Original Article

The Influence of Age, Sex, and BMI on Neck Cartilage and Bone Fractures in Hanging Deaths: A 6-Year Autopsy Study

T Bork, K Sehlikoglu[1], O Celbis[2], BS Oner[3]

Department of Forensic Medicine, Faculty of Medicine, Fırat University, Elazığ, [1]Department of Forensic Medicine, Faculty of Medicine, Adıyaman University, Adıyaman, [2]Department of Forensic Medicine, Faculty of Medicine, Alanya Alaaddin Keykubat University, Alanya, [3]Department of Forensic Medicine, Faculty of Medicine, Amasya University, Amasya, Turkey

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Abstract

Background: Asphyxia by hanging is caused by the constricting force of a ligature encircling the neck, with gravity pulling the body downward. Postmortem examinations should focus on cartilaginous and soft tissues in the neck region. **Aim:** The present study aims to demonstrate the effect of various variables such as age, sex, height, weight, and BMI on postmortem findings in cartilaginous and bone tissues in the neck region. **Materials and Methods:** The study is a retrospective descriptive study covering 248 cases of death by hanging. **Results:** The mean age of the cases was 39.8 years, and 69.8% (n = 173) of the cases were male. Thyroid cartilage fracture was observed in 98 (39.5%) cases and hyoid bone fracture in 80 (33.3%) cases. Hyoid bone fractures were 4.4 times more frequent in women ($P < 0.05$). Although there was no significant difference between the number of thyroid cartilage fractures and sex ($P = 0.274$). There was a significant difference in terms of weight ($P = 0.004$) in cases with thyroid fracture and in weight ($P = 0.001$) and height ($P = 0.037$) in cases with hyoid fracture. A significant difference was observed in BMI in the occurrence of thyroid cartilage fractures ($P < 0.05$). **Conclusion:** This study is one of the largest series in the literature and is an important study that reveals the statistical significance of neck cartilage and bone tissues in autopsy results. When investigating neck cartilage and bone fractures in cases of death by hanging, the attending physician should consider the physical condition of the individual.

Keywords: *Asphyxia death, hanging, neck injuries, suicide*

Introduction

Suicide attempt is generally defined as a self-destructive act carried out with some degree of intent to end one's life. Suicidal behavior refers to suicide death but also includes various types of suicide attempts that range from high lethality attempts to low-lethal attempts.[1] Hanging is a common method of suicide worldwide. It is a condition of asphyxiation caused by the constricting force of a material wrapped around the neck, with the gravity pulling the body of the suspended person downward.[2,3] Such deaths are of considerable forensic interest due to their potential overlap with other forms of neck compression, including homicidal strangulation, which have been discussed and studied due to their widespread use and similarity to other types of strangulation (manual and ligament strangulation).[4,5] The cases are classified as typical and atypical depending on the location of the knot on the neck. Cases where the knot is in the occipital region are defined as typical hanging.[6]

The present study aims to statistically demonstrate the effect of various variables such as age, sex, height, weight, and body mass index (BMI; kg/m^2) on postmortem findings in cartilaginous and bone tissues in the neck region.

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Address for correspondence: Dr. K Sehlikoglu, Altınşehir Quarter, Atatürk Boulevard, No: 1, Postal Code: 02040, Deanery of the Faculty of Medicine, Adiyaman University, Adiyaman, Turkey.
E-mail: keremsehlik@gmail.com

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Materials and Method

Sampling, setting, and procedure of the study

Forensic Medicine Institute Malatya Group Presidency is the largest autopsy center of the country serving in the East Anatolia region of Turkey. A total of 248 hanging-related deaths that occurred in that region between 2012 and 2018 were included in the study. Upon analysis of death scene investigation and autopsy reports together with the information gathered from the police, the cases of hanging fatalities of suicidal origin were selected and all cases were included in the study. Cases involving other causes of death were not included in the study. Autopsy was performed on all cases.

Age, sex, height, weight, date of incident, cervical vertebrae, hyoid bone, and thyroid cartilage fractures, ecchymosis in the soft tissues of the neck, and type of hanging were determined. BMI was calculated based on the height and weight of the cases. World Health Organization Classification was used for categorizing the cases based on their BMI as follows: <18.5, underweight; 18.5-24.9, normal weight; 25.0-29.9, preobesity; 30.0-39.9, obesity; >40.0, morbid obesity. Fractures in the neck region were categorized into three main groups: cervical vertebrae, thyroid cartilage, and hyoid bones. In cases of uncertainty, histological confirmation of ecchymosis was performed. Effects of individual characteristics and the type of hanging on fractures were evaluated. The material used in the hanging was not analyzed.

Statistical analyses

The data obtained were transferred to SPSS 22.0 (Statistical Package for Social Science) (IBM Corp, Armonk, NY). Descriptive statistics and continuous variables were presented as mean ± standard deviation. Mann–Whitney U-test was used for statistical analysis of continuous variables and Pearson's Chi-square test for categorical variables. Regression analysis was conducted to identify the factors influencing the occurrence of thyroid cartilage and hyoid bone fractures. The presence of fractures in the thyroid cartilage and hyoid bone was used as the dependent variable, while age, sex, weight, height, and BMI were included as independent variables. The value $P < 0.05$ obtained from the statistical analysis was considered significant.

Ethical statement

The privacy rights of human subjects were respected during the implementation of study by the authors. For the implementation of the study, ethical approval was obtained from the local Ethics Committee with the decision dated 11/06/2018 and numbered 2018/20-15. This study was performed in accordance with the ethical standards as laid down in the 1975 Declaration of Helsinki and its later amendments.

Results

The mean age of the cases was 39.86 ± 20.42 years. Of 248 cases, 173 (69.8%) were male and 75 (30.2%) were female. The mean height of the cases was 166.39 ± 10.62 cm and the mean weight was 67.28 ± 14.17 kg [Table 1].

The least number of suicides occurred at weekends: 26 (10.5%) on Saturdays and 25 (10.1%) on Sundays [Figure 1].

The suicide rate was higher during spring and summer, when the weather was hot [Figure 2].

Out of the laryngeal tissues, ecchymosis was mostly present in the thyroid cartilage. Findings of laryngeal tissue are provided in Table 2.

Of the 248 cases, 212 (85.5%) were typical hangings and 32 (12.9%) were atypical; the type of hanging was not specified in 4 (1.6%) cases.

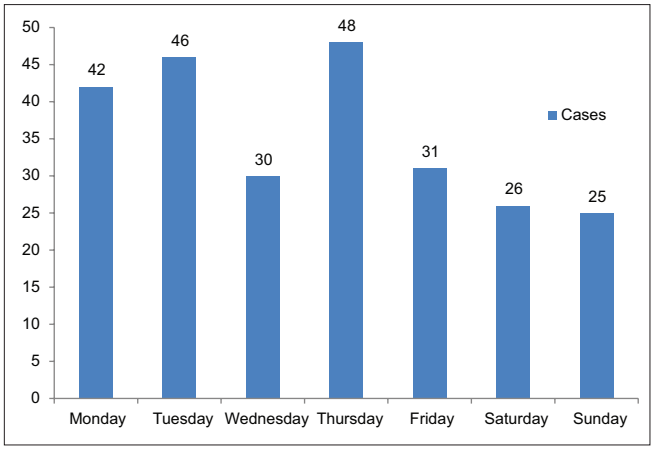

Figure 1: Distribution of cases by days

Table 1: The mean age, height, and weight of cases according to sex

Sex	Age (year)	Height (cm)	Weight (kg)
Male			
Mean	40.49	170.75	69.90
Number	173	173	173
Std. Dev.	20.12	9.09	13.03
Female			
Mean	38.40	156.34	61.24
Number	75	75	75
Std. Dev.	21.14	6.13	14.90
Total			
Mean	39.86	166.39	67.28
Number	248	248	248
Std. Dev.	20.42	10.62	14.17

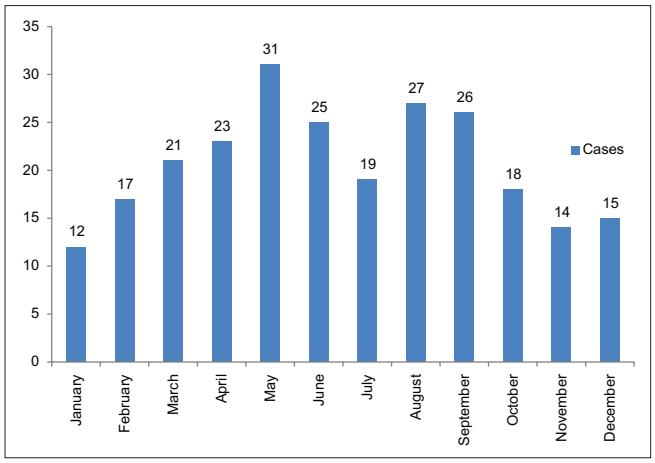

Figure 2: Distribution of cases by months

Table 2: Findings of laryngeal tissue

Findings of laryngeal tissue*	*n*	%
Thyroid cartilage fracture	98	39.5
Hyoid bone fracture	80	32.3
Thyroid cartilage ecchymosis	146	58.9
Hyoid bone ecchymosis	117	47.2
Cervical vertebrae fracture	3	1.2
Cervical paravertebrae ecchymosis	10	4.0

*In some cases, multiple laryngeal tissue findings were observed

Table 3: The variation of thyroid cartilage and hyoid bone findings according to the variables of the deceased

	Positive cases	Negative cases	*P*
Thyroid cartilage fracture			
Mean age	46.45±18.58 year	35.55±20.47 year	<0.05
Mean weight	70.60±12.68 kg	65.11±14.70 kg	0.004
Mean height	166.61±10.12 cm	166.26±10.96 cm	0.798
Mean BMI	25.40±4.48 kg/m^2	23.41±4.61 kg/m^2	<0.05
Hyoid bone fracture			
Mean age	44.13±19.82 year	37.82±20.44 year	0.007
Mean weight	69.62±11.33 kg	66.17±15.24 kg	0.001
Mean height	169.41±8.62 cm	164.96±11.19 cm	0.037
Mean BMI	24.31±3.99 kg/m^2	24.14±4.95 kg/m^2	0.484

There was no significant difference in terms of the type of hanging between those with and without thyroid cartilage fractures (P = 0.784). Further, no significant difference was observed in terms of the type of hanging between those with and without hyoid bone fractures (P = 0.743).

The variation of thyroid cartilage and hyoid bone findings according to the variables of the deceased is provided in Table 3.

Pearson's Chi-square test showed no significant difference between thyroid cartilage fracture and sex (P = 0.274); however, the risk analysis showed that thyroid fracture was 1.23 times more frequent in women than in men.

There was a significant difference between hyoid bone fracture and sex (P < 0.05); hyoid fracture was 4.41 times higher in women than in men.

Discussion

Overall, 248 cases of hanging-related deaths were included in the study. To the best of our knowledge, except for a few studies, there is no other study in the literature that included such a high number of cases. The high number of cases included can be attributed to the study being conducted in the largest forensic unit located in the East Anatolia region of Turkey. Hanging-related death stands out as the most common suicide method in the world. It is the leading suicide method in Germany and Japan. It is reportedly the second most common suicide method after poisoning in India and the most common method after firearms use in some states of the United States.[7,8]

In the present study, 69.8% (n = 173) of the cases were male. In most of the previous studies, the number of males seems to be dominant.[9,10] In the study by Russo *et al.,* the male/female ratio was reported as 4:1.[2] James and his colleagues reported that 60% of the cases were male.[11] Even if suicide attempts by women are more frequent worldwide, suicides resulting in death seem to be male-dominated.

In the study, cases of suicide increased during spring and summer [Figure 2]. The least number of cases were recorded at weekends [Figure 1]. The literature often reports increased suicide attempts during warmer climates.[12] Seasons exert hormonal and psychological effects on humans. Suicide attempts on weekdays seem to be more lethal, because on weekends other household members are at home or with the person.

In a study involving 178 cases, Zapotkova *et al*.[13] reported significantly higher occurrence of thyroid cartilage fractures in cases aged >40 years regardless of the sex; no such correlation was observed for hyoid fractures. In the study by Tugaleva *et al*.,[5] the number of laryngeal fractures tended to increase with age and weight. Few studies have statistically explored the combined effects of demographic and anthropometric variables on postmortem findings in hanging deaths. Our study found a height/weight/BMI mean of 170.75 cm/69.90 kg/23.8 kg/m^2 for men and 156.34 cm/61.24 kg/24.9 kg/m^2 for women. In Turkey, the mean height/weight/BMI was 172.6 cm/75.8 kg/25.4 kg/m^2 for men and 161.4 cm/66.9 kg/25.6 kg/m^2 for women.[14] In the present study, both women and men were below the mean height/weight/BMI in Turkey.

In forensic units of Turkey, a burial permit for cases of hanging is not issued with external examination. In our study, an autopsy was performed on all cases. Findings in the neck region in internal autopsy revealed ecchymosis in thyroid cartilage in 58.9% of the cases (n = 146), ecchymosis in hyoid bone in 47.2% (n = 117), and cervical paravertebral muscles ecchymosis in 4% (n = 10). Regarding the fractures, 39.5% (n = 98) had thyroid cartilage fracture, 32.3% (n = 80) had hyoid bone fracture, and 1.2% (n = 3) had cervical vertebrae fracture [Table 2]. Fracture rates in the neck cartilage bones were higher than those reported in most studies.[10,15] In a study by Garetier *et al*.[16] in 2016, more than half of the cases of hanging-related deaths reportedly had fractures in hyoid bone and thyroid cartilage or in both and rarely in the cervical vertebrae. A study by Nikolic *et al*.[17] reported thyroid cartilage fracture in 58% of cases.

Typical hanging follows an oblique course on the neck and more superficial towards the nape of the neck. Our study found typical hanging in 85.5% of the cases (n = 212). Other studies have reported similar rates (90%, 77%).[2,7] Nikolic *et al*.[17] reported that thyroid and hyoid fractures are caused by the position of the knot and no fracture is observed in atypical hanging cases where the knot is in the front. In our study, there was no statistically significant difference was found in thyroid and hyoid bone fractures based on the type of hanging. This may be associated with the limited number of atypical hanging cases in our study. We believe this could be due to the excessive force applied to the anterior part of the neck in typical hangings, compared to the relatively lower bilateral pressure exerted on the anterior neck tissues in atypical hangings.

Our study found that both thyroid and hyoid fractures significantly increased with increased age [Table 3]. We believe that this is attributable to the hardening and increased fragility of the cartilaginous tissues with the increasing age.

Thyroid cartilage fracture and hyoid bone fracture were 1.2 times and 4.41 times, respectively, more common in women than in men. We attribute this to higher BMI in women than in men because the mean BMI was 24.63 ± 4.15 kg/m^2 in men with thyroid cartilage fractures and 27.42 ± 4.77 kg/m^2 in women. Regardless of sex, the number of thyroid cartilage fractures significantly increased as the weight of the individual increased and that of hyoid bone fractures increased as both the height and weight increased. Considering the mechanism of hanging, the force applied to the neck by gravity increases in proportion to the mass of the person. Therefore, fractures in the neck increasing in proportion to BMI was an expected finding. The attending physician conducting an autopsy should consider this aspect while examination.

Fractures of the cervical spine and spinal cord injuries rarely occur in short-distance falls.[9] For cervical spinal cord injuries to occur, the distance of the fall must be at least 2.7 m.[18] The literature reports that cervical spine fracture is rare in hanging-related deaths.[19,20] A study by Russo *et al*.[2] reported cervical vertebrae fractures in 4% of the cases. In the present study, cervical vertebral fractures were observed only in 3 cases (1.2%). This is because most of our cases occurred at home, and the ceiling is typically not at sufficient heights for the falls to cause such fractures.

Bleeding in the area with the ligature mark is an important finding and must be expected in cases of hanging. Numerous studies have reported bleeding in the neck muscles underneath the ligature mark.[21,22] In some studies, all cases were reported to be in that category.[23,24] In our study, ecchymosis was observed in the soft tissues of the neck in the areas underneath the ligature mark. Ecchymosis was present in 58.9% surrounding the thyroid cartilage and 47.2% surrounding the hyoid bone. Histopathological sampling was performed on cases with suspected ecchymosis in macroscopy.

Conclusion

There are numerous studies in the literature that reveal findings on the soft and cartilaginous tissues of the neck in hanging-related deaths. However, there are no studies that statistically reveal the effects of age, sex, weight, height, and BMI on cartilaginous and bone tissues of the cases. In both sexes, increased age resulted in a higher number of thyroid cartilage and hyoid bone fractures. In men, fractures were more prevalent and more pronounced in the hyoid bone. The incidence of thyroid cartilage fractures increased with the increase in weight and hyoid bone fracture increases with increase in both weight and height. These findings may aid forensic pathologists in interpreting autopsy findings and estimating postmortem biomechanics in hanging deaths.

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Conflicts of interest

There are no conflicts of interest.

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