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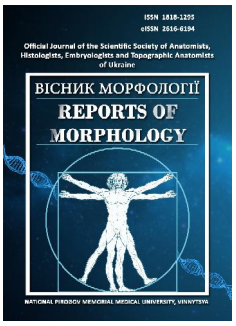

Comparison of temporal cavity indicators when firing "FORT 12R" and "AE 790G1" into a non-biological body simulator

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Gunshot injuries are extremely dangerous due to the extremely unpredictable compliance of ammunition after contact with the body. One of the key elements that takes place in this case is the formation due to high kinetic energy of a temporary cavity, which, despite its existence for a fraction of a second, causes severe damage to the tissues of the human body. The study of this phenomenon is one of the central elements of ballistics and requires an experiment on optically transparent media. The purpose of the study is to compare the parameters of the temporal cavity when fired from the "FORT 12R" and "AE 790G1" pistols into a non-biological simulator of the human body. To achieve the goal, 120 gelatin blocks were produced according to the generally accepted method, which were to be shot at close range, 25 and 50 cm. The blocks were left bare before shooting, or covered with cotton fabric, denim fabric or leatherette. After firing, transverse sections of the blocks were made in order to further measure the parameters of the temporary cavity formed as a result of the firing, according to generally accepted methods. The results of the analysis of the received data regarding the indicators characterizing the dimensions of the temporary cavity at different depths of the wound channel revealed a number of significant differences ($p<0.05$-0.01) between the studied pistols (in almost all cases, "AE 790G1" had larger values), groups of blocks covered with different types of fabrics, bare blocks (in almost all cases, the clothing had protective properties and reduced the size of the temporary cavity) and allowed to establish that during shots from the "FORT 12R" there was a sharp increase in the size of the temporary cavity with its sharp decrease at the end of the wound channel, while with shots from the "AE 790G1" the temporary cavity gradually increases, reaching a maximum at half the depth and then just as gradually decreases. Thus, when comparing the "FORT 12R" and "AE 790G1" pistols, differences in the features of the formation of the temporary cavity were revealed, which in turn is of interest not only for forensics, ballistics and forensic medicine, but also for clinical medicine.
Keywords: *gunshot injury, gunshot wounds, firearm, temporary cavity, imitator of the human body.*

Introduction

Gunshot injury is a common type of injury that often leads to death. The larger the caliber of the weapon, the greater the chance of a fatal outcome [2]. An analysis of the use of firearms in the city of Benin (Nigeria) from 1998 to 2002 showed 210 cases of fatal use of firearms. Most of them (88.1 %) were committed by criminals and a small part (9.0 %) by law enforcement agencies. 88.5 % of lethal use of weapons was murder, 4.3 % accidental and 0.5 % suicide [1]. Data from the National Electronic Injury Surveillance System in the USA showed that the death rate from the use of firearms is a fairly stable indicator and was 22 % in both 2003 and 2012 [5].

In Ukraine, the urgency of gunshot injury research has increased significantly since 2014 [15]. One of the peculiarities of this issue for Ukraine is the extreme urgency of studying gunshot injuries caused by non-lethal weapons, which are more widespread among different strata of the population, which is related to the peculiarity of the legal system.

One of the key tasks of ballistics is the study of projectile handling on the way to the target. We are talking about both pre-wound ballistics - how the projectile behaves when it comes into contact with the body, the impact of obstacles, weather factors, etc., and wound ballistics - the behavior of

the projectile in the object it hit, and first of all - the human body. In wound ballistics, a key place is occupied by the study of temporary cavities, formations that are the result of the transfer of excessive kinetic energy from the projectile to the surrounding tissues and fluids of the human body [4, 14].

One of the most effective and expedient methods of studying the temporal cavity is conducting ballistic experiments using a non-biological imitator of the human body, namely gelatin [3]. Due to the transparency and imitation of the physical characteristics of muscle and fat tissue, this material has become the most common. Also common practice is the use of time-lapse cameras, which allows recording processes lasting a fraction of a second [18] or combining gelatin with biological imitators of the human body [12]. At the same time, there are still ongoing discussions about the influence of various variables on the characteristics of gelatin, such as temperature factors, preparing features, etc. [13].

Taking into account the need to study the features of the temporary cavity for modern models of non-lethal firearms (primarily common in Ukraine), there is a need to conduct an experimental study on gelatin samples, taking into account the presence of obstacles in the form of clothing.

The purpose of the work is to conduct a comparative analysis of the indicators of the temporal cavity during shots from "FORT 12R" and "AE 790G1" pistols from different shooting distances into non-biological simulators of the human body covered and uncovered by various types of clothing.

Materials and methods

The study was performed on 120 gelatin blocks made according to the method of Fackler and Malinowski [6], divided into 2 groups of 60 blocks. Group 1 was subject to shooting using the "FORT 12R" pistol, group 2 - "AE 790G1" (both equipped with 9 mm cartridges, elastic bullets of traumatic effect). In each group, 4 subgroups of 15 blocks were formed: 1st group - bare blocks (BB), 2nd group - blocks covered with cotton fabric (CF), 3rd group - blocks covered with denim fabric (DF), 4th group - blocks covered with leatherette (LB). Shootings were carried out from contact range, 25 and 50 cm. After shooting, the blocks were examined according to The total crack length method [6], The Fackler's wound profile method [16] and The polygon-procedure method [17]. The results were photographed in accordance with the rules of forensic photography using an Alpha A6000 Sony digital camera.

The work was carried out as part of the research work of the National Pirogov Memorial Medical University, Vinnytsia 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).

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.

Results

TCLM values when fired from the "FORT 12R" and "AE 790G1" pistols have the following features: at a cut depth of 1 cm when fired at *contact range from the "FORT 12R" pistol*, significantly higher values ($p<0.05$-0.01) of the indicator were found at shots in BB, CF or LB compared to DF (87.16±8.09, 85.36±7.52, 87.16±14.45 and 66.16±9.05, respectively); when shooting from a *distance of 25 cm from the "FORT 12R" gun*, significantly higher values ($p<0.01$) of the indicator were found when shooting BBs compared to blocks covered with any types of fabrics (64.68±10.43, 10.42±3.56, 23.50±8.83 and 19.10±6.28, respectively) and significantly lower values ($p<0.05$-0.01) of the indicator when shooting in CF, compared to DF or LB (10.42±3.56, 23.50±8.83 and 19.10±6.28, respectively); when shooting from a *distance of 50 cm from the "FORT 12R" pistol*, significantly higher values ($p<0.05$) of the indicator were found when shooting at DF compared to BB or CF or LB (14.34±3.88, 7.860±2.862, 6.220±3.539 and 6.500±3.434, respectively); when comparing the values of the indicator when shooting from *"FORT 12R"* from different distances, significantly higher values ($p<0.05$-0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm, and when comparing the indicators at shooting distances 25 and 50 cm for all groups of blocks; when firing at *contact range from the "AE 790G1" pistol*, significantly lower values ($p<0.05$) of the indicator were found when firing at CF compared to DF or LB (75.38±23.23, 124.1±32.0 and 121.6±23.1, respectively); when shooting from a *distance of 25 cm from the "AE 790G1" gun*, significantly higher values ($p<0.05$-0.01) of the indicator were found when shooting BBs compared to blocks covered with fabrics (73.84±18.92, 32.10±19.26, 11.52±6.33 and 34.90±10.77, respectively); when comparing the values of the index when shooting from the *"AE 790G1"* from different distances, significantly lower values ($p<0.01$) of the index were found when shooting BBs from a distance of 50 cm compared to 25 cm and close (6.980±3.238, 73.84±18.92 and 87.22±25.76, respectively), significantly higher ($p<0.05$-0.01) values of the indicator when shooting in CF, DF at close range, compared to 25 and 50 cm (75.38±23.23, 32.10±19.26, 14.14±7.44 and 124.1±32.0, 11.52±6.33, 11.62±6.03

respectively) and significantly higher values (p<0.01) of the indicator at close range shots, compared to the shot distance of 25 cm, 50 cm and when comparing the indicators at the shot distances of 25 and 50 cm in LB (121.6±23.1, 34.90±10.77 and 6.160±3.607 in accordance). When comparing the values of the indicator when fired from the "FORT 12R" and "AE 790G1" pistols, its values were significantly higher (p<0.05-0.01) when fired from the "AE 790G1" when fired at close range in DF, LB and when fired from a distance of 25 cm in LB (124.1±32.0 and 66.16±9.05, 121.6±23.1 and 87.16±14.45, 34.90±10.77 and 19.10±6.28, respectively), and higher values when using "FORT 12R" only when shooting from a distance of 25 cm in DF (23.50±8.83 and 11.52±6.33, respectively);

at a cut depth of 2 cm when *contact shots from the "FORT 12R" pistol* revealed significantly lower values (p<0.05) of the indicator when shooting BB compared to LB (72.48±15.78 and 91.68±8.19 respectively); when fired from a *distance of 50 cm from the "FORT 12R" gun*, significantly lower (p<0.05-0.01) values of the indicator were found when fired at BB, CF and LB blocks, compared to DF (3.360±1.704, 3.300±3.213, 2.860±3.916 and 9.460±2.333, respectively); when comparing the values of the indicator when shooting from *"FORT 12R"* from different distances, significantly higher values (p<0.05-0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm, and when comparing the indicators at shooting distances 25 and 50 cm for both BB and LB (72.48±15.78, 16.58±10.64, 3.360±1.704 and 91.68±8.19, 9.300±2.570, 2.860±3.916, respectively) and also significantly higher values (p<0.01) of the indicator at close range shots compared to the shot distance of 25 cm, 50 cm for CF and DF (84.02±13.17, 7.760±2.162, 3.300±3.213 and 86.58± 13.57, 11.76±8.19 and 9.460±2.333, respectively); when *contact shots from the "AE 790G1" pistol* revealed significantly higher values (p<0.05-0.01) of the indicator when shooting at DF compared to BB and CF (156.3±22.6, 101.8±19.8 and 121.9±15.5, respectively); when shooting from a *distance of 25 cm from the "AE 790G1" pistol*, significantly higher values (p<0.05) of the indicator were found when shooting at BB or CF compared to DF, LB (35.24±13.75, 27.76±4.75, 15.30±6.89 and 19.84±6.07, respectively); when shooting from a *distance of 50 cm from the "AE 790G1" pistol*, significantly lower values (p<0.05-0.01) of the indicator were found when shooting BBs compared to covered blocks (0.460±1.029, 11.22±4.66, 7.254±8.344 and 5.080±3.235, respectively) and significantly higher values (p<0.05) of the indicator when shooting in CF than LB (11.22±4.66 and 5.080±3.235, respectively); when comparing the values of the indicator when shooting with the *"AE 790G1"* from different distances, significantly higher values (p<0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm, and when comparing the indicators at the shooting distances of 25 and 50 cm both for BB and CF or LB (101.8±19.8, 35.24±13.75, 0.460±1.029 and 121.9±15.5, 27.76±4.75, 11.22±4.66 and 129.4±34.8, 19.84±6.07, 5.080±3.235, respectively) and significantly higher values (p<0.01) of the indicator when shooting at close range, compared to the shooting distance of 25 cm, 50 cm when shooting in DF (156.3±22.6, 15.30±6.89 and 7.254±8.344, respectively); when comparing the values of the indicator when fired from the "FORT 12R" and "AE 790G1" pistols, it is significantly higher (p<0.05-0.01), its values were found when fired from the "AE 790G1" when fired at close range and 25 cm in BB (101.8±19.8, 35.24±13.75 and 72.48±15.78, 16.58±10.64, respectively), when shooting from all distances in CF (121.9±15.5, 27.76±4.75, 11.22±4.66 and 84.02±13.17, 7.760±2.162, 3.300±3.213, respectively), when shooting at close range in DF (156.3±22.6 and 86.58 ±13.57, respectively) and 25 cm in LB (19.84±6.07 and 9.300±2.570, respectively); significantly higher (p<0.05) values were found when firing "FORT 12R" BBs from a distance of 50 cm (3.360±1.704 and 0.460±1.029, respectively);

at a cut depth of 3 cm when *contact shots from the "FORT 12R" pistol* revealed significantly lower values (p<0.01) of the index when shooting BBs compared to blocks covered with fabrics (25.34±7.69, 88.28±15.13, 76.36±17.24 and 52.70±10.32, respectively) and significantly lower values (p<0.05) of the indicator when shooting at LB compared to CF or DF (52.70±10.32, 88.28±15.13 and 76.36±17.24, respectively); when shooting from a *distance of 25 cm from the "FORT 12R" pistol*, significantly lower values (p<0.05-0.01) of the indicator were found when shooting at BB, LB and CF and DF (0, 0, 5.060±3.159 and 5.340±3.727 in accordance); when comparing the values of the indicator when shooting with *"FORT 12R"* from different distances, significantly higher values (p<0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm when shooting at BB and LB (25.34±7.69, 0, 0.560±1.252 and 52.70±10.32, 0,0 respectively) and significantly higher values (p<0.05-0.01) of the indicator when shooting at close range, compared to a shot distance of 25 cm, 50 cm and when comparing indicators at shot distances of 25 and 50 cm for both CF and DF (88.28±15.13, 5.060±3.159, 0.860±1.923 and 76.36±17.24, 5.340±3.727 and 0, 0 respectively); when *contact shots from the "AE 790G1" pistol* revealed significantly lower values (p<0.05-0.01) of the indicator when shooting at BB compared to CF or DF (63.50±15.12, 105.0±24.8 and 106.1±16.1, respectively); when comparing the values of the indicator when shooting from the *"AE 790G1"* from different distances, significantly higher values (p<0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm when shooting at all groups of blocks (63.50±15.12, 0, 0 and 105.0±24.8, 4.540±4.194, 1.620±3.622 and 106.1±16.1, 1.060±2.370, 0 and 87.46±24.29, 0, 0, respectively); when comparing the values of the indicator when fired from

pistols "FORT 12R" and "AE 790G1" significantly higher (p<0.05-0.01), its values were found when fired from "AE 790G1" when fired at close range in BB and DF or LB (63.50±15.12 and 25.34±7.69, 106.1±16.1 and 76.36±17.24, 87.46±24.29 and 52.70±10.32, respectively);

at a cut depth of 4 cm when *contact shots from the "FORT 12R" pistol* revealed significantly lower values (p<0.01) of the index when shooting BBs compared to blocks covered with fabrics (0, 59.98±12.81, 66.80±17.45 and 28.40±6.97, respectively) and significantly lower values (p<0.01) of the indicator when shooting in LB compared to CF or DF (28.40±6.97, 59.98±12.81 and 66.80±17.45, respectively); when comparing the values of the indicator when shooting from *"FORT 12R"* from different distances, significantly higher values (p<0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm when shooting at all groups of blocks covered with fabrics (59.98±12.81, 0.260±0.581, 0 and 66.80±17.45, 0, 0 and 28.40±6.97, 0, 0, respectively); when *contact shots from the "AE 790G1" pistol* revealed significantly lower values (p<0.05-0.01) of the index when shooting BBs compared to blocks covered with fabrics (19.58±15.00, 60.48±10.73, 63.14±24.44 and 59.48±13.16, respectively); when comparing the values of the indicator when fired from the "AE 790G1" from different distances, significantly higher values (p<0.05-0.01) of the indicator were found when fired at close range, compared to a shot distance of 25 cm, 50 cm when fired at all groups of blocks (19.58±15.00, 0, 0 and 60.48±10.73, 0, 0 and 63.14±24.44, 0, 0 and 59.48±13.16, 0, 0, respectively); when comparing the values of the indicator when fired from "FORT 12R" and "AE 790G1" pistols, significantly higher (p<0.05-0.01) its values were found when fired from "AE 790G1" when fired at close range in BB and LB (19.58±15.00 and 0, 59.48±13.16 and 28.40±6.97, respectively);

at a cut depth of 5 cm when *contact shots from the "FORT 12R" pistol* revealed significantly lower values (p<0.01) of the indicator when shooting at BB or LB compared to CF or DF (0, 0, 24.26±10.75 and 40.16±15.03, respectively); when comparing the values of the indicator when shooting with *"FORT 12R"* from different distances, significantly higher values (p<0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm when shooting at CF or DF (24.26±10.75, 0, 0 and 40.16±15.03, 0, 0, respectively); when *contact shots from the "AE 790G1" pistol* revealed significantly higher values (p<0.05-0.01) of the indicator when shooting in CF compared to BB and DF or LB (37.80±6.97, 0, 12.58 ±12.39 and 18.78±17.41, respectively); when comparing the values of the indicator when shooting from *"AE 790G1"* from different distances, significantly higher values (p<0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm when shooting at CF (37.80±6.97, 0 and 0 respectively); when comparing the values of the indicator when fired from "FORT 12R" and "AE 790G1" pistols, its values were significantly higher (p<0.05) when fired at close range from "FORT 12R" in DF (40.16±15.03 and 12.58±12.39, respectively).

The *FWPM* values when fired from the "FORT 12R" and "AE 790G1" pistols have the following features: at a cut depth of 1 cm when fired at *contact range from the "FORT 12R" pistol*, significantly lower values (p<0.05) of the indicator were found when fired at LB compared to with BB and CF (11.60±1.78, 14.88±1.61 and 14.78±0.89, respectively); when shooting from a *distance of 25 cm from the "FORT 12R" pistol*, significantly higher values (p<0.05-0.01) of the indicator were found when shooting at BB compared to CF or LB (14.68±0.40, 5.800±1.528 and 10.42±2.74, respectively); when comparing the values of the indicator when shooting from *"FORT 12R"* from different distances, significantly higher values (p<0.05-0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm when shooting at CF (14.78±0.89, 5.800±1.528 and 5.840±3.537, respectively), when shooting at close range, 50 cm and 25 and 50 cm in BB and LB (14.88±1.61, 6.960±2.174 and 14.68±0.40, 6.960±2.174, 11.60±1.78, 4.840±2.232 and 10.42±2.74, 4.840±2.232, respectively), when shooting at close range compared to 50 cm when shooting at DF (14.48±2.98 and 7.360±1.679, respectively); when *contact shots from the "AE 790G1" pistol* revealed significantly lower values (p<0.05-0.01) of the indicator when shooting BBs compared to blocks covered with fabric (15.64±2.37, 21.96±3.01, 31.98±3.42 and 30.52±3.50, respectively) and when shot in CF compared to other tissue types (21.96±3.01, 31.98±3.42 and 30.52±3.50 respectively); when shooting from a distance of 25 cm from the *"AE 790G1"* pistol, significantly higher values (p<0.01) of the indicator were found when shooting at BB or LB compared to CF or DF (16.08±0.91, 18.32±2.69 and 9.960±3.807, 6.940±3.190, respectively); when comparing the values of the indicator when shooting from the "AE 790G1" from different distances, significantly higher values (p<0.01) of the indicator were found when shooting at close range, compared to the distance of a shot of 25 cm, 50 cm when shooting at CF and DF (21.96±3.01, 9.960±3.807, 8.360±3.679 and 31.98±3.42, 6.940±3.190, 6.000±2.035, respectively), for close shots compared to 25 cm shot distance, and 25 cm compared to 50 cm shots in BB (15.64±2.37, 6.260±2.422 and 16.08±0.91, 6.260±2.422, respectively), shots at close range, compared to shot distances of 25 cm, 50 cm and when comparing indicators at shot distances of 25 and 50 cm in LB (30.52±3.50, 18.32±2.69 and 4.780±2.084, respectively); when comparing the values of the indicator when fired from the "FORT 12R" and "AE 790G1" pistols, it is significantly higher (p<0.05-0.01), its values were found when fired at close range with the "AE 790G1" into blocks covered with fabrics and blocks covered with LB with distance of 25 cm (21.96±3.01 and 14.78±0.89, 31.98±3.42 and 14.48±2.98, 30.52±3.50 and 11.60±1, 78, 18.32±2.69 and 10.42±2.74,

respectively);

at a cut depth of 2 cm when *contact shots from the "FORT 12R" pistol* revealed significantly higher values ($p<0.05$) of the indicator when shooting at DF compared to BB and CF (7.380±1.633, 3.360±1.704, 2.920±2.699, respectively); when comparing the values of the indicator when shooting from "FORT 12R" from different distances, significantly higher values ($p<0.05$-0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm, and when comparing the indicators at shooting distances 25 and 50 cm in BB (17.38±2.36, 10.36±3.47 and 3.360±1.704, respectively), when shooting at close range, compared to 25 cm, 50 cm shot distance in CF or LB (14.94±2.00, 6.400±1.075, 2.920±2.699 and 16.94±1.50, 7.320±1.383, 2.860±3.916, respectively), when shooting at close range, compared to 50 cm shooting distance in DF (20.24±4.43 and 7.380±1.633, respectively); when *contact shots from the "AE 790G1" pistol* revealed significantly lower values ($p<0.05$-0.01) of the index when shooting BBs compared to blocks covered with fabric (21.00±2.60, 33.10±4.78, 41.04±1.60 and 39.56±2.35, respectively) and when shot in CF compared to other tissue types (33.10±4.78, 41.04±1.60 and 39.56±2.35 respectively); when fired from a distance of 25 cm from the "AE 790G1" pistol, significantly lower values ($p<0.05$) of the indicator were found when fired at DF compared to blocks covered with other fabrics (10.44±1.79, 14.64±2.02 and 14.80±2.34, respectively); when shooting from a *distance of 50 cm from the "AE 790G1" pistol*, significantly lower values ($p<0.05$-0.01) were found when shooting BBs compared to covered blocks (0.460±1.029, 8.060±3.015, 3.388±3.737 and 4.660±2.528, respectively) and when shooting in DF compared to CF (3.388±3.737 and 8.060±3.015, respectively); when comparing the values of the indicator when shooting with the "AE 790G1" from different distances, significantly higher values ($p<0.05$-0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm, and when comparing the indicators at the shooting distances 25 and 50 cm in all groups of blocks; when comparing the values of the indicator when fired from the "FORT 12R" and "AE 790G1" pistols, it is significantly higher ($p<0.05$-0.01), its values were found when fired at close range with the "AE 790G1" into blocks covered with fabrics and at a shot distance of 25 cm for CF and LB and for 50 cm only for CF (33.10±4.78 and 14.94±2.00, 41.04±1.60 and 20.24±4.43, 39.56±2.35 and 16.94±1.50, 14.64±2.02 and 6.400±1.075, 14.80±2.34 and 7.320±1.383, 8.060±3.015 and 2.920±2.699, respectively), and significantly greater ($p<0.05$) values found when shooting from a distance of 50 cm in BB with "FORT 12R" (3.360±1.704 and 0.460±1.029, respectively);

at a cut depth of 3 cm when *contact shots from the "FORT 12R" pistol* revealed significantly lower values ($p<0.05$-0.01) of the indicator when shooting BB compared to CF or DF (15.44±3.50, 21.06±1.83 and 27.34±4.88, respectively), and when shooting in LB, compared to DF (20.14±4.04 and 27.34±4.88, respectively); when shooting from a *distance of 25 cm from the "FORT 12R" pistol*, significantly lower values ($p<0.05$-0.01) of the indicator were found when shooting at BB or LB compared to CF and DF (0, 0, 4.360±2.629 and 5.340±3.727 respectively); when comparing the values of the indicator when shooting from "FORT 12R" from different distances, significantly higher values ($p<0.05$-0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm, and when comparing the indicators at shooting distances 25 and 50 cm in CF or DF (21.06±1.83, 4.360±2.629, 0.860±1.923 and 27.34±4.88, 5.340±3.727, 0 respectively), and when shooting up close, compared to distance shot 25 cm, 50 cm in BB and LB (15.44±3.50, 0, 0.560±1.252 and 20.14±4.04, 0, 0); when *contact shots from the "AE 790G1" pistol* revealed significantly lower values ($p<0.01$) of the indicator when shooting BBs compared to blocks covered with clothing (24.28±2.89, 39.16±5.46, 41.76±5.84 and 42.06±6.90, respectively); when comparing the values of the indicator when shooting with *"AE 790G1"* from different distances, significantly higher values ($p<0.01$) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm for all groups of blocks (24.28±2.89, 0, 0 and 39.16±5.46, 3.640±3.384, 1.620±3.622 and 41.76±5.84, 1.060±2.370, 0 and 42.06±6.90, 0, 0, respectively); when comparing the values of the indicator when fired from "FORT 12R" and "AE 790G1" pistols, its values were significantly higher ($p<0.01$) when fired at close range with *"AE 790G1"* at all groups of blocks (24.28±2.89 and 15.44±3.50, 39.16±5.46 and 21.06±1.83, 41.76±5.84 and 27.34±4.88, 42.06±6.90 and 20.14±4.04, respectively);

at a cut depth of 4 cm when *contact shots from the "FORT 12R" pistol* revealed significantly lower values ($p<0.01$) of the index when shooting BBs compared to blocks covered with clothing (0, 20.80±2.62, 26.42±3.97, 17.36±3.24, respectively) and significantly higher values ($p<0.05$-0.01) of the indicator when shooting in DF compared to CF and LB (26.42±3.97, 20.80±2.62 and 17.36±3.24, respectively); when comparing the values of the indicator when shooting from *"FORT 12R"* from different distances, significantly higher values ($p<0.01$) of the indicator were found when shooting at close range, compared to the distance of a shot of 25 cm, 50 cm into blocks covered with clothing (20.80±2.62, 0.180±0.402, 0 and 26.42±3.97, 0, 0 and 17.36±3.24, 0, 0, respectively); when *contact shots from the "AE 790G1" pistol* revealed significantly lower values ($p<0.01$) of the indicator when shooting BBs compared to blocks covered with clothing (11.92±7.74, 38.86±2.09, 34.48±6.67 and 39.30±3.71, respectively); when comparing the values of the indicator when shooting from *"AE 790G1"* from different distances, significantly higher values ($p<0.05$-0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm for all groups of

blocks (11.92±7.74, 0.0 and 38.86±2.09, 0, 0 and 34.48±6.67, 0, 0 and 39.30±3.71, 0, 0, respectively); when comparing the values of the indicator when fired from the "FORT 12R" and "AE 790G1" pistols, it is significantly higher (p<0.05-0.01), its values were found when fired at close range with the "AE 790G1" into all groups of blocks (11.92±7.74 and 0, 38.86±2.09 and 20.80±2.62, 34.48±6.67 and 26.42±3.97, 39.30±3.71 and 17.36±3.24 respectively);

at a cut depth of 5 cm when *contact shots from the "FORT 12R" pistol* revealed significantly lower values (p<0.01) of the indicator when shooting at BB or LB compared to CF and DF (0, 0 and 14.76±5.25, 20.10±4.33, respectively); when comparing the values of the indicator when shooting with *"FORT 12R"* from different distances, significantly higher values (p<0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm in CF and DF (14.76±5, 25, 0.0 and 20.10±4.33, 0.0, respectively); when *contact shots from the "AE 790G1" pistol* revealed significantly higher values (p<0.05-0.01) of the indicator when shooting in CF compared to other groups of blocks (28.50±2.05, 0, 11.34±11.16 and 15.12±13.84, respectively); when comparing the values of the indicator when shooting with the *"AE 790G1"* from different distances, significantly higher values (p<0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm for CF (28.50±2.05, 0 and 0 respectively); when comparing the values of the indicator when fired from the "FORT 12R" and "AE 790G1" pistols, its values were significantly higher (p<0.01) when fired at close range with the "AE 790G1" in CF (28.50±2.05 and 14.76±5.25, respectively).

PPM values when fired from "FORT 12R" and "AE 790G1" pistols have the following features: at a cut depth of 1 cm when fired at *contact range from a "FORT 12R" pistol*, significantly lower values (p<0.05) of the indicator were found when fired at DF compared to with LB (64.76±6.98 and 71.98±6.73, respectively); when shooting from a *distance of 25 cm from the "FORT 12R" pistol*, significantly higher values (p<0.01) of the indicator were found when shooting BBs compared to blocks covered with fabrics (53.20±6.37, 20.92±4.46, 28.68±6.11 and 27.72±10.01, respectively); when shooting from a *distance of 50 cm from the "FORT 12R" pistol*, significantly higher values (p<0.05) of the indicator were found when shooting at DF compared to BB and CF (21.44±5.57, 7.380±4.601 and 7.600±4.710, respectively); when comparing the values of the indicator when shooting from *"FORT 12R"* from different distances, significantly higher values (p<0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm, and when comparing the indicators at the shooting distances of 25 and 50 cm in BB and CF (67.18±3.05, 53.20±6.37, 7.380±4.601 and 66.06±3.58, 20.92±4.46, 7.600±4.710, respectively), when shooting at close range, compared to the shot distance of 25 cm, 50 cm in DF and LB (64.76±6.98, 28.68±6.11, 21.44±5.57 and 71.98±6.73, 27.72±10.01, 15.46±10.42, respectively); when *shooting at contact range from the "AE 790G1" pistol*, significantly lower values (p<0.05-0.01) of the indicator were found when shooting at BB or CF compared to DF or LB (77.70±10.48, 89.82±17.42 and 114.3±10.3, 118.7±10.0, respectively); when shots from *distance 25 cm by "AE 790G1" pistol* revealed significantly higher values (p<0.05-0.01) of the index when shooting BBs compared to blocks covered with clothing (54.22±4.42, 38.98±15.76, 25.92±13.33 and 46.56±10.44, respectively), and LB compared to DF (46.56±10.44 and 25.92±13.33, respectively); when comparing the values of the indicator when shooting with the *"AE 790G1"* from different distances, significantly higher values (p<0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm, and when comparing the indicators at the shooting distances of 25 and 50 cm in BB and LB (77.70±10.48, 54.22±4.42, 13.22±12.30 and 118.7±10.0, 46.56±10.44, 14.82±9.31, respectively), when shooting at close range, compared to a shot distance of 25 cm, 50 cm in CF or DF (89.82±17.42, 38.98±15.76, 23.18±7.42 and 114.3±10.3, 25.92±13.33, 24.52±11.68, respectively); when comparing the values of the indicator when fired from "FORT 12R" and "AE 790G1" pistols, it is significantly higher (p<0.05-0.01), its values were found when fired at close range with "AE 790G1" into blocks covered with fabrics, at a distance of 25 cm in LB and 50 cm in CF (89.82±17.42 and 66.06±3.58, 114.3±10.3 and 64.76±6.98, 118.7±10.0 and 71.98±6.73, 46.56±10.44 and 27.72±10.01, 23.18±7.42 and 7.600±4.710, respectively);

at a cut depth of 2 cm when *contact shots from the "FORT 12R" pistol* revealed significantly lower values (p<0.05-0.01) of the index when shooting BBs compared to blocks covered with fabrics (67.38±7.23, 77.14±3.73, 81.08±8.86 and 82.70±5.62, respectively), CF compared to LB (77.14±3.73 and 82.70±5.62, respectively); when fired from a *distance of 25 cm from the "FORT 12R" pistol*, significantly lower values (p<0.05) of the indicator were found when fired at CF compared to LB (15.16±7.39 and 27.32±9.28, respectively); when shooting from a *distance of 50 cm from the "FORT 12R" pistol*, significantly higher values (p<0.05-0.01) of the indicator were found when shooting at DF compared to BB and LB (11.92±6.26, 3.360±1.704 and 1.900±3.087, respectively); when comparing the values of the indicator when shooting from *"FORT 12R"* from different distances, significantly higher values (p<0.05-0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm, and when comparing the indicators at shooting distances 25 and 50 cm in BB and LB (67.38±7.23, 29.12±18.89, 3.360±1.704 and 82.70±5.62, 27.32±9.28, 1.900±3.087, respectively), at close range shots, compared to 25 cm, 50 cm shot distance in CF and DF (77.14±3.73, 15.16±7.39, 8.960±10.31 and 81.08±8.86, 17.40±14.28, 11.92±6.26, respectively); when *contact shots from the "AE 790G1" pistol* revealed significantly lower values (p<0.05-

0.01) of the index when shooting BBs compared to blocks covered with clothing (90.10±5.55, 111.5±12.8, 133.9±11.8 and 161.0±49.7, respectively) and CF compared to DF or LB (111.5±12.8, 133.9±11.8 and 161.0±49.7, respectively); when shooting from a *distance of 25 cm from the "AE 790G1" pistol*, significantly higher values (p<0.05-0.01) of the indicator were found when shooting at BB compared to CF or DF (45.10±4.89, 31.44±16.50 and 19.58±9.88, respectively); when shooting from a *distance of 50 cm from the "AE 790G1" pistol*, significantly lower values (p<0.05-0.01) of the index were found when shooting BBs compared to blocks covered with fabrics (0.460±1.029, 24.50±9.74, 16.43±12.53 and 6.660±4.230, respectively), LB compared to CF (6.660±4.230 and 24.50±9.74, respectively); when comparing the values of the indicator when shooting from the *"AE 790G1"* from different distances, significantly higher values (p<0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm, and when comparing the indicators at the shooting distances of 25 and 50 cm in BB and LB (90.10±5.55, 45.10±4.89, 0.460±1.029 and 161.0±49.7, 38.30±15.45, 6.660±4.230, respectively), when shooting at close range, compared to the shot distance of 25 cm, 50 cm in CF and DF (111.5±12.8, 31.44±16.50, 24.50±9.74 and 133.9±11.8, 19.58±9.88, 16.43±12.53, respectively); when comparing the values of the indicator when fired from "FORT 12R" and "AE 790G1" pistols, it is significantly higher (p<0.05-0.01), its values were found when fired at close range with "AE 790G1" at all groups of blocks (90.10±5.55 and 67.38±7.23, 111.5±12.8 and 77.14±3.73, 133.9±11.8 and 81.08±8.86, 161.0±49, 7 and 82.70±5.62, respectively) and when fired from a distance of 50 cm with "FORT 12R" in BB (3.360±1.704 and 0.460±1.029, respectively);

at a cut depth of 3 cm when *contact shots from the "FORT 12R" pistol* revealed significantly lower values (p<0.05-0.01) of the index when shooting BBs compared to blocks covered with clothing (32.42±18.64, 79.38±2.30, 85.30±8.74 and 70.22±11.39, respectively) and LB compared to DF (70.22±11.39 and 85.30±8.74, respectively); when shooting from a *distance of 25 cm from the "FORT 12R" pistol*, significantly lower values (p<0.05-0.01) of the indicator were found when shooting at BB or LB compared to CF and DF (0, 0 and 9.180±8.036, 4.440±4,014 respectively); when comparing the values of the indicator when shooting from "FORT 12R" from different distances, significantly higher values (p<0.05-0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm, and when comparing the indicators at shooting distances 25 and 50 cm in CF and DF (79.38±2.30, 9.180±8.036, 0.860±1.923 and 85.30±8.74, 4.440±4.014, 0, respectively), when shot at close range, compared to a shot distance of 25 cm, 50 cm in BB and LB (32.42±18.64, 0, 0.560±1.252 and 70.22±11.39, 0, 0, respectively); when *contact shots from the "AE 790G1" pistol* revealed significantly lower values (p<0.01) of the indicator when shooting BBs compared to blocks covered with clothing (81.64±5.41, 111.8±10.0, 118.2±11.8 and 119.3±18.6, respectively); when comparing the values of the indicator when shooting with *"AE 790G1"* from different distances, significantly higher values (p<0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm for all groups of blocks (81.64±5.41, 0, 0 and 111.8±10.0, 6.500±6.398, 1.620±3.622 and 118.2±11.8, 1.040±2.326, 0 and 119.3±18.6, 0, 0 respectively); when comparing the values of the indicator when fired from "FORT 12R" and "AE 790G1" pistols, its values were significantly higher (p<0.01) when fired at close range with "AE 790G1" in all groups of blocks (81.64±5.41 and 32.42±18.64, 111.8±10.0 and 79.38±2.30, 118.2±11.8 and 85.30±8.74, 119.3±18.6 and 70, 22±11.39, respectively);

at a cut depth of 4 cm when *contact shots from the "FORT 12R" pistol* revealed significantly lower values (p<0.01) of the index when shooting BBs compared to blocks covered with clothing (0, 70.60±7.19, 80.24±6.39 and 44.84±11.32, respectively) and LB compared to CF or DF (44.84±11.32, 70.60±7.19, 80.24±6.39, respectively); when comparing the values of the indicator when shooting with "FORT 12R" from different distances, significantly higher values (p<0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm in groups of blocks covered with clothing (70.60±7.19, 2.040±4.562, 0 and 80.24±6.39, 0, 0 and 44.84±11.32, 0, 0, respectively); when *contact shots from the "AE 790G1" pistol* revealed significantly lower values (p<0.01) of the indicator when shooting BBs compared to blocks covered with clothing (35.96±25.45, 96.32±12.52, 85.92 ±17.00 and 95.90±15.64, respectively); when comparing the values of the indicator when shooting with *"AE 790G1"* from different distances, significantly higher values (p<0.05-0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm for all groups of blocks (35.96±25.45, 0, 0 and 96.32±12.52, 0, 0 and 85.92±17.00, 0, 0 and 95.90±15.64, 0, 0, respectively); when comparing the values of the indicator when fired from "FORT 12R" and "AE 790G1" pistols, significantly higher (p<0.05-0.01) its values were found when fired at close range with "AE 790G1" in groups of BB, CF and LB blocks (35.96±25.45 and 0, 96.32±12.52 and 70.60±7.19, 95.90±15.64 and 44.84±11.32, respectively);

at a cut depth of 5 cm when *contact shots from the "FORT 12R" pistol* revealed significantly lower values (p<0.01) of the indicator when shooting at BB or LB compared to CF and DF (0, 0 and 35.12±9.92, 49.56±19.01, respectively); when comparing the values of the indicator when shooting from *"FORT 12R"* from different distances, significantly higher values (p<0.01) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm in CF or DF (35.12±9.92, 0, 0 and 49.56±19.01, 0, 0, respectively); when *contact shots*

from the "AE 790G1" pistol revealed significantly lower values ($p<0.01$) of the indicator when shooting BBs compared to CF (0 and 42.58±19.78, respectively); when comparing the values of the indicator when shooting from the *"AE 790G1"* from different distances, significantly higher values ($p<0.01$) of the indicator were found when shooting at close range, compared to the shooting distance of 25 cm, 50 cm for CF (42.58±19.78, 0 and 0 respectively); when comparing the values of the indicator when fired from the "FORT 12R" and "AE 790G1" pistols, its values were significantly higher ($p<0.05$) when fired at close range from the "FORT 12" in DF (49.56±19.01 and 17.06±18.04, respectively).

Since the cut depth of 6 cm was reached only by ammunition when fired at contact range with "FORT 12R" in DF, it was not possible to conduct any comparative analysis for *TCLM, FWPM* and *PPM* indicators.

Discussion

The results obtained by us agree quite well with the conclusions of the previous work, which also noted mainly higher damage values when fired from the "AE 790G1" pistol compared to the "FORT 12R" [9].

At the same time, the difference in the indicators of the temporary cavity when firing from "FORT 12R" draws attention. In contrast to the data of our research, the team of authors led by V. Gunas [7] established that "FORT 12R" forms an amphora-like profile of the temporary cavity, which is more reminiscent of the data obtained when fired with "AE 790G1". The explanation of this phenomenon can be both the design features of the "FORT 12RM" or the cartridges for it (this gun is produced with specific 45 Rubber bullets), and the features of the experimental model performed in the study (instead of blocks, shots were fired into torso simulators).

V. V. Shcherbak [20, 21] in his publications investigated the parameters of the temporary cavity formed during the firing of the combat pistols "FORT 12" and "FORT 12TP". At the same time, he noted the differences between the parameters of the cavities in the cases of the use of pistols: when fired with "FORT 12", the parameters of the cavity had a wave-like character (high indicators within the depth range of 6-10 cm) and reached a maximum at a depth of 15-23 cm, while "FORT 12TP" high cavity indicators were observed at depths of 4-10 cm and maximum at 16-24 cm.

As for the influence of layers of clothing on the parameters of gunshot damage, the opinion of the general public of scientists is unequivocal regarding the importance of taking into account the results of experimental ballistic studies using covering material on targets. Such conclusions were proved as a result of experimental studies by T. Stevenson [22] with co-authors in the study of military clothing, D. C. Kieser [8] and colleagues in the study of denim fabric and P. F. Mahoney [11] and others in the study of helmets.

The continuation of discussions regarding the optimal model for conducting a ballistic experiment was also noted. Thus, data on greater consistency of results when using a biological imitator of the human body and 20 % but not 10 % gelatin solutions were found [10], and the high value of using a support for the target during ballistic studies, especially if the target is small, was noted [19].

Conclusions

1. The use of the "AE 790G1" gun leads to the formation of a larger temporary cavity compared to the "FORT 12R".

2. All types of clothing used in the study contributed to the reduction of the temporary cavity indicators, thus showing protective properties that were most noticeable when fired from a distance of 25 cm.

3. When firing from "FORT 12R", the formation of a temporary cavity is noted, resembling in shape a jug with a wide base, which narrows sharply at the end, while when firing from "AE 790G1" a temporary cavity is formed, resembling an amphora with a thin base, which then expands and gradually narrows at the end.

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ПОРІВНЯННЯ РОЗМІРІВ ТИМЧАСОВОЇ ПОРОЖНИНИ ПРИ ПОСТРІЛАХ З ПІСТОЛЕТІВ "FORT 12R" ТА "AE 790G1" В НЕБІОЛОГІЧНИЙ ІМІТАТОР ТІЛА

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Вогнепальні ушкодження є вкрай небезпечними за рахунок непередбачуваного поводження боєприпасу після контакту з тілом. Одним із ключових елементів, що має місце при цьому, це утворення за рахунок високої кінетичної енергії тимчасової порожнини, що, незважаючи на своє існування на лічені долі секунди, призводить до важких ушкоджень тканин тіла людини. Дослідження цього явища є одним із центральних елементів балістики і вимагає проведення експерименту на оптично прозорих середовищах. Метою дослідження є порівняння показників тимчасової порожнини при пострілах із пістолетів "FORT 12R" та "AE 790G1" у небіологічний імітатор тіла людини. Для досягнення поставленої мети за загальноприйнятою методикою були виготовлені 120 желатинових блоків, які підлягали відстрілу з відстаней впритул, 25 та 50 см. Блоки перед відстрілом залишали ненакритими, або покривали бавовняною тканиною, джинсовою тканиною чи шкірозамінником. Після проведення відстрілу виконували поперечні розрізи блоків з метою подальшого вимірювання показників тимчасової порожнини, що утворилася в результаті прострілу, за загальноприйнятими методиками. Результати аналізу отриманих даних щодо показників, що характеризують розміри тимчасової порожнини на різних глибинах ранового каналу, виявили цілий ряд достовірних відмінностей (p<0,05-0,01) між досліджуваними пістолетами (практично в усіх випадках більші значення мав "AE 790G1"), групами блоків, вкритих різними видами тканин, ненакритими блоками (практично у всіх випадках одяг мав захисні властивості і зменшував розмір тимчасової порожнини) та дозволили встановити, що при пострілах з "FORT 12R" відмічається різке збільшення розмірів тимчасової порожнини з її різким зменшенням наприкінці ранового каналу, в той час як при пострілах з "AE 790G1" тимчасова порожнина поступово збільшувалась, сягаючи максимуму на половині своєї глибини і поступово зменшувалась. Таким чином, при порівнянні результатів пострілів пістолетів "FORT 12R" та "AE 790G1" виявлено відмінності в особливостях формування тимчасової порожнини, що в свою чергу становить інтерес не тільки для криміналістики, балістики та судової медицини але й для клінічної медицини.

Ключові слова: *вогнепальна травма, вогнепальні ушкодження, вогнепальна зброя, тимчасова порожнина, імітатор тіла людини.*