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CORRELATIONS OF THE INDICATORS OF THE DISTANCE OF THE SHOT AND THE TYPE OF CLOTHING WITH THE FEATURES OF DAMAGE AND GUNSHOT RESIDUE WHEN USING THE FORT 12R AND AE 790G1 PISTOLS

Abstract. A comprehensive approach to gunshot injury during a forensic medical examination requires a comprehensive assessment of all discovered material evidence. The key area that needs the most attention is the gunshot wound, during the examination of which it is necessary to pay attention to such characteristics as the shape, the size of the injury, the features of the damage to the adjacent clothing, the presence of macro and microscopic traces of the residual components of the shot, etc. All of them together allow vessels to know the nature of the injury, the weapon that caused it and the distance of the shot. The least researched type of firearm from a scientific point of view is non-lethal firearms, the number and new types of which are increasing every year. In this regard, there is a need to study modern and widespread in Ukraine samples of non-lethal firearms. The purpose of the study was

to establish the specifics of the correlations between the indicators of the distance of the shot and the type of clothing and the features of damage and residual components of the shot when using the "Fort 12R" and "AE 790G1" pistols. For this, a total of 120 gelatin blocks were produced, divided into four subgroups according to the covering material: bare blocks covered with cotton fabric, denim fabric with leatherette. In the future, the blocks were to be shot with a "Fort 12R" or "AE 790G1" pistol. The chromato-mass spectrometric method, infrared microscopy and X-ray fluorescence spectroscopy were used to identify the residual components of the shot. Transverse sections of the blocks were made at intervals of 1 cm with measurement of the indicators of the temporary cavity on each section according to generally accepted methods. Correlations were evaluated in the Statistica 6.1 license package. When firing from a pistol, both Fort 12R and AE 790G1, 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, numerous reliable average strength and strong correlations (r=-0.33 – -0.92) of the inverse strength and average strength direct (r=0.30 – 0.59) correlations were found; 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 indicators of the deposition of the residual components of the shot, few strong feedback correlations (r=-0.78) and medium-strength direct correlations (r=0.31 – 0.36) were established. The results of the correlation analysis made it possible to determine the most significant correlations between the indicators of the distance of the shot and the type of clothing and the features of damage and residual components of the shot both in the case of using the "Fort 12R" and "AE 790G1" pistols.

Keywords: damage to clothing, gunshot residue, firearm, gunshot injury, correlations.

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КОРЕЛЯЦІЇ ПОКАЗНИКІВ ВІДСТАНІ ПОСТРІЛУ ТА ВИДУ ОДЯГУ З ОСОБЛИВОСТЯМИ УШКОДЖЕНЬ І ЗАЛИШКОВИМИ КОМПОНЕНТАМИ ПОСТРІЛУ ПРИ ЗАСТОСУВАННІ ПІСТОЛЕТІВ «ФОРТ 12Р» ТА «АЕ 790G1»

Анотація. Комплексний підхід до вогнепальної травми при судово-медичному дослідженні вимагає всебічної оцінки усіх виявлених речових доказів. Ключовою областю, що потребує найбільшої уваги є вогнепальне поранення, при огляді якого необхідно звернути увагу на такі характеристики як форма, розмір ушкодження, особливості пошкодження прилягаючого одягу, наявність макро- і мікроскопічних слідів залишкових компонентів пострілу тощо. Усі вони разом дозволяють судини про характер ушкодження, знаряддя, що його викликало і дистанцію пострілу. Найменш дослідженим різновидом вогнепальної зброї з точки зору науки є нелетальна вогнепальна зброя, чисельність і нові різновиди якої зростають з року в рік. У зв'язку з цим існує потреба у вивченні сучасних і поширених в Україні зразків нелетальної вогнепальної зброї. Метою дослідження було встановити особливості зв'язків між показниками відстані пострілу та виду одягу та особливостями ушкоджень і залишкових компонентів пострілу при застосуванні пістолетів «Форт 12Р» та «АЕ 790G1». Для цього сумарно було виготовлено 120 желатинових блоків, поділених на чотири підгрупи відповідно до матеріалу покриву: голі блоки, покриті бавовняною тканиною, джинсовою тканиною шкірозамінником. В подальшому блоки підлягали відстрілу пістолетом «Форт 12Р» або «АЕ 790G1». Для виявлення залишкових компонентів пострілу застосовували хромато-мас-спектрометричний метод, інфрачервону мікроскопію та рентгенфлуоресцентну спектроскопію. Виконували поперечний розріз блоків з інтервалом у 1 см з вимірюванням на кожному зрізі показників тимчасової порожнини відповідно до загальноприйнятих методик. Оцінку кореляцій проводили в ліцензійному пакеті "Statistica 6.1". При пострілах з пістолету як Форт 12Р так і АЕ 790G1 між особливостями відстані пострілу та показниками пошкоджень одягу, небіологічного імітатору тіла людини, показниками відкладання залишкових компонентів пострілу встановлено численні достовірні середньої сили ти сильні зв'язки (r=-0.33 – -0.92) зворотної сили та середньої сили прямі (r=0.30 – 0.59) зв'язки; між особливостями покриву небіологічного імітатора тіла людини та показниками пошкоджень одягу, небіологічного імітатору тіла людини, показниками відкладання залишкових компонентів пострілу встановлено нечисленні сильні зворотні зв'язки (r=-0.78)

та середньої сили прямі зв'язки (r=0.31 – 0.36). Результати кореляційного аналізу дозволили визначити найбільш значущі взаємозв'язки між показниками відстані пострілу та виду одягу та особливостями ушкоджень і залишкових компонентів пострілу як у випадку застосування пістолету «Форт 12Р» так і «AE 790G1».

Ключові слова: пошкодження одягу, залишкові компоненти пострілу, вогнепальна зброя, вогнепальна травма, кореляції.

Statement of the problem. Since the era of mass production, in the structure of murders, suicides and accidents, gunshot injuries occupy an honorable place, which is equally common in countries of the world with different socio-economic development. From 2003 to 2015, more than 100,000 single injuries from firearms and about 57,000 cases of multiple injuries caused by firearms were recorded in the United States. At the same time, the mortality from them reached 13.26% and 18.84%, respectively [1]. In countries with military conflicts, the issue of gunshot injuries is particularly acute. Thus, according to the data of one hospital in Benghazi (Libya), in 2011, 1,761 patients with gunshot wounds were recorded. Of them, 95% were men aged 28.32±10.01 years. In total, gunshot injuries were the cause of death in 5.6% of young people in the country [2].

Unlike lethal firearms, non-lethal firearms are equipped with rubber-based ammunition, but they are dangerous under certain conditions of improper use. In the 1970s in Northern Ireland, the use of this type of weapon caused 14 deaths [3]. At the same time, successful compliance with well-known rules for handling it shows that it is possible to avoid not only fatalities but also serious injuries. Thus, an analysis of data from the USA regarding the use of non-lethal firearms revealed 2,322 cases, of which only 4% caused moderate injuries [4].

Interest in the study of this type of weapon is gradually growing among domestic researchers and is aimed at finding ways to identify the weapon, determine the distance of the shot and predict the potential damage it can cause [5, 6]. However, the appearance of new types of this weapon on the Ukrainian market makes it difficult to create a complete picture of the above-mentioned issues. Therefore, there is a need to constantly update the database and discover new data that will allow at least the identification of the weapon and the distance of the shot from it.

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 establish the specifics of the correlations between the parameters of the shot distance and the type of clothing and the features of damage and gunshot residue when using "Fort 12R" and "AE 790G1" pistols.

Research objects and methods. According to the generally accepted method [7],

120 gelatin blocks were made, which were covered with different types of clothing (cotton, denim, leatherette) or left bare. In the conditions of the shooting range, shots were fired at the studied blocks with the help of "Fort 12P" and "AE 790G1" pistols equipped with 9 mm elastic bullets. Shots were fired from close range, 25 and 50 cm. Further, a descriptive study was carried out using generally accepted forensic approaches. Microscopic examination in order to identify the features of damage and residual components of the shot was carried out using an MBS-10 microscope under magnification from ×4.8 to ×56.

Among the laboratory methods used: 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" in order to identify the components of smokeless powder and X-ray fluorescence spectroscopy using the ElvaX Plus device to detect the overlapping of elements on trace-receiving surfaces.

To estimate the temporary cavity formed, generally accepted calculation methods were used, namely: Fackler and Malinowski (The total crack length method (TCLM)) [7], Ragsdale and Josselson (The Fackler's wound profile method (FWPM)) [8] and Schyma (The polygon-procedure method (PPM)) [9].

Committee on Bioethics of National Pirogov Memorial Medical University, Vinnytsya (protocol № 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. When analyzing the data obtained during shots from the *Fort 12R* pistol, the following reliable correlations were established:

there is a feedback correlation between the shot distance indicator and: the number of medium-strength clothing tears (r= -0.50); the presence of soot has a strong feedback (r= -0.83); relative lead concentration of medium strength feedback (r= -0.42); the relative concentration of iron of medium strength has a direct correlation (r=0.35); the relative concentration of zinc of medium strength is a direct correlation (r=0.30); the size of the temporary cavity according to the TCLM method at the depth of the section of 1 cm has a strong feedback (r= -0.87); the size of the temporary cavity according to the TCLM method at the depth of the section of 2 cm has a strong feedback (r= -0.85); the size of the temporary cavity according to the TCLM method at the depth of the section of 3 cm has a strong feedback (r= -0.84); the size of the temporary cavity according to the TCLM method at the depth of the section of 4 cm, the average strength of the feedback (r= -0.69); the size of the temporary cavity according to the TCLM method at the depth of the section of 5 cm,

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the average strength of the feedback (r= -0.54); the frequency of occurrence of a temporary cavity according to the TCLM method at a cut depth of 2 cm is an average feedback force (r= -0.33); the frequency of occurrence of a temporary cavity according to the TCLM method at a cut depth of 3 cm has a strong feedback (r= -0.74); the frequency of occurrence of a temporary cavity according to the TCLM method at a cut depth of 4 cm is an average feedback force (r= -0.69); the frequency of occurrence of a temporary cavity according to the TCLM method at a cut depth of 5 cm of average force feedback (r= -0.55); the size of the temporary cavity according to the FWPM method at the depth of the cut of 1 cm, the average feedback force (r= -0.69); the size of the temporary cavity according to the FWPM method at the depth of the cut of 2 cm has a strong feedback (r= -0.81); the size of the temporary cavity according to the FWPM method at the depth of the cut of 3 cm has a strong feedback (r= -0.84); the size of the temporary cavity according to the FWPM method at the depth of the section of 4 cm, the average strength of the feedback (r= -0.69); the size of the temporary cavity according to the FWPM method at the depth of the section of 5 cm, the average feedback force (r= -0.54); the frequency of occurrence of a temporary cavity according to the FWPM method at a cut depth of 2 cm is a feedback of medium strength (r= -0.33); the frequency of occurrence of a temporary cavity according to the FWPM method at a cut depth of 3 cm has a strong feedback (r= -0.74); the frequency of occurrence of a temporary cavity according to the FWPM method at a cut depth of 4 cm is an average feedback force (r= -0.69); the frequency of occurrence of a temporary cavity according to the FWPM method at a cut depth of 5 cm is an average feedback force (r= -0.55); with the size of the temporary cavity according to the PPM method at the depth of the section of 1 cm, there is a strong feedback (r= -0.89); with the size of the temporary cavity according to the PPM method at the depth of the cut of 2 cm, there is a strong feedback (r= -0.88); with the size of the temporary cavity according to the PPM method at the depth of the cut of 3 cm, there is a strong feedback (r= -0.83); the size of the temporary cavity according to the PPM method at the depth of the section of 4 cm, the average strength of the feedback (r= -0.69); by the size of the temporary cavity according to the PPM method at the depth of the cut of 5 cm, there is an average feedback force (r= -0.54); the frequency of occurrence of a temporary cavity according to the PPM method at a cut depth of 2 cm of average force feedback (r= -0.33); the frequency of occurrence of a temporary cavity according to the PPM method at the depth of the cut of 3 cm has a strong feedback (r= -0.74); the frequency of occurrence of a temporary cavity according to the PPM method at a cut depth of 4 cm has a strong feedback (r= -0.80); the frequency of occurrence of a temporary cavity according to the PPM method at a cut depth of 5 cm of average force feedback (r= -0.55);

there is a strong inverse correlation between the indicator of the type of cover of the non-biological imitator of the human body and the area of the defect (r= -0.78).

When analyzing the data obtained during shots from the *AE 790G1* pistol, the following reliable correlations were established:

there is a strong inverse correlation between the shot distance indicator and: the number of clothing tears (r= -0.79); the presence of soot has a strong feedback (r= -0.74); the presence of diphenylamine weak feedback (r= -0.37); relative lead concentration of medium strength feedback (r= -0.60); the relative concentration of iron of medium strength has a direct correlation (r=0.53); the relative concentration of zinc of medium strength is a direct correlation (r=0.59); the size of the temporary cavity according to the TCLM method at the depth of the cut of 1 cm has a strong feedback (r= -0.85); the size of the temporary cavity according to the TCLM method at the depth of the section of 2 cm has a strong feedback (r= -0.92); the size of the temporary cavity according to the TCLM method at the depth of the section of 3 cm has a strong feedback (r= -0.83); the size of the temporary cavity according to the TCLM method at the depth of the section of 4 cm has a strong feedback (r= -0.81); the size of the temporary cavity according to the TCLM method at the depth of the section of 5 cm of the average force feedback (r= -0.58); the frequency of occurrence of a temporary cavity according to the TCLM method at a cut depth of 2 cm is an average feedback force (r= -0.33); the frequency of occurrence of a temporary cavity according to the TCLM method at a cut depth of 3 cm has a strong feedback (r= -0.79); the frequency of occurrence of a temporary cavity according to the TCLM method at a cut depth of 4 cm has a strong feedback (r= -0.83); the frequency of occurrence of a temporary cavity according to the TCLM method at a cut depth of 5 cm is an average feedback force (r= -0.58); the size of the temporary cavity according to the FWPM method at the depth of the cut of 1 cm has a strong feedback (r= -0.82); the size of the temporary cavity according to the FWPM method at the depth of the section of 2 cm has a strong feedback (r= -0.93); the size of the temporary cavity according to the FWPM method at the depth of the cut of 3 cm has a strong feedback (r= -0.83); the size of the temporary cavity according to the FWPM method at the depth of the section of 4 cm has a strong feedback (r= -0.81); the size of the temporary cavity according to the FWPM method at the depth of the section of 5 cm, the average feedback force (r= -0.58); the frequency of occurrence of a temporary cavity according to the FWPM method at a cut depth of 2 cm is a feedback of medium strength (r= -0.33); the frequency of occurrence of a temporary cavity according to the FWPM method at a cut depth of 3 cm has a strong feedback (r= -0.79); the frequency of occurrence of a temporary cavity according to the FWPM method at the depth of the cut of 4 cm has a strong feedback (r= -0.83); the frequency of occurrence of a temporary cavity according to the FWPM method at a cut depth of 5 cm is a feedback of medium strength (r= -0.58); with the size of the temporary cavity according to the PPM method at the depth of the section of 1 cm, there is a strong feedback (r= -0.89); with the size of the temporary cavity according to the PPM method at the depth of the cut of 2 cm, there is a strong feedback (r= -0.88); with the size of the temporary cavity according to the PPM method at the depth of the cut of 3 cm, there is a strong feedback (r= -0.83); with the size of the temporary cavity according to the PPM method at the depth of the section of 4 cm,

there is a strong feedback (r= -0.81); the size of the temporary cavity according to the PPM method at the depth of the section of 5 cm of average force feedback (r= -0.58); the frequency of occurrence of a temporary cavity according to the PPM method at a cut depth of 2 cm of average force feedback (r= -0.33); the frequency of occurrence of a temporary cavity according to the PPM method at the depth of the cut of 3 cm has a strong feedback (r= -0.79); the frequency of occurrence of a temporary cavity according to the PPM method at a cut depth of 4 cm has a strong feedback (r= -0.83); the frequency of the occurrence of a temporary cavity according to the PPM method at a cut depth of 5 cm of average force feedback (r= -0.58);

there is a strong inverse correlation between the indicator of the type of cover of the non-biological imitator of the human body and: the area of the defect (r= -0.78); the relative concentration of zinc of medium strength has a direct correlation (r=0.31); the frequency of occurrence of a temporary cavity according to the TCLM method at the depth of the section of 2 cm of average strength is a direct correlation (r=0.36); the frequency of occurrence of a temporary cavity according to the FWPM method at the depth of the cut of 2 cm of average strength is a direct correlation (r=0.36); the frequency of occurrence of a temporary cavity according to the PPM method at a cut depth of 2 cm of average strength has a direct correlation (r=0.36).

The analysis of scientific sources related to the residual components of the shot from 2019 to 2021 shows that mostly correlations are found with respect to such an element as lead, which is also clearly confirmed in our study [10].

It is also worth paying attention to the location of the residual components of the shot. It was established that their greatest concentration is within a radius of 3 cm from the gunshot wound. A decrease in the amount of physical evidence is noted in the shot distance from 20 to 60 cm, which to some extent is also confirmed by the data of our study [11].

Correct models for determining the distance of a shot can be built using the so-called "whales" of forensic ballistics – stibium, lead and barium. The authors proposed a model showing an accuracy of 6 cm at shot distances of 20-90 cm [12].

However, in any case, one should not limit oneself exclusively to laboratory data and pay attention to the morphological features of a gunshot wound, which also significantly changes with a change in the distance or other circumstances of the shot [13].

Conclusions. When firing from a Fort 12R pistol, between the characteristics of the shot distance and the indicators of damage to clothing, a non-biological simulator of the human body, in most cases, reliable medium-to-strong correlations (r=-0.33 - -0.89) were established, in all cases of reverse force; between the features of the shot distance and indicators of the deposition of the residual components of the shot in most cases, reliable medium-strength direct (r=0.30 – 0.35) and medium-strength and strong inverse (r=-0.42 – -0.83) correlations were established; a strong reliable feedback was established between the features of the covering of the non-biological imitator of the human body and the area of the defect (r= -0.78).

In the case of shots from the AE 790G1 pistol, between the features of the shot distance and indicators of damage to clothing, a non-biological simulator of the human body, in most cases, reliable medium-to-strong correlations (r=-0.33 – -0.92), in all cases of reverse force, were also established; between the characteristics of the shot distance and indicators of the deposition of the residual components of the shot in most cases, reliable medium-strength direct (r=0.53 – 0.59) and medium-strength and strong inverse (r=-0.37 – -0.74) correlations were established; 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, the deposition of the residual components of the shot, a reliable strong feedback relationship (r=-0.78) and few reliable medium-strength direct correlations (r=0.31 – 0.36) were established.

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