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LENGTH OF WOUND CHANNELS USING "FORT 12R" AND "AE 790G1" UNDER THE CONDITIONS OF USE OF VARIOUS TEXTILE MATERIALS

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The spread of firearms among different strata of the population as a result of socio-economic changes, legislative regulation of the right to carry them or the spread of military conflicts requires conducting a series of experimental studies in order to establish the characteristics of injuries that can be caused by modern weapons. The research carried out on non-biological human body simulators covered with different types of textiles using non-lethal pistols "Fort 12R" and "AE 790G1" made it possible to establish that at a shot distance of up to 50 cm, regardless of the type of textile, a defect with a depth of at least 1 cm is formed; defects with a depth of 5 cm do not occur in cases of a shot from a distance of 25 cm or more. When using these guns, the depth of the wound channel can be no more than 6 cm.

Key words: gunshot wound, gunshot injury, textile, gunshot weapon, elastic balls.

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ДОВЖИНА РАНОВИХ КАНАЛІВ ПРИ ЗАСТОСУВАННІ «ФОРТ 12Р» ТА «АЕ 790G1» ЗА УМОВИ ВИКОРИСТАННЯ РІЗНОМАНІТНИХ ТЕКСТИЛЬНИХ МАТЕРІАЛІВ

Поширення вогнепальної зброї серед різних верств населення як наслідок соціально-економічних змін, законодавчого регулювання права її на носіння або розповсюдження військових конфліктів вимагає проведення серій експериментальних досліджень з метою встановлення особливостей ушкоджень, які можуть викликати сучасні зразки озброєння. Виконане дослідження на небіологічних імітаторах тіла людини покритих різними видами текстилю з застосуванням пістолетів нелетальної дії «Форт 12Р» та «АЕ 790G1» дозволило встановити, що на дистанції пострілу до 50 см незалежно від виду текстилю утворюється дефект глибиною щонайменше 1 см; дефекти глибиною 5 см не зустрічаються у випадках пострілу з відстані 25 см і більше. При використанні зазначених пістолетів глибина ранового каналу може складати не більше 6 см.

Ключові слова: вогнепальна рана, вогнепальні ушкодження, текстильні матеріали, вогнепальна зброя, еластичні кулі.

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.

Firearms in modern society are tools that have different points of application: they are used both for military purposes and for self-defense, hunting, in sports competitions and for the purpose of law enforcement. Each of these goals requires the use of specific design features of not only weapons, but also ammunition, the projectile of which will hit the target.

When we talk about firearms used by law enforcement agencies or firearms for self-defense, we usually mean the type of weapon that is equipped with elastic bullets of traumatic effect (non-lethal weapons). Also, the design features of such weapons make it impossible to use military ammunition. In the modern sense, a weapon of non-lethal action, if not specified, is a collective concept that includes a number of different tools in terms of mechanism: these are firearms equipped with elastic bullets of traumatic action, tasers, gas pistols with an irritating effect, etc. [9]. However, the use of non-lethal weapons by law enforcement agencies does not always have a positive effect – it has been proven that the presence of this type of weapon in a police officer increases aggressiveness towards the latter [1].

The analysis of literary sources shows [7, 9, 10] that despite its name – a weapon of non-lethal action, lethal or severe consequences are rare when it is used.

Thus, if we take into account the data on forensic medical examinations of injured participants of the Revolution of Dignity, injuries in the form of bruises, abrasions, wounds, fractures, traumatic amputations, etc. were found in 55 subjects as a result of the use of non-lethal firearms, and in 133 persons as a result of the use of light and noise garnet [10].

International literature describes cases of contusion of the heart and lungs, craniocerebral trauma, penetrating eye and thoraco-abdominal trauma as a result of the use of non-lethal firearms [9].

At the same time, studies dealing with the study of non-lethal weapons from the point of view of ballistics, forensic medicine or criminology are few and do not cover the vast number of both non-lethal weapons and ammunition designed exclusively for use with them.

Another aspect that should be investigated at the current stage from the point of view of ballistics is the influence of clothing on changing the parameters of injuries or the wound channel caused by the use of non-lethal weapons. It is worth noting that the works devoted to the identification of the protective properties of textile materials or the creation of anti-ballistic textiles are more common [6, 14], however, in any case, they do not allow us to answer the key question – which types of fabric provide the best protective properties in the case of using non-lethal weapons actions? Does wearing clothes prevent more serious injuries when using traumatic bullets? All these and other questions are now more than ever a priority for study.

The purpose of the study was to compare the penetration depth of the projectile under the condition of using different types of textile material when firing from "Fort 12R" and "AE 790G1" from contact distances, 25 cm and 50 cm.

Materials and methods. To achieve the goal, the team of authors used a non-biological imitator of the human body, as close as possible to muscle and fat tissue – a 10.0 % solution of food gelatin. For the experiment, 120 gelatin blocks of standard size (30x15x15 cm) were made according to the method of Fackler and Malinowski [3] using edible gelatin type A 270 Bloom produced by TM "Junca Gelatines SL" (Spain). After that, the blocks were left for 48 hours in a room with a constant temperature of +4°C. To avoid distortion of the blocks during this time due to the multiplication of microbial microflora, propionic acid in the amount of 5 ml/l was added to the gelatin solution.

Shootings were carried out at the base of the shooting range of the Vinnytsia Scientific and Research Expert Forensic Center of the Ministry of Internal Affairs of Ukraine, with the prior fixation of the gun in the vises within 30 minutes from the moment of removing the blocks from the refrigerator. Before shooting, all blocks were covered with a transparent polyethylene film 200 μm thick to simulate the skin. "Fort 12R" and "AE 790G1" pistols equipped with the same elastic bullets of traumatic effect were used for the shots. Blocks were placed contact to the weapon and at distances of 25 cm and 50 cm. Depending on the covering material of the block, 4 subgroups were formed: blocks without covering with textile material; blocks covered with cotton fabric; blocks covered with denim fabric; blocks covered with leatherette.

After firing, the total crack length method (TCLM) [3] was measured, by making successive cross-sections of the block at intervals of 1 cm, which in turn made it possible to judge the penetration depth of the projectile.

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.

The statistical analysis of the obtained results was carried out in the licensed statistical package "Statistica 6.0" using non-parametric estimation methods. The reliability of the difference in values between independent quantitative values was determined using the Mann-Whitney U-test, and between qualitative values – according to the Weber E. (1961).

Results of the study and their discussion. Statistical analysis of the obtained indices revealed that when firing from all studied distances from both the "Fort 12R" and "AE 790G1" pistols into blocks covered with various cotton fabric, denim fabric, leatherette, and bare blocks, in 100 % of cases, penetrating damage to the gelatin block with formation of a wound channel with a depth of at least 1 cm.

Penetrating damage to the gelatin block with the formation of a wound channel with a depth of 2 cm was observed in 100 % of cases when shots were fired from both the "Fort 12R" and the "AE 790G1" pistol into blocks covered with cotton fabric, denim fabric, leatherette, and bare blocks at close range and 25 cm. When firing from a "Fort 12R" pistol at a distance of 50 cm, a defect of the wound channel to a depth of 2 cm was formed significantly more often ($p<0.0361$) when firing at bare blocks than at blocks covered with leatherette and when firing at blocks covered with denim than leather substitute (100 % and 40 %, respectively, in both cases). Also, during shots from the "Fort 12R" pistol into blocks covered with leatherette, a defect of the wound channel to a depth of 2 cm was formed significantly more often ($p<0.0361$) when shots were fired from close range and 25 cm than 50 cm (100 % and 40 %, respectively, in both cases). When shooting from the "AE 790G1" pistol at a distance of 50 cm, a defect of the wound channel to a depth of 2 cm was formed significantly more often ($p<0.0163$) when shooting at blocks covered with cotton, denim or leatherette than bare blocks (100 % and 20 %, respectively, in both cases). Also, when shots from the "AE 790G1" pistol were fired into bare blocks, a defect of the wound channel to a depth of 2 cm was formed significantly more often ($p<0.0163$) when shots were fired from close range and 25 cm than 50 cm (100 % and 20 %, respectively, in both cases).

When firing from a pistol "Fort 12R" into the goal blocks from a distance of 50 cm, a defect with a depth of 2 cm is formed significantly more often ($p<0.0163$) than when using "AE 790G1" (100 % and 20 %, respectively). When shots from the "AE 790G1" pistol are fired from a distance of 50 cm into blocks covered with leather substitute, a defect with a depth of 2 cm is formed significantly more often ($p<0.0361$) than when using "Fort 12R" (100 % and 40 %, respectively).

Penetrating damage to the gelatin block with the formation of a wound channel with a depth of 3 cm was observed in 100 % of cases when shots were fired from both the "Fort 12R" and the "AE 790G1" pistol into blocks covered with cotton fabric, denim fabric, leatherette, and bare blocks at close range. When firing from a "Fort 12R" pistol at a distance of 25 cm, a defect of the wound channel to a depth of 3 cm was formed significantly more often ($p<0.0163$-0.0070) when firing at blocks covered with cotton or denim than bare blocks (100 % and 0 % and 80 % and 0 %, respectively) and blocks covered with cotton or denim than blocks covered with leatherette (100 % and 0 % and 80 % and 0 %, respectively). Also, when shots from the "Fort 12R" pistol were fired at blocks covered with leatherette or bare blocks, a defect of the wound channel to a depth of 3 cm was formed significantly more often ($p<0.0163$-0.0070) when fired at close range than from distances of 25 cm and 50 cm, as well as at blocks covered with cotton and denim fabric when fired at close range and 25 cm than when fired from a distance of 50 cm. When fired from the "AE 790G1" pistol at a distance of 25 cm, a defect of the wound channel to a depth of 3 cm was formed significantly more often ($p<0.0361$) in blocks covered with cotton fabric than in bare blocks or blocks covered with leatherette (60 % and 0 %, respectively, in both cases). With shots from the "AE 790G1" pistol in all subgroups of blocks, regardless of block coverage, a wound channel defect to a depth of 3 cm was significantly more often ($p<0.0163$-0.0070) formed when shots were fired at close range than at 25 cm or 50 cm, with the exception of shots into blocks covered with cotton fabric, where there was a tendency ($p=0.0763$) for more frequent formation of this defect when shots were fired at close range than 25 cm.

When shots from the "Fort 12R" pistol were fired into the blocks covered with cotton fabric at a distance of 25 cm, there was a tendency ($p=0.0763$) to more frequent formation of a wound channel defect to a depth of 3 cm than when fired from the "AE 790G1" pistol (100 % and 60 %, respectively), and significantly more frequent ($p<0.0361$) formation of a wound channel defect to a depth of 3 cm when shots were fired into blocks covered with denim (80 % and 20 %, respectively) under similar conditions.

Penetrating damage to the gelatin block with the formation of a wound channel with a depth of 4 cm was observed in 100 % of cases when shots were fired from both the "Fort 12R" and the "AE 790G1" pistol into blocks covered with cotton fabric, denim fabric, and leatherette at close range. With the exception of a few (20 %) cases of formation of defects when using "Fort 12R" at a distance of 25 cm, in all other cases, the formation of a wound channel with a depth of 4 cm was not observed at all (0 %). When using "Fort 12R" at close range, wound channel defects with a depth of 4 cm were formed significantly more often ($p<0.0070$) when firing at blocks covered with cotton, denim, and leatherette than at bare blocks (100 % and 0 % in all cases).

When fired with "AE 790G1" significantly more often ($p<0.0163$) the formation of a wound channel defect with a depth of 4 cm was observed when fired close to bare blocks than when using "Fort 12R" (80 % and 0 %, respectively).

Penetrating damage to the gelatin block with the formation of a wound channel with a depth of 5 cm was observed in 100 % of cases when shots were fired from both the "Fort 12R" and "AE 790G1" pistols only at blocks covered with cotton fabric at close range. At the same time, defects with a depth of 5 cm did not occur at all (0 %) when fired from distances of 25 cm and 50 cm, regardless of the covering of the blocks, and were not formed even when fired at close range on bare blocks. When firing from the "Fort 12R" at close range, defects with a depth of 5 cm were formed significantly more often ($p<0.0070$) in blocks covered with cotton and denim fabrics than in bare blocks and blocks covered with leatherette (100 % and 0 %, respectively, in both cases). When fired with "AE 790G1" significantly more often ($p<0.0163$–0.0070) the formation of a wound channel defect with a depth of 5 cm was observed when fired close to cotton, denim fabric and leatherette compared to bare blocks (100 %, 60 %, 60 % and 0 % respectively) and a tendency ($p=0.0763$) to the formation of a wound channel defect with a depth of 5 cm was found when close shots were fired into denim and imitation leather compared to bare blocks (60 %, 60 % and 0 %, respectively).

When shooting with "AE 790G1", the formation of a wound channel defect with a depth of 5 cm was observed significantly more often ($p<0.0361$) when shooting close to blocks covered with leather substitute than when using "Fort 12R" (60 % and 0 %, respectively). When firing with "Fort 12R" there was a tendency to a more frequent ($p=0.0763$) formation of a wound channel defect with a depth of 5 cm

when firing close to blocks covered with denim fabric than when using "AE 790G1" (100 % and 60 %, respectively).

Defects with a depth of 6 cm were formed quite rarely (in 20 % of cases) only when shots were fired close to the blocks covered with denim fabric using the "Fort 12R" gun.

Defects with a depth of more than 6 cm were not formed when fired from both the "Fort 12R" and "AE 790G1" pistols.

The data of our study are supported by the results of an earlier experiment with the use of "Fort 12RM". What is special is the use by the team of authors as a target of a human torso simulator (also using a 10 % gelatin solution), which was worn in cotton T-shirts. When close-range shots were fired, the depth of the wound channel reached, as in our study, no more than 6 cm, but the minimum depth was 4 cm (compared to 5 cm in ours) [5].

T. Stevenson with co-authors [13] investigated the effect of Multi-Terrain Pattern UK military clothing on the characteristics of gunshot damage when shot at gelatin blocks using ammunition 7.62×39 mm and 5.45×39 mm. The results of the analysis of the obtained data showed the existence of a significant difference in the damage of blocks covered with the maximum amount of clothing and blocks without clothing or with one layer of clothing.

V. Sapielkin [12] carried out an experimental study on the effect of non-lethal "Teren-12P" bullets. The experiment consisted of two parts: in the first shot, a biological simulator of the human body (pig skin) was fired, in the second, a shot was fired at the volunteer's lower limb, which was covered with cotton clothing. In both cases, the shots were fired from a distance of 15 m. On the biological simulator, a "stamp-imprint" type injury was formed with a slight depression, but without skin penetration. A wound and a bruise formed on the volunteer's body.

When firing at close range from two Turkish 9 mm pistols and one German 8 mm pistol, the researchers found that the penetration depth of the ammunition into the gelatin covered with a non-biological impersonator of the human body ranged from 1 to 4.5 cm. Moreover, a greater penetration depth was noted when using ammunition with smoke powder [2].

When using a taser, the penetration depth reaches 4.2 cm when shot from 10 meters. To a large extent, the depth of penetration in the experiment depended on the availability of clothing and the use of a biological imitator (pig skin) as a skin imitator. Layers of clothing and the use of a biological mimic of human skin reduced the penetration depth [8].

One of the new directions in ballistics, which has considerable humanitarian significance, is the study of anti-ballistic properties of various types of textiles, both existing and testing new varieties. In addition, not only the material from which the textile is made is important, but also the mechanism of weaving the fibers of the textile material. The latter phenomenon can explain the differences in the obtained indices of various ballistic studies and should also be taken into account by researchers [6, 14, 15].

Particular attention should be paid to the phenomenon we encountered in our research – namely, the almost identical protective effect of blocks covered with leatherette and bare blocks. After all, at first glance it is logical that bare blocks should have deeper damage than blocks covered with cotton or denim fabric. First of all, this is due to the difficulty of choosing the most physiological skin simulator. Obviously, the best option for experimental work is the use of the skin of deceased persons – it can be used up to 24 hours after a person's death. However, the use of cadaveric material in research is legally limited in most countries. Biological (animal) mimics have a different density compared to human skin, while non-biological mimics have a different structure [4].

Numerous factors can affect the depth of the lesion, even the anthropometric indicators of a person [11], however, any explanation in the available literary sources regarding the phenomenon we discovered has not been found. In further research, we will investigate the dimensions of the temporary cavity, which will allow us to assess this phenomenon to a greater extent.

Conclusions

1. When firing from both "Fort 12R" and "AE 790G1" pistols from contact range, 25 and 50 cm, a wound channel of at least 1 cm in length is formed when using any textile covering material.

2. Both "Fort 12R" and "AE 790G1" do not cause penetrating damage of 4 cm or more when using any textile covering material at a shooting distance of 50 cm, and do not cause penetrating damage of 5 cm or more when using any textile covering material at a shooting distance of 25 cm.

3. "AE 790G1" does not cause penetrating damage 6 cm or more in length when using any textile covering material even at close range.

4. “Fort 12R” and “AE 790G1” cause damage of approximately the same depth.

5. Both “Fort 12R” and “AE 790G1” showed signs that the leather substitute has better protective properties than the other textile materials tested. At the same time, at the same level as leather substitute, the smallest damage was detected when examining bare blocks.

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