIPS BETWEEN GUNSHOT RESIDUE, DAMAGES TO HUMAN BODY SIMULATORS CAUSED BY «FORT 9R» OR «FORT 17R», AND SHOT DISTANCE, TYPE OF CLOTHING: AN EXPERIMENTAL STUDY

Abstract. A comprehensive approach to the examination of a gunshot injury is due to a significant number of factors that can affect the subsequent morphological, macroscopic and microscopic characteristics of the injury. Such factors include, in particular, the type of weapon used, the distance of the shot, and the type of cartridges with which the weapon was equipped. However, factors such as the presence or absence of clothing on the injured person's body are no less important, but at the same time underestimated. One of the ways to facilitate expert work for employees of institutions dealing with gunshot injuries would be to identify relationships between the specified parameters. The most expedient way to achieve this at the moment would be to conduct an experimental study using a simulator of

soft body tissues that is as close as possible to the human body. The purpose of the study was to establish correlations between the features of the deposition of the residual components of the shot, the features of damage to the simulator of the human body and the distance of the shot and the type of clothing that covered the simulator during shots from the "Fort 9R", "Fort 17R" pistols. Using the above-mentioned non-lethal pistols, 120 gelatin blocks imitating the soft tissues of the human body were shot at close range, 25 and 50 cm, with further analysis of the resulting damage and parameters of the temporary cavity in accordance with generally accepted methods. Chromato-mass spectrometry and infrared microscopy on a combined IR-Fourier spectrometer were used to detect gunpowder particles. X-ray fluorescence spectroscopy was used to detect overlapping elements. Statistical processing of the received data was carried out in the license package "Statistica 6.0". When firing from Fort 9R and Fort 17R pistols, numerous reliable weak, medium, and strong (r=-0.28 – -0.93), weak and medium force direct (r=0.28 – 0.62) correlations were established between the features of the shot distance, the type of cover of the human body simulator and indicators of damage to clothing, non-biological human body simulator, indicators of the deposition of residual components of the shot. Thus, the results of the correlation analysis revealed the most significant correlations, which can be used in the future in the examination of gunshot injuries caused by "Fort 9R" and "Fort 17R" pistols.

Keywords: firearm, gunshot injury, correlations, "Fort 9R", "Fort 17R".

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ВЗАЄМОЗВ'ЯЗКИ МІЖ ЗАЛИШКОВИМИ КОМПОНЕНТАМИ ПОСТРІЛУ, ПОШКОДЖЕННЯМИ ІМІТАТОРІВ ТІЛА ЛЮДИНИ ПРИ ПОСТРІЛАХ З «ФОРТ 9Р» І «ФОРТ 17Р» ТА ВІДСТАННЮ ПОСТРІЛУ І ВИДОМ ОДЯГУ: ЕКСПЕРИМЕНТАЛЬНЕ ДОСЛІДЖЕННЯ

Анотація. Комплексний підхід до виконання експертизи вогнепальної травми обумовлений значною кількістю факторів, що можуть впливати на подальшу морфологічну макроскопічну і мікроскопічну характеристику ушкодження. Такими факторами зокрема є вид зброї, що застосовувався, дистанція пострілу, різновид набоїв яким була споряджена зброя. Проте, не менш важливими, але водночас і недооціненими є такі фактори як наявність чи відсутність одягу на тілі постраждалої особи. Одним зі шляхів полегшення експертної роботи працівникам установ, що мають справу з вогнепальними пошкодженнями було б виявлення взаємозв'язків між зазначеними параметрами. Найбільш доцільними в даний момент шляхом досягнення цього було б проведення експериментального дослідження з застосуванням максимально наближеного до тіла людини імітатора м'яких тканин тіла. Метою дослідження було встановити кореляції між особливостями відкладання залишкових компонентів пострілу, особливостями пошкодження імітатора тіла людини та дистанцією пострілу і видом одягу, що покривав імітатор при пострілах з пістолетів «Форт 9Р», «Форт 17Р». Використовуючи вищезазначені пістолети нелетальної ділі виконано відстріл 120 желатинових блоків, що імітують м'які тканини тіла людини з дистанцій впритул, 25 та 50 см з подальшим аналізом утворених пошкоджень, параметрів тимчасової порожнини відповідно до загальноприйнятих методик. Для виявлення частинок пороху використано хромато-мас-спектрометричне дослідження та інфрачервону мікроскопію на суміщеному ІЧ-Фур'є спектрометрі. Для виявлення накладань елементів використано рентгенфлуоресцентну спектроскопію. Статистична обробка отриманих даних проведена в ліцензійному пакеті"Statistica 6.0". При пострілах з пістолетів «Форт 9Р» та «Форт 17Р» між особливостями відстані пострілу, видом покриву імітатора тіла людини та показниками пошкоджень одягу, небіологічного імітатору тіла людини, показниками відкладання залишкових компонентів пострілу встановлено численні достовірні слабкої, середньої сили ти сильні зв'язки (r=-0.28 – -0.93) зворотної сили та слабкої і середньої сили прямі (r=0.28 – 0.62) зв'язки. Таким чином результати кореляційного аналізу виявили найбільш

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значущі кореляції, що можуть бути в подальшому застосовані при експертизі вогнепальної травми заподіяної пістолетами «Форт 9Р» та «Форт 17Р».

Ключові слова: вогнепальна зброя, вогнепальна травма, кореляції, «Форт 9Р», «Форт 17Р».

Statement of the problem. All over the world, there has been an increase in the availability of firearms for the civilian population. This trend can be a consequence of increasing social tensions in society and armed conflicts in the country. In India, in particular, a significant increase in the sale of illegal firearms has been noted. If in 2020, about 68,000 cases of the construction of homemade firearms were recorded, then in 2021 this indicator became more than 74,000, and in 2022 it reached the number of more than 84,000 units [1]. A dangerous trend is also the increase in cases of access to firearms among minors. Thus, in the USA from 2014 to 2015, 2,715 fatal cases of this nature were recorded. Of these, 62.1% were murders and 31.4% were suicides [2]

In Ukraine, a significant increase in fatal cases of death as a result of the use of firearms was recorded in 2014 and concerned the city of Kyiv, Zaporizhzhia, Donetsk, Luhansk, and Dnipropetrovsk regions [3]. All this has activated research processes and new scientific developments by experts in order to modernize knowledge about gunshot trauma. In particular, the topic of using modern laboratory research methods occupied a key place in the examination [4].

One of the relevant topics, which was practically not investigated before in the framework of forensic ballistics, was the study of clothing damage as a result of a gunshot wound and its effect on the formation of a gunshot wound [5]. The result was the discovery of new data that confirmed the influence of clothing on the dimensions of the temporal cavity. Obtaining such data became possible due to conducting experimental shootings using non-biological simulators of the human body [6]. However, the amount of research carried out is extremely small and cannot meet the current needs of forensic medicine, and this, in turn, requires conducting new ballistic experiments.

Connection of the publication with planned scientific research works. The work was carried out as part of the research work of the National Pirogov Memorial Medical University, Vinnytsya at the expense of state funding of the Ministry of Health of Ukraine: "Characteristics of damage to human body tissue simulators caused by non-lethal weapons" (state registration number 0121U107924).

The purpose of the article – to determine the correlations between the features of the deposition of the gunshot residue, the features of damage to the non-biological simulator of the human body and the distance of the shot and the type of clothing covering the simulator, when fired from the "Fort 9R" and "Fort 17R" pistols.

Research objects and methods. To achieve the goal, 120 gelatin blocks imitating muscle and fat tissue of the human body were produced in accordance with

the generally accepted methodology [7], which were stored at a temperature of 4 degrees Celsius. Further, from the data, the blocks formed 4 groups depending on their covering: bare blocks, blocks covered with cotton fabric, denim fabric, leatherette. With the help of "Fort 9R" and "Fort 17R" pistols equipped with elastic rubber bullets, shooting was carried out at close range, 25 and 50 cm.

The resulting injuries were described in accordance with the general descriptive principles of forensic medicine. Microscopic examination in order to identify residual components of the shot was carried out using MBS-10 (magnification from ×4.8 to ×56). The chromatographic-mass spectrometric method on the Shimadzu GC-2010 Plus device and infrared microscopy on the Fourier-transform infrared spectroscopy Nicolet iN10 of the company "Thermo Fisher Scientific" were used to identify the components of smokeless powder. X-ray fluorescence spectroscopy on the ElvaX Plus device was performed to detect the overlap of elements.

Evaluation of the parameters of the temporary cavity formed during the shot was carried out over the entire depth of the gunshot defect with an interval of 1 cm using methods The total crack length method (TCLM) [7], The Fackler's wound profile method (FWPM) [8] and The polygon-procedure method (PPM) [9].

Committee on Bioethics of National Pirogov Memorial Medical University, Vinnytsya (protocol No 11 From 03.12.2020) found that the studies do not contradict the basic bioethical standards of the Declaration of Helsinki, the Council of Europe Convention on Human Rights and Biomedicine (1977), the relevant WHO regulations and laws of Ukraine.

Correlations were evaluated in the license package "Statistica 6.1" using Spearman statistics.

Presentation of the main material.

Research results and their discussion. In the overall analysis of all the obtained indicators when firing from the *Fort 9R* pistol, the following reliable correlations were found with the distance of the shot:

direct correlation of weak strength with the relative concentration of iron (r= 0.28) and medium strength with the relative concentration of zinc (r= 0.62); inverse correlations of weak force with the size indicator and the frequency of occurrence of a temporary cavity according to the TCLM method at a depth of 5 cm (r= -0.28 in both cases), the size indicator and the frequency of occurrence of a temporary cavity according to the FWPM method at a depth of 5 cm (r= -0.28 in both cases), the indicator of the size and frequency of occurrence of a temporary cavity according to the PPM method at a depth of 5 cm (r= -0.28 in both cases); inverse correlation of average strength with relative lead concentration (r= -0.60); strong inverse correlations with the indicator of the size of the temporary cavity according to the TCLM method at a depth of 1 cm (r= -0.84), the indicator of the size of the temporary cavity according to the TCLM method at a depth of 2 cm (r= -0.81), the indicator of the size and frequency of occurrence of the temporary

cavity according to the TCLM method at a depth of 3 cm (r= -0.82 and r= -0.80, respectively), the size indicator and the frequency of occurrence of a temporary cavity according to the TCLM method at a depth of 4 cm (r= -0.76 and r= -0.77, respectively), strong inverse correlations with the size indicator of a temporary cavity according to the FWPM method at a depth of 1 cm (r= -0.81), an indicator of the size of a temporary cavity according to the FWPM method at a depth of 2 cm (r= -0.81), an indicator of the size and frequency of occurrence of a temporary cavity according to the FWPM method at a depth of 3 cm (r = -0.82 and r= -0.80, respectively), the indicator of the size and frequency of occurrence of the temporary cavity according to the FWPM method at a depth of 4 cm (r= -0.76 and r= -0.77, respectively), strong inverse correlations with the indicator of the size of the temporary cavity according to the PPM method at 1 cm deep (r= -0.89), the indicator of the size of the temporary cavity according to the PPM method at a depth of 2 cm (r= -0.83), the indicator of the size and frequency of the temporary cavity according to the PPM method at a depth of 3 cm (r= -0.82 and r= -0.80, respectively), as an indicator of the size and frequency of occurrence of a temporary cavity according to the PPM method at a depth of 4 cm (r= -0.76 and r= -0.77, respectively).

In the overall analysis of all the obtained indicators when firing from the *Fort 9R* pistol, the following reliable correlations were found with the type of cover of the block:

direct correlation of the average strength with the relative concentration of zinc (r= 0.30); inverse correlations of weak strength with the presence of diphenylamine and centralite (r= -0.26 in both cases) and inverse correlation of medium strength with defect area (r= -0.52).

In the overall analysis of all the obtained indicators when firing from the *Fort 17R* pistol, the following reliable correlations were found with the distance of the shot:

direct correlations of mean strength with relative iron concentration (r= 0.34) and relative zinc concentration (r= 0.53); inverse correlation of a weak force with the frequency of occurrence of a temporary cavity according to the TCLM method at a depth of 2 cm (r= -0.26); inverse correlations of the average force with the area of the defect (r= -0.36), the number of breaks (r= -0.36), the presence of soot (r= -0.67), the relative concentration of lead (r= -0.49), the indicator of the size of the temporary cavity according to the TCLM method on at a depth of 3 cm (r= -0.69), the indicator of the size and frequency of occurrence of the temporary cavity according to the TCLM method at a depth of 4 cm (r= -0.51 in both cases), the indicator of the size of the temporary cavity according to the FWPM method at a depth of 3 cm (r= -0.69), the indicator of the size and frequency of occurrence of a temporary cavity according to the FWPM method at a depth of 4 cm (r= -0.51 in both cases), the indicator of the size of a temporary cavity according to the PPM method at a depth of 3 cm (r= -0.69), the indicator of the size and frequency of occurrence of a temporary cavity cavities according to the PPM method at a depth

of 4 cm (r= -0.51 in both cases); strong inverse correlations with the indicator of the size of the temporary cavity according to the TCLM method at a depth of 1 cm (r= -0.93), the indicator of the size of the temporary cavity according to the TCLM method at a depth of 2 cm (r= -0.89), the frequency of occurrence of a temporary cavity according to the TCLM method at a depth of 3 cm (r= -0.71), the indicator of the size of the temporary cavity according to the FWPM method at a depth of 1 cm (r= -0.89), the indicator of the size of the temporary cavity according to the FWPM method at a depth of 2 cm (r= -0.88), the frequency of occurrence of the temporary cavity according to the method FWPM at a depth of 3 cm (r= -0.71), an indicator of the size of the temporary cavity according to the PPM method at a depth of 1 cm (r= -0.93), an indicator of the size of the temporary cavity according to the PPM method at a depth of 2 cm (r= -0.88), the frequency of occurrence temporary cavity according to the PPM method at a depth of 3 cm (r= -0.71).

In the overall analysis of all the obtained indicators when firing from the *Fort 17R* pistol, the following reliable correlations were found with the type of cover of the block:

direct correlations of average strength with the relative concentration of zinc (r= 0.40), with the relative concentration of iron (r= 0.42) and the number of clothing tears (r= 0.42); inverse correlations of the average force with the relative concentration of lead (r= -0.38), the relative concentration of copper (r= -0.31), with the presence of soot (r= -0.52), the size indicator and the frequency of occurrence of a temporary cavity according to the TCLM method at a depth of 4 cm (r= -0.39 and r= -0.37, respectively), an indicator of the size and frequency of occurrence of a temporary cavity according to the FWPM method at a depth of 4 cm (r= -0.38 and r= -0.37, respectively), an indicator of the size of a temporary cavity according to the PPM method at a depth of 1 cm (r= -0.29), the indicator of the size and frequency of occurrence of a temporary cavity according to the PPM method at a depth of 4 cm (r= -0.38 and r= -0.37, respectively).

Similar data were obtained by a team of authors headed by Kusliy Yu.Yu. [10], where numerous correlations of a different nature were also found, both with damage characteristics, parameters of the temporary cavity, and features of the deposition of the residual components of the shot. In particular, in other studies [11], the author and co-authors found convincing evidence regarding the important role of the features of clothing damage in the process of identifying the distance of the shot and the weapon of the shot, which is also quite consistent with the data we obtained.

At the same time, it is worth noting that foreign authors to a greater extent pay the greatest attention to studying the features of the deposition of the residual components of the shot, such as those that can establish the distance of the shot, the type of weapon, etc. [12]. However, it is worth understanding that the most optimal is the use of as much evidence as possible, and therefore the way of limiting the research to only the use of residual components of the shot, without paying attention to other physical evidence, may be wrong.

Thus, it is promising to use all available evidence in the examination, with the possible involvement of neural networks for systematic analysis of the received information [13].

Conclusions. In the case of shots from Fort 9R, between the features of the shot distance and indicators of damage to clothing, a non-biological simulator of the human body, and the deposition of residual components of the shot, in most cases reliable weak, medium force and strong correlations (r=-0.28 – -0.89) of recoil force and few weak and medium direct correlations (r= 0.28 – 0.62); between the characteristics of the coating of the non-biological imitator of the human body and the relative concentration of zinc, a direct correlations of medium strength was established (r= 0.30), and with the presence of diphenylamine and centralite and the area of the defect, inverse correlations of weak and medium strength were established (r= -0.26 – -0.52)

In the case of shots from Fort 17R, between the features of the shot distance and indicators of damage to clothing, a non-biological simulator of the human body, indicators of the deposition of residual components of the shot, numerical reliable weak, medium and strong relationships (r=-0.26 – -0.93) of return force and direct correlations were established medium strength with relative iron concentration (r= 0.34) and relative zinc concentration (r= 0.53); between the features of the cover of the non-biological human body simulator and the indicators of damage to clothing, the non-biological human body simulator, and the deposition of the residual components of the shot, numerically reliable average force direct (r= 0.40 – 0.42) and reverse (r = -0.29 – -0.52) relationships were established.

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