

Petechiae in Hanging

A Retrospective Study of Contributing Variables

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Abstract: Petechiae, one of the classic signs of asphyxia, are thought to be more frequently observed in cases of hanging where part of the body is supporting the victim's weight, ie, cases of incomplete hanging. However, there is very little evidence-based medicine to support this claim. The present study is intended to evaluate the relationship between petechiae and the type of hanging (complete vs. incomplete). Furthermore, several other variables were analyzed to determine if they contribute significantly to the presence of petechiae. An 8.5-year retrospective study of 206 cases of death by hanging reviewed autopsy reports for the presence of petechiae. For each case, the following information was also compiled: gender and age, height and weight, body mass index, the type of hanging (complete or incomplete suspension), the type of ligature used (narrow or wide), and whether or not the victim had received cardiopulmonary resuscitation maneuvers. Statistical analysis revealed that the incidence was higher among incomplete hanging victims compared with cases of complete suspension and that the incidence of petechiae varied inversely with the height of the victims. The other factors were not shown to contribute significantly to the presence of petechiae.

Key Words: asphyxia, hanging, petechiae

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Petechiae are pinpoint hemorrhages resulting from the rupture of small vessels.¹ In hanging, mechanical obstruction of venous return to the heart causes an increase in intravascular pressure that induces overdistention of the thin-walled peripheral venules and this can lead to rupture. The venules located in areas that are low in connective tissue, such as the conjunctiva and sclera of the eyes, the skin of the upper eyelid, the forehead, behind the ears, and around the mouth are more prone to rupture.² Capillary bleeding is not visible to the naked eye, so it is in fact small venules that create petechial lesions.²

Despite the fact that the presence of petechiae is considered one of the classic signs of asphyxia, petechiae are not commonly observed in cases of hanging.^{1–3} In such cases it is believed that the total occlusion of both the arterial and venous supply creates a stabilization, rather than an increase, in intravascular pressure in the head. In keeping with this, it is often stated in the literature that petechiae are more frequently observed in cases of hanging where part of the body is supporting the victim's weight, ie,

cases of incomplete hanging, because it is believed that the jugular veins become occluded while the deeper and less compressible carotid and vertebral arteries remain patent.^{3,4} However, there is very little evidence-based medicine (EBM) to support this claim. Only 4 studies exist in the English forensic literature that have investigated this hypothesis.^{5–8} Of these studies, only one reviewed more than 100 cases.⁸ Combined, the 4 studies examined a total of less than 500 cases. Clearly, in this era of EBM, more studies are required before the theory that incomplete hangings lead to a higher incidence of petechiae can be regarded as a fact. Evidence from research is the best foundation upon which to build one's practice and to make sound clinical decisions.⁹ Forensic pathology is no exception and is rapidly becoming more of a science than an art (Foster C).¹⁰ Nevertheless, there are still several areas of forensic pathology based mainly on tradition, with textbooks containing explanations and descriptions of "common knowledge" that is not supported by modern research data. The present study is intended to contribute to EBM by evaluating the relationship between petechiae and the type of hanging (complete vs. incomplete). Several other variables such as victim's age, height, weight, the body mass index (BMI), type of ligature, and cardiopulmonary resuscitation were analyzed to determine if they contribute significantly to the presence of petechiae.

MATERIALS AND METHODS

In the province of Quebec (Canada), a single centralized forensic laboratory covers the entire 7.5 million population. Over an 8.5-year period (2000–mid 2009), all autopsy cases performed at this laboratory were retrospectively reviewed for suicidal hanging deaths.

All autopsy cases performed in Quebec during the study period are compiled in an Excel database. This database was manually searched for hanging cases and the complete files of selected cases were then consulted. These files include autopsy reports, autopsy notes, autopsy sketches and photographs, toxicological reports, preliminary information from the coroner's request for autopsy, and preliminary police reports.

A total of 309 suicidal hanging deaths were found. Of these, 1 case was excluded because it was not a typical hanging but a hanging from height, with dislocation of neck vertebrae (hanging after jumping from a bridge). Additionally, 50 cases were excluded from the analysis because postmortem changes interfered with the evaluation of petechiae (significant decomposition, skeletal, and charred bodies). Finally, 52 cases were also excluded because the type of hanging was not specified in the autopsy files, thus making their analysis not applicable to the present study.

Overall, a total of 206 cases were analyzed for the presence of conjunctival, palpebral, gingival and facial petechiae. For each case, the following information was also compiled: gender and age, height and weight, the type of hanging (complete or incomplete), the type of ligature used (rope, wire, clothes, sheet, or lace), and the presence of alcohol or drugs. A note was also added

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TABLE 1. Incidence of Petechiae

	No. Cases	%
Absence of petechiae	112	54%
Presence of petechiae	94	46%
Isolated palpebral petechiae	17	8%
Isolated conjunctival petechiae	4	2%
Isolated buccal petechiae	7	3%
Palpebral + conjunctival petechiae	10	5%
Palpebral + buccal petechiae	6	3%
Conjunctival + buccal petechiae	4	2%
Petechiae in all 3 locations	46	22%

about whether or not the victim had received cardiopulmonary resuscitative maneuvers. The BMI was subsequently calculated according to the WHO international formula (weight (kg)/height² (m²)) and adapted for children and adolescents. The reported data were statistically analyzed using the SPSS Statistics 16.0 software.

RESULTS

General Incidence of Petechiae

External examination of hanging victims revealed petechiae in 46% of cases. Palpebral petechiae were observed in 38%, conjunctival petechiae in 31%, and buccal petechiae in 31%. Further details on the distribution of petechiae are presented in Table 1.

Incidence of Petechiae in Relation to Cardiopulmonary Resuscitation Maneuvers

Of the 206 hanging victims, 36 underwent attempts at cardiopulmonary resuscitation (CPR). The incidence of petechiae in victims that did and did not receive CPR is compared in Table 2. No significant difference existed between the 2 groups ($\chi^2 = 0.34, df = 1, N = 206, P = 0.56$).

Incidence of Petechiae in Relation to the Type of Hanging

Of the 170 victims without reanimation maneuvers, 128 died of an incomplete hanging and 42 of complete suspension. The incidence of petechiae in incomplete hanging (50%) was significantly higher than in complete hanging (29%) ($\chi^2 = 5.87, df = 1, N = 170, P = 0.02$). The age and sex distribution was similar between both groups (Table 3).

TABLE 2. Incidence of Petechiae in Relation to Reanimation Manoeuvres

	No. Cases	Age	Gender	Incidence of Petechiae
Without reanimation	170	35.04 ± 10.9	140 M:30 F	44.7%
Incomplete hanging	128			50.4%
Complete hanging	42			28.6%
With reanimation	36	34.25 ± 10.6	33 M:3 F	45.1%
Incomplete hanging	28			60.7%
Complete hanging	8			12.5%

TABLE 3. Incidence of Petechiae in Relation to the Type of Hanging

	No. Cases*	Age	Gender	Incidence of Petechiae
Incomplete hanging	128	34.1 ± 13.8	105 M:23 F	50.0%
Complete hanging	42	37.8 ± 13.4	35 M:7 F	28.6%

*Victims without reanimation maneuvers.

Incidence of Petechiae in Relation to the Type of Ligature

The type of ligature was known in all 170 cases of hanging victims without reanimation maneuvers: 72 ropes, 28 electrical cords, 27 pieces of clothing, 30 bed sheets, and 13 shoe strings. These types of ligatures were regrouped into 2 broad categories: narrow and wide. Examples of narrow ligatures include rope, electrical cords, and shoe strings, whereas the term wide ligatures encompasses pieces of clothing and bed sheets. The incidence of petechiae was similar ($\chi^2 = 0.66, df = 1, N = 170, P = 0.42$) for wide and narrow ligatures (47% and 40%, respectively), as depicted in Table 4.

Incidence of Petechiae in Relation to Age

The incidence of petechiae decreased slightly with age, from 61% in teens to 40% in adults over 40 years of age (Table 5). However, the differences between the 3 age groups was not statistically significant ($\chi^2 = 2.41, df = 2, N = 170, P = 0.30$), and neither was the statistical comparison of victims older to younger than 40-year-olds ($\chi^2 = 0.66, df = 1, N = 170, P = 0.42$).

Incidence of Petechiae in Relation to the BMI

In the studied population, only 2 hangings occurred in underweight individuals. For the remaining 204 cases, the relationship between the incidence of petechiae and the BMI is presented in Table 6. There was no statistically significant difference between the incidence of petechiae in normal weight individual and overweight individual ($\chi^2 = 0.13, df = 1, N = 204, P = 0.71$). The comparison between the 3 groups (normal weight, overweight, and obese) was not statistically significant either ($\chi^2 = 0.82, df = 2, N = 204, P = 0.67$).

Incidence of Petechiae in Relation to Height

The incidence of petechiae varied inversely with the height of the victims: 77% in victims of less than 1.60 m, 44% in victims between 1.60 and 1.79 m, and 35% in victims of 1.80 m or more ($\chi^2 = 5.36, df = 2, N = 204, P = 0.07$). As illustrated in Table 7, this

TABLE 4. Incidence of Petechiae in Relation to the Type of Ligature

	No. Cases*	Incidence of Petechiae
Narrow ligature	113	46.9%
Incomplete hanging	76	54.5%
Complete hanging	37	30.6%
Wide ligature	57	40.4%
Incomplete hanging	51	43.1%
Complete hanging	6	16.7%

*Victims without reanimation maneuvers.

TABLE 5. Incidence of Petechiae in Relation to Age

	No. Cases*	Incidence of Petechiae
0–9	0	—
10–19	18	61.1%
20–39	95	44.2%
>40	57	40.4%

*Victims without reanimation maneuvers.

is not merely attributable to a difference in the proportion of complete versus incomplete hangings in the different height groups. Among incomplete hanging victims, a similar inverse relationship with height was noted: 83% of victims less than 1.60 m tall had petechiae, whereas 48% were present in victims between 1.60 and 1.79 m and 41% were noted in victims of 1.80 m or more ($\chi^2 = 4.64$, $df = 2$, $N = 155$, $P = 0.10$).

Summary of the Variables in the Incidence of Petechiae

Multiple logistic regression models were constructed to evaluate the effects of CPR, type of hanging, type of ligature, age, height, and BMI acting jointly on the risk incidence of petechiae. Adjusted odds ratios were calculated for variables of interest. Two variables were statistically significant: the incidence of petechiae was higher among incomplete hanging victims compared with cases of complete suspension (OR = 3.1, $P = 0.002$) and the incidence of petechiae varied inversely with the height of the victims (OR = 0.51, $P = 0.035$). The other factors were not statistically significant: CPR, type of ligature, age, and BMI. If controlled for the type of hanging, the effect of the type of ligature and BMI on the development of petechiae was not statistically significant ($P > 0.05$). A summary of adjusted odds ratios for variables of interest is presented in Table 8.

Incidence of the Various Types of Petechiae in Relation to Studied Factors

Finally, the effect of the various factors on the incidence of petechiae was studied taking the various localizations of petechiae into account: conjunctival, palpebral and buccal petechiae. Adjusted odds ratios are presented in Table 9. The type of

TABLE 6. Incidence of Petechiae in Relation to the BMI

	No. Cases*	Incidence of Petechiae
Normal weight	112	43.8%
Incomplete hanging	84	50.0%
Complete hanging	28	25.0%
Overweight and Obese	56	46.4%
Overweight	41	51.2%
Incomplete hanging	33	51.5%
Complete hanging	8	50.0%
Obese	15	33.0%
Incomplete hanging	10	40.0%
Complete hanging	5	20.0%

*Victims without reanimation maneuvers.

TABLE 7. Incidence of Petechiae in Relation to Height

Height	No. Cases*	Incidence of Petechiae
Less than 1.60 m	13	77%
Incomplete hanging	12	83%
Complete hanging	1	0%
1.60–1.79 m	128	44%
Incomplete hanging	94	48%
Complete hanging	34	32%
1.80 m or more	29	35%
Incomplete hanging	22	41%
Complete hanging	7	14%

*Victims without reanimation maneuvers.

hanging was a statistically significant factor for all types of petechiae. Height however seems to be of importance only for palpebral petechiae (OR = 0.412, $P = 0.01$).

DISCUSSION

General Incidence of Petechiae

The incidence of petechiae in hanging deaths varies greatly from one study to the next: 23% in both James and Silcocks and Suarez-Penaranda et al, 30% in Elfawal and Awad, 48% in both Luke et al and Samarasekera and Cooke, and 69% in Luke.^{5–8,11,12} By compiling all these previous studies, the incidence on 768 cases would be of 39%. This incidence is in keeping with the 46% found in the present study.

The distribution of petechiae is further discussed in only 2 of these studies.^{5,8} In Samarasekera and Cooke, external petechiae were observed on the eyelid in 27%, in the conjunctiva in 33%, and in both location in 18%.⁸ In Luke et al, conjunctival petechiae were isolated in 17% and combined with facial petechiae in 10%; facial petechiae were never found in cases without conjunctival petechiae.⁵ The description of the distribution of petechiae in hanging in the present study is the most detailed so far. The most common location of petechiae was the eyelid (38%), followed by the conjunctiva (31%), and the buccal mucosa (31%). Twenty percent of cases had petechiae present in all 3 locations.

TABLE 8. Summary of Studied Factors

	Petechia	
	OR	Sig
CPR	1.406	0.386
Incomplete hanging	3.148	0.002
Wide ligature	0.601	0.105
Age	0.706	0.17
Height	0.505	0.035
BMI	1.02	0.62
Model χ^2	19.3	0.005
Nagelkerke R^2	0.12	

$P < 0.05$ in gray.

OR indicates odds ratio.

TABLE 9. Studied Factors in Relation to the Localization of Petechiae

	Palpebral Petechiae		Conjunctival Petechiae		Buccal Petechiae	
	OR	Sig	OR	Sig	OR	Sig
CPR	1.137	0.749	1.683	0.202	0.892	0.788
Incomplete hanging	3.119	0.005	3.821	0.003	4.305	0.002
Wide ligature	0.634	0.156	0.498	0.041	0.674	0.238
Age	0.599	0.051	0.621	0.079	0.783	0.364
Height	0.412	0.01	0.716	0.328	0.583	0.121
BMI	1.042	0.31	1.039	0.36	1.022	0.612
Model χ^2	21.7	0.01	19.1	0.004	16.8	0.010
Nagelkerke R^2	0.136		0.125		0.111	

OR indicates odds ratio.

Incidence of Petechiae in Relation to CPR Maneuvers

It has been proposed that CPR can lead to facial petechiae through the abrupt, forceful reflux of blood from the heart into the veins of the head and neck, which results in traumatic rupture of small venules during chest compressions.⁴ One of the most frequently cited papers used to support the argument that CPR can cause petechiae was written by Hood et al¹³ It is a case series of 4 nonasphyxial deaths in which the victims received CPR and were found to have prominent facial petechiae. The causes of death described were myocardial infarction, epilepsy and 2 cases of a gunshot wound to the head. Because asphyxia was presumably not involved, the authors assumed that the presence of petechiae was independent of the cause of death and thus attributable to CPR alone. Alternatively, other authors consider those same causes of death to be occasionally associated with petechiae even without CPR, thus emphasizing the lack of consensus in the literature as to what circumstances increase the incidence of facial petechiae.^{14,15} The only way to avoid the bias of cause of death interfering with the interpretation of the postmortem effects of CPR would be to look at victims that did and did not receive CPR within the context of individual conditions, as opposed to inhomogeneous case groups. Interestingly, only one author appears to have attempted such an analysis with promising results requiring further investigation.¹⁶ The author effectively demonstrated how the overall prevalence of petechiae among deaths due to all causes of death was 11% among victims without CPR and 19% among victims having received CPR. The difference was statistically significant, suggesting that CPR does play a role in the development of petechiae. However, when controlled for cause of death, the impressive difference quickly

disappeared. Other studies investigating the incidence of petechiae in victims following CPR are scarce. A study by Raven et al reviewed 50 deaths in which there had been endotracheal intubation and chest compression prior to death.¹⁷ They noted that 6% were found to have facial petechiae and 21% were found to have conjunctival, bulbar and/or palpebral petechiae. Based solely on this observation and without a control group, the authors declared that these changes should be attributed to chest compressions with no mention whatsoever of the cause of death in these cases. Further adding to the confusion are several papers that describe an association between CPR and petechiae that is based on limited case reports rather than statistical studies.^{13,14,18} For example, the discussion of one study mentions that CPR seems to enhance the development of conjunctival petechiae. Full review of the text reveals that the claim appears to be based solely on the observation that 2 out of 3 isolated abdominal gunshot wound victims with conjunctival petechiae had received CPR.¹⁴ The author did not proclaim the association as fact, and probably felt quite comfortable making the statement considering it was written that it “seems to,” but unfortunately this can be misleading and has led to other authors citing Rao as a reference to justify the implication of CPR in the development of petechiae. Another article that has been cited for similar reasons is a series of cases involving resuscitation artifacts.¹⁸ Only 2 of the cases described in the paper contained examples of petechiae following CPR but the cause of death was not mentioned in either of those cases making it very difficult to conclude anything more than a passive association. The only way to effectively assess whether or not CPR increases the occurrence of petechiae would be to assess the presence of petechiae in victims that received CPR compared with a control group of victim from the same cause of death that did not receive CPR. In the present study, only cases of hanging were analyzed, thus the cause of death was the same for both the CPR and non-CPR control group. No significant difference was found in the incidence of petechiae among hanging victims that did and did not receive CPR.

TABLE 10. Incidence of Petechiae in Relation to the Type of Hanging in the English Literature

Ref	No. Cases	% of Petechiae		Statistical Significance
		Incomplete Hanging	Complete Hanging	
5	56	61%	25%	$P = 0.02$
6	74	46%	22%	$P = 0.014$
7	61	62%	21%	No data
8	233	48%	33%	No data
Total: 424		Average: 54%	Average: 25%	

Incidence of Petechiae in Relation to the Type of Hanging

It is often stated in forensic textbooks that the incidence of petechiae in hanging with incomplete suspension of the body is higher than in hanging with complete free suspension.^{3,4} In incomplete hanging, occlusion of the venous return can occur without a disruption of arterial supply. Because the deeper and less compressible arteries remain patent while venous drainage is blocked, the persistence of arterial circulation generates high

intravascular pressure in the head and neck. However, there are very few studies to support this assumption: only 4 studies can be found in the English literature, for a total of only 424 cases (Table 10). Furthermore, only 2 of these 4 studies used a statistical test to demonstrate the higher incidence of petechiae in incomplete hanging, the other 2 were only descriptive.

In the present study, the incidence of petechiae was significantly higher in incomplete hanging, with 50% of victims exhibiting petechiae compared with 29% in the complete suspension group. These results are similar to the incidence found in the literature (Table 10): petechiae are observed in 46% to 62% of incomplete hangings and in 21% to 33% of complete suspensions.

This important role played by the type of hanging in the incidence of petechiae may explain the great variability of the general incidence of petechiae found from one study to the next. As a matter of fact, studies with a greater proportion of incomplete hangings will report higher general incidence than studies with a smaller one. Therefore, it may not be useful to attempt to describe the general incidence in textbooks and papers.

Incidence of Petechiae in Relation to the Type of Ligature

It is well known that the type of ligature used on the victim affects the depth of the furrow left in the skin following a hanging death.^{1,3,4} Elfawal and Awad demonstrated that plastic ligature marks were deeper than the cotton ones.⁷ The type of ligature has also been implicated in some studies as a factor in the development of fractures of the neck, but not in others studies.^{5,6,8,19} However, only one study evaluates the relationship between the incidence of petechiae and the type of ligature. In this study by James and Silcocks, no statistically significant difference in the incidence of petechiae was found between 10 soft ligatures and 66 hard ones.⁶ Similarly, no difference was found in the present study in the incidence of petechiae between narrow and wide ligatures. Therefore, the type of ligature does not seem to be an important variable in the development of petechiae.

Incidence of Petechiae in Relation to Age

With the aging process, skin degeneration occurs: vascularization progressively atrophies, the supportive dermis deteriorates, and the collagen and elastic fibers become sparse and disorganized.²⁰ Considering these changes, it is plausible that age will have an impact on the development of external petechiae. Only one previous English paper previously assessed the relationship between the incidence of petechiae in relation to age.⁶ As in the present study, there was no significant relationship between age and presence of petechiae in hanging. However, it is worthy to note that a paper on petechiae in nonstrangulation deaths found that petechiae were more common in middle-aged than elderly men dying of cardiac disease.¹⁶ Further studies are needed to evaluate the role of age in the development of petechiae.

Incidence of Petechiae in Relation to the BMI

The incidence of petechiae between obese, overweight and normal-weight individuals was not statistically significant. As far as we know, this is the first study to assess BMI as a possible variable in the incidence of petechiae in hanging.

Incidence of Petechiae in Relation to Height

The incidence of petechiae varied inversely with the height of the victim. This is the first study to suggest that height is an important variable in the incidence of petechiae. This role of

height was also observed when looking at cases of incomplete hanging alone. The mechanism to explain how height would create a pathophysiological effect on petechiae remains unclear at this time. It is possible that this finding is confounded by a correlation with another hidden factor affecting the development of petechiae. Further studies are required to confirm or disprove height as an important variable.

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