CHARACTERISTICS OF SOFT TISSUE WOUNDS CAUSED BY BULLETS FROM INFANTRY GUNS ON EXPERIMENTAL ANIMALS

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Abstract

Objectives: To describe some characteristics of soft tissue wounds caused by bullets from infantry guns on experimental animals. ***Methods:*** A descriptive study on the characteristics of macroscopic lesions of soft tissue wounds caused by bullets from infantry guns on experimental animals. Shooting on each pig corresponds to a type of ammunition, including 5.56 x 45mm bullet, 7.62 x 39mm bullet, and 9 x 19mm bullets to create wounds in the chest area, liver area, abdomen, and buttock area, then those lesions were examined. ***Results:*** All wounds had entry wounds with a size smaller than the size of the corresponding bullet. Most entry wounds were round (range of 65% - 75%), while others were oval in shape. Bullets 9 x 19mm caused the most graze wounds (45%). Bullets with high damage energy and velocity caused larger outlet damage and were larger than the corresponding bullet size. The exit wounds caused by 7.62 x 39mm bullets and 5.56 x 45mm bullets were mainly in oval shape (80% and 85%, respectively); the rest were star-shaped. Exit wounds from the 9 x 19mm bullet were mostly oval in shape (92.5%). The shape of the 7.62 x 39mm and 5.56 x 45mm bullet-related permanent cavities had an angular, jagged form, the 9 x 19mm bullet permanent cavities were mostly straight, with little angle. ***Conclusion:*** All entry wounds had a smaller size than that of the corresponding bullet, most of which were round. The bullets with high velocity and energy damage caused larger damage and larger than the corresponding bullet size, mostly oval in shape, the rest were star-shaped. The shape of the 7.62 x 39mm and 5.56 x 45mm bullet permanent cavities had an angular, jagged form, the 9 x 19mm bullet permanent cavity was mostly straight, with little angle.

Keywords: Soft tissue wounds; Bullets; Experimental animals.

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INTRODUCTION

Over the years, firearm-related injuries have become the leading cause of death or disability in many people around the world. According to one study, there was an estimation of 195,000 - 276,000 firearm injury deaths globally in 2016, the majority of which were firearm homicides [1]. Among the types of wounds caused by firearms, simple soft tissue wounds accounted for a high proportion of the total number of wounds (60 - 70%). In addition, injuries to bones, joints, blood vessels, and internal organs were accompanied by soft tissue wounds [2]. This study was conducted to: *Describe some characteristics of soft tissue wounds caused by bullets from infantry guns on experimental animals.*

MATERIALS AND METHODS

1. Materials

Research materials with ammunition include 5.56 x 45mm bullets fired on AR-15 gun; 9 x 19mm bullets fired on FN pistol; 7.62 x 39mm bullets fired on AK submachine gun.

Experimental materials: Pigs weighing from 50 - 100kg.

2. Methods

* *Research design:* The descriptive study on the macroscopic characteristics of soft tissue wounds caused by infantry gun bullets on experimental animals.

* *Research content:* Experimental animals are pigs weighing from 50 - 100kg, transported to the shooting site of infantry guns on the planned shooting day. Shooting on each pig corresponds to a type of ammunition, including 5.56 x 45mm bullet fired on AR-15 gun, 7.62 x 39mm bullet fired on AK submachine gun, and 9 x 19mm bullets fired on FN pistol to create wounds on experimental animals. In the chest area, liver area, abdomen, and buttock area. Shooting two bullets in each position, and each type of ammunition on each experimental pig, for a total of 15 pigs (120 bullets of all kinds).

* *Research criteria:*

Characteristics of the size, structure, and shape of the entry wound and the exit wound; the diameter, length, and morphology of permanent cavity.

* *Statistical analysis:* Collected data were entered and processed on the SPSS 22.0 biomedical statistical software.

3. Ethics

This article used the partial data from the Ministry of National Defence research project with contract No. 353/2020/HĐ-NCKHCN between the Department of Military Science, Ministry of National Defence, and Vietnam Military Medical University.

RESULTS

Table 1. Entry wound size by location (n = 120).

Location of soft tissue wound	Bullet 7.62 x 39mm	Bullet 5.56 x 45mm	Bullet 9 x 19mm	p
Length (cm), Median (min - max)				
Chest area	0.7 (0.6 - 0.7)	0.5 (0.5 - 0.5)	0.8 (0.7 - 0.8)	< 0.001*
Liver area	0.7 (0.7 - 0.7)	0.5 (0.4 - 0.5)	0.8 (0.7 - 0.8)	< 0.001*
Abdomen	0.7 (0.6 - 0.7)	0.5 (0.4 - 0.5)	0.8 (0.7 - 0.8)	< 0.001*
Buttock	0.7 (0.6 - 0.7)	0.5 (0.4 - 0.5)	0.8 (0.7 - 0.8)	< 0.001*
p	> 0.05	> 0.05	> 0.05	
Width (cm), Median (min - max)				
Chest area	0.7 (0.5 - 0.7)	0.5 (0.4 - 0.5)	0.8 (0.7 - 0.8)	< 0.001*
Liver area	0.7 (0.6 - 0.7)	0.5 (0.4 - 0.5)	0.8 (0.7 - 0.8)	< 0.001*
Abdomen	0.7 (0.6 - 0.7)	0.4 (0.3 - 0.5)	0.8 (0.6 - 0.8)	< 0.001*
Buttock	0.7 (0.5 - 0.7)	0.4 (0.3 - 0.5)	0.8 (0.7 - 0.8)	< 0.001*
p	> 0.05	> 0.05	> 0.05	

(: Kruskal Wallis Test)*

The 9 x 19mm bullets caused the largest wound size in all target positions, followed by the 7.62 x 39mm bullets, and the 5.56 x 45mm bullet wounds caused the smallest.

Table 2. Entry and exit wound shape by location (n = 120).

Location of soft tissue wound		Bullet 7.62 x 39mm	Bullet 5.56 x 45mm	Bullet 9 x 19mm	p
Entry wound shape, n (%)					
Chest area	Round	7 (70)	8 (80)	8 (80)	> 0.05
	Oval	3 (30)	2 (20)	2 (20)	
Liver area	Round	6 (60)	8 (80)	7 (70)	> 0.05
	Oval	4 (40)	2 (20)	3 (30)	
Abdomen	Round	8 (80)	6 (60)	5 (50)	> 0.05
	Oval	2 (20)	4 (40)	5 (50)	
Buttock	Round	9 (90)	4 (40)	9 (90)	< 0.05
	Oval	1 (10)	6 (60)	1 (10)	
Exit wound shape, n (%)					
Chest area	Round	0 (0)	0 (0)	1 (10)	> 0.05
	Oval	9 (90)	9 (90)	9 (90)	
	Star	1 (10)	1 (10)	0 (0)	
Liver area	Round	0 (0)	0 (0)	1 (10)	> 0.05
	Oval	9 (90)	8 (80)	9 (90)	
	Star	1 (10)	2 (20)	0 (0)	
Abdomen	Round	0 (0)	0 (0)	0 (0)	> 0.05
	Oval	9 (90)	10 (100)	10 (100)	
	Star	1 (10)	0 (0)	0 (0)	
Buttock	Round	0 (0)	0 (0)	1 (10)	> 0.05
	Oval	5 (50)	7 (70)	9 (90)	
	Star	5 (50)	3 (30)	0 (0)	

(: Chi-square Test)*

Only buttock soft tissue wounds had different proportions of entry wound shape among infantry gun bullets, in which 5.56 x 45mm bullets caused oval inlet wounds, accounting for the majority (60%), 7.62 x 39mm bullets and 9 x 19mm bullets mainly produced circular wounds.

At the positions of outlet wounds caused by 7.62 x 39mm bullets and 5.56 x 45mm bullets were oval and star-shaped; none of them was round. Exit wounds due to the 9 x 19mm bullets were mostly oval, not star-shaped.

Table 3. Characteristics of perforation by location (n = 120).

Location of soft tissue wound		Bullet 7.62 x 39mm	Bullet 5.56 x 45mm	Bullet 9 x 19mm	p
Entry wound perforation, n (%)					
Chest area	Yes	4 (40)	2 (20)	4 (40)	> 0.05
	No	6 (60)	8 (80)	6 (60)	
Liver area	Yes	3 (30)	3 (30)	5 (500)	> 0.05
	No	7 (70)	7 (70)	5 (50)	
Abdomen	Yes	4 (40)	4 (40)	5 (50)	> 0.05
	No	6 (60)	6 (60)	5 (50)	
Buttock	Yes	4 (40)	2 (20)	4 (40)	> 0.05
	No	6 (60)	8 (80)	6 (60)	

(: Chi-square Test)*

In the chest area, 7.62 x 39mm bullets and 9 x 19mm bullets created grazing wounds, accounting for 40%, and 5.56 x 45mm bullets were 20%. In the liver area, the 9 x 19mm bullets caused the highest percentage of grazing wounds with 50%, the 7.62 x 39mm and 5.56 x 45mm bullets only had 30%. In the abdominal area, 9 x 19mm bullets caused the highest percentage of grazing wounds with 50%, 7.62 x 39mm and 5.56 x 45mm bullets only had 40%. In the buttock area, 7.62 x 39mm bullets and 9 x 19mm bullets caused 40% grazing wounds, and 5.56 x 45mm bullets were 20%.

Table 4. Exit wound size by location (n = 120).

Location of soft tissue wound	Bullet 7.62 x 39mm	Bullet 5.56 x 45mm	Bullet 9 x 19mm	p
Length (cm), Median (Min - max)				
Chest area	2.2 (1.5 - 3)	1.8 (1.1 - 2.6)	1.0 (0.8 - 1.1)	< 0.001*
Liver area	1.9 (1.1 - 30)	2.1 (1.1 - 2.8)	1.0 (0.8 - 1.3)	< 0.001*
Abdomen	1.8 (1 - 2.2)	1.6 (1 - 3)	1.2 (0.9 - 1.3)	< 0.05*
Buttock	4.6 (3.2 - 6.1)	2.9 (1.5 - 5)	1.1 (0.8 - 1.5)	< 0.001*
p	< 0.001*	< 0.05*	> 0.05	
Width (cm), Median (Min - max)				
Chest area	1.5 (1.0 - 2.2)	1.1 (1 - 1.7)	0.8 (0.7 - 0.8)	< 0.001*
Liver area	1.1 (0.6 - 2)	1.5 (0.9 - 2.2)	0.8 (0.7 - 1)	< 0.05*
Abdomen	1.0 (0.7 - 1.5)	1.1 (0.7 - 1.8)	0.8 (0.8 - 1)	< 0.05*
Buttock	3.1 (2.0 - 3.6)	2.1 (1.1 - 3.2)	0.8 (0.7 - 1.1)	< 0.001*
p	< 0.001*	< 0.05*	> 0.05	

(: Kruskal Wallis Test)*

The size of exit wounds caused by 7.62 x 39mm bullets and 5.56 x 45mm bullets were significantly larger than that of the 9 x 19mm bullet exit wounds. The size of exit wounds in the buttock area due to 7.62 x 39mm bullets and 5.56 x 45mm bullets were larger than the outlet wound size in other areas, the difference was statistically significant.

Table 5. Comparison of exit wound with bullet size according to soft tissue wound location (n = 120).

Location of soft tissue wound		Bullet 7.62 x 39mm	Bullet 5.56 x 45mm	Bullet 9 x 19mm	p
Exit wound vs bullet size, n (%)					
Chest area	More	10 (100)	10 (100)	5 (50)	< 0.05
	Less	0 (0)	0 (0)	5 (50)	
Liver area	More	10 (100)	10 (100)	7 (70)	< 0.05
	Less	0 (0)	0 (0)	3 (30)	
Abdomen	More	10 (100)	10 (100)	8 (80)	> 0.05
	Less	0 (0)	0 (0)	2 (20)	
Buttock	More	10 (100)	10 (100)	6 (60)	< 0.05
	Less	0 (0)	0 (0)	4 (40)	

(: Chi-square test)*

All exit wounds of 7.62 x 39mm and 5.56 x 45mm bullets were larger than the size of the bullets, and wounds caused by 9 x 19mm bullets created outlet wounds larger than the size of corresponding bullets in the range of 50 - 80%, the difference was statistically significant.

Table 6. Comparison of the length of exit wound with entry wound by the location of the soft tissue wound (n = 120).

Location of soft tissue wound		Bullet 7.62 x 39mm	Bullet 5.56 x 45mm	Bullet 9 x 19mm
Length (cm), median (min - max)				
Chest area	Entry	0.7 (0.6 - 0.7)	0.5 (0.5 - 0.5)	0.8 (0.7 - 0.8)
	Exit	2.2 (1.5 - 3)	1.8 (1.1 - 2.6)	1.0 (0.8 - 1.1)
p		< 0.05	< 0.05	< 0.05
Liver area	Entry	0.7 (0.7 - 0.7)	0.5 (0.4 - 0.5)	0.8 (0.7 - 0.8)
	Exit	1.9 (1.1 - 3)	2.1 (1.1 - 2.8)	1.0 (0.8 - 1.3)
p		< 0.05	< 0.05	< 0.05
Abdomen	Entry	0.7 (0.6 - 0.7)	0.5 (0.4 - 0.5)	0.8 (0.7 - 0.8)
	Exit	1.8 (1 - 2.2)	1.6 (1 - 3)	1.2 (0.9 - 1.3)
p		< 0.05	< 0.05	< 0.05
Buttock	Entry	0.7 (0.6 - 0.7)	0.5 (0.4 - 0.5)	0.8 (0.7 - 0.8)
	Exit	4.6 (3.2 - 6.1)	2.9 (1.5 - 5)	1.1 (0.8 - 1.5)
p		< 0.05	< 0.05	< 0.05
Width (cm), median (min - max)				
Chest area	Entry	0.7 (0.5 - 0.7)	0.5 (0.4 - 0.5)	0.8 (0.7 - 0.8)
	Exit	1.5 (1 - 2.2)	1.1 (1 - 1.7)	0.8 (0.7 - 0.8)
p		< 0.05	< 0.05	> 0.05
Liver area	Entry	0.7 (0.6 - 0.7)	0.5 (0.4 - 0.5)	0.8 (0.7 - 0.8)
	Exit	1.1 (0.6 - 2)	1.5 (0.9 - 2.2)	0.8 (0.7 - 1)
p		< 0.05	< 0.05	< 0.05
Abdomen	Entry	0.7 (0.6 - 0.7)	0.4 (0.3 - 0.5)	0.8 (0.6 - 0.8)
	Exit	1.0 (0.7 - 1.5)	1.1 (0.7 - 1.8)	0.8 (0.8 - 1)
p		< 0,05	< 0.05	< 0.05
Buttock	Entry	0.7 (0.5 - 0.7)	0.4 (0.3 - 0.5)	0,8 (0.7 - 0.8)
	Exit	3.1 (2.0 - 3.6)	2.1 (1.1 - 3.2)	0,8 (0.7 - 1.1)
p		< 0,05	< 0.05	> 0.05

(: Mann-Whitney U test)*

The length of exit wounds at all positions was larger than the length of entry wounds in the same bullet, the difference was statistically significant.

The width of exit wounds at most positions was larger than the width of entry wounds in the same bullet, the difference was statistically significant. Only chest and buttock wounds caused by 9 x 19mm bullets, the width of inlet and outlet wounds did not have a statistically significant difference.

Table 7. Macroscopic characteristics of the permanent cavity.

Characteristics		**Bullet 7.62 x 39mm**	**Bullet 5.56 x 45mm**	**Bullet 9 x 19mm**
			n (%)	
Size (n = 30)	Entry < Exit	10 (100)	10 (100)	10 (100)
	Entry > Exit	0 (0)	0 (0)	0 (0)
Shape (n = 30)	Straight	1 (10)	1 (10)	9 (90)
	Angular	9 (90)	9 (90)	1 (10)
Length, TB ± SD (cm) (n = 40)		0.27 ± 0.07	0.28 ± 0.05	0.25 ± 0.05
Wall of wound	Tissue necrosis	9 (22.5)	19 (47.5)	0 (0.0)
	Hemorrhage	31 (77.5)	21 (52.5)	40 (100)
	Congestion	0 (0)	0 (0)	0 (0)
Objects in wound	Yes	0 (0)	0 (0)	0 (0)
	No	40 (100)	40 (100)	40 (100)

All permanent cavities had outlet sizes larger than inlet sizes; there was no foreign object in the wounds. The shape of the 7.62 x 39mm and 5.56 x 45mm bullet permanent cavities were angular and jagged (90%), while the 9 x 19mm bullet permanent cavities were mostly straight, with little angle. Wound wall caused by 7.62 x 39mm bullets caused tissue necrosis was 22.5%, hemorrhage accounted for 77.5%, 5.56 x 45mm bullets caused tissue necrosis was 47.5%, hemorrhage accounted for 52.5%, 9 x 19mm bullets caused hemorrhagic wounds.

DISCUSSION

In this study, we recorded macroscopic lesions of the entry wounds that were characterized by the size of inlet wounds which was smaller than the size of the corresponding bullet. Most of the entry wounds from infantry gun bullets were circular. 9 x 19mm bullets caused the most graze wounds.

The study of Vichan Peonim et al. (2016) on 5.56 x 45mm bullet wounds on M-16 rifles in Thailand showed that 71.88% of inlet wounds had a typical round-shaped, smaller than bullet size. Most inlet wounds had very small lacerations but no scuffs. This is different from civilian ammunition, which is a cylindrical, low-velocity round-head projectile that causes an entrance wound about the same size as the bullet diameter and is usually round or oval in shape, with a graze. In addition, the authors also noted that 28.13% of the inlet wounds were atypical with characteristics depending on the location of the injury and the stability of the bullet [3]. The outlet wounds were usually larger than the corresponding inlet wounds [4]. The exit wounds were usually jagged, rough, and larger in diameter than the entry wounds. Low-velocity bullets can create puncture-like wounds (incisions) [5, 6].

Regarding exit wounds from the infantry gun, we found that most of the 7.62 x 39mm and 5.56 x 45mm bullets created wounds with holes larger than the size of the bullets. When compared with the inlet wounds, we found that in the same bullet, the outlet wound size was significantly larger than the inlet wound size, the difference was statistically significant. In which the length of outlet wounds at all positions was larger than the length of inlet wounds in the same bullet, the difference was statistically significant. The outlet wound width at most locations was larger than the inlet wound width in the same ammunition, the difference was statistically significant. Regarding the shape of outlet wounds, the outlet wounds caused by 7.62 x 39mm bullets and 5.56 x 45mm bullets were mainly in oval shape, the remaining cases were star-shaped, without a circular outlet wound. Meanwhile, the outlet wounds from the 9 x 19mm bullet had an oval shape.

In the study of Vichan Peonim et al. (2016) on 5.56 x 45mm bullet wounds on M-16 rifles in Thailand, the exit wounds had different sizes and shapes depending on the bullet's trajectory when the bullet left the body [3].

In our study, all permanent cavities had outlet sizes larger than inlet sizes; there was no foreign object in the wound. The shape of permanent cavities from 7.62 x 39mm and 5.56 x 45mm bullets were angular and jagged,

while the 9 x 19mm bullet permanent cavities were mostly straight, with little angularity. The assessment of the image of the wound is very important in determining the initial characteristics of the wound, zoning the type of bullet that causes damage, the type of gun, and the shooting distance that causes these wounds.

Research results have shown the possibility of clinically practical application, especially in field surgery. The goal of treating firearm and bullet wounds needs attention, early surgery, and thoroughly resolving the wounds, including inlet and outlet wounds, as well as permanent activities, while outlet wounds required a treatment, which was considerably wider than inlet wounds.

CONCLUSION

All of the wounds had entry wounds with a size smaller than the size of the corresponding bullet. Most inlet wounds were round (65% - 75%), while others were oval in shape. 9 x 19mm bullets caused the most graze wounds (45%). Bullets with higher damage energy and velocity caused larger outlet damage and larger than the corresponding bullet size. The outlet wounds caused by 7.62 x 39mm bullets and 5.56 x 45mm bullets were mainly oval in shape (80% and 85%, respectively), the rest were star-shaped. Outlet wounds from the 9 x 19mm bullets were mostly in oval shape (92.5%). The shape of the 7.62 x 39mm and 5.56 x 45mm bullet permanent cavities had an angular, jagged form (90%), the 9 x 19mm bullet permanent cavities were mostly straight, with little angle.

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