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## Correlation of Circumstances with Pathological Findings in Asphyxial Deaths by Hanging: A Prospective Study of 61 Cases from Seattle, WA

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**ABSTRACT:** Correlation of the circumstances of death with the pathologic findings in this prospective study of deaths by hanging affords insight pertaining to certain of the pathophysiologic mechanisms involved in fatalities of this type. The presence of conjunctival and facial/periorbital petechial hemorrhages correlates with increasing levels of body support below the point of ligature suspension. Hyoid bone and/or thyroid cartilage fractures (found in 26% of cases) are most frequently identified in those persons found completely suspended and in victims in the older age ranges. No hyoid bone/thyroid cartilage fractures, internal soft tissue injury, or petechiae were present in 13 (21%) of the study cases.

**KEYWORDS:** pathology and biology, asphyxia, hemorrhage, hanging deaths, pathologic findings, correlation with circumstances of death

In biological systems, the extent and type of pathology and toxicology findings can often be correlated with the specific circumstances of the fatal event. While such correlations are never perfect, their use in forensic scientific investigations forms an important component of the substance of the experienced investigator's expertise. In addition, enlightened interpretation of postmortem findings may assist in elucidating the circumstances of death in situations where the circumstances may either be as yet unresolved or are later found to have been confabulated.

Deaths resulting from violent asphyxia, and hanging deaths in particular, demonstrate a relative paucity of anatomic findings. Nevertheless, it is important to document the pathology present in such cases for the purpose of excluding other forms of trauma or other modes of death that may denote murder made to appear as suicide.

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In addition, it has appeared to us that subtle differences in the particular constellation of anatomic changes within the hanging death category may reflect how death occurred through a gradation of pathophysiological alterations based on both the rapidity and the degree of completeness of ligature compromise of the musculature, airway, or vascular structures of the neck.

This prospective study analyzes and correlates certain demographic and circumstantial data with the anatomical findings in 61 consecutive asphyxial deaths by hanging investigated by the King County (Seattle, WA) Medical Examiner's Office. In terms of manner of death, 59 cases were classified as suicides and two were found to have resulted from accidental (autoerotic) means.

## Materials and Methods

During the 5-year period from 1978 to 1982 there were an average of 176.2 suicides per year in King County, Washington, acquired from a catchment cohort population of approximately 1.26 million. Deaths by hanging constituted 9.3% of these cases. The yearly incidence ranged from 10 cases in 1978 to 27 in 1981, averaging 19 fatalities per year.

The hanging deaths that comprise this study consist of 61 cases consecutively investigated from March 1981 to March 1984, by the King County Medical Examiner's Office. A complete postmortem examination was conducted in each case, either personally performed or individually supervised by one of the authors. Those few cases that demonstrated putrefactive changes severe to the extent that adequate interpretation of postmortem findings was compromised were excluded from the study. Before initiation of the project, a data protocol was prepared that included certain personal, demographic, circumstantial, and pathological information. Completion of the protocol was effected by the prosecutor in each instance.

Regarding definition of terms, characterization of cases in which the victim was found completely suspended or with only the feet touching the surface below the point of ligature suspension should be self-explanatory. Support below the suspension point at the level of the knees constituted those cases identified as being partially supported and, at the level of the buttocks (individuals found seated, for example), those cases considered largely supported.

Data were transferred to appropriate computer format and integrated with the software *Powerhouse*, a fourth generation programming language. Analysis and management of the data elements and subelements were implemented on the Hewlett Packard 3000 computer system at the Armed Forces Institute of Pathology.

## Results

### *Demographic and Situational Data*

The age, race, and sex distribution of the 61 study cases is presented in Table 1. The victims' ages ranged from 14 to 89 years (one case each). The mean age was 41.3 years and the median age, 37 years.

A verbal suicide threat or expression of suicidal intent was recorded in 22 cases. A suicide note was recovered in 22 instances. However, in only nine deaths were both a threat and a note identified in the same case. Neither threat nor note appeared to be age-dependent.

With the premise that the psychodynamics leading to suicide are beyond the scope of this study, background information signifying intent was recorded when it was available. Health or financial concerns were mentioned in ten cases each. A psychiatric history or occupational or romantic difficulty was noted in 13 cases each. Other factors were specified in 14 cases, and in 15 cases no motivation was identified. In 21 cases multiple reasons for suicide were noted. Distribution of the type of suicidal motivation by age was random, save for the parameter of health, which was skewed to the older age ranges. A prior suicide attempt was documented in

TABLE 1—Age, race, and sex of hanging victims.

Age, years	White Male	White Female	Black Male	Black Female	Total
10-19	5 <sup>a</sup>	1	0	0	6
20-29	13 <sup>a</sup>	2	1	0	16
30-39	9	1	1	0	11
40-49	7	0	0	0	7
50-59	3 <sup>a</sup>	2	0	0	5
60-69	9	3	0	0	12
70-79	2	0	0	0	2
80-89	1	1	0	0	2
Total	49	10	2	0	61

<sup>a</sup>Includes one male of an other race.

nine cases, one attempt by hanging (the belt broke), and four each by ingestion of drugs or by other means. In 43 cases there was no record of a prior suicide attempt.

A history of current alcohol or drug abuse was present in eleven and seven cases, respectively. Positive postmortem blood ethanol levels were noted in 16 cases, values equal to or greater than 0.2 g/100 mL being present in only 2 victims. A negative blood ethanol level was recorded in 44 cases. Laennec's cirrhosis or fatty metamorphosis of the liver was found at autopsy in 15 cases. More than half of the cases with the highest levels of ethanol were within the latter group.

#### *Type of Ligature*

The ligature material employed consisted of a rope or clothesline in 32 cases, a leather belt in 8 cases, a soft belt or necktie in 7 cases, and a length of sheet or other cloth in 6 cases. Other ligature material was used in eight cases. The width of the ligature was recorded as being 25.4 mm (1 in.) or less in 46 cases and was greater than 25.4 mm (1 in.) in 7 cases. The ligature consisted of a single circumferential wrap in 52 cases, 2 wraps in 6 cases, and 3 or more wraps in 3 cases.

The site of the ligature knot was at the left side of the neck in 20 instances, at the right side and at the back of the neck in 17 cases each, and at the front of the neck in 3 cases. The length of the ligature from the neck to the fixed point of attachment was less than 305 mm (12 in.) in 5 cases and greater than 305 mm (12 in.) in 41 deaths. In no case was the ligature item known to have been purchased specifically for the purpose of committing suicide.

#### *Position of Body*

Twenty victims were found completely suspended, and an additional twenty-six were found with only their feet touching the surface below the point of suspension. The bodies in six cases were partially supported, and four victims were largely supported by the surface below the suspension point. In five deaths this determination could not be made. A chair or other initial elevating device was present in 41 instances and was not present in 15. Positive correlation was noted between the presence of a chair and other scene information which indicated the dropping of the body against the ligature and rapid ligature entrapment of the neck.

#### *Pathologic Findings*

*Ligature Furrow*—An abrasion furrow or patterned blanched lividity reflecting the imprint of the overlying ligature was noted in each study case. In 45 of the 61 cases, the ligature impres-

sion was located superior to the thyroid cartilage prominence. Bodies of individuals in the younger age ranges found completely suspended or with only their feet touching were more apt to have their ligatures located superior to the thyroid prominence. With advancing age, this distinction became less clear.

*Petechial Hemorrhages*—The distribution of petechial hemorrhages by body position is presented in Table 2. Table 3 depicts the relationship between the extent of body support and the incidence of petechiae and thyroid cartilage/hyoid bone fractures, sorted by age.

Direct correlation was noted between the presence of conjunctival petechiae and increasing extent of body support below the point of ligature suspension. For example, conjunctival petechiae were noted in 5 of 20 bodies found completely suspended, in 15 of 26 bodies found with the feet touching, in 4 of 6 bodies partially supported, and in 3 of the 4 found largely supported. The incidence of conjunctival petechiae in individuals found completely suspended versus the incidence of this finding in all other study cases, where increasing levels of body support were present, was statistically significant ( $P = 0.02$ , using a Yates corrected chi-square statistic).

TABLE 2—Distribution of petechial hemorrhages by body position.

	Petechiae Positive	Petechiae Negative
Conjunctivae	5/29 <sup>a</sup>	15/32 <sup>a</sup>
Bulbar, upper	1/11	19/50
Bulbar, lower	1/12	19/49
Palpebral, upper	2/10	18/51
Palpebral, lower	3/25	17/36
Face	2/10	18/50
Larynx	5/19	15/42

<sup>a</sup>Cases completely suspended/total cases per category.

TABLE 3—Petechial hemorrhages/fractures.

Age, years	Conjunctival Petechiae	Facial Petechiae	Hyoid Fracture	Thyroid Fracture
BODY POSITION: COMPLETELY SUSPENDED				
15	No	No	No	No
22	No	No	No	No
24	No	No	Yes	Yes
27	No	No	No	No
27	No	No	No	No
27	No	No	Yes	No
29	Yes	No	No	No
30	No	No	No	No
37	No	No	No	No
45	No	No	No	No
49	No	No	No	No
59	No	No	No	No
60	No	No	Yes	Yes
60	Yes	Yes	No	No
60	Yes	Yes	Yes	No
62	No	No	No	No
63	Yes	No	No	No
69	Yes	No	Yes	No
72	No	No	No	No
72	No	No	No	No

TABLE 3—Continued.

Age, years	Conjunctival Petechiae	Facial Petechiae	Hyoid Fracture	Thyroid Fracture
<b>BODY POSITION: ONLY FEET TOUCHING</b>				
14	No	No	No	No
15	Yes	Yes	No	No
16	No	No	No	No
19	Yes	No	No	No
19	No	No	No	No
22	No	No	No	No
23	No	No	No	No
24	Yes	No	Yes	No
25	Yes	Yes	No	No
26	Yes	No	No	No
27	No	No	No	No
30	Yes	No	No	No
31	Yes	No	No	No
33	No	No	No	No
33	Yes	Yes	No	No
35	Yes	Yes	Yes	No
40	Yes	No	No	No
47	No	No	No	No
47	Yes	Yes	No	No
51	Yes	No	Yes	Yes
51	No	No	Yes	No
52	No	No	No	Yes
60	Yes	No	No	No
63	No	No	Yes	No
66	Yes	No	Yes	Yes
66	Yes	No	No	No
<b>BODY POSITION: PARTIALLY SUPPORTED</b>				
30	Yes	No	No	No
36	Yes	Yes	No	No
39	Yes	No	No	No
42	No	Unk	No	No
42	Yes	Yes	Yes	Yes
56	No	No	No	No
<b>BODY POSITION: LARGELY SUPPORTED</b>				
25	Yes	No	No	No
63	Yes	Yes	No	No
83	No	No	No	Yes
89	Yes	No	Yes	Yes

Of the six study cases with conjunctival petechial hemorrhages identified in diffuse distribution, that is, at the superior and inferior palpebral and the superior and inferior bulbar regions, no bodies were found completely suspended. Only 4 of the 29 hanging victims positive for conjunctival petechiae were without inferior palpebral lesions, and these 4 cases were randomly distributed by age. Two of the four victims were found completely suspended.

Petechiae involving the skin surfaces of the face or periorbital tissues were not present in cases without conjunctival petechiae. Although these observations were limited in some instances by skin pigmentation, the incidence of facial petechiae seemed to reflect the degree of body suspension, to the extent that only 2 of 20 victims completely suspended exhibited facial petechiae. However, only 8 of 36 cases not completely suspended exhibited such lesions. In contrast to conjunctival and facial petechiae, the incidence of laryngeal mucosal petechiae

(present in 19 cases) seemed to be independent both of age of victim and degree of suspension/support.

**Soft Tissue Hemorrhage**—The presence of hemorrhage involving the soft tissues or strap musculature of the anterior neck, found in 23 and 14 cases, respectively, was strongly associated with victims who were found completely suspended or with only their feet touching. Only one fatality with strap muscle hemorrhage exhibited any degree of body support below the suspension point. Fractures of the hyoid bone or thyroid cartilage were present in three strap muscle hemorrhage cases. Strap muscle hemorrhage was independent of the age of the victim. Six of the fourteen cases with hyoid fractures and five of the eight cases with thyroid fractures failed to exhibit either soft tissue or strap muscle hemorrhage.

**Fractures**—Cervical vertebral fractures of the type that have been described as occurring in judicial hangings [1-3] were not observed in this study.

Fractures of the larynx or hyoid bone were present in 16 (26%) cases and were not identified in 45 cases. The hyoid bone was fractured in 14 cases, and the thyroid cartilage was fractured in 8 cases. No fractures of the cricoid cartilage were identified in any study case.

Although the youngest victim exhibiting hyoid or thyroid fracture was 24 years old, fracture distribution sorted by age was disproportionately represented in the older age ranges. Only 5 of the 22 total fractures occurred earlier than the median age of 37 years. In 12 of the 14 cases with hyoid bone fractures and in 5 of the 8 thyroid fracture deaths, the ligature was located superior to the thyroid prominence. Rope was used in causing nine of fourteen hyoid fractures and four of eight thyroid fractures, approximately proportional to the incidence of the use of rope as a ligature instrument in this study.

Fracture of the hyoid bone and thyroid cartilage sorted by age was random for those individuals found completely suspended. In all other circumstances of body position, which reflected increasing degrees of body support, fractures were age-related. For example, 57% of fractures (four of seven) in the completely suspended group involved victims above the median age of 37 years. Figures for the only-feet-touching group and for the partially supported and largely supported groups were 77% (seven of nine), 100% (two of two), and 100% (three of three), respectively. All three fractures in the latter group involved individuals in their 80s. The youngest fracture victim found in a supported position was 42 years of age.

Of the six study deaths with coincident hyoid bone and thyroid cartilage fractures, five victims were older than the median age. Two were completely suspended (ages 24 and 60 years), two were found with the feet touching (ages 51 and 66 years), one was partially supported (age 42 years), and one was largely supported (age 89 years). Fracture incidence was independent of the specific composition, width, and number of wraps of the ligature employed, as well as of the height, weight, and sex of the victim.

**Negative Findings**—In 13 of the study deaths no hyoid bone or thyroid cartilage fracture was present, no conjunctival or facial/periorbital petechiae were identified, and there was no evidence of strap muscle or soft tissue hemorrhage. Eleven cases demonstrated only strap muscle or soft tissue hemorrhage or both at autopsy. Of the latter cases, all six cases with strap muscle hemorrhage exhibited soft tissue hemorrhage as well and only one body was found with any degree of support below the suspension site.

As previously noted, the two accidental study deaths were autoerotic in nature. Both victims were in their 30s, and the body of each was found partially supported. Bulbar and palpebral conjunctival petechiae were present in one individual and hemorrhage involving the soft tissues of the anterior neck in the other. Neither victim exhibited hyoid bone or thyroid cartilage fractures.

## Discussion

In spite of the vagaries inherent in individual biological variation and in the interpretation of pathologic findings by different observers, this study defines certain of the pathophysiologic

mechanisms involved in asphyxial deaths by hanging, based on the correlation between the circumstances of death and the pathology identified. The interpretations reached serve to expand upon and to consolidate available anecdotal or retrospective information [1-4] in the topic area of violent asphyxial deaths in general and deaths by hanging in particular.

One theory regarding the pathogenesis of petechial hemorrhage formation in deaths by asphyxia suggests that these lesions are the product of disproportionate vascular compromise resulting from external compression of the neck. Circumferential tension required to occlude the jugular veins has been shown experimentally to be 2 kg (4.4 lbs), the carotid arteries 5 kg (11 lbs), the trachea 15 kg (33 lbs), and the vertebral arteries 30 kg (66 lbs) [1]. Assuming significant venous compromise with virtually all but the most flaccid of hanging ligatures, the level of small vessel and intracapillary pressure and the incidence of petechiae resulting therefrom should reflect the extent of coincident carotid and vertebral arterial compromise. Complete arterial occlusion coincident with venous occlusion, a circumstance most apt to occur with bodies of hanging victims completely suspended, for example, would then be expected to cause no increase in intracapillary pressure and a relative paucity of petechiae. Circumstances affording reduced ligature pressure to the neck and less arterial compromise might be expected to result in increased levels of intravascular pressure and more frequent petechiae. The findings of this study regarding petechial hemorrhage formation, with particular reference to conjunctival and facial/periorbital surfaces, tend to support this thesis.

As has been discussed, the presence of petechial hemorrhages directly correlates with the degree of body support below the point of ligature attachment. Findings of a similar nature have been described in deaths by ligature strangulation, in contradistinction to those associated with manual strangulation [5]. Petechial hemorrhages are often more prevalent in the former condition than the latter, probably because of the fact that disproportionate venous/arterial compromise may be more effectively accomplished with the aid of a ligature instrument than with the hands alone.

Even though the rationalization of petechial hemorrhages in hanging victims would seem to be supported by the data presented, selected cases within each body position category exhibit findings divergent from those expected. For example, conjunctival petechiae were noted in five individuals found completely suspended and were absent in three of the ten with demonstrated support below the suspension point. Possible explanations for these discordant findings might include the tightness and the duration of tentative application of the ligature before the ultimate application of pressure, the absence of an easily running slip knot, and, in those persons completely suspended, canting of the head and neck away from the knot, permitting incomplete arterial compromise at the canted site. Regarding the latter consideration, three of the five completely suspended victims with conjunctival petechiae were found with lateral (right-sided) ligature knots, in contrast to anterior or posterior knots.

The disparity between the frequency of retrospectively and prospectively determined autopsy findings is emphasized in the recent bifurcated study of suicidal hanging deaths by Paparo and Siegel [6]. Hyoid/thyroid fractures were noted in 15% (20 of 134) of cases retrospectively analyzed and in 46% (12 of 26) of their prospective series. Although these authors noted fractures disproportionately among victims in the older age ranges, as we did, they describe no correlation between fracture incidence and degree of body suspension.

Fractures of the thyroid cartilage and/or hyoid bone were present in 16 (26%) of the 61 study cases. In individuals found completely suspended, fractures were independent of the age of the victim and presumably resulted from rapid and forceful constriction of the neck by the ligature supporting the entire body weight. With lesser degrees of suspension and force and increasing support, fractures became progressively age-dependent. Clearly, the two dominant factors here involve the relationship of force over time and the degree of ossification and brittleness of the hyoid bone and thyroid cartilage. The fact that fractures occurring in individuals found largely supported below the suspension site were uniformly present in octogenarians attests to the importance of the composition of the tissue substrate against which the force of the ligature is directed.

Cricoid cartilage fractures were not identified in this study or in a previous report of hanging deaths [7] where this finding was documented. A single cricoid fracture was noted in a study of 160 cases (among 32 total fractures) by Paparo and Siegel [6]. Consequently, identification of a cricoid fracture in an alleged hanging victim should alert the prosecutor to the possibility that further investigation into the circumstances of death may be appropriate. The proviso here, of course, is that dissection and exposure of the cricoid cartilage with fracture documentation will have been effected before opening the larynx for internal examination.

No evidence of hyoid bone/thyroid cartilage fracture, soft tissue trauma, or petechial hemorrhage was present in 13 (21%) of the study cases. Hemorrhage involving the soft tissues and musculature of the anterior neck was the only evidence of internal pathology in eleven (18%) cases. The lack of age-dependency of the latter parameter and its association with cases found without support reflects its relationship to rapid entrapment and constriction or stretching of the relatively elastic structures of the anterior neck. In addition, the poor correlation noted between hyoid/thyroid fractures and soft tissue/strap muscle hemorrhage may be the result of local tamponade caused by pressure elevation at the fracture site as well as by arterial compromise.

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