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PECULIARITIES OF THE PROJECTILE PENETRATION DEPTH WHEN FIRED WITH "FORT 9R" AND "FORT 17R" PISTOLS WHILE USING DIFFERENT CLOTHING FABRIC

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The study of the protective qualities of various types of clothing when fired from non-lethal firearms, which are mainly used by law enforcement agencies, is one of the promising directions of the so-called humanitarian direction of forensic medicine. The conducted experimental research with the use of human body simulators covered with different types of fabric and "Fort 9R" and "Fort 17R" pistols made it possible to establish that at close-range shot distances of 50 cm and any type of fabric, a wound channel is formed to a depth of at least 1 cm; at the same time, "Fort 9R" in any case does not cause the formation of a wound channel longer than 6 cm, and "Fort 17R" deeper than 5 cm; cotton fabric has better protective qualities when fired with "Fort 9R", and leatherette when fired with "Fort 17R".

Key words: gunshot wound, gunshot injury, gunshot weapon, elastic balls, different fabrics.

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ОСОБЛИВОСТІ ГЛИБИНИ ПРОНИКНЕННЯ СНАРЯДУ ПРИ ПОСТРІЛАХ З ПІСТОЛЕТІВ «ФОРТ 9Р» ТА «ФОРТ 17Р» ПРИ ЗАСТОСУВАННІ РІЗНИХ МАТЕРІАЛІВ ТКАНИНИ ОДЯГУ

Вивчення захисних властивостей різних видів одягу при пострілах з нелетальної зброї, що перебуває на озброєнні переважно органів правопорядку є одним з перспективних напрямків так званого гуманітарного напрямку судової медицини. Проведене експериментальне дослідження з застосуванням імітаторів тіла людини вкритих різним видом текстильного матеріалу та пістолетів «Форт 9Р» та «Форт 17Р» дозволило встановити, що при дистанціях пострілу впритул – 50 см та будь яких видів текстильного матеріалу утворюється рановий канал на глибину щонайменше 1 см; в той же час «Форт 9Р» в будь якому випадку не викликає утворення ранового каналу довжиною більше 6 см, а «Форт 17Р» глибиною більше 5 см; бавовняна тканина має кращі захисні властивості при пострілах з «Форт 9Р», а шкірозамінник при пострілах з «Форт 17Р».

Ключові слова: вогнепальна рана, вогнепальні ушкодження, вогнепальна зброя, еластичні кулі, різні тканини.

The study is a fragment of the research project"Characteristics of damage to human body tissue simulators caused by non-lethal weapons", state registration No. 0121U107924.

Among all types of firearms, non-lethal firearms are still the least researched. Its appearance was primarily due to the need of arm law enforcement agencies for an effective means that can stop offenders but at the same time not cause serious physical harm. In addition, in the future, such types of weapons became available to a wider range of people, in particular, representatives of journalistic professions, judicial bodies, etc.

However, despite the name "non-lethal" firearms, more and more data indicates the existence of serious and lethal consequences when it being used. Thus, during the protests over the killing of George Floyd in Minneapolis, non-lethal firearms were accounted for 15.5 % of all injuries protesters had. When considering medical records from hospitals, 18.0 % of patients had a traumatic brain injury, 11.0 % of patients had an eye injury, and 8.0 % underwent surgery for their injuries. In 40.0 % of cases, injuries were localized in the head and neck area [5].

Indeed, the face area is most often damaged by this type of weapon. The analysis of literature between 1975–2016 years showed that the eye area (38.0 %), cheekbone (20.7 %), nose (19.0 %) and lower jaw (17.5 %) are most often affected in head injuries. The upper jaw is rarely affected (4.8 %) [1].

An analysis of lower limbs injuries caused by non-lethal weapons in Kashmir showed that most of the victims had isolated soft tissue injuries, bone fractures and, to a lesser extent, nerve, ligament and joint injuries [3].

In Ukraine, the events of the Revolution of Dignity are the most revealing case regarding using non-lethal weapons. In the period from February 24 to March 6, 2014, the survey revealed 322 victims, 55 of whom were injured by non-lethal weapons. Most of the injuries were localized in the head area and lower limbs, which confirms the general trend observed in other countries [11].

All this prompts a more active investigation of wound ballistics of gunshot trauma. Wound ballistics is one of the most complicated and complex sections of forensic medicine, which is caused by the complex interaction of the projectile with the surface of the human body, further features of the formation of a temporary pulsating cavity, interactions with various tissues in the human body, which can radically change the course and depth of the wound channel [13].

One of the aspects that is practically not investigated for all types of firearms, and especially weapons of non-lethal action, is the influence of clothing on the peculiarities of the formation of the gunshot wound channel. The most optimal way to solve this problem is to conduct an experiment using a non-biological simulator of the human body and the most common types of material for clothing, taking into account the distance of the shot.

The purpose of the study was to investigate and compare how different types of fabric affect the penetration depth of the projectile when fired from the "Fort 9R" and "Fort 17R" pistols at close range, 25 cm and 50 cm.

Materials and methods. Imitation of human body tissues was achieved by production of gelatin blocks measuring 30x15x15 cm. For its production, a 10.0 % grout of food gelatin type A 270 Bloom (TM "Junca Gelatines SL", Spain) was used with the addition of propionic acid in the amount of 5 ml/l of gelatin grout for inhibition of microbial flora. According to Fackler and Malinowski method [4], the blocks were previously stored for 48 hours at a temperature of +4°C. To simulate the skin, all blocks were covered with a 200-μm-thick transparent polyethylene pellicle.

A total of 120 blocks were produced for the study, which were divided accordingly: two groups of 60 blocks, were to be shot using "Fort 9R" and "Fort 17R". In its turn, 4 subgroups were formed in each group, depending on the use of covering material: subgroup 1 – gelatin blocks that were not covered with fabric; subgroup 2 – blocks that were covered with cotton fabric, subgroup 3 – blocks that were covered with denim fabric, subgroup 4 – blocks that were covered with leatherette.

Blocks within each subgroup were shot at point-blank, 25 cm, and 50 cm shooting distances using the above-described pistols equipped with the same 9 mm cartridges (elastic traumatic bullets). All actions were carried out within 30 minutes from the moment blocks were removed from the refrigerating chamber at the base of the Vinnytsia shooting range of the Scientific and Research Expert Forensic Center of the Ministry of Internal Affairs of Ukraine, with the prior fixation of the gun in vices.

Subsequently, a cross-section of each block was carried out with an interval of 1 cm, and photo-fixation in accordance with the rules of forensic photography using a digital camera ("Alpha A6000 Sony camera"), which allowed to measure The total crack length method (TCLM), The Fackler's wound profile method (FWPM), The polygon-procedure method (PPM) [4]. Taking into account the greatest depth of the cross-section where the TCLM occurs at the same time allowed us to estimate the penetration depth of the projectile, which we used in this study.

Committee on Bioethics of National Pirogov Memorial Medical University, Vinnytsya (protocol No. 42 from 25.11.2020) 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.

The statistical analysis of the obtained results was carried out in the licensed statistical package "Statistica 6.0". The reliability of the difference in values between independent qualitative values was determined by the formula Weber E.: $t = (P_1 - P_2) / \sqrt{[((N_1P_1 + N_2P_2) / (N_1 + N_2)) \times ((100 - (N_1P_1 + N_2P_2) / (N_1 + N_2)) \times ((N_1 + N_2) / (N_1N_2))]}$, where, P_1 and P_2 are the percentages with which one or another indicator met; N_1 and N_2 are the number of indicators in the studied groups.

Results of the study and their discussion. When analyzing the results of shooting at close range, 25 and 50 cm using "Fort 9R" and "Fort 17R" pistols at bare blocks and blocks covered with various types of fabric, in 100 % of cases there was penetrating damage to the gelatin block with the formation of a wound channel at least 1 cm deep.

When analyzing the results of shooting at close range using "Fort 9R" and "Fort 17R" pistols in bare blocks and blocks covered with various types of fabric, and shootings from distances of 25 and 50 cm when shooting at blocks covered with cotton and leatherette in 100 % of cases, penetrating damage to the gelatin block occured with the formation of a wound channel 2 cm deep. At the same time, for the "Fort 17R" pistol, some tendencies were established ($p=0.076$ in all cases) for more frequent formation of a wound channel 2 cm deep when shooting denim fabric at close range than from a distance of 50 cm (100 % and 60 %, accordingly), when fired from a distance of 50 cm into cotton fabric and leatherette compared to denim (100 %, 100 % and 60 %, accordingly), and when fired into denim from a distance of 50 cm from a pistol "Fort 9R" compared to "Fort 17R" (100 % and 60 %, accordingly).

When analyzing the results of a shooting from close range with the use of "Fort 9R" and "Fort 17R" pistols, in 100 % of cases there was a penetrating damage to the gelatin block with the formation of a wound channel 3 cm deep only when firing at bare blocks and blocks covered with denim fabric. When firing from a distance of 50 cm, the formation of a defect with a depth of 3 cm was not observed in any case (0 %). At the same time, for the "Fort 9R" pistol, it was established that:

– there is a tendency ($p=0.076$) towards the more frequent formation of a wound channel with a depth of 3 cm when shots were fired at a bare block at close range than from a distance of 25 cm (100 % and 60 %, accordingly);

– significantly more often ($p<0.036$–0.007) a wound channel with a depth of 3 cm was formed when shots were fired at a bare block from a close distance than from a distance of 50 cm; from a distance of 25 cm than from a distance of 50 cm (100 % and 0 %, 60 % and 0 %, accordingly); when fired at a block covered with cotton fabric from a close distance compared to 25 cm and from a close distance compared to 50 cm (80 % and 0 %, 80 % and 0 %, accordingly); when fired at a block covered with denim fabric from a close distance compared to 25 cm and from a close distance compared to 50 cm (100 % and 0 %, 100 % and 0 %, accordingly); when fired at a block covered with leatherette from close range compared to 25 cm and from close range compared to 50 cm (100 % and 0 %, 100 % and 0 %, accordingly);

– significantly more often ($p<0.036$ in all cases) a wound channel with a depth of 3 cm was formed when fired from a distance of 25 cm into a bare block compared to blocks covered with cotton, denim, and leatherette (60 %, 0 %, 0 %, and 0 %, accordingly).

For the "Fort 17R" pistol, it was established that:

– significantly more often ($p<0.036$–0.007) a wound channel with a depth of 3 cm was formed when fired at a bare block from a close range than from a distance of 25 cm and a close range than from a distance of 50 cm (100 % and 0 %, 100 % and 0 %, accordingly); when firing at a block covered with cotton fabric from a close range compared to 25 cm and from a close range compared to 50 cm (100 % and 0 %, 100 % and 0 %, accordingly); when fired at a block covered in denim fabric from a close range compared to 25 cm and from a close range compared to 50 cm (100 % and 0 %, 100 % and 0 %, accordingly); when fired at a block covered with leatherette from a close range compared to 25 cm and from a close range compared to 50 cm (60 % and 0 %, 60 % and 0 %, accordingly);

– there is a tendency ($p=0.076$) for more frequent formation of a 3 cm deep wound channel when close-up shots were fired in bare blocks than blocks covered with leatherette, blocks covered with cotton fabric than covered with leatherette, and blocks covered with denim fabric than with leatherette (100 % and 60 % in all cases).

When firing from a pistol "Fort 9R" into the bare blocks from a distance of 25 cm, a wound channel with a depth of 3 cm was formed significantly more often ($p<0.036$) than when firing from a pistol "Fort 17R" (60 % and 0 %, accordinly); there is a tendency ($p=0.076$) for a more frequent formation of a wound channel with a depth of 3 cm when firing at close range from the "Fort 9R" pistol into blocks covered with leatherette, than when firing from the "Fort 17R" (100 % and 60 %, accordingly).

When analyzing the results of a close-range shooting using "Fort 9R" and "Fort 17R" pistols, in 100 % of cases, penetrating damage to the gelatin block with the formation of a wound channel 4 cm deep occurred only when shots were fired at bare blocks. When fired from a distance of 25 and 50 cm, the formation of a defect with a depth of 4 cm was not observed in any cases (0 %). At the same time, for the “Fort 9R” pistol, it was established that:

– significantly more often ($p<0.007$ in all cases) a wound channel with a depth of 4 cm was formed when shots were fired at a bare block from a close range than 25 cm and a close range than 50 cm (100 % and 0 %, 100 % and 0 %, accordingly); when fired at a block covered with denim fabric from a close range compared to 25 cm and from a close range compared to 50 cm (100 % and 0 %, 100 % and 0 %, accordingly); when fired at a block covered with leatherette from close range compared to 25 cm and from close range compared to 50 cm (100 % and 0 %, 100 % and 0 %, accordingly); there is a tendency ($p=0.076$) for more frequent formation of a wound channel with a depth of 4 cm when firing at a block covered with cotton fabric from a close range compared to 25 cm and from a close range compared to 50 cm (40 % and 0 %, 40 % and 0 %, accordingly);

– significantly more often ($p<0.036$ in all cases) a wound channel with a depth of 4 cm was formed when shots were fired at a close range at bare blocks compared to blocks covered with cotton fabric (100 % and 40 %, accordingly), as well as when shots were fired into blocks covered with denim fabric or leatherette, than cotton fabric (100 %, 100 % and 40 %, accordingly).

For the “Fort 17R” pistol it was established that:

– significantly more often ($p<0.007$ in all cases) a wound channel with a depth of 4 cm was formed when fired at a bare block from a close range than from a distance of 25 cm and a close range than from a distance of 50 cm (100 % and 0 %, 100 % and 0 % accordingly); when fired at a block covered with cotton fabric from a close range compared to 25 cm and from a close range compared to 50 cm (100 % and 0 %, 100 % and 0 %, accordingly);

– significantly more often ($p<0.016$–0.007) a wound channel with a depth of 4 cm was formed when shots were fired at close range at a bare block than the one covered with denim fabric or leatherette (100 %, 20 % and 0 %), as well as covered with cotton fabric than denim fabric or leatherette (100 %, 20 % and 0 %).

When close-range shots were fired at blocks covered with denim fabric or leatherette, significantly more often ($p<0.016$–0.007) a wound channel with a depth of 4 cm was formed using “Fort 9R” than “Fort 17R” (100 % and 20 %; 100 % and 0 %, accordingly), and a wound channel with a depth of 4 cm was more often formed when fired at close range at blocks covered with cotton fabric, using “Fort 17R” than “Fort 9R” (100 % and 40 %, accordingly).

When analyzing the results of a shooting from distances of 25 and 50 cm, using “Fort 9R” and “Fort 17R” pistols, the formation of a defect with a depth of 5 cm was not observed in any case (0 %). The formation of defects with a depth of 5 cm was also not detected when fired from the “Fort 17R” pistol, even when fired at close range. At the same time, for the “Fort 9R” pistol, it was established that:

– there is a tendency ($p=0.076$) for more frequent formation of a wound channel with a depth of 5 cm when firing at a bare block at close range than at a distance of 25 cm, and when firing at close range than at a distance of 50 cm (40 % and 0 %, 40 % and 0 % accordingly);

– there is a tendency ($p=0.076$) for more frequent formation of a wound channel with a depth of 5 cm when close-range shots were fired at a bare block than at a block covered with cotton fabric or leatherette (40 % and 0 %, 40 % and 0 %, accordingly).

When fired at close range, there is a tendency ($p=0.076$) for more frequent formation of a 5 cm deep defect when firing at a bare block using “Fort 9R” than “Fort 17R” (40 % and 0 %, accordingly).

Defects with a depth of 6 cm were formed in a few cases only when close-range shots were fired at bare block using the “Fort 9R” pistol.

Defects with a depth of more than 6 cm were not formed when firing from both the “Fort 9R” and “Fort 17R” pistols.

In most publications related to forensic ballistics, the role of clothing in a gunshot injury is reduced to material evidence that can accumulate the products of a shot, or damages of a specific shape and size can be formed on it, which will later allow the identification of a weapon [2]. There are only few publications that indicate its role in the mechanics of wound ballistics.

Wightman G. with co-authors [15], when performing experimental shots with rubber bullets into gel covered with different types and number of layers of clothing, found significant differences in the length of the wound channel. Thus, the presence of a T-shirt reduced the penetration depth by 50.0 %, fleece fabric by 65.0 %, and denim fabric stopped projectiles when fired from a distance of 9 meters.

At the same time, another group of researchers found that a layer of clothing increases the risk of an indirect fracture. In a series of experiments using a combined type of simulator (bone in ballistic gel) and 5.56×45 mm NATO cartridges, it was found that clothing causes the formation of a large surface temporary cavity, which causes significant lateral pressure and thus creates the prerequisites for the formation of an indirect fracture [6].

There are interesting results of an experiment by Mabbott A. and Carr D. J. [9] regarding the study of the protective properties of the HG2 bulletproof vest, which was created to protect British police officers from "light" firearms, when shot at with 223 Remington cartridges. As it turned out, the depth and area of gelatin damage was greater when the blocks were covered with HG2 body armor than when the blocks were "bare".

Luo S. and others [8] investigated the reaction of ballistic gelatin to shots in body armor directly adjacent to it. As it turned out, even in such conditions, a temporary cavity is formed, which will be located directly at the point of impact of the projectile into the body armor.

When shooting at gelatin covered with high-quality polyethylene, which is the basis of most modern soft body armor, statistically significant differences in the impact speed of the projectile were found, which in turn is a key indicator in modeling the expected penetration depth of the projectile [12].

At the same time, when shooting at a biological simulator of the lower limb (lower limb of a deer) protected by one, four and no layers of clothing used by the armed forces of the United Kingdom, no statistically significant differences in the indicators of the wound channel were found by scientists [14].

The change in the properties of the wound channel can be influenced even by the previous impregnation of the tissue with blood [7].

And although damage by arrows does not concern either ballistics or non-lethal weapons, the results of an experiment conducted by a group of scientists led by MacPhee N. [10] are worth attention. When shooting from a bow from different distances into gel covered with different types of clothing, scientists found that loose and tight-fitting clothing reduces the penetration depth of an arrow at a distance of 10 meters from 0 % to 98.33 % and from 14.06 % to 94.12 %, accordinly.

Conclusions

1. When firing from "Fort 9R" and "Fort 17R" pistols at close range, 25 and 50 cm, a wound channel with a length of at least 1 cm is formed when using any textile covering material.

2. Both "Fort 9R" and "Fort 17R" do not cause penetrating damage of 3 cm or more when using any fabric for covering at a shot distance of 50 cm, and do not cause penetrating damage of 4 cm or more when using any fabric for covering at a shot distance of 25 cm.

3. "Fort 17R" does not cause penetrating damage of 5 cm or more when using any fabric even at close range.

4. Deeper damage is more common when firing the "Fort 9R" pistol compared to the "Fort 17R".

5. When firing from "Fort 9R" pistol there were signs that the cotton fabric had better protective properties than the other fabrics tested, while the Fort 17R shots showed the leatherette.

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MORPHOGENESIS OF THE ZERO-STAGE OSTEONECROSIS FORMATION OF THE LOWER JAW BASED ON THE USE OF AMINOBISPHOSPHONATES

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The dynamics of morphostructural changes in the mandibular bones of laboratory white rats after a 3-month exposure to pamidronic acid at the dose of 63 mg/kg was studied. Light microscopy methods were used, including qualitative and quantitative characteristics in assessing the structural state of the bone through the parameters that characterize the histoarchitectonics of the lower jaw using indices and their abbreviations proposed by the committee on histomorphometric nomenclature of American Society for Bone and Mineral Research. Three new functional indices for assessing physiological processes in bones were studied. It was established that administration of pamidronic acid to laboratory white rats for 3 months leads to myelofibrosis and focal osteosclerosis with osteodystrophic changes, similar to the processes that develop in ossifying osteitis.

Key words: aminobisphosphonate, osteonecrosis, osteocytic osteolysis, lower jaw.

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МОРФОГЕНЕЗ ФОРМУВАННЯ НУЛЬОВОЇ СТАДІЇ ОСТЕОНЕКРОЗУ НИЖНЬОЇ ЩЕЛЕПИ НА ТЛІ ВИКОРИСТАННЯ АМІНОБІСФОСФОНАТІВ

Вивчено динаміку морфоструктурних змін нижньощелепних кісток лабораторних білих щурів при 3-місячному впливі памідронової кислоти в дозі 63 мг/кг. Використовували методи світлової мікроскопії, включаючи якісні і кількісні характеристики оцінки структурного стану кістки через параметри, які характеризують гістоархітектоніку нижньої щелепи з використанням показників і їхніх абревіатур, запропонованих комітетом з гістоморфометриченої номенклатури Американського товариства дослідження кісток та мінералів. Досліджені три нових функціональних показники для оцінки фізіологічних процесів у кістках. Установлено, що введення памідронової кислоти лабораторним білим пацюкам протягом 3 місяців веде до мієлофіброзу й вогнищевого остеосклерозу з остеодистрофічними змінами подібно до процесів, які розвиваються при оссифікуючому оститі.

Ключові слова: амінобісфосфонат, остеонекроз, остеоцитарний остеоліз, нижня щелепа.

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Bisphosphonates have been known since the middle of the 11th century. It is worth noting that these compounds are able to prevent significant loss of bone mass and are used for palliative therapy in bone metastases of malignant neoplasms, which are combined with hypercalcemia syndrome. Such side effects as osteonecrosis of the jaws come to the fore, which is particularly pronounced when patients use aminobisphosphonate mixtures. Data from the literature indicate a certain uncertainty in the morphological justification of their negative impact on bone tissue. Clinical side syndromes are manifested in the form of osteonecrosis of the jaws and are defined as a condition characterized by exposure of the bone of the lower and (or) upper jaw, which persists for 8 weeks in the absence of previous radiation or metastases. A similar wording characterizes the state of infection of the jawbones when the integrity of the mucous membranes is violated, which is confirmed by morphological studies [5, 8, 11].