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Fracture of the neck structures in suicidal hangings: A Retrospective study on contributing variables

Renaud Clément [a,b], Jean-Pierre Guay [c], Anny Sauvageau [a,d,*]

[a] Laboratoire de Sciences Judiciaires et de Médecine Légale, Montreal, Canada
[b] Laboratoire de Médecine Légale, Faculty of Medicine, Nantes, France
[c] School of Criminology, University of Montréal & Montreal Philippe-Pinel Institute, Canada
[d] Office of the Chief Medical Examiner, Edmonton, Canada

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ABSTRACT

Introduction: Several factors may play a role in the development of fractures of the neck structures in hanging. It has been repetitively demonstrated that the incidence of fractures increases with age. The role of other variables is less clear, different studies presenting contradictory results on the role of gender, the type of suspension, or the type of ligature. However, most of these studies evaluated these factors independently of the age of the victims. Considering that age is probably the most important factor in the development of neck structure fractures, all other contributing factors should be studied in relation to age. The aim of the present study is to evaluate the role of contributing factors to the development of neck structure fractures, taking age categories into account.
Materials and methods: A total of 206 cases were analysed for the presence and localization of thyroid fracture. For each case, the following information was also compiled: the presence and localization of other neck structure fractures, gender and age, height and weight, body mass index (BMI) type of suspension (complete or incomplete), type of ligature used (rope, wire, clothes, sheet or lace) and localization of the knot (anterior, right, left or posterior).
Results: The incidence of neck structure fractures increased with age ($\chi^2 = 21.85$; $p < .001$) and is significantly higher in male victims (31.4%) compared to female victims (11.8%) ($\chi^2 = 5.41$; $p = .02$). The incidence of fractures varied significantly with the height ($t = 2.19$; $p = .031$; $D = .33$), weight ($t = 4.38$; $p < .001$; $D = .89$) and BMI ($t = 3.84$; $p < .001$; $D = .60$). The incidence of fractures did not vary significantly with the type of suspension (i.e. complete hanging with feet off the ground or incomplete hanging with body parts partially supporting the weight of the body) ($\chi^2 = 3.12$; $p = .077$; Phi = .077) and the type of ligature (i.e. narrow vs wide) ($\chi^2 = .05$; $p = .828$; Phi = .015). However, when taking the age of the victims into account, a different picture was revealed: in individuals aged 40 years or more, victims with complete suspension of the body presented with a significantly higher incidence of fractures (63.2%) compared to victims with incomplete suspension (31.0%) ($\chi^2 = 6.79$; $p = .009$; Phi = .318).
Conclusion: Several variables contribute to the development of neck structure fractures in hanging. Age is probably the most important one. Other contributing factors are gender, height, weight, BMI and the type of suspension.

1. Introduction

Fractures of the neck structures figure among the classic autopsy findings in suicidal hangings [1–3]. The incidence of such fractures varies from one study to the next, from 0 to 76.8% [4,5]. In a recent paper, a meta-analysis of all English studies revealed an incidence of neck structure fractures of 36.6% ± 24.7 [6]. The majority of these fractures are isolated thyroid cartilage fracture (15.3% ± 12.1), followed by isolated hyoid bone fracture (11.5% ± 12.1) and combined thyroid cartilage and hyoid bone fracture (7.5% ± 6.1). Cricoid fracture is virtually non existent in suicidal hangings.

Several factors may play a role in the development of fractures of the neck structures in hanging. It has been repetitively demonstrated that the incidence of fractures increases with age [7–17]. The role of gender is less clear: some authors found a male predominance of fractures [9,15,18] whereas other observed a female predominance [7,13] or no significant difference between genders [11,19]. Similarly, studies on the role of several other

* Corresponding author at: Office of the Chief Medical Examiner, 7007, 116 Street, Edmonton, Alberta, Canada T6H 5R8. Tel.: +1 780 427 4987; fax: +1 780 422 1265.
E-mail address: anny.sauvageau@gmail.com (A. Sauvageau).

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factors have shown opposite results: the type of suspension (i.e. complete hanging with feet off the ground or incomplete hanging with body parts partially supporting the weight of the body) [7,9,13,14,20], the type of ligature [7,9,16], the location of the knot or the highest suspension point [9,10,12,13,19] and the suspension time [13,15]. However, most of these studies evaluated these factors independently of the age of the victims. Considering that age is probably the most important factor in the development of neck structure fractures, all other contributing factors should be studied in relation to age. The aim of the present study is to evaluate the role of contributing factors to the development of neck structure fractures, taking age categories into account.

2. Materials and methods

The province of Quebec (Canada) operates under a coroner system. A coroner may or may not, in performing his death investigation, order a forensic autopsy. In Quebec, a single centralized forensic laboratory covers the entire population of 7.5. Over an 8.5-year period (2000–mid 2009), all autopsy cases performed at this laboratory were retrospectively reviewed for suicidal hanging deaths. During the study period, six forensic pathologists worked at one time or another in the forensic laboratory. For hanging deaths, they all were performing autopsies with dry-neck dissection.

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 since 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 post-mortem changes interfered with the evaluation of BMI (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 analysed for the presence and localization of thyroid fracture. For each case, the following information was also compiled: the presence and localization of other neck structure fractures, gender and age, height and weight, type of suspension (complete or incomplete), type of ligature used (rope, wire, clothes, sheet or lace) and localization of the knot (anterior, right, left or posterior). The types of ligatures were regrouped into two 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 localization of the knot was defined by its relation to the sterno-cleido-mastoid muscles: a knot localized anteriorly to the sterno-cleido-mastoid muscle was designated as anterior, a knot localized posteriorly to the sterno-cleido-mastoid muscle was described as posterior whereas as knot localized on the sterno-cleido-mastoid muscles were labeled as lateral. The BMI was subsequently calculated according to the WHO international formula (weight (kg)/height^2 (m^2)) and adapted for children and adolescents. The reported data was statistically analysed using the SPSS Statistics 16.0 software. The effect sizes were measured using Cohen [21], a measure of the strength of the relationship between two variables in a statistical population. Cohen proposed the following guidelines for interpreting d: $d = .20$ is small effect size, $d = .50$ is moderate and $d = .80$ is large.

3. Results

3.1. Incidence and distribution of fractures of the neck structures

Of the 206 suicidal hangings, most cases did not present any fracture of the neck structures (72%). Of the 28% of victims presenting with a fracture of the neck structure, the majority presented with an isolated fracture of the thyroid cartilage. The distribution of fractures is depicted in Table 1.

Table 1
Distribution of fractures of the neck structures.

	Number of cases	Percentage
Absence of fracture	148	72
Presence of fracture	58	28
Isolated thyroid fracture	45	22
Isolated hyoid fracture	3	1
Combined thyroid and hyoid fracture	10	5
Cricoid fracture	0	0

Table 2
Incidence of fractures in relation to age.

Age	Absence of fracture		Presence of fracture	
	n	%	*n*	%
Less than 40	114	82	25	18
40 and more	34	51	33	49

Pearson Chi-square = 21.851; $p = .000$.

3.2. Incidence of fracture in relation to age and gender

The incidence of neck structure fractures increased with age ($\chi^2 = 21.85$; $p < .001$). Victims of less than 40 years of age presented an incidence of fracture of 18% whereas this incidence increased significantly to 49% in victims of 40 years or more (Table 2). The average age of victims without fractures of the neck structures was 31.7 compared to 42.6 for victims presenting fractures (t (204) = 5.66, $p < .001$; $D = .88$) (Table 3).

As for gender, the incidence rate of fracture is significantly higher in male victims (31.4%) compared to female ones (11.8%) ($\chi^2 = 5.41$; $p = .02$). Results are shown in Table 4.

3.3. Incidence of fracture in relation to the height, weight and BMI

The incidence of fractures varied significantly with the height ($t = 2.19$; $p = .031$; $D = .33$), weight ($t = 4.38$; $p < .001$; $D = .89$) and BMI ($t = 3.84$; $p < .001$; $D = .60$) (Table 3). The average height of hanging victims with fractures of the neck structures was of 1.74 m compared to 1.71 m for victims without fractures. As for the average weight and BMI of victims with fractures, it was of 78.2 kg and 25.6 respectively, compared to 68.6 kg and 23.2 in victims without fractures. Further analyses of covariance with age of the victim as a covariate indicate that differences remained significant. Table 5 shows mean height, weight and BMI in relation to age and the presence of fracture, whereas Table 6 estimates marginal

Table 3
Analysis of age, height, weight and BMI in relation to fractures of the neck structures.

Variable	Absence of fracture mean	Presence of fracture mean	t	p	D[a]
Age	31.7	42.6	5.66	<.001	.88
Height	1.71	1.74	2.19	.031	.33
Weight	68.6	78.2	4.38	<.001	.89
BMI	23.2	25.6	3.84	<.001	.60

[a] Cohen's d.

Table 4
Incidence of fractures in relation to gender.

	Mean age		% (n)	Mean age	t	p
Male victims	35.4 ± 13.2	Absence of fracture	68.6 (118)	32.2 ± 12.2	4.99	<.001
		Presence of fracture	31.4 (54)	42.4 ± 12.6		
Female victims	31.4 ± 13.8	Absence of fracture	88.2 (30)	29.5 ± 13.5	2.32	.032
		Presence of fracture	11.8 (4)	45.5 ± 4.7		

Pearson Chi-square = 5.408; $p = .020$.