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PAPER

PATHOLOGY/BIOLOGY

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Amussat's Sign in Hanging—A Prospective Autopsy Study

ABSTRACT: Amussat's sign is typically a transverse laceration of the intimal layer of carotid arteries described in cases of hanging. Subtotal laceration of the carotid artery is not strictly specific for hanging and can be also caused by blunt neck trauma, extreme overstretching, or whiplash-injuries. In a prospective autopsy study of 178 cases of hanging, Amussat's sign was found in 29 cases (a relative frequency of 16.1%). A statistically significant association between the occurrence of tears in the intimal layer of carotid arteries and the victims' age was discovered in the cases studied (the frequency increased with age; $p < 0.05$). The occurrence of Amussat's sign was independent of gender, weight, completeness of the victim's body suspension, and position of the ligature knot on the neck. The study demonstrates the fact that the most probable cause of Amussat's sign is a combination of direct compression of the artery by the rope and indirect stretching because of the gravitational drag produced by the weight of the body.

KEYWORDS: forensic science, hanging, Amussat's sign, cervical vessels, vital sign, autopsy

Hanging is a form of ligature strangulation in which the force applied to the neck derives from the gravitational drag of the victim's body weight. The most important signs in the diagnostics of hanging are internal neck injuries (1,2). Such vital findings are evidence of a premortem origin of hanging. Ligature marks themselves are mainly a postmortem phenomenon (3). Injury to cervical vessels as a result of hanging is one such basic diagnostic sign. The best known is the so-called Amussat's sign (4), i.e., transverse laceration in the intimal layer of the carotid artery (Fig. 1). Only rarely are these breaches oriented longitudinally. It is possible to have multiple tears (Fig. 2) and subintimal hematomas can be found around them. It must be emphasized that subtotal lacerations of the carotid artery are not specific for hanging only, but can also be caused by blunt neck trauma, extreme overstretching (5), or whiplash-injuries (6).

In rare cases, intimal layer tears are combined with tears to the media or adventitia of the artery. Injuries to the intimal layer can even result in dissection of the medial layer of the carotid artery, with subsequent narrowing of its lumen (7,8). Such traumatic rupture in the artery wall can also be a morphological substrate for the potential formation of wall thrombosis and subsequent cerebral ischemia in surviving patients (1,9). Large subintimal hematomas (10) or intramural bleeding can also result in the narrowing of the arterial lumen. Injuries of a similar nature occur also in the area of the vertebral arteries, and with an even higher frequency than in carotid arteries (11), especially in judicial hanging (12). Nevertheless, the carotid and vertebral arteries are not strictly comparable in mechanical terms.

The objective of this paper is a descriptive analysis and statistical evaluation of injuries to the intimal layer of the carotid arteries and internal jugular veins in the hanging victims studied. The possibility of an association between the type of hanging, the completeness of the victim's body suspension, the victim's weight, gender, age, and the occurrence of Amussat's sign in carotid arteries and internal jugular veins, respectively, was explored.

Materials and Methods

A prospective, consecutive, and continuous group of cases of hanging was set up from autopsies carried out at the Institute of Legal Medicine in Hradec Králové within the period of 2005–2007 (36 months in total). The entire group comprised suicide cases with the exception of one accident. In the given time period, a total of 2226 autopsies were carried out, of which there were 185 cases of hanging; 7 cases of hanging were excluded because of advanced putrefaction (severe devastation of neck organs by insects). In addition to autopsy findings, all cases underwent full police investigations with reviews of previous histories and circumstantial evidence.

The point of the ligature knot was determined on the basis of the appearance of the ligature line, its course, depth and width, and the available anamnesis, including photodocumentation of the place where the body was found. A possible association between the occurrence of Amussat's sign and the types of ligatures was not studied.

For the identification and quantification of intimal tears in the carotid arteries and internal jugular veins in connection with the location of ligature knots, all cases were divided into four categories according to the position of the knot on the neck (I–IV, Fig. 3). In cases of posterior hanging (I), the ligature knot was situated in the posterior midline, the limit was the inner side of the mastoid process. In cases of anterior hanging (II), the ligature knot was situated in the anterior midline, the limit was the inner side of the sternocleidomastoid muscle. When the ligature knot was placed on the sides of the neck or head between mentioned limits (on the

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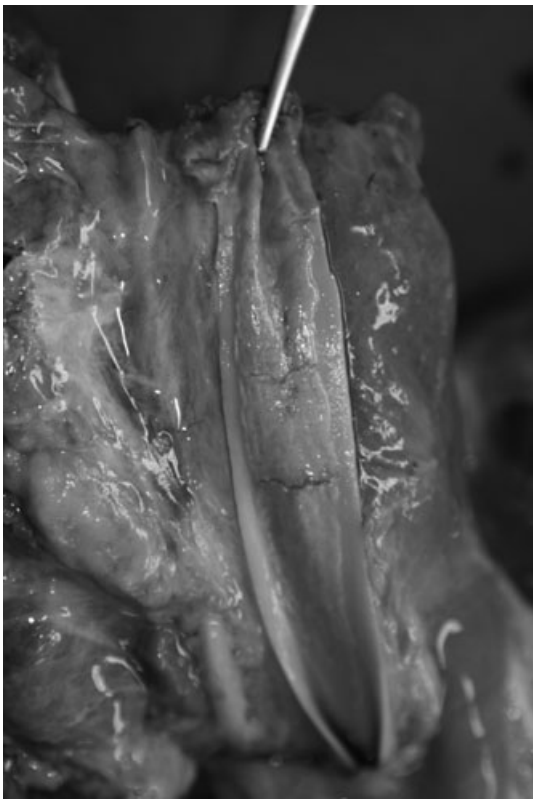

FIG. 1—*Amussat's ruptures in the left common carotid artery in the case of an atypical hanging with the location of the ligature knot on the right side of the neck.*

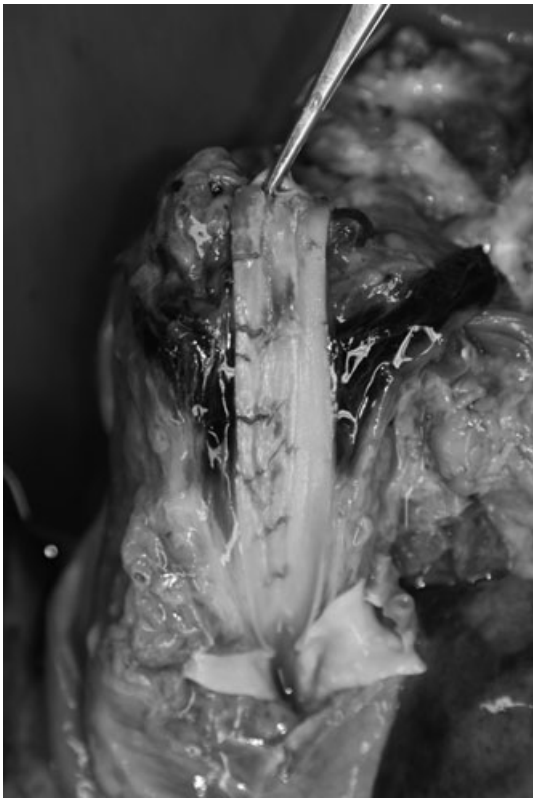

FIG. 2—*Multiple Amussat's ruptures in the right common carotid artery in a case of posthanging decapitation with the location of the ligature knot on the left side of the neck.*

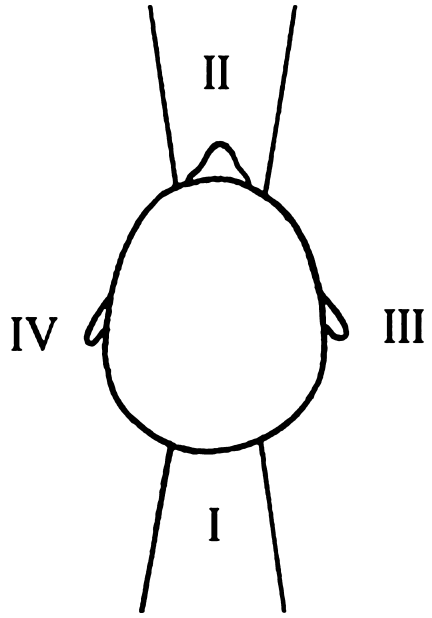

FIG. 3—*Subcategorization of cases according to the location of the knot into four groups.*

right, or on the left), then the category was right hanging (III) or left hanging, respectively (IV). Furthermore, individual cases were divided according to the completeness of the victim's suspension into two main subcategories: free body suspension (A, complete hanging) and incomplete body suspension (B, incomplete hanging). Each case in the group was marked with an alphanumeric code proceeding from these two categories; e.g., typical posterior hanging with free body suspension was marked as 1A. The carotid arteries and internal jugular veins were evaluated after evacuation of the neck organs; the intimal layer of these vessels was visualized by longitudinal cutting with the blunt arm of scissors.

The statistical analysis was carried out using the chi-square test for contingency tables and logistic regression to see if any dichotomous variables depended on quantitative ones. A p-value <0.05 was considered significant and <0.001 was considered highly significant. Calculations were performed with the NCSS program using Windows.

Results

The analyzed group consisted of 178 cases of hanging. Only one case was an accident (autoerotic asphyxial manipulation). The other cases were suicides only. In the group of 178 cases of hanging, there were 150 men (84%) and 28 women (16%), aged between 14 and 94. The average age of the individuals was 50. Men ranged from 14 to 91 years (average 50.04) and women from 20 to 94 (average 55.04). There were 99 men of a total of 112 cases with free body suspension (male/female ratio was 7:6) and 51 men of 66 cases with incomplete body suspension (male/female ratio was 3:4). In the group, there were 112 cases of hanging with free body suspension (63%) and 66 cases with incomplete body suspension (37%). The age distribution in the free suspension group was similar to that in the incomplete suspension group (unpaired t-test, Mann–Whitney test, and Kolmogorov–Smirnov test).

Of the 178 cases of hanging, injury of at least one carotid artery, meaning transverse or longitudinal laceration in the intimal layer, was found in 29 cases (16.1%). Bilateral carotid injuries occurred in only two cases (1.1%) and exclusively in cases of typical

posterior hanging with free body suspension (=IA). In cases of typical anterior hanging, no tears in the intimal layer of the carotid arteries were noted (=IIA, IIB; Table 1). Lacerations of the intimal layer of the carotid arteries in cases of lateral hanging (III, IV) were more often observed on the side contralateral to the suspension point, i.e., at the point of the biggest pressure acting upon the neck organs. No injury to the internal jugular veins, meaning transverse or longitudinal tears in their intimal layers, was observed in the cases studied.

In cases of hanging with free body suspension, Amussat's sign was proved in 20 cases of 112 (17.9%); in cases of hanging with incomplete body suspension Amussat's sign was identified in 9 cases of 66 (13.7%; Table 2). A statistical investigation (chi-square test) did not show significant associations between the completeness of the victim's body suspension, position of the ligature knot on the neck, gender of the victim, and the occurrence of ruptures in the intimal layer of the carotid arteries.

A statistically significant association between the individual's weight and the occurrence of ruptures in the intimal layer of the carotid arteries was not discovered (logistic regression test). However, the logistic regression test discovered a significant association between the individual's age and the occurrence of ruptures in the intimal layer of the carotid arteries (increasing frequency with age; $p = 0.035$, Fig. 4).

Discussion

Autopsy studies published so far state a relatively low frequency of occurrence of intimal ruptures in the walls of carotid arteries: Schroeder and Saternus in 7.4% of 204 cases of hanging (13), Suárez-Peñaranda et al. (14) in 9.1% of 228 cases of hanging, Lesser (15) in 14% of 50 cases of hanging, Laiho in 16% of 124 cases of hanging (16), Jankovich in 25% of 12 cases of hanging (17). Nikolic et al. (2003) in a retrospective study of 175 cases of hanging proved injuries to carotid arteries (meaning transverse intimal tears and perivascular hematomas) on the left side of the neck in 7.4% of the cases and on the right side of the neck in 10.9% of the cases (3). These published studies (except for the prospective study by Laiho et al. in 1968; [16]) were exclusively retrospective autopsy studies, which need not always ensure absolute unity in the methodological approach and interpretation of findings. The last and also the largest retrospective study published (14) suggested that the occurrence of intimal lacerations in the walls of carotid arteries and internal jugular veins is independent of the position of the ligature knot and the victim's weight, gender, and age.

This prospective and standardized autopsy study demonstrated the fact that ruptures of the intimal layer of carotid arteries occurred more often in individuals of older age categories (Fig. 4). This observation most probably relates to the advancement of degenerative atherosclerotic changes in arteries that are directly dependent on the individual's age. However, the exact relationship between the severity of degenerative atherosclerotic changes and the occurrence of injuries to the intimal layer of cervical vessels was not studied and is a matter requiring further research. The extreme resistance of veins to atherosclerotic degenerative changes and the higher mechanical malleability of veins as a result of their elasticity most probably explains the absence of lacerations of the intimal layer of internal jugular veins in the hanging cases studied.

The absence of transverse tears in the intimal layer of carotid arteries in a group of individuals where the ligature knot was situated at the anterior midline (II, anterior hanging) was a surprising observation. It is possible that in such cases the ligature does not produce intense pressure upon the area of the nerve-vascular bundles of the neck; cervical vessels in such cases are mainly exposed to traction forces in a longitudinal direction. This is an observation, however, that was not found in the latest studies (3,14).

It is possible to consider that the occurrence of intimal tears in the carotid artery area relates not only to the traction but also to the direct pressure of the ligature on the neck. The acting pressure of the ligature very likely leads to deformation and fixation of the part of the artery below the ligature to the deeper tissue structures of the neck. The proximal section of the artery below the point of its fixation is then exposed to traction forces that lead to a forced, downward stretching of this part of the artery. A combination of forced compression of the artery and its longitudinal stretching could be the most frequent mechanism leading to the occurrence of ruptures in the intimal layer of carotid arteries in hanging. This suggestion is supported by the bilateral occurrence of intimal tears in the carotid arteries in cases of posthanging decapitations, where a combination of the extreme radial pressure of the tightening rope and high-powered axial traction is always present (18,19). The aforementioned idea is also supported by the bilateral occurrence of Amussat's ruptures in the intimal layer of carotid arteries exclusively in cases of posterior hanging with free body suspension (IA),

TABLE 1—*Distribution table of injuries to the intimal layer of carotid arteries in relation to the type of hanging – absolute frequencies. No occurrence of ruptures of the intimal layer of carotid arteries was discovered in cases of anterior hanging.*

	Amussat's Rupture				
Type of Hanging	Left	Bilateral	Right	None	Total
I (Posterior)	7	2	3	84	96
II (Anterior)	0	0	0	11	11
III (Right lat.)	6	0	4	25	35
IV (Left lat.)	2	0	5	29	36
Total	15	2	12	149	178

TABLE 2—*Distribution table of injuries to the intimal layer of carotid arteries in relation to completeness of suspension of the victim—absolute frequencies.*

	Amussat's Rupture				
Suspension	Left	None	Right	Bilateral	Total
Free	9	92	9	2	112
Incomplete	6	57	3	0	66
Total	15	149	12	2	178

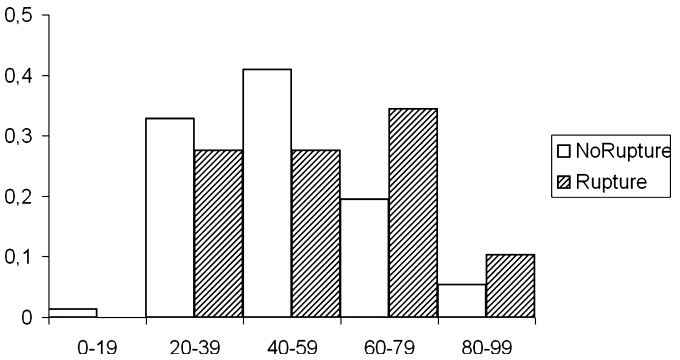

FIG. 4—*Association between the occurrence of Amussat's ruptures and the victim's age—relative frequency histogram. More frequent occurrence in old victims was confirmed by a test of logistic regression (significant association,* $p < 0.05$*).*

where the pressure on the carotid arteries is symmetrically intensive on both sides of the neck and longitudinal traction in the direction of the artery is guaranteed. This suggestion needs to be verified by future research (a larger file of cases is needed because of the relatively low occurrence of vascular injuries in hanging).

Conclusion

- A statistically significant association between the victim's weight, gender, position of the ligature knot on the neck, completeness of the body's suspension, and the occurrence of ruptures in the intimal layer of carotid arteries was not found.
- A statistically significant association between the occurrence of ruptures in the intimal layer of the carotid arteries and the victims' age was discovered in the group of cases studied. Most probably, this finding is directly connected with the advancement of atherosclerotic degenerative changes in these arteries, but further research is necessary.
- The study results show that intimal tears to carotid arteries as a result of hanging could be produced by direct pressure of the ligature on the neck organs as well as by indirect stretching because of the gravitational drag produced by the victim's body weight.

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