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Characterization of Lesions in Hanging Deaths

ABSTRACT: Hanging is a common method of committing suicide and a routine task in medico-legal autopsies. The hanging mark is the most relevant external sign and its characteristics are well known, but, for unknown reasons, there are major differences in reports on internal findings. We retrospectively studied 228 consecutive cases of hanging deaths. A complete standard autopsy was performed for every case. We investigated the association between the characteristics of the hanging mark and the frequency of bone, cartilage, soft tissue, and vascular injuries with the mode of suspension. Most cases (75.3%) presented some kind of bone or cartilage fracture, but these were unrelated to any of the variables studied. Vascular lesions are clearly more infrequent: intimal injuries were found in the carotid artery (9.1%), the jugular vein (2.2%), and ruptures of the carotid adventitial layer (21.7%). These could be partially associated with the use of a hard fixed noose and body weight.

KEYWORDS: forensic science, death, asphyxia, hanging deaths, autopsy, neck injury, suicide

Hanging is a form of death due to constriction of the neck when the force applied is derived from the gravitational drag of the victim's body weight (1–4).

The vast majority of hangings are suicidal and only occasionally are accidental or homicidal cases reported (5–12). Internationally, death by hanging ranks among the most common method of suicide (13), accounting for more than 50% of all suicides in Saudi Arabia (14,15) and Hungary (16,17), while in Norway and Denmark it falls to second place with a frequency of 25% and 17%, respectively (18). In the autonomous Spanish region of Galicia, hanging accounts for 65.6% of all suicides (19), while in the nearby region of Coimbra (Portugal), it occupies second place (13%) behind pesticide ingestion (20). Nevertheless, despite the frequency of hanging, the associated neck injuries are rarely submitted to systematic analysis, and discrepancies in the findings reported by different authors are sometimes striking (13,14).

Our intention in this paper is to describe the lesions found in an extensive series of hangings from the files of two institutions: the Institute of Legal Medicine of Santiago de Compostela (Spain) and the National Institute of Legal Medicine of Portugal-Coimbra. The pathological findings were reviewed and related to the characteristics of the method of suspension and ligatures employed. The results obtained were compared to those in the literature.

Materials and Methods

All cases of hanging were found in the records of the Institute of Legal Medicine of the University of Santiago de Compostela, Spain,

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Received 24 May 2007; and in revised form 18 Sept. 2007; accepted 13 Oct. 2007.

and the National Institute of Legal Medicine of Portugal-Coimbra. The study consisted of 228 consecutive cases (128 from Santiago and 100 from Coimbra), which were reviewed retrospectively and included detailed autopsy reports and photographs.

Each case was subjected to a complete autopsy, including toxicological analysis when considered necessary. The technique for examination of the neck was similar in both institutions. In brief, after brain removal, a V-shaped incision from the manubrium to both mastoid processes was made. Individual dissection of the neck muscles was made in every case. To avoid possible iatrogenia, the tongue, larynx, and hyoid bone were removed in block, and the hyoid bone was then dissected and the larynx longitudinally opened through its posterior aspect. The cervical vertebrae were examined for fractures, the carotid and jugular vessels were opened *in situ* and the intima inspected. Histopathological examination was carried out in selected cases.

The basic demographic data, as well as circumstantial and pathological information were recorded for each case whenever possible. Some records were excluded from certain parts of the analysis due to insufficient information.

Statistical analysis was carried out using Pearson's chi-square test, independent *t*-test, and Kolmogorov–Smirnov test. A probability level of $p \leq 0.05$ was considered significant. Mathematical approach was made using SPSS version 13 for Windows.

Results

General Features

Apart from two accidental hangings, the medico-legal etiology was always suicidal. Males formed the majority of cases (77.8%), while females represented only 22.2% of the total. Ages ranged from 1 to 91 years, with an average of 51.65 years. Men ranged from 13 to 91 years (average 51.01) and women from 1 to 87 (average 53.86). The distribution by age and sex is shown in Fig. 1. The case of the 1-year-old girl referred to an accidental hanging in the crib.

The deaths had higher frequency on Mondays (44 cases) followed by Sundays and Tuesdays, with 38 and 36 cases, respectively. The differences were not significant. Toxicological

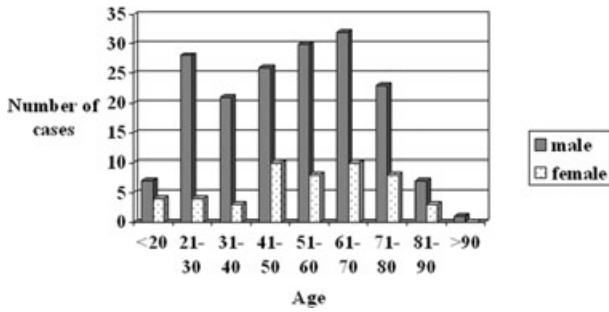


FIG. 1—Distribution by age and sex.

investigation was carried out in 128 cases and revealed positive results only for alcohol in 29% of cases with levels between 0.18 and 2.7 g/L. No other toxicological substances were found.

Type of Suspension and Ligature

The type of suspension (complete vs. incomplete) was known in 194 cases, of which complete hanging represented 62.4%. The type of ligature applied usually involved a fixed knot (65.4%) and only 21.5% of the cases used a running knot (in 13.1%, these data were not recorded). Women used a hard-fixed knot more frequently than men with a value of $p = 0.0077$. The vast majority of the cases of incomplete suspension corresponded to individuals hanging from the ceiling with a long ligature.

Placement of the Ligature Knot

The knot was located on the left side of the neck in 35.3% of cases, and on the right for 28.5%. While 32.1% were suspended from the back of the neck, only 4.1% cases were suspended from the front (Fig. 2).

Hanging Mark

A single circumferential wrap was present in 84.7% of cases, and only in 14.9% were there two wraps. The mark frequently appears with a parchment-like consistency (90.4%). No association between the hanging mark and the type of suspension was found.

Asphyxial Signs

Facial congestion was present in 42.9%, and petechial hemorrhages of the face and conjunctiva appeared in 23.4%. No association between indications of asphyxia and the ligature or type of knot employed was found.

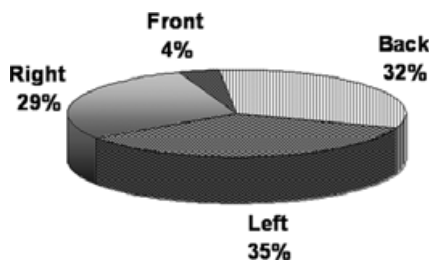


FIG. 2—Location of the knot.

Argent Line

This silvery line, formed by condensation of the subcutaneous fat tissue under the furrow, is a common finding, present in 76.8% of the cases, but its appearance is not associated with any parameter.

Fractures of the Hyoid Bone and/or Laryngeal Cartilages

In 75.3% of the corpses studied, some type of fracture of this neck structure was revealed. This was more common when a hard-fixed noose was used ($p = 0.012$). Distribution of these injuries is shown in Fig. 3.

The hyoid bone was broken in 110 cases (48.4%) (one case lacked information), but no significant differences between men (52%) and women (36%) were found. Fractures occurred on the right side in 17.7% of the cases, on the left in 16.2%, and on both sides in 14.5% of cases. There are no differences between the locations of the knot and the fracture.

Thyroid cartilage fractures were present in 107 cases (47.1%) (one case lacked information) (45.12% in men and 54% in women). Fracture of the right greater cornu of the hyoid appeared in 16.7% of all cases, of the left in 17.1%, and both greater cornu were damaged in 13.2%. There was no significant difference between the side of the fracture and the position of the knot. No fractures were found in the cricoid cartilage.

No association between the presence of hyoid bone or thyroid cartilage fractures and age or sex could be demonstrated. The presence of fractures was also independent of the mode of suspension (complete vs. incomplete).

Cervical Fractures

These were present in 3.6% of the corpses (seven out of the eight cases were men). All fractures were in C2. There was no significant difference in the presentation of cervical fracture with gender, mode of suspension, or body weight.

Muscle Hemorrhages

These were found in neck muscles in 55.8%. The most frequently affected muscle was the sternocleidomastoid. There was no association between the presence of muscle hemorrhage, fracture, type of knot, mode of suspension, age, or body weight.

Vascular Lesions

Injuries of the intima of the carotid artery were found in 9.1% of the cases. Its occurrence was independent of age, gender, weight, mode of hanging, and type of noose with no significant differences.

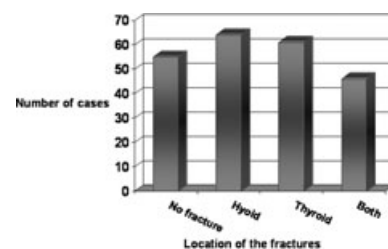


FIG. 3—Frequency of neck fractures.

The adventitial layer of the carotid was ruptured in 21.7% of cases. There was a higher frequency for males ($p = 0.023$) and when a hard-fixed knot was used ($p = 0.0084$). Intimal injuries in the jugular were present in 2.2% of cases, all of which were located on the right side. The number of cases with lesion is too low to draw any conclusion.

Discussion

Hanging is a very common method of committing suicide (13–16,18,21), and in Galicia (NW Spain) it is the preferred method, constituting 65.6% of all suicides (19), with an incidence similar to that of Saudi Arabia (15) and Hungary (16). However, in Portugal, it accounts for only 13% of cases and occupies second place behind self-poisoning (20). This fact is probably related to the relative ease of access to pesticides in Coimbra, where the population employed in farming is higher than in Santiago.

In our study, and in most material previously reported, males account for the majority of cases of death by hanging, conforming to the idea that violent death is more commonly associated with males (8,10,11,17,22,23).

Hanging is less frequent at the extremes of the age groups and the literature points to individuals between 40 and 60 years as a risk group (24). However, in our study no statistical difference in distribution by age was found, and the distribution according to age is more uniform than expected.

Although a higher frequency of hangings took place on Mondays, probably due to cultural factors, no significant differences were found. We observed that complete hangings predominated over incomplete, thus conforming with findings stated in the literature (14,25).

In our series, the knot is typically located in lateral and posterior locations around the neck, and the anterior position is uncommon, as previously reported (14,23,26). A hard-fixed knot was more common than a running knot, especially in women ($p = 0.0077$).

The presence of a hanging mark, generally unique and lying above the larynx, has been reported in many published studies (2,3,26,27), and this fact was further corroborated by our own investigations. A common finding in our series (76.6%), but only occasionally reported in the literature, is a condensation of the subcutaneous fat tissue under the furrow, known as an argent line (2,28).

The finding of facial congestion and petechiae has been considered as a classical sign of an asphyxial mode of death, but its real significance has been challenged (3,4). Although some authors affirm that these signs are more frequent in incomplete hangings (3,27,29), we found no statistical association.

Laryngeal fractures were absent in some reports (14,30) but were described in up to 76.6% of other studies (3,21,23,29,31). In our material, it was present in 75.3% of the cases, with fractures in hyoid only slightly more common than in the thyroid cartilage. The discrepancies in the frequency of fractures between different series is probably related to the method of autopsy employed, as previously noted by Paparo and Siegel (32). Several authors have shown that the rate of fractures increases with age (33), which might explain some differences in the incidence of fractures between authors. Nevertheless, this association is not apparent in our study.

The relationship between the incidence of fractures and gender is controversial. While some studies have shown that these lesions were more frequent in women (32), others, contrariwise, state the same for men (13), while still others inform that no gender

association was found (34). We share this last opinion, because we have been unable to find a significant correlation between the presence of bone or cartilage fractures and gender. Previous authors have studied the relationship of this fracture with the type of ligature and have shown that these fractures are less frequent when a knot in a soft textured rope is used (33). Fractures of the neck were more common when a hard-fixed noose was used ($p = 0.012$), probably due to a different distribution of neck pressure.

Fracture of the cervical column is an uncommon finding (approximately 3%) and no association with any variables studied was found, probably because the figure is too low. Nevertheless, seven out of the eight cases corresponded to men, probably reflecting the greater body weight of men.

Hemorrhages in at least one of the neck muscles were present in 55.8% of the cases. This figure was considerably greater than the 2.9–33% given in the literature (21,34–36). In our autopsies, all neck muscles were dissected independently, which may help to explain the differences found. Hemorrhages were more common in men, probably because of the greater body weight of males, and consequent greater traction to the neck, which, moreover, has greater muscular mass. Only in one series was a large rate (96%) of hemorrhages reported at the origin of the sternocleidomastoid muscles in hanging (37). This could reflect a bias in the inspection of a particular anatomical area.

Nevertheless, no association was observed between the location of hemorrhages and the placement of the noose, nor the type of hanging, nor the type of knot, nor the presence of fractures, although this latter association has been found in previous studies (23,33).

We found that vascular lesions were more common in the carotid, with tears in the adventitial layer of the carotid in 21.7% of the autopsies. The fact that they were significantly more common in males, and particularly so when a fixed knot was used, most probably reflects the greater body weight in males and the maintained pressure exerted by this type of knot. Lesions in the intima were less frequent and unrelated to any of the parameters investigated. The greater occurrence of lesions in the carotid artery than in the jugular vein could be explained by the higher content of elastic fibers in the latter, which makes it more stretchable and, consequently, more resistant to rupture. Decapitation is an unusual complication (38), which was not present in our series. The rate of alcohol intoxication was 29%, similar to previous reports (17,36,39).

In summary, although the lesions associated with death by hanging are well known, significant but unexplained differences in the reported frequencies do exist in the literature. The explanations could be many, and an inadequate autopsy investigation cannot be ruled out. Other parameters, difficult to evaluate in the postmortem examination, might also help to explain many differences, including variations in anthropometric parameters and other circumstantial evidence, such as the velocity of the fall. Most probably, prospective studies employing very strict technical criteria with regard to the carrying out of the autopsy could help to settle this problem. Adherence to an autopsy protocol, such as that recommended by the Council of Europe (40), could be useful.

Acknowledgments

This study was partially supported by Grants XUGA20807B98 and Grant 2006/CI194-USC.

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