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PECULIARITIES OF SOOT DEPOSITION, TEARING OF CLOTHING AND HUMAN BODY SIMULATOR DURING SHOOTINGS FROM «FORT 12R» AND «AE 790G1» PISTOLS

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Summary. The study of macroscopic features of the clothing damage or the damage to the human body, the presence of additional factors of a shot on it – is one of the basic methods of analysis used in medical forensics. The appearance of new types of firearms requires the appropriate conduct of experimental research in order to update the theoretical database of experts.

The purpose of the work to investigate the features of soot deposition, tearing of clothing and a human body simulator when using «FORT 12R» and «AE 790G1» pistols.

Material and methods. For the study, 120 gelatin blocks were used, which later remained bare or were covered with one of the fabrics: cotton, denim or leatherette. After that, shots were fired from close range, 25 and 50 cm using «FORT 12R» and «AE 790G1» pistols, with subsequent analysis of macroscopic soot deposition around the entrance firing hole and the number of ruptures in clothing or a human body simulator, if the shot was fired at a bare block.

Results. When analyzing soot deposition, it was reliably established ($p<0.0070$) or a tendency ($p=0.0763$, only for leatherette) towards its macroscopic detection when shots were fired at close range in all studied groups of bare blocks and blocks covered with clothing when shots were fired from a distance of 25 cm and the absence of the soot when fired from a distance of 50 cm when fired from both pistols. When comparing the data on the number of ruptures between the «Fort 12R» and «AE 790G1» pistols, reliably ($p<0.01$-0.05) higher values were found when firing with the «AE 790G1» from a close distance into blocks covered with cotton and denim fabric, when shot from 25 cm into the blocks covered with cotton fabric and a slight tendency ($p=0.095$) to higher values when shot with the «AE 790G1» from a close distance into the blocks covered with leatherette.

Conclusions. When using the «FORT 12R» and «AE 790G1» pistols, practically no differences in soot deposition was found, however, when analyzing the number of ruptures in clothing and the human body simulator, higher values were found when using the «AE 790G1» pistol.

Keywords: gunshot injury; gunshot wounds; forensic medical examination; non-lethal weapons; soot; clothing ruptures; firearm.

Introduction. Forensic medical examination is still one of the most complex cases in the practice of a forensic medical expert, which requires the application of a whole complex of knowledge and capabilities of the physical evidence examination department, in particular, a wide range of instrumental research methods. This is one of the reasons why during the time of Ukraine's independence, researches aimed at studying new types of weapons and equipment for them gradually gained momentum [1].

All this gave an impetus to change the model of ballistic experiments, which is the first step to the study of one or another type of firearm. Thus, there are still only few studies using human body simulators or studies of a complex consisting of a human body simulator and layers of clothing, which could bring the experimental model closer to a more realistic one [2].

In the modern Ukrainian realities, taking into account the events of the recent past and the current situation [4], the study of firearms is a priority area for forensic medicine and medicine in general. However, taking into account the obsolescence of the material and technical base of the forensic laboratory (in particular, departments of medical forensics), the first priority in the study of new types of firearms should be the assessment of macroscopic changes that can be seen with the unaided eye.

The purpose of the work is to investigate and compare the features of soot deposition and the number of ruptures formed on different types of clothing and a human body simulator at different shooting distances when using «FORT 12R» and «AE 790G1» pistols.

Material and methods. In order to achieve the goal, 120 blocks measuring 30x15x15 cm were produced for the study according to the Fackler and Malinowski method [5]. For the maximum imitation of the human body, the blocks were made from a 10% solution of edible gelatin type A 270 Bloom (TM «Junca Gelatines SL», Spain), which was stored for 2 days before shooting at a temperature of +4oC with the prior addition of propionic acid in the amount of 5 ml/l of the solution gelatin to inhibit microbial flora.

Subsequently, the blocks were divided into two groups depending on the pistol, and within the group to four subgroups depending on the fabric covering the block, namely: in the first subgroup, the blocks were not covered with clothing; in the second group blocks were covered with cotton fabric; in the third group blocks were covered with denim fabric; in the fourth group blocks were covered with leatherette. In all four groups, the blocks were covered with a protective film 200 μm thick to imitate human skin.

The first group of blocks was shot with the «Fort 12R» pistol, the second group with the «AE 790G1» pistol. In both groups, 9 mm elastic bullets of traumatic effect were used. Shots were fired from close range, 25 and 50 cm on the base of the Vinnytsia shooting range of the Scientific and Research Expert Forensic Center of the Ministry of Internal Affairs of Ukraine within 30 minutes from the moment the blocks were removed from the refrigerating chamber with prior fixation of the gun in the vices.

In accordance to the rules of forensic photography, the objects and the results of the study were photographed using a digital camera (camera «Alpha A6000 Sony»), followed by a study with an unaided eye of the soot deposition and the formation of ruptures on the covering material of the block or on the surface of the block itself, if it was bare.

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. formula:

$$t = \frac{P_1 - P_2}{\sqrt{\frac{N_1P_1 + N_2P_2}{N_1 + N_2} \times \left(100 - \frac{N_1P_1 + N_2P_2}{N_1 + N_2}\right) \times \frac{N_1 + N_2}{N_1N_2}}},$$

where, P1 and P2 are the percentages with which one or another indicator met;
N1 and N2 are the number of indicators in the studied groups.

Research results and their discussion. An analysis of indicators of soot deposition around incoming gunshot damage showed the following features when fired from the «Fort 12R» pistol:

when shots were fired *at close range* in all subgroups (both bare blocks and blocks covered with different fabrics), macroscopic layering of soot was noted in all studied blocks (100% in all cases);

when fired from *a distance of 25 cm* in bare blocks in all cases, macroscopically no soot layering was detected (0% in all cases), while when fired at covered blocks, soot was detected in all fired blocks (100% in all cases);

when fired from *a distance of 50 cm*, no soot was detected in any of the fired blocks (0% in all cases);

when comparing the frequency of soot deposition at different shooting distances on *bare blocks*, it is reliably ($p<0.0070$) more often observed when shooting from close range than 25 and 50 cm (100%, 0% and 0%, accordingly), when shooting at blocks covered with *cotton, denim* or *leatherette* is reliably ($p<0.0070$) more often observed when shooting from a distance of 25 than 50 cm (100%, 100% and 0%, respectively, in all cases).

The analysis of indicators of *soot deposition* around the incoming gunshot damage showed the following features when fired from the *«AE 790G1»* pistol:

when shots were fired *at close range*, there was a tendency (p=0.0763) of soot deposition when shots were fired at bare blocks, blocks covered with cotton and denim compared to leatherette (100%, 100%, 100% and 60%, accordingly);

when fired from a *distance of 25 cm and 50 cm*, the indicators were similar to those obtained when fired from *«Fort 12R».*

when comparing the frequency of soot deposition at different shot distances on *bare blocks*, blocks covered with *cotton* and *denim fabric*, the data were similar to those obtained with shots from *«Fort 12R».* Only when shots were fired into blocks covered with *leatherette*, when shots were fired from a distance of 25 cm, a tendency (p=0.0763) to soot deposition was observed compared to the distance at close range (100 and 60%, accordingly), and significantly more often (p<0.0070-0.0361) soot was deposited when shot from a distance of 25 cm and close range than when shot from a distance of 50 cm (100%, 60% and 0%, accordingly);

When analyzing the data on soot deposition between the «Fort 12R» and «AE 790G1» pistols, a trend (p=0.0763) was found for more frequent soot deposition when firing the block covered with leatherette with «Fort 12R» pistol at close range (100% and 60%, accordingly).

Analysis *of the number of ruptures* around the incoming gunshot damage revealed the following features when fired from the «*Fort 12R»* pistol:

when shooting *at close range*, significantly higher (p<0.05-0.01) values of the number of ruptures were observed when firing at bare blocks than blocks covered with cotton, denim, and leatherette (4.000, 0.800±1.789, 0.400±0.894, and 2,400±0,894, accordingly), significantly greater (p<0.05) values of the number of ruptures when shot leatherette than denim (2.400±0.894 and 0.400±0.894, accordingly) and a slight trend (p=0.095) to greater values when shot leatherette than cotton (2.400±0.894 and 0.800±1.789, accordingly);

when shooting from *a distance of 25 cm*, significantly higher (p<0.05) values of the number of ruptures were observed when shooting at bare blocks than at blocks covered with cotton and denim (1.800±1.095 and 0 and 0, accordingly), and significantly higher (p<0.05) the value of the number of ruptures when shot in leatherette compared to cotton and denim (1.600±1.342 and 0 and 0, accordingly);

when shooting from a *distance of 50 cm*, no significant differences or tendencies towards differences were detected;

when comparing the number of ruptures at different shot distances, significantly higher values (p<0.01) were found when shooting at *bare blocks* from a close range than 25 or 50 cm (4.000, 1.800±1.095 and 0.400±0.894, accordingly), a slight trend (p= 0.095) to higher values when shooting from a distance of 25 cm than 50 cm (1.800±1.095 and 0.400±0.894, accordingly) and significantly higher values (p<0.01) when shooting at a *leatherette* from a close range than 50 cm and from a distance of 25 cm than 50 cm (2.400±0.894 and 0 and 1.600±1.342 and 0, accordingly);

Analysis of *the number of ruptures* around the incoming gunshot damage revealed the following features when fired from the *«AE 790G1»* pistol:

when shooting *at close range* significantly higher (p<0.05-0.01) values of the number of ruptures were observed when shooting at bare blocks than covered with denim fabric (4,000 and 2,000 accordingly), cotton than denim (3,600±0,894 and 2,000 accordingly) and leatherette than denim fabric (3,600±0,548 and 2,000, accordingly);

when shooting from *a distance of 25 cm*, significantly higher (p<0.05) values of the number of ruptures were observed when shooting bare blocks than covered with denim fabric (1.600±1.140 and 0, accordingly), cotton than denim (2.800±1.789 and 0, accordingly) and a trend to a greater value of the number of ruptures when shot at leatherette than denim (0.600±1.342 and 0, accordingly);

when shooting from *a distance of 50 cm*, no significant differences or tendencies towards differences were detected;

when comparing the number of ruptures at different shooting distances, significantly higher values ($p<0.01$-0.05) were found when shooting *bare blocks* from a close range than 25 cm or 50 cm (4,000, 1,600±1,140 and 0, accordingly) and 25 cm than 50 cm (1,600±1,140 and 0, accordingly), when shooting at blocks covered with *cotton fabric* from a close range than 50 cm and 25 cm than 50 cm (3,600±0,894, 0,200±0,447 and 2,800±1,789, 0,200±0,447 accordingly), when shooting blocks covered with *denim fabric* from 25 cm and 50 cm (2,000 and 0 in both cases, accordingly), when shooting blocks covered with *leatherette* from 25 cm and 50 cm (3,600± 0.548, 0.600±1.342 and 3.600±0.548, 0 accordingly).

When comparing the data on the number of ruptures between the «Fort 12R» and «AE 790G1» pistols, significantly ($p<0.01$-0.05) higher values were found when firing with the «AE 790G1» from a close range into blocks covered with cotton and denim fabric (3.600±0.894, 0.800±1.789 and 2.000, 0.400±0.894, accordingly), when shot from 25 cm into blocks covered with cotton fabric (2.800±1.789 and 0, accordingly) and a slight tendency ($p=0.095$) to higher values when shot from «AE 790G1» from a close range into blocks covered with leatherette (3,600±0,548 and 2,400±0,894, accordingly).

Thus, there is again a trend toward more massive damage to clothing and the human body simulator with the «AE 790G1» pistol compared to the «Fort 12R», as in the past study, where there were significant higher values or trends toward higher values for the area index defect when fired with «AE 790G1» compared to «Fort 12R» [6].

The features of damage to various types of fabric when fired from the «Fort-12» at close range were studied by V. V. Shcherbak [7]. When the fabric was fixed in the frame, the following damage occurred: when shots were fired into the denim fabric, the number of radial ruptures was 2-4; when shooting at cotton fabric – 4; when shots were fired at cotton knitwear – multiple ruptures.

When firing at cotton fabric from different shooting distances, however, using the same «Fort-12» at a distance of up to 35 cm, soot deposition was visually detected, and at a shooting distance of more than 40 cm, it was no longer detected. [8].

When close-range shots were fired into the gelatin torso simulators of an adult man dressed in cotton knitwear, using «Fort-12RM», the researchers discovered the deposition of additional factors both from the outside and inside the investigated tissue, with the formation of soot deposits in the form of a drop or candle flame on the inner surface [9].

The authors of the study [10] discovered the following features of damage during shots from the «Fort-12RM» from different distances into cotton fabric without using a human body simulator under it: during close-range shots, the deposition of additional factors of the shot around the incoming damage was determined; at the shot distance of 25 cm and 50 cm, no soot was detected. The authors described the presence of tissue ruptures when shot at close range, but did not specify their number.

An experiment similar to the research method, but with the use of a «Fort-17R» pistol and a leatherette, was performed by a group of scientists led by P. Yu. Bobkov [11] established that in the cases of a shot at close range, 20 and 50 cm detected soot deposition (20 and 50 cm – microscopically), but no tissue ruptures were detected.

Conclusions. When firing from both «Fort 12R» and «AE 790G1», a deposit of soot around the incoming firing hole was observed in all the studied groups at close range (with the exception of shots with «AE 790G1» at leatherette) and at a distance of 25 cm (with the exception of groups of bare blocks). As with shots from «Fort 12R» and «AE 790G1» at a distance of 50 cm, no soot deposition was observed.

Close range shots from the «AE 790G1» into blocks covered with fabric and blocks covered with cotton fabric at a firing distance of 25 cm showed a significantly greater number or tendency toward more ruptures than similar groups shot with the «Fort 12R».

Prospects for further research. In the future, it is planned to investigate the specifics of damage to the human body simulator, namely using the calculation methods of Fackler and Malinowski (1985) – The total crack length method, Ragsdale and Josselson (1988) – The Fackler's wound profile method and Schyma (1998) – The polygon- procedure method that will allow to evaluate wound ballistics.

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ОСОБЛИВОСТІ ВІДКЛАДАННЯ КІПТЯВИ, РОЗРИВІВ ОДЯГУ ТА ІМІТАТОРА ТІЛА ЛЮДИНИ ПРИ ПОСТРІЛАХ З ПІСТОЛЕТІВ «ФОРТ 12Р» ТА «AE 790G1»

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Резюме. Дослідження макроскопічних особливостей пошкоджень одягу чи ушкоджень тіла людини, наявність додаткових чинників пострілу на ньому є одним з базових методів аналізу, що застосовують в судово-медичній криміналістиці. Поява нових різновидів вогнепальної зброї потребує відповідного проведення експериментальних досліджень з метою оновлення теоретичної бази даних експертів.

Мета роботи – дослідити особливості відкладання кіптяви, розривів одягу та імітатора тіла людини при використанні пістолетів «ФОРТ 12Р» та «AE 790G1».

Матеріал і методи. Для дослідження використано 120 желатинових блоків, що в подальшому або лишалися голими або покривалися одним з видів тканин: бавовняною, джинсовою тканиною чи шкірозамінником. Після чого відстрілювалися з відстаней впритул, 25 та 50 см з використанням пістолетів «ФОРТ 12Р» та «AE 790G1» з наступним аналізом макроскопічного відкладання кіптяви навколо вхідного вогнепального отвору та кількості розривів одягу або імітатора тіла людини, якщо постріл виконували в голий блок.

Результати. При аналізі відкладання кіптяви встановлено достовірно ($p<0,0070$) або тенденцію ($p=0,0763$, тільки для шкірозамінника) до її макроскопічного виявлення при пострілах впритул в усі досліджувані групи блоків та блоки, покриті одягом, при пострілах з відстані 25 см і відсутність кіптяви при пострілах з відстані 50 см при пострілах з обох пістолетів. При порівнянні даних щодо кількості розривів між пістолетами «Форт 12Р» та «AE 790G1» виявлено достовірні ($p<0,01-0,05$) більші значення при пострілах з «AE 790G1» з відстані впритул у блоки, вкриті бавовняною та джинсовою тканиною, при пострілі з 25 см у блоки, вкриті бавовняною тканиною, і незначну тенденцію ($p=0,095$) до більших значень при пострілах з «AE 790G1» з відстані впритул у блоки, вкриті шкірозамінником.

Висновки. При використанні пістолетів «ФОРТ 12Р» та «AE 790G1» практично не виявлено відмінностей у відкладанні кіптяви, проте при аналізі кількості розривів одягу та імітатора тіла людини виявлено більші значення при застосуванні пістолету «AE 790G1».

Ключові слова: вогнепальна травма; вогнепальні ушкодження; судово-медична експертиза; нелетальна зброя; кіптява; розриви одягу; вогнепальна зброя.

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