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# Appearance and characteristics of the gunshot wounds caused by different fire weapons – animal model

Изглед и карактеристике рана нанесених пројектилима из различитог ватреног оружја – анимални модел

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# Appearance and characteristics of the gunshot wounds caused by different fire weapons – animal model

## Изглед и карактеристике рана нанесених пројектилима из различитог ватреног оружја – анимални модел

**SUMMARY**

**Introduction/Objective** Gunshot residues on the skin (GSR) of a victim are important evidence, with far better precision, for reconstructive questions in the forensic investigation of cases involving gunshot wounds.

The aim of this experimental study was to analyze is there any significant difference in macroscopic characteristics of wounds that were caused with different types of weapons from three different distances.

**Methods** Study was conducted in Department of Ballistic and Mechanoscopic Expertise, Federal Police Directorate. Experiments were done on pigskin and 55 samples were made. Shooting was conducted using a system for safe firing. Samples of the pigskin were shot by firing projectiles from four different weapons and from three different distances, (contact wound, 5 cm and 10 cm).

**Results** At the contact range; wounds caused by automatic rifle had horizontal, vertical diameters larger than those made by pistols. Diameters on the wounds that were caused with different pistols, were similar. At the range of 5 cm narrowest part of contusion ring significantly differ even through pistol wounds. Diameters at the range of 10 cm are in favor of these results. Gunpowder residues scattering area was statistically different depending of type of weapon ($p = 0.004$).

**Conclusion** Wound diameters and surface area are useful for differentiation between pistol and rifle caused wounds. It is unsecure method for determination of pistol caliber or fire range. GSR have much greater potential for future analyses, but even GSR can't be used to determinate pistol caliber.

**Keywords:** gunshot wounds; gunshot residues; macroscopic examination; caliber; fire range

**САЖЕТАК**

**Увод/циљ** Расип барутних честица (РБЧ) на кожи жртве је важан доказ, са високом прецизношћу, кориштен да би се добили одговори о реконструкцији догађаја, те да би се објасниле ране изазване ватреним оружјем.

Циљ ове експерименталне студије је била анализа макроскопских карактеристика рана насталих пројектилима из ватреног оружја, а овисно од калибра и врсте оружја те удаљености.

**Метод** Студија је спроведена у Одјелу за балистичка и механоскопска вјештачења, Федерална Управа Полиције. Експеримент је спроведен на 55 узорака свињске коже. Експериментална пуцњава је вршена помоћу система за сигурну пуцњаву. Пуцање је вршено са три удаљености: контакт, 5 цм и 10 цм.

**Резултати** Приликом прислона оружја, ране настале пуцањем из аутоматске пушке имале су хоризонталне и вертикалне дијаметре сигнификантно веће од оних нанесених пуцањем из пиштоља. Дијаметри рана узроко-ваних различитим пиштољима су имали сличне карак-теристике, без значајне разлике. На удаљености од 5 цм најужи део нагњечног прстена је имао различите вредности и међу ранама нанесеним испаљивањем пројектила из пиштоља. Дијаметри рана изазваних пројектилима са удаљености од 10 цм иду у корист претходно наведеним резултатима. РБЧ је статистички значајно различит и овисан о врсти оружја ($p = 0,004$).

**Закључак** Дијаметри, као и површина ране корисни показатељи у диференцијацији између рана нанесених пројектилима из пиштоља односно аутоматске пушке. Метода је несигурна у утврђивању калибра и удаљености пуцања. РБЧ има много већи потенцијал за будуће анализе, али и оне не могу бити кориштене за утврђивање калибра пројектила испаљеног из пиштоља.

## INTRODUCTION

Throughout history, ballistics experts and forensic medicine experts have classified gunshot wounds with respect to range by a variety of methods. All of these methods include inspection and comparison with test firings or patterns of gunshot residues (GSR) at a wound site [1]. Firearm-related injuries are a leading cause of morbidity and mortality in the world. In many shooting cases, bullets hit surfaces of various parts of the human body (often the head) directly. For the purpose of assessing the shooting distance, most of the forensic literature describes only visual/microscopic methods for examination of the wound appearance and discharge



 

particle patterns around. Shooting distances from human body surfaces can be divided roughly into four ranges: contact, near contact range, intermediate range and distant range [2, 3]. In contact wounds, the muzzle of the weapon is held against the surface of the body at the time of shooting. The appearance of tearing, scorching, soot, or the imprint of the muzzle characterizes contact wounds. In near contact wounds, the muzzle of the weapon is not in contact with the skin, being held a short distance away (a few centimeters). Characteristic of this kind of gunshot is a wide zone of powder soot overlaying seared blackened skin around the entrance wound. Intermediate range gunshot wound is one in which the muzzle of the weapon is held away from the body at the time of discharge, but is still close so that gunpowder expelled from the muzzle can produce "powder tattooing" of the skin [4].

An impact velocity of only 150 to 170 fps is required to penetrate skin. Most entrance wounds, regardless of range, are oval to circular with a punched-out clean appearance and are often surrounded by a zone of reddish damaged skin (the abrasion ring).While powder tattooing of the skin implies a close-range wound, the fact that there are different forms of propellant powder makes this an unreliable finding. Also, indicative of a close-range injury is a cherry hue appearance of underlying muscle due to carboxyhemoglobin, formed by carbon monoxide release during combustion [5].

Wound diameters and only visual analysis of dispersion of gunshot residues (GSR) are used in practice, like some kind of screening method, just to check does it fit to the known story from crime scene, etc. fire range. Previous studies have pinpoint that the caliber of the bullet that caused an entrance wound in the skin cannot be determined by the diameter of the entrance. A .38-caliber (9-mm) bullet can produce a hole having the diameter of a .32 caliber (7.65-mm) bullet and vice versa. The size of the hole is due not only to the diameter of the bullet but also to the elasticity of the skin and the location of the wound. An entrance wound in an area where the skin is tightly stretched will have a diameter different from that of a wound in an area where the skin is lax. Bullet wounds in areas where the skin lies in folds or creases may be slit-shaped [2].

The size of an entrance hole in bone cannot be used to determine the specific caliber of the bullet that perforated the bone though it can be used to eliminate bullet calibers. Thus, a bullet hole 7.65 mm in diameter would preclude it having been caused by a 9-mm (.38 caliber) weapon. Bone does have some elasticity, however, so that a 9-mm bullet may produce a 8.5-mm defect.



 

In earlier ages, researchers tried to prove potential usage of wound size, its surface area, but results were very inconclusive. Gunshot residues on the skin of a victim are important evidence, with far better precision, for reconstructive questions in the forensic investigation of cases involving gunshot wounds [3]. Powder soot may help to differentiate between entrance and exit wounds, draw conclusions on the muzzle-to-target distance and on the muzzle-target angle [5, 6]. Gunshot residue (GSR) consists of particles composed of antimony, barium and lead that arise from the condensation of primer vapors [3] and also soot debris consisting of carbon and metallic fragments [6] In recent times there weren't any studies that tried to determinate or to exclude type of weapon or distance between body and weapon with only wound characteristics.

The aim of this experimental study is to analyze is there any significant difference in macroscopic characteristics of wounds that were caused with different types of weapons from three different distances.



**MATERIALS AND METHODS:**

Study is conducted in Department of Ballistic and Mechanoscopic Expertise, Center for Forensic and Information Support, Federal Police Directorate. Study is performed in accordance with the ethical principles in compliance with the law on the protection of animals in our country. Study is approved by Ethical committee of Medical Faculty at University of Sarajevo and used data is part of the author PhD thesis (Figures 1 and 2).

Sample subject is pig (Figure 1). In total 30 shooting pigskin was used, on which 60 shooting were made, but 5 of them due to the technical errors weren't included in analyzes. Part of the pig body size is approximately 120 x 45 x 20 m composed of skin, subcutaneous and muscle tissue, areas of the chest and abdomen, which is attached to a solid surface. Shooting was conducted using a system for safe firing from the firearm (Verifire-The Secure Firing Device, Twin Tooling, Canada) (Figure 3). Samples of the pig skin was shot by firing projectiles from four different weapons and from three different distances (contact wound, and near contact wound, 5 cm and 10 cm) (Figure 4). The weapons used in the experiment were most commonly used in the Balkan region in last 10 years according to Federal and local police. Characteristics of weapons and projectiles are presented in (Table 1, Figure 3). Because it was done in

 

experimental conditions and using firearm device all samples were included in analyses (Figure 3, Table 1).

After shooting the dimensions of the wound, contusion ring, and the area of scattering of gunshot powder particles were measured. Based on these dimensions we have made calculation of the wound area. As a model of surface rhombus was taken into account (Figure 4).

**Statistical analysis**

Results are presented as count (percent) or median (interquartile range) depending on data type. Fisher's exact test was used to assess significant differences between groups regarding nominal variables. Mann-Whitney U test was used to test the differences between different weapons regarding interval data. No adjustment method for p values were used due to small sample size and experimental nature of the study. All data were analyzed using SPSS 20.0 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.) and R 3.4.2. (R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.).

**RESULTS:**

In total 55 wounds were analyzed, caused with four different weapons and from three different distances. Distribution based on the range was very similar, with no statistically significant difference in distribution, Fisher's Exact test p = 0.992 (Table 2).

First, we have tested is there any significant difference in any of examined characteristics of wound in total, without considering range of firing. No significant difference was found in the horizontal diameter of the wound, vertical diameter of the wound, or even surface between four different calibers. Contusion ring in the narrowest and in the widest diameter has significantly different values; furthermore, area of GSR was significantly different between tested calibers (Table 2.). We did comparison of wound characteristics caused with pistols, and based on that we have concluded that widest and narrowest parts of contusion ring significantly differ (widest p = 0.002, narrowest p = 0.005), as do GSR scattering area p = 0.036.



 

At the contact range; wounds caused with automatic rifle had horizontal, vertical diameters significantly larger than those made by pistols ($p < 0.05$ *vs.* tested pistols). Diameters on the gunshot wounds that were caused with different pistols, were very similar and none of them was statistically different ($p > 0.05$) (Table 3).

Furthermore, wound surface area from automatic rifle was significantly larger than surface areas created with different pistol calibers (*vs.* C.Z. M70 $p = 0.016$, *vs.* M57 $p = 0.036$; *vs.* CZ 85 B 9 mm $p = 0.036$). At the contact, the values of widest and narrowest part of contusion ring around the wound in total are significantly different ($p = 0.003$ and $p = 0.004$ retrospectively). We found that Independently values of contusion ring at close range (contact) had similar widest part diameter when firing from pistol with 7.62 mm, pistol with 9 mm or with automatic rifle with 7.62 mm caliber ($p > 0.05$). Gunpowder residues scattering area significantly differ between weapons when firing from close contact ($p = 0.007$). Pistol C.Z. M70 7.65 mm had smallest GSR scattering area, while wounds from automatic rifle had biggest GSR scattering area, but size was very inconsistent.

At the range of 5 cm, there wasn't any significant difference in the diameters of the wound, or even in wound surface: horizontal diameter ($p = 0.526$); vertical diameter ($p = 0.898$), surface area ($p = 0.903$). Widest part of CR was significantly larger when wounds were caused with automatic rifle ($p = 0.001$). Furthermore, there wasn't any difference when wounds caused with pistols were compared. Narrowest part of CR was statistically different between wounds ($p = 0.015$). Narrowest part of contusion ring had differences even on pistol wounds. Gunpowder residues scattering area was statistically different when firing with different weapons from 5 cm range ($p = 0.007$), with wounds from automatic rifles standing out.

Also, diameters at the range of 10 cm are in favor of these results, with very similar results ($p > 0.05$). Horizontal diameters between Pistol CZ M70 and Pistol CZ85B were significantly different. Vertical diameter of wound caused with Pistol CZ M57 (7.62 mm caliber) is significantly larger than when it is caused with 9 mm pistol or automatic rifle. At the range of 10 cm, wounds had significantly different diameters of widest part of CR ($F=17,819$, $p = 0.001$). Regarding narrowest part of CR there was no statistically significant difference ($F = 3.608$ $p = 0.063$). Gunpowder residues scattering area was statistically different depending of type of weapon ($F = 10.231$, $p = 0.004$). Interesting is that there was no statistically significant difference between GSR surface area around wounds that were caused with pistols.



 

Also analyses of wounds caused from different ranges with same caliber were tested. Wounds caused with pistol with 7.65 mm caliber, had similar dimensional characteristics, and range of firing didn't have any influence. Wounds caused with pistols C.Z. M57 with 7.62 mm caliber had significantly different horizontal diameter ($p = 0.001$). There was significant difference between horizontal diameters when firing was with direct contact on skin and from 5 cm range ($p = 0.04$), also comparing wounds from direct contact between pistol and skin and those from 10 cm range, there was significant difference ($p = 0.007$). Horizontal diameters of wound didn't statistically differ when comparing those from 5 cm and 10 cm range.

Pistol with 9 mm caliber caused much smaller wounds when firing from 5 od 10 cm than those that were caused from direct contact (*vs.* 5 cm $p = 0.001$; *vs.* 10 cm $p = 0.001$). Also vertical diameter was significantly smaller on wounds caused from 10 cm range than from direct contact ($p = 0.004$). Surface area of the wound is decreasing with the increase of the distance ($p = 0.001$).

Widest part and narrowest part of CR differ when using pistol with 7.65 mm caliber, measuring from three different fire ranges ($p = 0.005$). Also GSR surface area had significantly different values ($p = 0.002$), with trend of GSR area increasing with increase in distance. GSR surface area had significant change in value due to the change of fire range ($p = 0.049$). This was due to the smaller size of GSR scattering area when firing at the direct contact.

Statistically different values of widest ($p = 0.007$) and narrowest part of CR ($p < 0.001$) were measured on wounds caused with 9 mm pistol from different distances. Also GSR scattering area significantly differ based on distance ($p = 0.002$). Automatic rifle had statistically different values of widest and narrowest part of CR, based on distance ($p = 0.002$ and $p = 0.057$ retrospectively). There was no difference between wounds that were caused from 5 and 10 cm ($p > 0.05$). GSR surface area also significantly differ between different distances, as surface widens with increase of distance ($p = 0.027$).



**DISCUSSION:**

Small number of papers is done on this topic. In practice we are searching for efficient, practical and cheap methods that could be used for determination of firing distance and caliber.

 

Berryman H.E. et all did comparison of wound dimeters on head injuries, with diameters measured on skull. They have concluded that there is no significant difference between .22 (5.6mm) caliber and .25 (6.35 mm) caliber at close range wounds, while the .38 caliber (9 mm) wounds were significantly different ($p < 0.001$) [7].

In our experiment no matter which weapon we have used, there wasn't any significant difference between 5 and 10 cm range. Both of these values are categorized in near contact range, but diameters are decreasing with increase of distance. There aren't any papers that have tested ranges that were so close.

Karen Isha Sahu et all. have in their study on cotton cloth sheet, wound caused with 9 mm pistol had similar gunshot patterns as our results. Horizontal diameter was wider for all the patterns at 5 cm range, but at 10 cm blackening was more dominant [8].

In our study, we used geometrical shape of rhomb. Matoso et all. [9] in their study have proven that different morphologies in the entrance holes are produces by three different calibers, using the same skull at the same shot distance of 10 cm. 9 mm wound was irregular, triangular, while 10 mm caliber was round.

At the contact, in the comparison of wounds caused with different weapons, the values of widest and narrowest part of contusion ring around the wound in total are significantly different ($p=0,003$ and $p=0,004$ retrospectively). Independently we found that contusion ring at close range (contact) had similar widest part diameter when firing from pistol with 7,62 mm, pistol with 9 mm or with automatic rifle with 7,62 mm caliber ($p>0,05$).

Gunpowder residues scattering area significantly differ between weapons when firing from close contact ($p=0,007$). Turillazi et all. (10] in their study showed that at 0.2 cm distance circumferential blackening with soot deposited in zone around entrance was, while on 5 cm, a wide zone of powder soot overlying seared blackened skin was evident in the wound. Also area median when 7.65 mm and 9 mm caliber were used wasn't significantly different. These results are in regard with our results. Authors have proven that GSRs deposits in the skin surrounding entrance wounds strictly correlate with shooting distance. In our study GSR surface area had significantly different values ($p=0,002$) when comparing calibers, with trend of GSR area increasing with increase in distance. This is explained with a fact that both ranges 5 cm and 10 cm are categorized in near contact range. Intermediate range has a smaller GSR area, and in contact wounds with 0° angle, GSR are in the wound channel [10].



 

Also, narrowest parts of contusion ring could be used for determination between calibers, even between pistols. There is almost no difference between 7.65 mm caliber and 9 mm caliber.

Creating a computer software for calculation of wound area is one of the goals in future. Petruk Vasyl et all. discussed multispectral method and means for determining the distance of the shot on the skin tissues. Using the computer model they made an output of the expert system to generate diagnostic solution in the form of the distance to the target. They made a neural network. Multispectral improved method and means for determining the distance of shooting on the basis of the study gunshot injuries of the skin tissues, which allows to register the skin damage biological tissue forensic expert and use the findings as an evidence base [11].

Possibility to use unburned propellant powder for shooting- distance determination is analyzed in multiple articles. Rolf Hofer et all. have concluded that infrared luminescence inspection of gunshot residue is an easy and reliable method for the detection of propellant particles in target tissue for about 80–90% of ammunition types. The quantification of unburned propellant particle densities can be used to draw shooting distance curves. The curve slope strongly depends on the morphology of the propellant particles. Muzzle-to-target distances could be determined up to 1.5 m for pistols and up to 3 m for a revolver [12].

GSR are most used method in this time for determination of fire range. Even micro-CT analysis are based on GSR. Giovanni Cecchetto et all. have described: “By increasing the firing distance, micro-CT analysis demonstrated a clear decreasing trend in the mean GSR percentage, particularly for shots fired from more than 15 cm. For distances under 23 cm, the powder particles were concentrated on the epidermis and dermis around the hole, and inside the cavity; while, at greater distances, they were deposited only on the skin surface. Statistical analysis showed a nonlinear relationship between the amount of GSR deposits and the firing range, well explained by a Gaussian-like function [13]”. In our study GSR area is also in correlation with firing range.

Hlavaty L. et al. Have analyzed histologic findings when estimating the range of fire. They have proven that although variations existed, dark material of gunshot residues was histologically identified in many skin, soft tissue, and bone sections at all ranges with tested calibers. These nonparallel results decrease the dependability of histology for range of fire estimation and reinforce using gross observation. [14].



 

**Limitations of study:**

Small number of samples and only three ranges were included in this study. In future studies intermediate range and long range gunshot wounds should be taken into account and analyzed. In addition, we have made this experimental study on pig skin, more precise data would be collected from experiment which is done on cadaver skin.

## CONCLUSION:

New study on larger sample should be conducted, that would include not only experimental conditions, but also in outside real conditions. Also, computer software that would automatically analyse wound dimensions should be made for easier work. Based on this small sample, vertical and horizontal diameters, also wound surface area are useful for differentiation between pistol and rifle caused wounds from contact and near close range. It is unsecure method for determination of pistol caliber or fire range.

Gunshot residues have much greater potential for future analyses, but even GSR can't be used to determinate pistol caliber. It can be used to determinate rifle inflected wounds, as it had significantly higher values then GSR scattering area around the pistol inflected wounds. In the case if there is known weapon, GSR scattering area can be used to determinate range. Since real-time shots were made at various angles, it is necessary to introduce a correction coefficient.

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**Conflict of interest:** None declared.



 

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**Figure 1**. Pig as a subject is used in this study due to its similarity with human skin



 

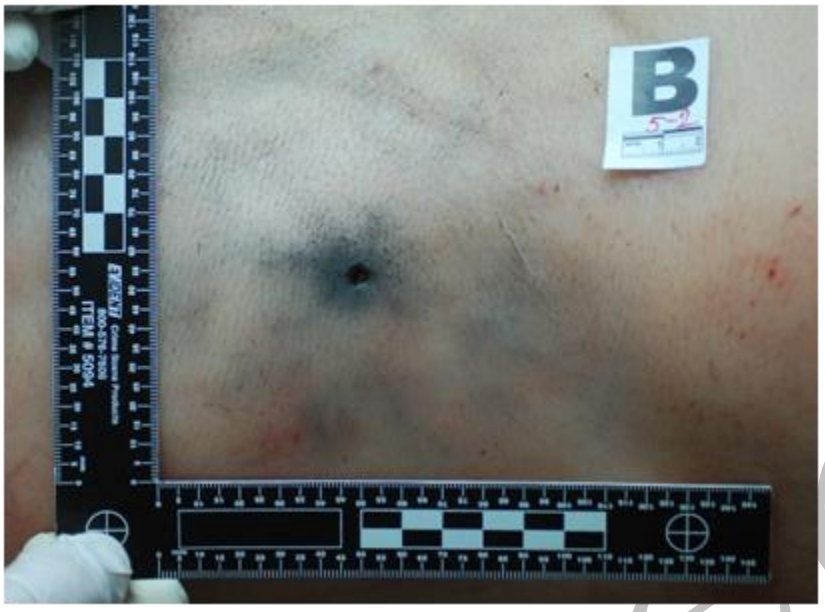


**Figure 2**. Sample of pig skin, shoot from CZ M70 Pistole



 


**Figure 3**. System Verifier-The Secure Firing Device, Twin Tooling, Canada



 

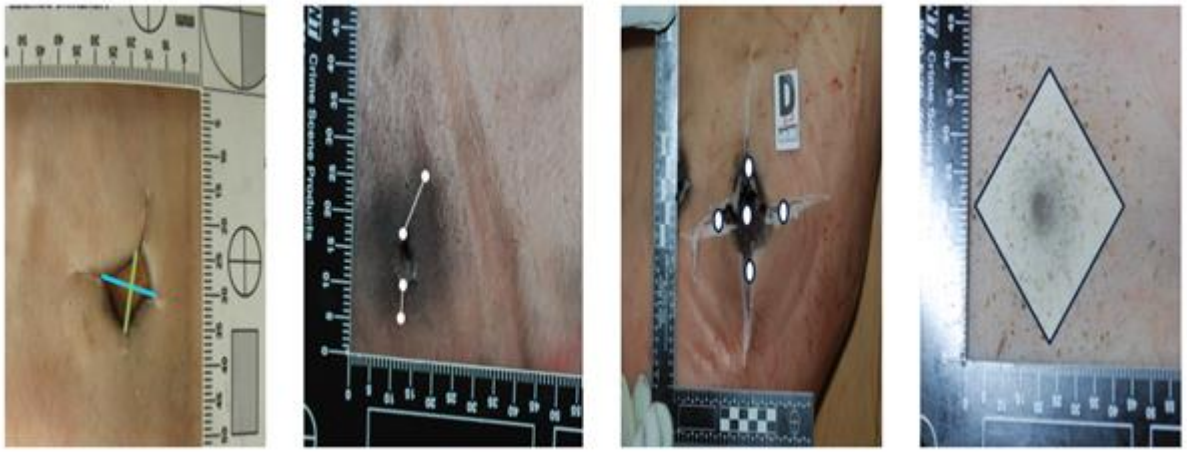

**Figure 4**. Examined characteristics of the wound

Dimensions of the wound, contusion ring and the scattering area of gunshot powder particles were measured after shooting. Based on these dimensions we have calculated the wound area. The size of the wound was determined using five points. One central point, was taken and around it the others. In one clockform, up to 12h, 3h, 6h and 9h. The values of surface area were calculated using the rhombus as a model.



 

**Table 1.** Weapons of the experiment

| Weapons | Caliber | Ammunition | Mark missiles | Manufacturer | Notation of sample |
|---|---|---|---|---|---|
| Pistol *Crvena zastava* M70 | 7.65 mm | 7.65 x 17 mm (0.32 AUTO) | PPU 0.32 AUTO | Prvi partizan Užice, Serbia | A |
| Pistol *Crvena zastava* M57 | 7.62 mm | 7.62 x 25 mm | PPU 2001 | Prvi partizan Užice, Serbia | B |
| Pistol *Češka Zbrojovka* Model CZ 85 B | 9 mm Luger | 9 x 19 mm Luger | PPU 9 mm LUGER | Prvi partizan Užice, Serbia | C |
| Automatic rifle *Zavod Crvena zastava* M70AB2 | 7.62 mm | 7.62 x 39 mm | IK 91 | Igman, Konjic, Bosnia and Hercegovina | D |



 

**Table 2.** General characteristics of examined wounds

| Parameters | Weapon | | | |
|---|---|---|---|---|
| | [a] Pistol CZ M70 (n = 14) | [b] Pistol CZ M57 (n = 13) | [c] Pistol CZ 85B (n = 13) | [d] Rifle CZ M70AB2 (n = 15) |
| **Range** | | | | |
| Contact | 4 (28.6%) | 3 (21.4%) | 3 (21.4%) | 5 (33.3%) |
| 5 cm | 4 (28.6%) | 5 (35.7%) | 5 (35.7%) | 5 (33.3%) |
| 10 cm | 6 (42.8%) | 5 (35.7%) | 5 (35.7%) | 5 (33.3%) |
| Wound horizontal diameter (mm) | 4.3 (2.7) | 4.0 (1.65) | 3.2 (2.5) | 4.5 (15.0) |
| Wound vertical diameter (mm) | 4.7 (1.3) | 4,5 (1.5) | 4.0 (2.0) | 4.5 (18.0) |
| Surface area ($mm^2$) | 21.2 (16.5) | 20.0 (10.5) | 12.0 (26.1) | 20.0 (376.5) |
| Wideset part of CR (mm) | 4.3 (3.0) [b, d] | 9.0 (5.8) [a, d] | 4.0 (7.0) [d] | 20.0 (15.0) [a, b, c] |
| Narrowest part of CR (mm) | 2.2 (2.0) [b, d] | 4,5 (2.0) [a, c] | 1.7 (1.5) [b, d] | 4.0 (12.0) [a, c] |
| GSR scattering area ($mm^2$) | 2034 (2037) [c, d] | 1606 (1595) [c, d] | 903 (724) [a, b, d] | 4108 (2740) [a, b, c] |

Data are presented as median (interquartile range) or count (percent)



 

**Table 3.** Comparison of wound diameters based on type of gun and range

| Parameters | Weapon | | | |
|---|---|---|---|---|
| | [a] Pistol CZ M70 | [b] Pistol CZ M57 | [c] Pistol CZ 85B | [d] Rifle CZ M70AB2 |
| Contact (N) | 4 | 3 | 3 | 5 |
| Horizontal diameter (mm) | 6.8 (3.1) [d] | 6.5 (3.0) [d] | 6.0 (1.0) [d] | 19.5 (2.0) [a, b, c] |
| Vertical diameter (mm) | 5.0 (3.0) [d] | 5.0 (1.5) [d] | 7.0 (3.0) [d] | 26.0 (7.5) [a, b, c] |
| Wound surface area ($mm^2$) | 30.7 (40.2) [d] | 28.0 (15.7) [d] | 42.0 (13.0) [d] | 507.0 (193.0) [a, b,] |
| Widest part of CR (mm) | 4.5 (1.5) [d] | 13.0 (12.0) | 11.0 (4.0) | 12.0 (2.0) [a] |
| Narrowest part of CR (mm) | 2.5 (1.0) [b, c] | 6.0 (7.0) [a] | 8.0 (2.0) [a, d] | 4.0 (1.0) [c] |
| GSR scattering area ($mm^2$) | 567.5 (144.2) | 1000.0 (76.6) | 627.0 (487.0) | 1575.0 (483.0) |
| 5 cm (N) | 4 | 5 | 5 | 5 |
| Horizontal diameter (mm) | 4.2 (1.8) | 4.0 (1.0) | 3.0 (0.7) | 4.0 (1.8) |
| Vertical diameter (mm) | 4.7 (2.3) | 4.0 (2.5) | 4.0 (1.0) | 4.5 (0) |
| Wound surface area ($mm^2$) | 21.2 (13.9) | 20.0 (10.0) | 12.0 (6.0) | 18.0 (5.6) |
| Widest part of CR (mm) | 6.5 (2.1) [d] | 8.1 (1.0) [d] | 6.0 (5.0) [d] | 29.0 (6.5) [a, b, c] |
| Narrowest part of CR (mm) | 3.0 (0.3) [b, d] | 4.5 (1.0) [a, c, d] | 2.0 (0.5) [b, d] | 15.0 (0) [a, b, c] |
| GSR scattering area ($mm^2$) | 2144.7 (602.0) | 1710.0 (2480.6) | 558.0 (771.0) [d] | 4180.0 (1208.0) [c] |
| 10 cm (N) | 6 | 5 | 5 | 5 |
| Horizontal diameter (mm) | 4.0 (2.0) [c] | 3.3 (1.0) | 3.0 (1.8) [a] | 3.0 (0.5) |
| Vertical diameter (mm) | 3.8 (2.5) | 4.5 (1.2) [c, d] | 2.8 (1.0) [b] | 2.5 (1.0) [b] |
| Wound surface area ($mm^2$) | 17.6 (14.0) | 18.0 (5.6) [c] | 8.0 (4.6) [b] | 8.7 (3.0) |
| Widest part of CR (mm) | 2.7 (0.5) [b, d] | 12.0 (5.8) [a, d] | 3.0 (0) [d] | 21.0 (8.5) [a, b, c] |
| Narrowest part of CR (mm) | 1.0 (1.0) [b, d] | 4.0 (2.0) [a] | 1.5 (0.3) [d] | 3.5 (1.0) [a, c] |
| GSR scattering area ($mm^2$) | 2534.5 (2676.1) | 2012.5 (964.0) [d] | 1053.0 (350.0) [d] | 4444.0 (302.5) [b, c] |



 