

Anoxic brain injury – state after hanging

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Summary

Aim of the study. To analyze the deaths of persons who hanged themselves in Vilnius County, focusing on cases where death did not occur suddenly but over a while after developing anoxic brain injury. To assess the prevalence, demographics, medical management, vital signs, and complications of these cases.

Material and methods. A retrospective analysis of the State Forensic Medical Service's anonymized autopsy data from 2014 to 2023 was conducted. Cases of near-hanging, in which anoxic brain injury was one of the complications leading to death, were selected. Statistical data analysis was performed using Microsoft Office Excel.

Results. From 2014 to 2023 in Vilnius County, out of 2149 cases of hanging, near-hanging with anoxic brain injury was diagnosed in 10 cases. Males made up 80% of the

sample. The average age of the subjects was 44.5 ± 17.7 years. Most of the hangings took place in a prison (40%). The average duration of initial cardiopulmonary resuscitation (CPR) was 9.4 ± 2.9 minutes. The duration of CPR performed by Emergency Medical Services averaged 22.6 ± 10.2 minutes. On average, inpatient treatment was initiated within 2.49 ± 0.9 hours.

During the initial condition assessment at the medical facility, the average respiratory rate was 16 ± 4.9 breaths per minute, systolic blood pressure (BP) – 102.3 ± 31.6 mmHg, diastolic BP – 63.4 ± 21.8 mmHg, heart rate – 105 ± 21.9 beats per minute, and Glasgow Coma Scale score – 4.4 ± 3.3 . The mean duration of coma was 6.8 ± 10.3 days. Patients survived an average of 8.7 ± 15.8 days. The condition was often complicated by respiratory and heart failure (80%) and pneumonia (50%). The thyroid cartilage was fractured in one subject. Data on the use of psychoactive substances were present in 40% of the cases.

Conclusions. Near-hanging cases with anoxic brain injury are rare in Vilnius County. A trend of these cases has been observed among persons in prison or using psychoactive substances. Along with anoxic brain injury and coma, the most common complications were respiratory and heart failure, as well as pneumonia. Patients had severe impairment of vital functions, and the average survival was 8.7 days.

Keywords: anoxic brain injury, autopsy, hanging, suicide, forensic medicine.

INTRODUCTION

Hanging is the tightening of the neck in a noose due to the body's weight and gravity [1]. Most often, hanging is used for suicide, whereas accidental hangings or homicides are less frequent [1]. Hanging is one of the most prevalent ways of suicide globally [2]. In Lithuania, hanging was the predominant method of suicide in 2022, accounting for 88% of male suicides and 82% of female suicides [3]. Hanging is considered a highly lethal method of suicide, with a mortality rate exceeding 84% [4, 5]. Cases in which an individual who has attempted hanging does not die immediately but survives long enough to be admitted to the hospital are identified as near-hanging [4]. Hypoxia-induced brain injury is a primary cause of morbidity and mortality among near-hanging patients [6]. The researchers found

a significant negative correlation between cerebral anoxia and survival [7]. In cases of near-hanging, anoxic brain injury results from a combination of factors, including cardiac arrest, compression of the neck vessels supplying the brain, and inadequate blood oxygenation due to airway obstruction [8]. Irreversible damage to nervous tissue can occur within 4–5 minutes of disrupted oxygen supply to the brain [8]. There is a lack of studies that have thoroughly examined near-hanging cases [9, 10].

The purpose of this article is to analyze the deaths of persons who hanged themselves in Vilnius County, focusing on cases where death did not occur suddenly but over a while after developing anoxic brain damage. Moreover, this study assesses the prevalence, demographics, medical management, vital signs, and complications associated with these cases.

MATERIAL AND METHODS

A retrospective analysis of the State Forensic Medical Service's anonymized autopsy data from 2014 to 2023 was conducted. Cases of near-hanging, in which anoxic brain injury was one of the complications leading to death, were selected. Statistical data analysis was performed using Microsoft Office Excel. Descriptive statistics methods were used for data evaluation.

RESULTS

Demographics

Among 2149 diagnosed cases of hanging in Vilnius County from 2014 to 2023, 10 cases were associated with anoxic brain injury. Men constituted 80% (n=8) of the sample, while women accounted for 20% (n=2). The average age of the subjects was 44.5 ± 17.7 years, with ages ranging from 27 to 84 years.

The seasonal distribution of cases showed that 30% (n=3) occurred in autumn, winter, and spring, while 10% (n=1) occurred in summer. Regarding locations, 40% (n=4) of the hangings took place in a prison, 30% (n=3) at home, 20% (n=2) in a hospital, and 10% (n=1) on the street. A shoelace was used in 20% (n=2) of cases, a belt in 20% (n=2), and in the remaining 60% (n=6) the exact method was unspecified, although it was likely a noose. The demographic details are provided in Table 1.

Table 1. Demographic characteristics of subjects

Characteristic	Mean $\pm$ SD or n (%)
Gender:	
Male, n (%)	8 (80)
Female, n (%)	2 (20)
Age (years), mean $\pm$ SD	44.5 ± 17.7
Season:	
Autumn, n (%)	3 (30)
Winter, n (%)	3 (30)
Spring, n (%)	3 (30)
Summer, n (%)	1 (10)
Location:	
Prison, n (%)	4 (40)
Home, n (%)	3 (30)
Hospital, n (%)	2 (20)
Street, n (%)	1 (10)
Type of ligature:	
Unspecified, likely a noose, n (%)	6 (60)
Belt, n (%)	2 (20)
Shoelace, n (%)	2 (20)

Abbreviation: SD – standard deviation.

Cardiopulmonary resuscitation and treatment initiation

Cardiopulmonary resuscitation (CPR) conducted before the arrival of Emergency Medical Services (EMS) lasted an average of 9.4 ± 2.9 minutes. The duration of CPR performed by EMS averaged 22.6 ± 10.2 minutes. The mean time from the incident to the initiation of inpatient care was 2.49 ± 0.9 hours (Table 2).

Table 2. Duration of cardiopulmonary resuscitation and time to inpatient treatment

Characteristic	Mean $\pm$ SD	Min	Max
Duration of CPR until EMS arrival^a (minutes)	9.4 ± 2.9	7	15
Duration of CPR performed by EMS^b (minutes)	22.6 ± 10.2	10	30
Time to inpatient treatment^a (hours)	2.49 ± 0.9	1.6	4.1

^a indicated in 6 cases, ^b indicated in 5 cases. Abbreviations: CPR – cardiopulmonary resuscitation, EMS – Emergency Medical Services, Max – maximum, Min – minimum, SD – standard deviation.

Vital signs

During the initial assessment in the hospital, the mean respiratory rate was 16 ± 4.9 breaths per minute, the mean systolic blood pressure (BP) was 102.3 ± 31.6 mmHg, and the mean diastolic BP was 63.4 ± 21.8 mmHg. The average heart rate (HR) was 105 ± 21.9 beats per minute. The level of consciousness was assessed using the Glasgow Coma Scale (GCS), with an average score of 4.4 ± 3.3 (Table 3). All patients (n=10) required intubation and mechanical ventilation, with 30% (n=3) undergoing tracheotomy between days 4 and 16.

Table 3. Vital signs during initial assessment at the hospital

Characteristic	Mean $\pm$ SD	Min	Max
Respiratory rate^a (breaths per minute)	16 ± 4.9	10	22
Systolic blood pressure^b (mmHg)	102.3 ± 31.6	66	154
Diastolic blood pressure^b (mmHg)	63.4 ± 21.8	34	94
Heart rate^b (beats per minute)	105 ± 21.9	76	150
Glasgow Coma Scale (score)	4.4 ± 3.3	3	14

^a indicated in 5 cases, ^b indicated in 9 cases. Abbreviations: Max – maximum, Min – minimum, SD – standard deviation.

Complications

The mean duration of coma (GCS ≤ 8) was 6.8 ± 10.3 days. From the initial assessment at the medical facility until death, 60% (n=6) of patients maintained a GCS score of 3. In addition to coma and anoxic brain injury observed in all patients, other complications included respiratory and cardiac dysfunction in 80% (n=8), pneumonia in 50% (n=5), sepsis and multiple organ dysfunction syndrome in 20% (n=2), cerebral edema in 20% (n=2), cerebral congestion in 10% (n=1), and tracheoesophageal fistula in 10% (n=1) of patients (Fig.). From the initiation of inpatient treatment, the mean survival time was 8.7 ± 15.8 days, with a range from 8.87 hours to 52 days.

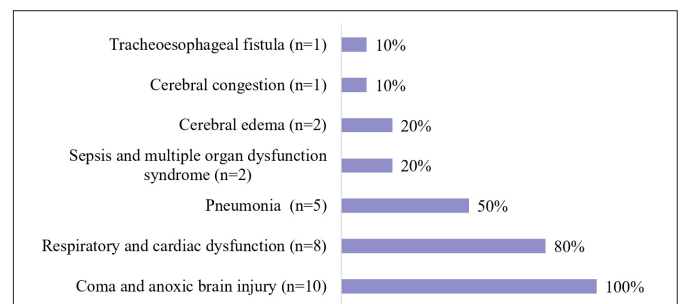


Fig. Complications after near hanging

Autopsy findings

In all cases, a ligature mark was observed on the neck during either the autopsy or the initial hospital assessment. No fractures of the hyoid bone or vertebrae were detected in any of the cases. However, in one subject, fractures were noted in both superior horns of the thyroid cartilage.

Toxicological examination

After death, toxicological examinations were conducted on 6 out of 10 individuals. Ethyl alcohol was detected in the urine of one individual at a concentration of 0.15‰. Additionally, traces of thiopental and pentobarbital were found in the internal organs of another individual. Among the four individuals who did not undergo post-mortem toxicological testing, ethyl alcohol was detected in the blood of two individuals on the day of the event, at concentrations of 3.08 g/L and 0.04 g/L, respectively.

DISCUSSION

Most of our study sample was male (80%). This finding is consistent with other studies examining near-hanging cases, where men were also the predominant group [7, 11, 12]. Literature indicates that men are more likely to choose lethal and violent methods of suicide, including hanging [13]. Middle-aged men are at high risk of suicide [14], which aligns with our study results, where the average age of the subjects was 44.5 ± 17.7 years. Another significant risk factor for suicide is the use of psychoactive substances [15]. In our study, data on the use of psychoactive substances were available in 40% of the cases. Although the mechanisms of seasonal variation in suicide rates are not well understood, hangings are generally more frequent in the spring [16]. In our study, the frequency of hangings was relatively consistent across seasons, with the lowest number of cases occurring in summer. Most hangings occurred in prisons (40%) and at home (30%). According to the literature, 75% of hangings happen at home, 15% in public places, and 10% in prisons or hospitals [4].

In cases of hanging, the cause of death is primarily due to compression of the neck structures, with the force exerted depending on the weight of the body and the acceleration of the fall [17]. Initially, a force of approximately 2 kilograms is sufficient to compress the jugular veins, leading to facial and cerebral edema, followed by loss of consciousness [17, 18]. When a stronger force of 5 kilograms compresses the carotid arteries, brain ischemia occurs, and compression of the carotid sinus can result in cardiac arrest [17, 18]. Compression of the airways requires an even greater force – approximately 15 kilograms [17, 18]. In cases of hanging where the individual falls from a height greater than their own, typically in judicial hangings, sudden death occurs due to fractures of the cervical spine and severing of the spinal cord [4]. A small proportion of individuals survive after a suicide attempt [10]. The timing of death following hanging is not precisely defined and can range from a few minutes to several months [10]. In our study, individuals survived from 8.87 hours to 52 days, with a mean of 8.7 ± 15.8 days.

Debbarma et al. determined that near-hanging patients survived from 1 to 15 days [8]. In contrast, a study by Sane et al. reported survival times ranging from 9 hours to 72 days [9].

The survival rate of near-hanging individuals can be influenced by several factors, including the force exerted on the neck, the time until the person is found, the promptness of first aid or transportation to the hospital, the patient's age and physical condition, and the intensity of treatment [9, 10, 19]. In Kao and Hsu's study, poor prognosis was associated with a 3-point GCS score, dilated pupils, absence of pupillary light reflex, acidosis, and the need for intubation either at the scene or in the emergency department [2]. The study also found that patients with poor functional outcomes had, on average, a longer duration of CPR (11.55 ± 6.6 minutes) compared to those with good functional outcomes (0.53 ± 1.0 minutes). In our study, the average duration of CPR until EMS arrival was 9.4 ± 2.9 minutes. Moreover, the mean duration of CPR performed by EMS was 22.6 ± 10.2 minutes. Patients presented with low blood pressure (mean systolic BP 102.3 ± 31.6 mmHg), increased heart rate (mean HR 105 ± 21.9 bpm), and impaired consciousness (mean GCS 4.4 ± 3.3 points). Similar vital signs were observed in a study by Ramadoss et al., where near-hanging patients had a median systolic BP of 105 mmHg, a median pulse rate of 98 beats per minute, and a GCS score of ≤ 8 in 96.7% of cases [11]. In our study, intubation and mechanical ventilation were used in all patients, with tracheotomy performed in 3 out of 10 cases. However, Sane et al. reported tracheotomy in 6 out of 10 cases [9]. The dysfunction of vital functions in individuals who attempted hanging emphasizes the importance of prompt CPR and intensive treatment.

Patients who survive until hospital admission often die later due to complications related to hanging [9]. Fatal complications such as hypoxic encephalopathy, pneumonia, post-obstructive pulmonary edema, laryngeal edema, acute respiratory distress syndrome, brain infarction, or abscess may develop [9, 10, 20]. Among near-hanging patients, hypoxic encephalopathy is identified as the most common cause of death [9, 10]. Due to its significant metabolic needs, the brain is especially vulnerable to oxygen deprivation [21]. Brain edema and encephalopathy result from nervous tissue necrosis [8]. According to Sane et al., hypoxic encephalopathy was the cause of death in 7 out of 10 near-hanging patients, with pneumonia being the second most frequent cause [9]. Similarly, in our study, alongside coma and anoxic brain damage, the most common complications were respiratory and cardiac dysfunction (80%) and pneumonia (50%).

A ligature mark is a typical sign of hanging [1, 17]. In our study, a ligature mark was observed on the neck of all individuals. Laryngeal fractures occur in 5% to 40% of cases, hyoid fractures in 15% to 72.5% of cases, and thyroid cartilage fractures in 9% to 43% of cases, particularly among individuals over 30 years old [22, 23]. In our study, one case involved a fracture of the superior horns of the thyroid cartilage. The prevalence of cervical spine fractures ranges from 0.8% to 3.6% [17]. Kao and Hsu found no cervical spine fractures in any of the 41 cases [2]. Likewise, there were no vertebral fractures among our subjects.

Our study has limitations. The generalizability of the results is constrained by the small sample size. Additionally, due to the retrospective nature of the study, some data on the circumstances of the hanging and the patient's vital signs are incomplete.

CONCLUSIONS

Near-hanging cases with anoxic brain injury are rare in Vilnius County. A trend of near-hanging cases with anoxic brain injury has been observed among persons in prison or using psychoactive substances. All patients required treatment in the Intensive Care Unit to stabilize and maintain vital signs. Along with anoxic brain injury and coma, the most common complications were respiratory and heart failure, as well as pneumonia. All cases, even with inpatient treatment, resulted in death. Patients had severe impairment of vital functions, and the average survival was 8.7 days.

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Santrauka

ANOKSINIS GALVOS SMEGENŲ PAŽEIDIMAS – BŪKLĖ PO PASIKORIMO

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Tyrimo tikslas. Išanalizuoti Vilniaus apskrityje pasikorusių asmenų mirties atvejus, kai jie mirdavo ne staiga, o per tam tikrą laiką, išsivysčius anoksiniam galvos smegenų pažeidimui (PASP – pasikorimas su anoksiniu smegenų pažeidimu). Įvertinti šių atvejų paplitimą, demografinius duomenis, medicinos pagalbos ypatybes, gyvybinius rodiklius ir komplikacijas.

Tyrimo medžiaga ir metodai. Atlikta retrospektyvioji Valstybinės teismo medicinos tarnybos 2014–2023 m. autopsijų nuasmenintų duomenų analizė. Atrinkti pasikorimo atvejai, kai anoksinis galvos smegenų pažeidimas buvo viena iš mirtį sukėlusių komplikacijų. Statistinė duomenų analizė atlikta naudojant *Microsoft Office Excel* programą.

Rezultatai. Vilniaus apskrityje 2014–2023 m. iš 2149 pasikorimo atvejų PASP diagnozuotas 10 atvejų. Vyrų sudarė 80 % imties. Vidutinis tiriamųjų amžius buvo $44,5 \pm 17,7$ metų. Daugiausia pasikorimų įvyko įkalinimo įstaigoje (40 %). Vidutinė pradinio kardiopulmoninio gaivinimo trukmė buvo $9,4 \pm 2,9$ min., greitosios medicinos pagalbos teikto kardiopulmoninio gaivinimo trukmė – $22,6 \pm 10,2$ min. Stacionarus gydymas vidutiniškai pradėtas per $2,49 \pm 0,9$ val. Atliekant pirminį būklės vertinimą gydymo įstaigoje vidutinis kvėpavimo

dažnis buvo $16 \pm 4,9$ k./min., sistolinis arterinis kraujospaudimas (AKS) – $102,3 \pm 31,6$ mmHg, diastolinis AKS – $63,4 \pm 21,8$ mmHg, širdies susitraukimų dažnis – $105 \pm 21,9$ k./min., Glasgow komos skalės balas – $4,4 \pm 3,3$. Koma vidutiniškai truko $6,8 \pm 10,3$ dienos. Pacientai vidutiniškai išgyveno $8,7 \pm 15,8$ dienos. Dažnai būklę komplikavo kvėpavimo funkcijos ir širdies veiklos sutrikimas (80 %), plaučių uždegimas (50 %). Skydinė kremzlė lūžo vienam tiriamajam. Duomenų apie psichoaktyviųjų medžiagų vartojimą buvo 40 % atvejų.

Išvados. PASP yra retas atvejis Vilniaus apskrityje. PASP tendencija pastebėta tarp asmenų, esančių įkalinimo įstaigoje ar vartojančių psichoaktyvias medžiagas. Kartu su anoksiniu galvos smegenų pažeidimu ir koma dažniausios komplikacijos buvo kvėpavimo funkcijos ir širdies veiklos sutrikimas, abipusis plaučių uždegimas. Pacientai pasižymėjo sunkiu gyvybinių funkcijų sutrikimu ir vidutiniškai išgyveno 8,7 dienos.

Reikšminiai žodžiai: anoksinis galvos smegenų pažeidimas, autopsija, pasikorimas, savižudybė, teismo medicina.

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