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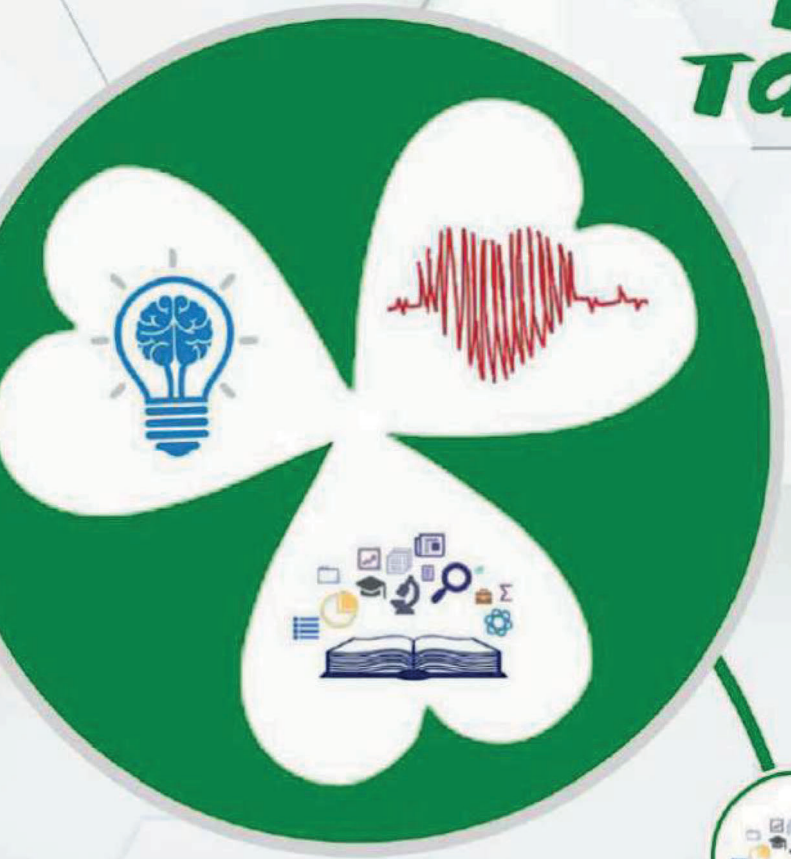
Перспективи та інновації науки



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WAYS OF MODELING A BALLISTIC EXPERIMENT FOR THE NEEDS OF A FORENSIC MEDICAL EXAMINATION OF A GUNSHOT INJURY

Abstract. One of the ways to perform forensic medical research in the gunshot injury examination section is to conduct situational, controlled ballistic studies, which help to understand the position of the shooter at the time of the shot, determine the distance, the angle of the shot and other circumstances of its execution. Also, simulation of gunshot trauma is the main way of obtaining new and reliable information for scientists in the field of criminology. Thus, a natural question arises - what is the best way to simulate a gunshot injury? What simulators of the human body can be used, and what are the advantages and disadvantages of each of them? What must be considered when modeling a gunshot injury? In order to solve these issues, a review of literary sources covering 10 years was carried out using key words related to ballistics and human body simulators. As a result, up-to-date data on models of ballistic research were obtained and summarized. In particular, it was found that there are practically no publications dealing with the use of human cadaveric material - instead, almost all works are performed using a non-biological imitator of the human body (gelatine 10% or 20%) in combination with various types of skin of animal origin. The number of works that use mathematical, computer models of gunshot injury simulation is growing rapidly. However, there is still no model that would fully meet the main request of forensic experts, namely a complete imitation of the human body, which would include imitation of skin, subcutaneous fat, muscle tissue, bones and internal organs. Most models cover only a few of the specified parameters. It is likely that computer models will be closest to the implementation of this task. There is an increasing number of works where a layer of clothing is taken into account when conducting ballistic research, as an obstacle

that affects the final indicators. Thus, it is possible to draw a conclusion about the rapid evolution and significant changes that the field of forensic ballistics has undergone. Ballistic research models have largely become more complex and complicated, which in turn increases their reliability and the possibility of implementation in practical activities.

Keywords: firearm, gunshot injury, biological simulators of the human body, non-biological simulators of the human body, ballistic experiment.

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ШЛЯХИ МОДЕЛЮВАННЯ БАЛІСТИЧНОГО ЕКСПЕРИМЕНТУ ДЛЯ ПОТРЕБ СУДОВО-МЕДИЧНОЇ ЕКСПЕРТИЗИ ВОГНЕПАЛЬНОЇ ТРАВМИ

Анотація. Одним зі шляхів виконання судово-медичних досліджень в розділі експертизи вогнепальної травми є проведення ситуаційних, контрольованих балістичних досліджень, які допомагають зрозуміти позицію стрілка в момент виконання пострілу, визначити дистанцію, кут виконання пострілу та інші обставини його скоєння. Також моделювання вогнепальної травми є головним шляхом отримання нової і достовірної інформації для науковців в галузі криміналістики. Таким чином постає закономірне питання – яким чином найкраще виконати симуляцію вогнепальної травми? Які імітатори тіла людини можна застосовувати, та які мають кожний з них переваги та недоліки? Що необхідно враховувати при моделюванні вогнепальної травми? Для вирішення даних питань виконано огляд літературних джерел на глибину 10 років за ключовими словами, що стосуються балістики та імітаторів тіла людини. Як наслідок отримано та узагальнено сучасні дані стосовно моделей виконання балістичних досліджень. Зокрема, виявлено, що практично відсутні публікації де йде мова про застосування людського трупного матеріалу – натомість практично всі роботи виконуються з застосування небіологічного імітатора тіла людини (желатин 10% або 20%) в комбінації з різними видами шкірних покривів тваринного походження. Стрімко зростає кількість робіт де застосовують

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математичні, комп'ютерні моделі симуляції вогнепальної травми. Проте, досі відсутня будь яка модель яка повністю б відповідала головному запиту судово-медичних експертів, а саме повноцінна імітація тіла людини, що включала б в себе імітацію шкірних покривів, підшкірно-жирової клітковини, м'язової тканини, кісток та внутрішніх органів. Більшість моделей охоплюють лише кілька з зазначених параметрів. Ймовірно, що найбільш близькими до реалізації даної задачі будуть комп'ютерні моделі. Зростає кількість робіт де при проведенні балістичного дослідження враховується шар одягу, як перешкода, що впливає на фінальні показники. Таким чином можна зробити висновок про стрімку еволюцію та значні зміни, що застала галузь судової балістики. Моделі виконання балістичних досліджень значною мірою стали більш складними і комплексними, що в свою чергу підвищує їх достовірність і можливість реалізації в практичній діяльності.

Ключові слова: вогнепальна зброя, вогнепальна травма, біологічні імітатори тіла людини, небіологічні імітатори тіла людини, балістичний експеримент.

Statement of the problem. Gunshot injury remains a significant challenge for health care facilities. In addition to requiring immediate medical attention, a gunshot wound can be disabling, often an accident resulting from careless handling or play by children, and most importantly, often results in death. In the USA, up to 6.6% of all deaths are due to the use of firearms. In particular, 67% of all murders and 50% of all suicides are committed with the use of firearms, and according to data from 2005, more than 3,000 cases of death from the use of firearms involved persons under the age of 15 [1]. Data from an analysis of gunshot injury referral rates in the US from 2003 to 2012 showed that the frequency of referrals increased by 49% during that period, while the death rate decreased from 25% to 18%. At the same time, adjusting the data according to trends showed that in fact both in 2003 and in 2012 the mortality rate was the same 22% [2].

In Denmark, from 1992 to 2016, there were 315 firearm-related deaths, which accounted for 22% of all homicides. In Holova, 58.1% of injuries were localized on the head and 46.7% on the chest. Pistols were used in most cases (43.8%), rifles came in second place (41.0%) [3].

In Benin City (Nigeria) from 1998 to 2002, 210 deaths from gunshot injuries were recorded, which accounted for 27.2% of all deaths recorded by the forensic medical service. In 88.5% of cases of gunshot wounds, the manner of death was homicide, in 4.8% it was self-defense, in 4.3% it was an accident, and in 0.5% it was suicide. The most frequent location of a gunshot wound was the torso [4].

For Ukraine, the examination of gunshot trauma has become more relevant than ever with the beginning of the large-scale invasion of Russia, which provoked a surge in deaths from gunshot and explosive injuries and, as a result, there was a

need to improve existing knowledge regarding the examination of these cases [5]. For the first time, this topic was seriously raised in 2014 with the beginning of the Revolution of Dignity on Independence Square. Both non-lethal firearms and combat firearms were used by law enforcement forces during the illegal dispersal of protesters, resulting in numerous deaths and injuries among the civilian population. At the same time, the forensic medical service could not fully satisfy the bodies of inquiry with answers to all their questions [6].

In particular, an important element in conducting a forensic medical examination of a gunshot injury is the use of modern laboratory equipment capable of detecting the residual components of a shot [7].

No less important is the examination of not only the body of the deceased person, but also the clothes or other objects found on or near it. A person's clothing in the event of a gunshot injury is a source of a significant amount of valuable information [8].

One of the ways to examine a gunshot wound in forensic medicine is to conduct experimental ballistic studies to simulate the circumstances of a shot or to perform a series of shots in order to identify specific identifying features of a weapon. In any case, this requires the use of an adequate and as complete as possible model of an experimental shot, in particular, the correct selection of a human body simulator, taking into account the prohibition of the use of cadaveric material for scientific purposes.

Connection of the publication with planned scientific research works. The work was carried out as part of the research work of the National Pirogov Memorial Medical University, Vinnytsya at the expense of state funding of the Ministry of Health of Ukraine: "Characteristics of damage to human body tissue simulators caused by non-lethal weapons" (state registration number 0121U107924).

The purpose of the article – evaluate the most expedient and effective simulation models of ballistic research in accordance with the modern needs of forensic medical examination.

Research objects and methods. To achieve the goal of the research, a search for publications was performed in the scientometric databases Scopus, Web of Science, and Google Academy. The criteria for inclusion in the results section of the publication were: no more than 10 years old, the presence of a clearly described research materials and methods section in the publication. The search was carried out using the following keywords: gunshot injury, ballistic experiment simulation, human body simulators, head simulators, ballistic gelatin. A total of 12 publications that fully met our criteria were included in the literature review.

Committee on Bioethics of National Pirogov Memorial Medical University, Vinnytsya (protocol No 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.

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Presentation of the main material.

Research results and their discussion. In ballistics, there are such varieties as internal ballistics, which studies the behavior of a projectile during the acceleration phase inside the barrel of a firearm, intermediate ballistics, which studies the projectile in the first seconds after the projectile leaves the barrel, external ballistics, which studies the flight of the projectile from the first centimeters after departure from barrel to the target and finally terminal ballistics, which studies the projectile when it penetrates the target, which can be both an inanimate object, an obstacle and a living object, for example, a human body [9].

Due to the restrictions or complete ban on the use of human cadaveric material for ballistic research, most ballistic experiments are conducted using biological substitutes, such as various kinds of animal tissues, non-biological imitators of the human body, which are mostly represented by ballistic 10% or 20% gelatin or ballistic plasticine or their combinations with the application of covering gelatin blocks with animal skin flaps. The newest methods include the use of computer simulation models of human body tissues or the same human body simulators [10].

Currently, the most common imitator among ballistic studies is gelatin, which is an optically transparent medium and therefore allows you to see the movement of the projectile through it and record the temporary cavity that is formed when shots are fired [11]. In its essence, gelatin is a fibrous protein, collagen, the basis of which is skin and bone tissue. Due to this, gelatin has a non-linear viscoelastic reaction when a projectile penetrates it. Gelatin has the characteristics of a solid substance at a low rate of penetration and a liquid at a high rate [12].

Using a high-speed camera when shooting gelatin blocks from different pistols revealed a quasi-constant deceleration of FMJ bullets in gelatin with a relative velocity loss of 8.4% when using .32 auto cartridges and 13.2% when using 9 mm Luger. In particular, balls with the ability to expand show the greatest deceleration [14].

To imitate a human head, the authors of the study proposed various models that included the brain of cattle and gelatin. The shots were fired from a .22 caliber air rifle (AR). Data from experimental shots showed that, on average, bull brain absorbed 50 ± 5% of Ek, and simulators 46–58 ± 5%. The Ek of the .22 LR was 141 ± 3.7 J. Bovine brain absorbed 27% of the Ek of the .22LR, and the simulants absorbed 15–29%. [15]

Among the tissues of the human body that are sometimes found in scientific literature is bone tissue. Thus, Matoso and co-authors compared incoming gunshot injuries to the skull when fired from three different ammunition. As a result, it was found that even when shots were fired in the same area, skull damage with different morphology was formed [13].

It is no less important to take into account when performing a ballistic experiment, the influence of an obstacle in the form of clothing on the wound morphology. When shots are fired from a 12-gauge gun into gelatin covered with

animal skin and clothing, it was found that denim and cotton fabrics provide greater protection than polyester [16].

Shots at the clothing samples recorded in the frames do not allow us to fully judge the adequate size and overall morphology of the damage. So, for example, when using the same gun, but when firing at cotton fabric located on top of a human torso simulator, a group of researchers obtained radically different damage characteristics, in particular, the authors observed the formation of a volcanic rise in clothing fabric, deposition of soot in the form of a candle, a change in shape and size of the hole [17, 18].

Different types of clothing have different effects on the depth of the wound channel when using the same type of weapon and shot distance, which allows solving another problem in the process of conducting ballistic experiments - identifying clothing with greater protective properties [19].

It is important to increase the number and impact of publications on mathematical modeling of gunshot damage to gelatin and other imitators of the human body, which allows for more accurate reporting of ballistic research results [20].

Conclusions. Ballistic research modelling methods have become more complex and multi-faceted over the past decade, which is due to greater inquiries from forensic experts.

The use of ballistic research allows not only to satisfy the needs of practicing forensic experts, but also scientists, who can thus discover new aspects of the interaction of ammunition with the human body.

The use of experimental ballistic models with obstacles, in particular, in the form of clothing, is justified, because they cause changes in the results of the ballistic experiment compared to shots fired without taking into account this obstacle.

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