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## Autopsy features relevant for discrimination between suicidal and homicidal gunshot injuries

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**Abstract** A total of 624 consecutive gunshot autopsies from the Institutes of Legal Medicine in Münster and Hamburg was investigated retrospectively. In a subsample of 284 suicides and 293 homicides ( $n=577$ ), a large variety of features such as firearm, ammunition, number and site of entrance wounds, shooting distance and direction of the internal bullet path were recorded and binary logistic regression analysis performed in the case of bullet paths. Females constituted 26.3% of the homicide victims and 10.6% of the suicides. Short-barrelled firearms outnumbered long arms in homicides by 6:1 and in suicides by 2:1. More than 1 gunshot injury was found in 5.6% of the suicides (maximum 5 gunshots) and in 53.9% of the homicides (maximum 23 gunshots). The suicidal gunshots were fired from contact or near contact range in 89% while this was the case in only 7.5% of the homicides. The typical entrance wound sites in suicides were the temple (36%), mouth (20%), forehead (11%) and left chest (15%) but uncommon entrance wound sites such as the eye, ear, and back of the neck and head were also encountered. In suicidal gunshots to the right temple ( $n=107$ ), only 6% of the bullet paths were directed downwards and only 4% were directed from back-to-front. In gunshots to the left chest ( $n=130$ ), bullet paths running right-to-left or parallel occurred frequently in suicides (75%) and infrequently in homicide victims (19%). From 61 suicides who fired the gun inside their mouth, only 1 pointed the gun downwards. Consequently, some bullet path directions cannot be considered indicative of suicide: downwards and back-to-front in gunshots to the temple, left-to-right in gunshots to the left chest and downwards in mouth shots. The isolated autopsy findings can only be

indicative of suicide or homicide but the combined analysis of several findings can be associated with a high probability.

**Keywords** Gunshot injuries · Homicide · Suicide · Autopsy · Discrimination

### Introduction

In gunshot fatalities, a reconstruction of the events can be possible on the basis of a variety of autopsy and scene findings. However, unfavourable factors such as putrefaction, burning or dumping of the body can make this very difficult. In such deficiency cases, comparison of available findings to typical characteristics of suicide and homicide by firearms can be of assistance in determining the manner of death. A considerable number of publications deal with the characteristics of suicide and homicide by firearms [1, 2, 3, 5, 8, 11, 12, 29, 30, 35, 39, 40, 41, 44, 45, 46, 48] but the direction of the internal bullet path has rarely been investigated in a series of cases although this can also be relevant [11, 26]. In this study, a large series of gunshot autopsies is evaluated with special emphasis on the geometry of the internal bullet path.

### Material and methods

The files of two German Institutes were checked for firearm-related autopsies: The Institute of Legal Medicine, University of Münster ( $n=302$  from 1967–1997), and the Institute of Legal Medicine, University of Hamburg ( $n=322$  from 1985–1997). The records included a detailed autopsy report with photographs and examination of the clothing, and a summary of the police report. In a number of cases, the scene had been investigated and the full police reports and court documents were also available. Cases where the original investigation did not establish a clear and reliable manner of death were dismissed ( $n=15$ ) and there were 32 accidents. The remaining 577 cases of suicide and homicide form the basis of this study. The following parameters were recorded from the files: manner of death, gender and age, firearm, bullet, number and sites of entrance wounds, shooting distance, blood alcohol concentration (BAC), and a short case history.

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Whenever there was clear information in the autopsy records, the course of the bullet path inside the body was reconstructed and assigned to one of three categories for every plane relative to a standing position:

- Frontal plane: back-to-front, parallel, front-to-back
- Horizontal plane: upwards, parallel, downwards
- Sagittal plane: left-to-right, parallel, right-to-left.

The path was coded as being parallel if the angle between the bullet path and a main plane was less than 5°.

Binary logistic regression analysis of the direction of the bullet paths and the manner of death was performed for every plane separately using the software SPSS 10.0. A *p*-value of less than 0.05 was considered significant. The probability calculations are based on the regression analysis results.

## Results

Among the female victims, homicide was approximately 2.5 times more frequent than suicide (Table 1) and the mean age of homicide victims was younger than that of suicides (Table 2). Blood alcohol analysis yielded positive results in 106 suicides (37.3%) and in 60 homicide victims (20.5%).

Short-barrelled firearms were used most frequently – pistols and revolvers outnumbered rifles and shotguns in homicides by almost 6:1 and in suicides by 2:1 (Table 3). In two rifle suicides, the limited reaching distance of the arm was overcome by simple mechanical devices which

**Table 1** The gender in 577 cases of suicide and homicide

	Suicides	Homicides
Females	30 (10.6%)	77 (26.3%)
Males	254 (89.4%)	216 (73.3%)
Total	284 (100%)	293 (100%)

**Table 2** The age distribution in 577 cases of suicide and homicide

Classification	Age groups (years)					Un-known	Total
	<21	21–40	41–60	>60			
Suicide	14 (4.9%)	103 (36.3%)	114 (40.1%)	49 (17.3%)	4 (1.4%)	284 (100%)	
Homicide	18 (6.1%)	165 (56.3%)	85 (29.0%)	21 (7.3%)	4 (1.4%)	293 (100%)	

**Table 3** Types of firearm used in 577 cases of suicide and homicide

	Pistol	Revolver	Rifle	Shotgun	Other <sup>a</sup>	Unknown
Suicide	120	49	53	25	21	16
Homicide	148	42	15	18	4	66
Total	268	91	68	43	25	82

<sup>a</sup>Other the 25 unusual weapons included 10 slaughter guns, 8 gas weapons, 3 home-made guns, 2 submachine guns, 1 nail gun and 1 modified signal pen gun.

pulled the trigger. The most common calibres encountered were 5.6 mm rimfire (24%) and 9 mm Luger (21%) in suicides and 9 mm Luger (30%) and 7.65 mm Browning (25%) in homicides.

A total of 1,006 entrance wounds was recorded in the 577 fatalities. More than 1 gunshot injury was found in 5.6% of the suicides and in 53.9% of the homicides (Table 4). Of the suicidal gunshots, 89% were fired from contact or near contact range while 92.5% of the homicide victims suffered intermediate or distant gunshot injuries (Table 5).

The general distribution of the sites of the entrance wounds shows that the head and chest were involved in 98.7% of the suicides while the distribution was more even in homicide victims (Table 6). A more detailed analysis of the entrance wounds in the head and chest identified the temple (36%), mouth (20%), forehead (11%) and left chest (15%) to be the most common sites in suicides but some shots were also fired to very uncommon regions including the eye, ear, parietal region and nape of the neck (Tables 7, 8). The dorsal surface of the body was the target in almost half of the homicidal gunshots while this

**Table 4** The number of entrance wounds (*n*=1,066) in 577 individuals

No. of shots	Suicide	Homicide
1	268	135
2	13	62
3	1	37
4	1	25
5	1	13
6	0	11
7–12	0	9
23	0	1

**Table 5** The shooting distance in 1,004 entrance wounds (the shooting distance was unknown in 2 homicidal injuries)

Entrance wound	Suicide	Homicide
Contact	128 (41.8%)	22 (3.2%)
Near contact	145 (47.4%)	30 (4.3%)
Intermediate range	33 (10.8%)	104 (14.9%)
Distant	0	542 (77.6%)
Total	306 (100%)	698 (100%)

**Table 6** General distribution of the entrance wound sites in all 1,006 gunshot injuries

Entrance wound site	Suicide	Homicide
Head	252 (82.4%)	232 (33.1%)
Neck/nape	3 (1.0%)	38 (5.4%)
Chest	50 (16.3%)	139 (19.9%)
Abdomen	1 (0.3%)	54 (7.7%)
Back and lateral trunk	0	153 (21.9%)
Extremities	0	84 (12.0%)
Total	306 (100%)	700 (100%)

**Table 7** Distribution of the 484 entrance wounds in the head

Head wound location	Suicides	Homicides
Forehead	33	19
Temple (right)	111	18
Temple (left)	14	24
Mouth	61	3
Floor of mouth	11	3
Eye	5	16
Cheek	2	29
Back of head	4	57
Nape	1	22
Vertex area	4	15
Ear (right)	6	12
Ear (left)	0	14
Total	252	232

**Table 8** Distribution of the 189 entrance wounds in the chest

Location of chest wounds	Suicide	Homicide
Left chest	45	86
Presternal	3	10
Right chest	2	43
Total	50	139

**Table 9** Entrance wound right temple, horizontal and frontal plane. The direction of the bullet path in 123 cases (there was no bullet path or the direction was unknown in 4 suicides and in 2 homicide victims)

Direction of bullet path	Suicides (n=107)	Homicides (n=16)
Frontal plane		
Front-to-back	69 (64.5%)	10 (62.5%)
Parallel	34 (31.8%)	3 (18.75%)
Back-to-front	4 (3.7%)	3 (18.75%)
Horizontal plane		
Upwards	65 (60.7%)	3 (18.8%)
Parallel	36 (33.6%)	11 (68.7%)
Downwards	6 (5.7%)	2 (12.5%)

For the bullet paths running back-to-front versus front-to-back or parallel  $p=0.02$ .

The probability  $p$  for the bullet paths directed front-to-back and upwards or parallel is 0.90 (strongly indicating suicide) while for the bullet paths running back-to-front and downwards  $p=0.31$  (indicating homicide).

For the horizontal plane  $p>0.05$ .

was a very rare finding in suicides but did occur including 4 gunshots to the back of the head (Tables 6, 7).

From a large number of 107 suicidal gunshots to the right temple, only 4% were directed from back-to-front and only 6% were directed downwards (Table 9). Compared to homicides, the frontal plane showed a significant difference (Table 9). In gunshots to the left chest ( $n=130$ ), bullet paths running right-to-left or parallel occurred fre-

**Table 10** Entrance wound left chest, saggital plane. The direction of the bullet path in 130 cases (the direction was unknown in one suicide)

Direction of bullet path	Suicides (n=44)	Homicides (n=86)
Right-to-left	17 (38.6%)	6 (7.0%)
Parallel	16 (36.4%)	10 (11.6%)
Left-to-right	11 (25.0%)	70 (81.4%)

For the bullet paths running right-to-left or parallel versus left-to-right  $p=0.001$ .

The probability  $p$  for the bullet paths running left-to-right and downwards or parallel is 0.13 (strongly indicating homicide), and for the bullet paths from right-to-left and upwards  $p=0.77$  (indicating suicide)

**Table 11** Entrance wound mouth, horizontal plane. The direction of the bullet path in 64 cases

Direction of bullet path	Suicides (n=61)	Homicides (n=3)
Upwards	55 (93.2%)	2
Parallel	3 (5.1%)	0
Downwards	1 (1.7%)	1

**Table 12** Entrance wound back of the head or nape of the neck, horizontal plane. The direction of the bullet path in 82 cases (the direction was unknown in 2 homicide victims)

Direction of bullet path	Suicides (n=5)	Homicides (n=77)
Upwards	4	20 (26.0%)
Parallel	1	48 (62.3%)
Downwards	0	9 (11.7%)

quently in suicides (75%) and infrequently in homicide victims (19%), which is also a significant difference (Table 10). In the horizontal plane, gunshots to the chest directed downwards dominated in both suicides (70.4%) and homicide victims (58.1%).

From 61 suicides who fired the gun inside their mouth, only 1 pointed the gun downwards (Table 11) and of 77 homicide victims having an entrance wound in the back of the head or neck, most showed a horizontal bullet path (Table 12). Due to the small number of the corresponding subsets (Tables 11, 12), a statistical analysis was not suitable.

No additional information was gained when long- and short-barrelled firearms were differentiated. The course of the bullet path in the horizontal plane varied in suicidal gunshots to the left chest using a long-barrelled firearm ( $n=16$ ): 8 bullet paths (50%) were directed downwards while 3 (19%) were upwards and 5 (31%) horizontal.

## Discussion

### Demographics and weapons

The younger mean age and the lower frequency of blood alcohol in homicide victims is in accordance with previous studies [7, 11, 17, 30, 33, 40, 41, 45]. Females constituted only 1–3% of the firearm suicides in studies from Scandinavia [11, 17, 30] and 5–7% in studies from German-speaking countries [5, 33, 40] and Great Britain [1, 2, 7, 41]. The female proportion of 10% found in this study is still lower than the 20–30% reported from the USA [20, 38, 46] but it showed an increase over time. Compared to the 26% female homicide victims, it appears large enough to weaken the validity of Knight's hypothesis that "a shot woman is a murdered woman until proven otherwise" [31].

The preference of short-barrelled firearms, especially of pistols, in both suicides and homicides was also found in studies from German-speaking countries [33, 40] and North America [12, 46] whereas long-barrelled weapons and especially shotguns prevailed in Scandinavia [11, 29, 49], Great Britain [1, 7, 41] and Australia [45]. This difference is due to historical and legal reasons.

### The number and the site of the entrance wounds

Suicides commonly fire a single gunshot but 5.6% in this study and 1–7% in other studies [12, 20, 25, 33, 40] fired more than once. Two or more body regions may be involved [5, 12, 20, 21, 25] and as many as 9 [16] and 14 [6] gunshots to the chest and two penetrating gunshots to the head [23, 25] have been reported. Immediate incapacitation occurs necessarily only if essential centres in the CNS are injured [13, 22, 23, 25, 27]. Consequently, suicide can only be ruled out if two gunshots (or the first one) from a non-automatic firearm have wounded these centres. Multiple gunshot wounds in homicides have been reported in 26–55% [7, 11, 33, 41, 49] compared to 53% in this study. The number of entrance wounds in homicides is only limited by the magazine capacity or by the time and ammunition available.

The "classical" entrance wound sites in suicides – temple, mouth, forehead and left chest – established before [1, 2, 5, 7, 8, 9, 11, 12, 18, 29, 33, 34, 35, 39, 40, 41, 44, 46] were verified: 82% of the entrance wounds were located there but 9% were found in very atypical sites such as the eye, the back of the head, the parietal region, the cheek or the ear. Gunshots to the back [18], the nose [32], the spectacle lens [42] and extremities [20, 36] have been published in suicides as well as intrarectal [37] and tangential grazing gunshots [25]. Consequently, atypical entrance wound sites in a fatality suspected to represent a suicide should definitely raise the level of suspicion but this finding alone cannot exclude suicide. In homicides, the main targets are the head (30–50%) and the thorax (25–45%) [7, 19, 29, 30, 40, 41, 48] but due to the dy-

namic situation, the distribution is more even and many bullets enter via the dorsal surface of the victim.

### The shooting distance

This parameter has received little attention in the literature and inconsistent classifications render a comparison difficult. In several series of suicides, contact or near contact wounds were present in more than 97% [2, 8, 46], Karlsson [29] reported obvious contact wounds in 80%. The present study underlines that the vast majority of suicides have contact or near contact wounds but it also demonstrates that a small group does not follow this rule. The size of this minority may vary from <1% [46] to 10% (this study). In homicides, intermediate and especially distant gunshots predominate clearly while contact and near contact wounds were found in only 6–11% [8, 29, 46, this study]. This finding can indicate surprise or defencelessness of the victim or a scenario similar to an execution.

### Direction of the bullet path

The direction of the internal bullet path may differ between suicides and homicides for a particular entrance wound site. Suicides commonly intend to have a stable and comfortable position of the shooting hand and a fatal effect of the gunshot. The geometric relations of the body and firearm may thus establish typical positions of the firearm and typical suicidal bullet paths. Contrary to this static setting in suicides, homicides occur in a dynamic situation including motion, resistance or flight of the victim and distant gunshots. This may cause internal bullet paths which vary from typical suicidal bullet paths in the same entrance wound location. It is clear that ricocheting bullets may interfere with these considerations but occur infrequently and can usually be recognised by bullet deformation and trace evidence [28].

The direction of the bullet path as indicator of suicide versus homicide has rarely been investigated. One study [47] only considered the horizontal plane and the bullet paths were not correlated to the exact entrance sites. Druid [11] analysed 213 suicides but only 54 homicides. In this study, 293 homicides and 284 suicides were investigated but still, the small number of gunshots in some subsets (e.g. homicidal mouth shots) prevented a meaningful statistical analysis. Nevertheless, the following conclusions can be drawn from a careful interpretation of the results:

1. Gunshots to the right temple. Suicides commonly show a bullet path directed front-to-back and upwards (or parallel). A bullet path running back-to-front and/or downwards is not indicative of suicide despite the typical entrance wound site. Druid [11] also found that bullet paths running back-to-front occur infrequently in suicides.

2. Gunshots to the left chest. Suicides commonly fire from right-to-left or parallel while homicidal bullet paths frequently run from left-to-right. Thus, bullet paths directed from left-to-right are not typical for suicide.
3. Gunshots to the mouth. Suicides clearly prefer an upwards direction while a descending course is a rarity, which is also the experience of others [4, 11, 15]. In homicides, many bullet paths appear to be directed parallel to the horizontal plane [4, 14] but the total number of reports is small and bullet paths directed upwards [11, 50, this study] and downwards [11, this study] have also been reported.
4. Gunshots to the back of the head or neck. If a suicide chooses this atypical site, the bullet path is usually directed upwards while all directions occur in homicides.

A controversial subject is suicidal gunshots to the left chest with a long-barrelled firearm. A systematic deviation from the horizontal plane may be expected because the distance from the muzzle to the trigger is frequently longer than the arm of the suicide. Sellier [43, 44] considered an upwards direction to be common while a downwards direction is typical in the opinion of DiMaio [10]. The present study demonstrates that both directions occur. This is not surprising because the trigger can be reached by both raising and lowering the stock of the weapon and different positions of the upper body can be taken [24].

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## Conclusions

The single autopsy findings as to the number and site of the entrance wounds, the shooting distance and also the direction of the internal bullet path can represent indications of the manner of death. A combination of typical findings in any one case can represent strong evidence for suicide or homicide and "atypical patterns" should ring an alarm. Establishing a general phenomenology of suicide and homicide by firearms therefore appears to be justified. However, the peculiar characteristics of an individual case should never be sacrificed to general or preconceived notions because atypical findings do occur and in very rare cases, the "opposite" manner of death may be mimicked. This demonstrates that efforts to reconstruct the events are always important.

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