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Frequency of Bone Lesions: An Inadequate Criterion for Gunshot Wound Diagnosis in Skeletal Remains

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ABSTRACT: A retrospective study was carried out on 130 fatalities due to gunshot wounds to determine whether the combined absence of bone damage and projectile in a skeleton is sufficient to eliminate a diagnosis of gunshot wound. Our findings showed that bone lesions were present in about 90% of the cases and were associated with intracorporeal projectile(s) in about 70% of the cases. The presence or absence of bone lesions seemed independent of the gun characteristics, the shot conditions, and the type of death. The cause of death was predominantly brain injury in cases with bone lesions whereas thoracic, abdominal, and peripheral vascular causes were more frequently encountered in cases without bone damage. We concluded that the combined absence of bone lesions and intracorporeal projectile (about 5% in our series) cannot exclude a diagnosis of death secondary to gunshot wounds.

KEYWORDS: forensic science, forensic pathology, gunshot wounds, bone lesion, skeleton, autopsy

The discovery of skeletal remains requires appropriate postmortem investigation in order to rule out possible trauma. In this context, a diagnosis of gunshot wound depends on the discovery of suggestive bone lesion(s) and/or projectile(s). The aim of our study was to question whether the lack of any bone lesion and of any projectile in a skeleton is sufficient to rule out gunshot wounds. The frequency of bone lesions and of intracorporeal projectile(s) according to the characteristics of the gun used, the shot conditions, and the circumstances of death was established retrospectively in intact bodies, where death had been due to gunshot wounds. We extrapolated our results to the examination of skeletons.

Materials and Methods

A restrospective study was carried out on 130 cases who died from gunshot wounds and whose autopsy was performed from 1995 to 1998 in the Department of Pathology and Forensic Medicine in Garches. All putrefied and carbonized bodies were excluded. Those cases that showed bone damage secondary to another causal agent (resuscitation, blunt instrument) were also excluded from the study. For each case, the frequency, type, and site of bone lesions were listed according to gun characteristics, shot conditions, and circumstances of death. The gun characteristics were obtained from the police and ballistic records when available. The shot conditions and circumstances of death were established by the postmortem data. The gun characteristics corresponded to gun type (handgun, rifle, shotgun), ammunition type (bullet, pellet), and to caliber (small, medium, large). The caliber of the rifled weapons was arbitrarily defined according to three categories: small (<6 mm), medium (between 6 and 8 mm), and large (>8 mm) according to the bullet diameter. The caliber of shotguns was also arbitrarily defined according to three categories: small (<16 mm), medium (between 16 and 18 mm) and large (<18 mm) according to the bore diameter. The shot conditions included presumed range of fire (hard-contact, loose-contact, near-contact, intermediate, and distant ranges), the number of shots (single or multiple) and the presence/absence of intracorporeal projectile(s). The data relative to gun characteristics and shot conditions were classified as "undetermined" when they could not be established with accuracy. The circumstances of death were defined as the cause and the type of death (homicide, suicide, accident). The main causes of death were cerebral, thoracic, abdominal, peripheral vascular injuries, and those secondary to lesions of the cervical spinal cord. The cause of death was judged complex when there were lesions of vital organs in different sites capable of causing death.

Two groups were defined according to the presence/absence of bone lesions and of intracorporeal projectile(s): 1. Bone lesion(s) with or without intracorporeal projectile(s); 2. Absence of bone lesion with or without intracorporeal projectile(s). Different parts of the gun ammunition, even nonmetal parts such as the wad, were considered projectiles in the study.

Moreover, the frequency of bone lesions according to their anatomical site was analyzed. The anatomical sites classified were the ribs and sternum, the vertebral column, the skull and facial bones, the upper limbs (including clavicles and scapulae), and the lower limbs (including the pelvis). The frequency of the site of bone lesions according to the type of death was also assessed. The bone lesions typical of a gunshot wound were taken into account. The morphological characteristics of entrance and exit bone wounds were used as described by Di Maio (1).

Results

The mean age of the studied population was 39-years-old (range: 1–90 years old). The sex ratio (men/women) was 2.7. Table 1 shows the respective frequency of bone lesions and of intracorporeal projectile(s) according to the different groups. Table 2 gives the frequency of bone lesions according to the gun characteristics. Most of the gunshot wound deaths in our series were caused by a

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TABLE 1—*Frequency of bone lesions and intracorporeal projectile(s) in gunshot wound fatalities* (N = *130).*

	N	%
Bone lesions with projectile(s)	92	70.8
Bone lesions without projectile	24	18.5
Projectile(s) without bone lesion	8	6.1
No bone lesion and no projectile	6	4.6

TABLE 2—*Frequency (%) of bone lesions according to the gun characteristics.*

		Bone Lesions With or Without Projectile	Absence of Bone Lesion (*N* = 14)	
		(*N* = 116)	With Projectile (*N* = 8)	Without Projectile (*N* = 6)
Type of gun	Handgun	38 (32.8)	1 (12.5)	1 (16.7)
	Rifle	16 (13.8)	2 (25)	2 (33.3)
	Shotgun	34 (29.3)	3 (37.5)	…
	Undetermined	28 (24.1)	2 (25)	3 (50)
Type of ammunition	Bullet	71 (61.2)	2 (25)	5 (83.3)
	Pellet	44 (38)	6 (75)	1 (16.7)
	Undetermined	1 (0.8)	…	…
Caliber	Small	36 (31)	1 (12.5)	2 (33.3)
	Medium	15 (12.9)	2 (25)	1 (16.7)
	Large	30 (25.9)	2 (25)	…
	Undetermined	35 (30.2)	3 (37.5)	3 (50)

TABLE 3—*Frequency (%) of bone lesions according to the shot conditions.*

		Bone Lesions With or Without Projectile	Absence of Bone Lesion (*N* = 14)	
		(*N* = 116)	With Projectile (*N* = 8)	Without Projectile (*N* = 6)
Range of fire	Hard-contact	7 (6)	1 (12.5)	…
	Loose-contact	41 (35.3)	3 (37.5)	1 (16.7)
	Near-contact	16 (13.8)	1 (12.5)	…
	Intermediate	20 (17.2)	2 (25)	2 (33.3)
	Distant	5 (4.3)	1 (12.5)	1 (16.7)
	Undetermined	27 (23.4)	…	2 (33.3)
Number of shots	Single	77 (66.4)	6 (75)	4 (66.6)
	Multiple	38 (32.8)	2 (25)	1 (16.7)
	Undetermined	1 (0.8)	…	1 (16.7)

hand gun (30.7%), by a bullet (59.2%), and by a small caliber (30%). The frequency of bone lesions according to the shot conditions is shown in Table 3. A single shot was the most common (66.9%). With regard to the range of fire, loose-contact entrance wounds were the most common (34.6%). Table 4 shows the frequency of bone lesions according to the circumstances of death. Cerebral injuries were the most common causes of death (43%).

TABLE 4—*Frequency (%) of bone lesions according to the circumstances of death.*

		Bone Lesions With or Without Projectile	Absence of Bone Lesion (*N* = 14)	
		(*N* = 116)	With Projectile (*N* = 8)	Without Projectile (*N* = 6)
Causes of death	Cerebral	65 (56)	…	…
	Cervical spinal cord	2 (1.7)	…	…
	Thoracic	19 (16.4)	4 (50)	1 (16.7)
	Abdominal	6 (5.2)	3 (37.5)	3 (50)
	Vascular	1 (0.9)	1 (12.5)	1 (16.7)
	Complex	23 (19.8)	…	1 (16.7)
Type of death	Homicide	59 (50.9)	5 (62.5)	4 (66.7)
	Suicide	54 (46.5)	3 (37.5)	2 (33.3)
	Accident	3 (2.6)	…	…

TABLE 5—*Frequency (%) of bone lesions according to anatomical site.*

Anatomical Site	Single	Combined	Total of Lesions (*N* = 142)
Skull and face (*N* = 69)	61 (63.8)	10 (13)	71 (48.6)
Vertebral column (*N* = 17)	6 (5.3)	10 (70.6)	16 (12)
Ribs and sternum (*N* = 43)	28 (27.7)	15 (39.5)	43 (30.3)
Limbs (*N* = 13)	3 (3.2)	10 (76.9)	13 (9.1)

TABLE 6—*Frequency (%) of the anatomical site of bone lesions according to the type of death.*

Anatomical Site	Homicide	Suicide	Accident
Skull and face (*N* = 69)	33 (47.8)	34 (49.3)	2 (2.9)
Spinal column (*N* = 17)	16 (94.1)	1 (5.9)	…
Ribs and sternum (*N* = 43)	29 (67.5)	13 (30.2)	1 (2.3)
Limbs (*N* = 13)	12 (92.3)	1 (0.7)	…

Homicide deaths were slightly more (52.3%) than suicides. Table 5 shows the frequency of bone lesions according to their anatomical site. 81% of the lesions were single site and 9% more than one site. Table 6 shows the frequency of bone lesions according to the type of death. The bone lesions were typical of gunshot wounds in about 42% of the cases. In 96% of these, the lesions were entrance or exit wounds in the skull and the remainder were pellets embedded in vertebrae.

Discussion

Most previous studies of bone lesions secondary to gunshot wounds were limited to lesions of the skull. They paid special attention to the morphological characteristics of the penetrating cranial wounds (2). They also tried to estimate the bullet caliber from the measurement of the diameter of cranial entrance defects (3,4).

In our series of 130 gunshot deaths, the majority of cases had a single shot by a bullet of small caliber, performed at contact range by a hand gun due to homicide, and caused death by isolated cerebral injuries. Bone lesions secondary to gunshot wounds were pre-

sent in about 90% of the cases. They corresponded in most cases to fractures and/or penetrating bony defects, and more rarely to erosions or to a pellet embedding in bone. The preferential anatomical sites were the skull, the ribs, and the sternum. They were typical of gunshot wounds in about 40% of the cases. The majority (about 70%) also had an intracorporeal projectile(s). The presence or lack of bone lesions did not seem to depend on the gun characteristics (type of gun, type of ammunition, caliber), the shot conditions (number of shots and range of fire) and the type of death, although more bone lesions would be excepted in cases of multiple shots carried out at contact or close range, with ammunition of large caliber. Because details were imprecise in many cases, the different frequency between the group with bone lesions and the group without lesions could not be evaluated statistically. The frequent unavailability of police and ballistic records explains the large number of undetermined gun types and caliber. The main cause of death was cerebral injury in the group with bone lesions whereas thoracic, abdominal, and peripheral vascular causes of death were found in cases without bone damage. In cases with bone lesions, the anatomical site of bone lesions corresponded with the site of lesions which were the causes of death. The cranial lesions were very often single, because of their severity. Conversely the lesions of the vertebral column and of the upper and lower limbs were more often combined with other lesions at different sites. The frequency of bone lesions to the skull was similar in the cases of homicide and suicide. On the other hand, the lesions of the spinal column, the limbs, the ribs, and sternum were more frequently encountered in homicides than in suicides.

The diagnosis of gunshot wounds in a skeleton is difficult, and must be made very carefully. Bone lesions secondary to gunshot wounds are often nonspecific and may be simulated by other agents, such as blunt instruments. As well as being nonspecific, these bone lesions are sometimes very minor, such as erosions, which can be missed. The bony penetrating defects must be distinguished from the foramina that are present in about 7% of cases in the sternum, according to the study of Cooper et al. (5) and from cranial lacuna. They also have to be differentiated from bone defects secondary to postmortem alterations. Postmortem bone alterations may be induced by soil chemical erosion or mechanical erosion, and by animal or plant activity (6). The possibility of gunshot wounds inflicted after death must also be eliminated (7). Apart from the aforementioned difficulties, bone lesions can be absent because of the incomplete character of the discovered skeleton, or because of the deleterious effects of postmortem damage caused by environmental factors. In addition, in about 10% of the cases, the projectile(s) does not cause bone lesions. When the site of the gunshot wound is thoracic, the lack of any bone lesion is explained by the intercostal track of the projectile(s). The finding of projectile(s) in the skeleton, or located in the area where the skeleton lay, is an additional factor in favor of the diagnosis of gunshot, but is not conclusive. But this argument is not definitive. Finding a projectile(s) may be due to an old nonlethal gunshot wound, sometimes even unknown to the victim (8). Consequently the presence of projectile(s) has more meaning if the site is intracranial and even more so if there are associated cranial lesions. Indeed the cranial lesions are more likely to exhibit characteristics suggestive of their etiology. Ballistic tests on the recovered projectile(s) are required in every case in order to eliminate the possibility of an old gunshot wound in which the ammunition used could have some distinctive features due to its age. As the presence of an intracorporeal projectile may be limited to small fragments, it is essential to X-ray the skeleton and especially the possible sites of bone lesions. The search for projectile(s) in the ground is also necessary. The presence of small and subtle fractures (i.e., to the spinous and transverse vertebral process, ribs, or pelvis), which are easily overlooked during autopsy, could explain the lack of bone lesions in some of the gunshot wounds fatalities in our series. However, full radiography of all our cases was performed before autopsy in order to avoid this problem. Moreover, in one case, we were certain of the absence of bone damage and projectile: the only bullet track with entrance and exit wounds caused a fatal injury of the right superficial femoral artery without any pelvic or femoral fracture at autopsy with radiography.

In conclusion the lack of bone lesions and intracorporeal projectiles in the victims of gunshot wounds does not exclude death secondary to gunshot wounds in a skeleton. This diagnosis must be made very carefully because of the nonspecificity of bone lesions and of the rare possibility of the presence of intracorporeal projectile(s) due to an old nonlethal gunshot.

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