Original Article

The Prevalence of Exit Gunshot Wound Shapes and the Relationship of the Shape to the Location of Exit Wounds

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Abstract

Objective: To study the prevalence of exit gunshot wound shapes and the relationships of exit gunshot wound shapes with sex, shooting distances, and sites of exit wounds.

Design: Retrospective cross-sectional study

Methods: Seventy-five autopsy reports of handgun death from 2010 to 2020 were retrospectively reviewed. There were 151 entrance wounds, 52 non-penetrating bullets, and one graze wound, leaving 98 complete wounds in the study. The following parameters were recorded from the files: sex, age, number of bullet tracks, sites of entrance wounds, shooting distance, bone perforation, sites of exit wounds, and shapes of the exit wounds. The primary outcome was exit gunshot wound shapes (circular, slit-like, crescent, stellate, and irregular). Prevalence of the shapes of exit gunshot wounds were recorded, and multinomial logistic regression analysis of the shape of exit wound, sex, shooting distance, bone perforation, and site of the exit wound was performed.

Results: The most common shape of the exit gunshot wounds was circular wound with 31 cases (31.6%), followed by stellate, irregular, slit-like and crescent wound (27 cases (27.6%), 24 cases (24.5%), 12 cases (12.2%), 4 cases (4.1%)), respectively. The sex factor and the shooting distance did not affect the exit wound shape. Head exit location increased the likelihood of stellate wound formation compared to circular wound (adjusted odd ratio = 177.91, [95% CI 10.85 to 2,916.05], P-value < .001). Head exit location increased the likelihood of irregular shaped wounds compared to circular wound (adjusted odd ratio = 17.65, [95% CI, 1.54 to 201.84], P-value = .021). Bone perforation increased the likelihood of irregular shaped wounds compared to circular wound (adjusted odd ratio = 6.09, [95% CI, 1.54 to 24.10], P-value = .021)

Conclusions: Exit gunshot wounds to the head are more likely to be stellate and irregular in shape. A stellate-shape wound can be an entrance or exit wound of the head and should be interpreted carefully.

Keywords: Exit wound, Gunshot injuries, Gunshot wound, The shape of the exit wound, Site of the exit wound

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Introduction

The direction of gunshot wounds is a major issue in forensic medicine because it helps diagnose the circumstances of death. Determining the direction of a gunshot requires examination of the entrance and exit wounds. There have been many studies of gunshot entrance wounds[1-7] but few studies of exit wounds[8] and those few are only in specific areas, such as the skull[9-11] or they are computed tomography studies.[12,13] However, the overall picture of gunshot exit wounds has not been studied.

Most standard forensic textbooks describe exit gunshot wounds only as tending to be larger than entrance gunshot wounds and of nonspecific shapes.[14-18] DiMaio[14] groups the shapes of exit gunshot wounds into five categories: circular, slit-like, crescent, stellate, and completely irregular. Only the stellate wound is commonly found in bony skin areas such as the head. The shape of an exit wound does not depend on bullet shape or firing range.[14]

The objective of this study was to determine the prevalence of shapes of exit gunshot wounds and to examine relationships between shapes of exit wounds with sex, shooting distance, bone perforation, and site of the wound.

Methods

This study was approved by The Human Research Ethics Committee of Thammasat University (Medicine) (MTU-EC-PA-0-124/64). The study was conducted in a university hospital in a province that is about 46 km away from Bangkok; the area is about 1,525 square kilometers. The population is approximately 1.16 million people. The condition is an agricultural society mixed with industrial estates. The hospital is responsible for approximately 20% of the province; the average number of autopsy cases is 959.2 cases per year, with 10.5 deaths from firearms per year.

This study examined autopsy reports of 105 cases of firearm-related deaths at the Division of Forensic Medicine, Thammasat University Hospital from 2010 - 2020. The autopsy reports of death from shotgun or rifle (n = 13), decomposed bodies (n = 3), wounds altered by treatment (n = 9), and insufficient data (n = 5) were excluded. There for, the remaining of 75 cases of handgun death form the basis of this study. The following parameters were recorded from the files: sex and age, number of bullet tracks, sites of entrance wounds, shooting distance, sites of exit wounds and the shapes of exit wounds. The primary outcome was to classify the shapes of the exit wounds into five categories: circular, slit-like, crescent, stellate and irregular (Figure 1). The circular wound is defined as a wound that is round or oval. The slit-like wound is defined as a wound with are long straight slit, and the crescent wound is defined as a long slit and curved wound. The stellate wound is defined as a wound are multiple radial ruptures. The irregular wound is defined as a wound that does not meet the characteristics of the four groups above.
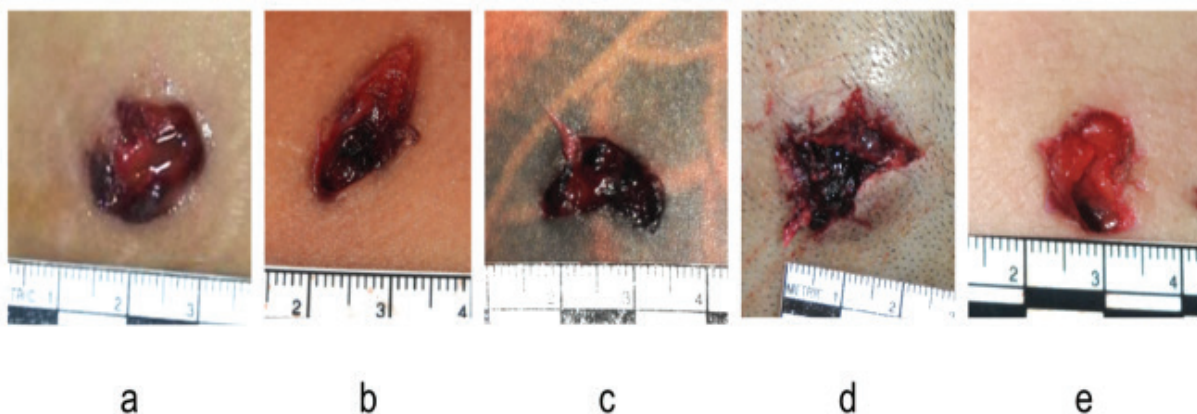

Figure 1 Exit gunshot wound: (a) circular shape (b) slit-like shape (c) crescent shape (d) stellate shape
(e) irregular shape.

Multinomial logistic regression analysis of the shape of exit wound and sex, shooting distance, and the sites of exit wound was performed using the software Stata SE version 16.0 (StataCorp LLC). The shape of the exit wound was categorized by sex, shooting distance, bone perforation, and site of the exit wound. A *P*-value of less than 0.05 was considered significant.

Results

Of the 75 handgun-related death reports, 61 were male (81.3%), 14 were females (18.7%). The deceased's age ranged between 15 to 88 years, with a median age of 36 years. There were 13 cases (17.3%) under 21 years, 33 cases (44.0%) between 21 and 40 years, 23 cases (30.7%) between 41-60 years, and six cases (8.0%) above 60 years. The manner of death were suicide 23 cases (20 (87.0% males), 3 (13.0%) females) and 52 homicides (41 (78.8% males), 11 (21.2%) females) (Table 1).

Table 1 The sex and manner of death of 75 cases

	Suicide	Homicide	Total, No. (%)
Male, No. (%)	20 (87.0)	41 (78.8)	61 (81.3)
Female, No. (%)	3 (13.0)	11 (21.2)	14 (18.7)
ZTotal, No. (%)	23 (100)	52 (100)	75 (100)

There were 151 entrance wounds, 52 non-penetrating bullets, and one graze wound, leaving 98 complete wounds in the study.

There were 35 cases of gunshot wounds to the head and all of them exited from the head. There were 38 cases of gunshot wounds that entered a trunk; 34 cases exited from the trunk and 4 exited from the extremities. Twenty-five cases of gunshot wounds entered extremities; 23 cases exited from the extremities and two penetrated and exited from the trunk (Table 2).

Table 2 Distribution and shooting distance of 98 complete wounds

Site of the exit wound	Shooting distance	Site of the entrance wound		
		Head	Trunk	Extremities
Head				
	Contact	17	0	0
	Near contact	3	0	0
	Intermediate	1	0	0
	Distant	14	0	0
Trunk				
	Contact	0	1	0
	Near contact	0	0	0
	Intermediate	0	1	0
	Distant	0	32	4
Extremities				
	Contact	0	0	3
	Near contact	0	0	0
	Intermediate	0	1	0
	Distant	0	1	20
Total		35	36	27

Overall, the most common shape of the exit gunshot wounds was circular with 31 cases (31.6%), followed by stellate, irregular, slit-like, and crescent (27 cases (27.6%), 24 cases (24.5%), 12 cases (12.2%), 4 cases (4.1%)), respectively. Of the 74 males, the most common finding were circular wounds with 26 cases (35.1%), followed by stellate, irregular, slit-like, and crescent wound (19 cases (25.7%), 17 cases (23.0%), 10 cases (13.5%), 2 cases (2.7%)), respectively. Among the 24 women, the most common finding were stellate lesions with 8 cases (33.3%), followed by irregular, circular, slit-like, and crescent wound (7 cases (29.2%), 5 cases (20.8%), 2 cases (8.3%), 2 cases (8.3%)) respectively (Table 3).

Table 3 The shape of the exit wound and sex

Sex	Circular	Slit-like	Crescent	Stellate	Irregular	Total
Male, No. (%)	26 (35.1)	10 (13.5)	2 (2.7)	19 (25.7)	17 (23.0)	74 (100)
Female, No. (%)	5 (20.8)	2 (8.3)	2 (8.3)	8 (33.3)	7 (29.2)	24 (100)

Shooting distances were categorized into 2 groups, near and far. Contact range and near contact range were classified as sub-groups of near. Intermediate-range and distant range were classified as sub-groups of far. Among the 24 cases from near group, the most common findings were stellate lesions with 18 cases (75.0%), followed by 2 cases of circular wound (8.3%), 2 cases of irregular wound (8.3%), 1 case of slit-like wound (4.2%) and 1 case of crescent wound (4.2%). In the 74 cases from far group, the most common findings were circular wound with 29 cases (39.2%), followed by 22 cases of irregular wound (29.7%), 11 cases of slit-like wound (14.9%), 9 cases of stellate wound (12.2%), and 3 cases of crescent wound (4.1%) (Table 4).

Table 4 The shape of the exit wound and shooting distance

Shooting distance	Circular	Slit-like	Crescent	Stellate	Irregular	Total
Near, No. (%)	2 (8.3)	1 (4.2)	1 (4.2)	18 (75.0)	2 (8.3)	24 (100)
Contact	2	1	1	15	2	
Near contact	0	0	0	3	0	
Far, No. (%)	29 (39.2)	11 (14.9)	3 (4.1)	9 (12.2)	22 (29.7)	74 (100)
Intermediate range	0	1	0	1	1	
Distant range	29	10	3	8	21	

Bone perforations are classified into not perforated and perforated groups. Among the 33 not perforated group cases, the most common were circular wounds with 20 cases (60.6%), 6 cases of irregular wound (18.2%), 5 cases of slit-like wound (15.2%), 2 cases of crescent wound (2.9%) and none of the stellate wound. In the 65 cases in the perforated group, the most common findings were stellate wound with 27 cases (41.5%) followed by 18 cases of irregular wound (27.7%), 11 cases of circular wound (16.9%), 7 cases of slit-like wound (10.8%), and 2 cases of crescent wound (3.1%) (Table 5).

Table 5 The shape of the exit wound and bone perforation

Bone perforation	Circular	Slit-like	Crescent	Stellate	Irregular	Total
Not perforated, No. (%)	20 (60.6)	5 (15.2)	2 (6.1)	0 (0)	6 (18.2)	33 (100)
Perforated, No. (%)	11 (16.9)	7 (10.8)	2 (3.1)	27 (41.5)	18 (27.7)	65 (100)

Sites of exit wounds are classified into head and non-head groups. Among the 35 head group cases, the most common were stellate-shaped wound with 24 cases (68.6%) 8 cases of irregular wound (22.9%), 1 case of circular (2.9%), 1 case of slit-like wound (2.9%), and 1 case of crescent wound (2.9%). In the 63 cases in the non-head group, the most common findings were circular wound with 30 cases (47.6%) followed by 16 cases of irregular wound (25.4%) and 11 cases of slit-like wound (17.5%), 3 cases of crescent wound (4.8%), and 3 cases of stellate wound (4.8%) (Table 6).

Table 6 The shape of the exit wound and site of the exit wound

Site of the exit wound	Circular	Slit-like	Crescent	Stellate	Irregular	Total
Head, No. (%)	1 (2.9)	1 (2.9)	1 (2.9)	24 (68.6)	8 (22.9)	35 (100)
Non-head, No. (%)	30 (47.6)	11 (17.5)	3 (4.8)	3 (4.8)	16 (25.4)	63 (100)
Trunk	16	8	2	0	10	
Extremities	14	3	1	3	6	

The multinomial logistic regression method studied factors related to the five exit gunshot wound shapes. The circular wound shapes used as the base for comparison as it was the most common. The sex factor and the shooting distance do not affect the exit wound shape. Head exit location increased the likelihood of stellate wound formation compared to circular wound (adjusted odd ratio = 177.92, [95% CI 10.85 to 2,916.05], P-value < .001) after sex, shooting distance and bone perforation control. Head exit location increased the likelihood of irregularly shaped wounds compared to circular wound (adjusted odd ratio = 17.65, [95% CI, 1.54 to 201.84], P-value = .021) after sex, shooting distance and bone perforation controls. Bone perforation increased the likelihood of irregularly shaped wounds compared to circular wound (adjusted odd ratio = 6.10, [95% CI, 1.54 to 24.11], P-value = .010) after sex, shooting distance and site of the exit wound controls (Table 7). Exit wounds in the non-head group showed no statistically significant differences in exit wound shapes.

Table 7 Adjusted odd ratio of stellate wound vs circular wound and irregular wound vs circular wound

	Stellate vs Circular		P-value	Irregular vs Circular		P-value
	AOR	95% CI		AOR	95% CI	
Sex	0.08	0.01 - 0.67	.021	0.25	0.05 -1.15	.075
Shooting distance	0.83	.36 - 1.92	.659	1.69	0.69 - 4.15	.246
Bone perforation	$8.53*10^7$	0 - ∞	.992	6.10	1.54 - 24.11	.010
Sites of the exit wound	177.92	10.85 - 2,916.05	< .001	17.65	1.54 - 201.84	.021

Discussion

The proportion of firearm deaths was higher among males than among females. The gender proportions of both suicide (87.0% male vs 13.0% female) and homicide (78.8% male vs 21.2% female) were consistent with a study in Germany.[19]

The homicide rate was higher than the suicide rate by about two-fold in our study, which is not consistent with the German study in which the suicide rate was close to the homicide rate.[19] In Sweden, suicide rates were higher than homicide rates.[20] This proportion may differ from country to country.

In this study, the sex factor did not affect the shape of the exit gunshot wounds.

Our study sorted exit wounds into five shapes according to DiMaio's classification. Head exit wounds were more likely to be stellate shape (AOR = 117.92) or irregular shape (AOR = 17.65) than circular shape, consistent with DiMaio's study[14] because the skin around the skull is tighter and there is a tendency for the wound to be torn. In the non-head group, when examined in detail, the trunk showed no stellate morphology, which may be because the skin on the trunk is less tight than the skin on the head. A stellate lesion was found in the extremities, but it couldn't be interpreted due to insufficient occurrence. Regarding shooting distance, in the near group (contact and near contact range) there were multiple stellate morphological wounds (Table 4). However, when calculated by multinomial logistic regression analysis, no significant differences from shooting distance were found because shooting distances at close range are more often found in the head.

The bullet perforating through the bone may be deformed and push the bone throughout the exit wound, affecting the shape of the exit wound.

In this study, the gunshot wounds perforating bone were more likely to be irregular (AOR = 6.10) and not affect circular, slit-like and crescent wound shape. The bone perforation factor to the stellate wounds could not be interpreted because all head wounds must pass through the skull.

This study is consistent with standard textbooks stating that the shape of the exit wound is related to the site of the exit wound factor.[14] Furthermore, it is not related to the shooting distance. However, this study is limited by the relatively small number of samples and slit-like and crescent lesions were less common. The factor of bullet size and bullet shape should get more study.

The entrance gunshot wound to the head at all shooting distances may cause stellate-shaped wounds.[14-18,21] In this study, all head exit gunshot wounds had entered from the head (Table 2). Interpretation of wound shape alone should be avoided. Other information, such as the seared edge of the wound and beveling of the skull, should be considered when interpreting results.

This study proved that the site of an exit gunshot wound to the head is more likely to be stellate or irregular shape and the gunshot wound that perforating bone is more likely to be irregular shape, while sex and shooting distance do not affect the shape of a gunshot exit wound. This study had a relatively small sample size and did not collect information about the size or shape of the bullet. Therefore, further studies should be conducted on this issue. An entrance and exit wound to the head can be stellate-shape and should be interpreted carefully.

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Conflicts of interest. All authors report no conflicts of interest relevant to this article.

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