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DIAGNOSTICS OF MECHANICAL ASPHYXIA – EXPERIENCE OF FOREIGN COUNTRIES (LITERATURE REVIEW)

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The aim of this study is to establish modern, global trends in the diagnosis of mechanical asphyxia.

Materials and methods: search and bibliographic method (theoretical analysis, systematization and classification of library catalogues, printed and electronic sources on mechanical asphyxia) from open anchor databases Scopus preview, Web of Science and using information retrieval systems Google Scholar, Open Ukrainian Citation Index (OUCI), ScienceDirect on the Internet.

Results: mechanical asphyxia, as one of the most common types of violent death, ranks first among deaths from mechanical injuries. Its study is of great interest among medical scientists in various fields, especially for resuscitators and forensic experts. Establishing the causes of asphyxia, clinical and morphological manifestations, and the consequences that unfortunately most often lead to death. With the rapid development of society, science is also developing rapidly, and the latest sensitive methods of diagnosing diseases are emerging. However, unfortunately, in the post-Soviet space, the diagnosis of most pathological conditions, including asphyxia, is determined by experience and sensory organs, which are determined using instrumental research methods in compliance with the requirements of evidence-based medicine.

Given the peculiarities of the pathophysiological processes of the asphyxiation state and their manifestations in the body, doctors should rely primarily on general knowledge about hypoxic and asphyxiation disorders, which are determined using instrumental research methods in compliance with the requirements of evidence-based medicine.

Conclusions: at present, the diagnosis of asphyxia consists of many morphological features. Failure to take into account the state of the body, the presence of chronic diseases, and drug or alcohol intoxication at the time of asphyxiation complicate the diagnosis. Detection of individual clinical manifestations or morphological features does not allow asserting its lifelong origin. Therefore, it is necessary to use modern research methods that should expand the possibilities of forensic diagnosis of the viability of injuries in terms of evidence-based medicine and provide forensic experts with a scientific basis for their results. One such method is immunohistochemical, which is gaining popularity and consolidating its position in the EU, China, Japan and America. In addition, this method is well-established and widespread in morphological studies of differential diagnosis of tumours. Some scientific works prove the expediency of using the immunohistochemical method to solve the problems of forensic expert practice, which is an actual scientific and practical task

Keywords: mechanical asphyxia, forensic examination, immunohistochemical markers

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1. Introduction

The human body is an open biological system with many connections to the environment. Along with many living conditions, the body needs enough oxygen to function properly. Reducing its amount in the environment or in the body itself leads to hypoxia, the increasing phenomena of which can lead to irreversible disorders in the body, and in more severe manifestations to death.

It is worth mentioning that hypoxia is divided into different types depending on the cause and mechanism of its development, namely: exogenous hypoxia (with a decrease in the partial pressure of oxygen in the air), respiratory (as a consequence of external respiration), hemic (disorder of the blood system), circulatory (in circulatory disorders), tissue (against the background of sufficient

oxygen supply, the inability of tissues of the organs to absorb it) and hypoxia of mixed type.

Nevertheless, in different circumstances, separate types of hypoxia are almost non-existent, usually mixed hypoxia. The most practical for forensic experts are the types of acute oxygen starvation with the development of asphyxia. It is known that asphyxia is a condition, in which the body does not receive oxygen, and carbon dioxide is not excreted, or these processes are significantly slowed down.

The aim of the work is to analyze the literature on the state of diagnosis of mechanical asphyxia in the works of authors from different countries, the use of different diagnostic methods in the practice of forensic institutions to clarify the state of asphyxia.

2. Materials and methods

The literature review used a search and bibliographic method (theoretical analysis, systematization and classification of library catalogues, printed and electronic sources on mechanical asphyxia) from open scientific databases Scopus preview, Web of Science and using information retrieval systems Google Scholar, Open Ukrainian Citation Index (OUCI), ScienceDirect on the Internet.

3. Results

Among the different types of asphyxia for forensic experts, mechanical asphyxia is of the greatest interest. In turn, mechanical asphyxia is divided according to the reasons for its formation. Controversy among forensic scientists over the types of mechanical asphyxia has persisted for decades. According to some authors, mechanical asphyxia should be divided into two types - asphyxia from compression (combines hanging; strangulation with a loop, arms; compression of the chest and abdomen) and asphyxia from closure (all types of airway and orifice closures, drowning). However, according to most scientists, there are five types of mechanical asphyxia: 1) strangulation (hanging, from squeezing the neck with a noose or arms); 2) obturation (from the closure of the airways and openings); 3) compression (chest and abdomen compression); 4) drowning; 5) asphyxia in a limited (closed) space. Regarding the latter type, there is also another definition - asphyxia due to lack of breathable air [1].

Asphyxia, as a pathological condition, has been studied quite extensively and carefully. In the development of asphyxia there are separate successive stages: preasphyxia; inspiratory dyspnea; expiratory dyspnea; resting stage; terminal respiratory movements; final respiratory arrest. It is proved that pathophysiological disorders and their main clinical manifestations in different types of mechanical asphyxia occur quite uniformly with a certain sequence of violations of vital functions of the body [2].

Determining the viability of injuries is part of the problem of diagnosis and is of great importance in forensic practice. That is why, when investigating the circumstances of the event in cases of suspicion of concealing traces of crime and simulating suicide, the question of determining the viability of the injury, and distinguishing them by time of formation is crucial for investigative bodies and the court [3, 4].

A number of morphological features, especially strangulation asphyxia, characterizes each type of mechanical asphyxia. Such signs are called specific for this type of death. Such signs include: strangulation furrow; hemorrhages into the skin and soft tissues in the area of the loop and near it, which are detected macroscopically; muscular strangulation furrow; anisocoria; clamping the tip of the tongue between the teeth; blood flow from the nose and external auditory canals; tears of the intima of the common carotid artery (sign of Amus) in combination with hemorrhage in the adventitia of the artery (sign of Martin); hemorrhages in the regional lymph nodes of the neck; fractures of the hyoid bone and laryngeal cartilage; hemorrhages in the intervertebral discs (sign of Simon); hemorrhages into the retrobulbar tissue (Scher-

bak's sign). There is also a set of other morphological features adopted by forensic doctors – general asphyxia, which in turn are divided into external and internal.

The presence of a strangulation furrow on the neck is accepted by scientists around the world as the main species sign of strangulation asphyxia. Therefore, the greatest attention was paid to the study of morphological features of the strangulation furrow. During the period of development of forensic medicine, as a separate scientific discipline, many morphological features of mechanical asphyxia have been identified. From the very beginning, the external morphological features of their dependence on a number of factors were studied [4].

However, with a variety of diagnostic criteria, the authors of many forensic textbooks and manuals emphasize that the detection of most morphological features, which are considered specific together with the general affinity, do not give full certainty about the lifelong formation of strangulation asphyxia, because they are purely macroscopic or sectional features [2, 4].

There is no perfect formula for diagnosing the lifelong origin of asphyxia. Each isolated trait only partially indicates the type or type of death and is not characteristic of death from asphyxia, but, at the same time, the combination of such traits, combined with additional research methods, can provide grounds for claiming death of asphyxia origin. Given the practical application, it is more appropriate to determine the viability of asphyxia morphological manifestations, rather than the viability of the formation of damage because in some cases a person dies before asphyxia.

Therefore, based on the acquired scientific knowledge and age experience on this issue, we believe that forensic diagnosis of mechanical asphyxia can be most justified only in a comprehensive macroscopic and microscopic examination of tissues and organs of the corpse, taking into account general asphyxia and species characteristics of a particular asphyxia type.

Therefore, in the forensic examination of corpses suspected of dying from asphyxia, to confirm the cause of death objectively and reasonably, confirmation by additional instrumental research methods is required. Microscopy significantly complements the study and allows a more substantiated statement about the presence or absence of certain pathological conditions. However, textbooks and manuals on forensic histology do not contain clear and uniform criteria and approaches for determining specific manifestations of asphyxia. Most of the signs detected by microscopy are also found in other pathological conditions. It should also be borne in mind that in its various forms, the onset of death is rapid, and the human body does not have time to develop microscopic signs of asphyxiation. The researcher does not always take into account the presence of concomitant chronic diseases of the cardiovascular and/or respiratory systems, against which the period of death is reduced many times, bypassing the classic stages of respiratory failure, which are absent in the study of corpses, which greatly complicates expert opinion [5].

Thus, according to the classification of D. V. Bogomolov and co-authors [6], the first morphological reactive changes at the microscopic level, such as arterial spasm; plethora of arteries, veins, capillaries; fibrin loss;

marginal standing of leukocytes can be detected at least 5–10 minutes after the action of a mechanical stimulus. At the same time, for the development of such phenomena as connective or nervous tissue edema, hemolysis of erythrocytes in hemorrhages, an increase in the number of neutrophils in the lumens of blood vessels, the appearance of the first macrophages requires from 30 minutes.

Many works by foreign scholars study gender, age, social, regional and cultural factors in connection with suicides by hanging. For example, Reisch T., Hartmann C., Hemmer A., Bartsch C. [7] analyzed 6,497 suicides registered at eight Swiss Forensic Institutes (IRMs), of these, 1,282 (19.7 %) committed suicide by hanging. Based on the used statistical tests, it was proved that in cases of suicide by hanging in the groups “men” and “women”, no significant differences were found in socio-demographic variables [7].

Italian scientists Russo, Verzeletti, Piras, Mauro, Ferrari and oth. [8] during the 33-year period from 1983 to 2015, the Institute of Forensic Medicine of Brescia (Northern Italy) analyzed 260 deaths, of which approximately 40 % were deaths from asphyxia. 82 % of the victims were men; 18 % are women. The upward trend was observed in the age group of 20 to 60 years, and the largest number of cases was observed in the age group of 41 to 50 years (23 % of cases). The most common locations chosen by victims were the home environment, followed by remote or secluded outdoor locations. The most common ligature material was rope. Pathological data were evaluated in all cases [8].

Scientists from Finland Juha Kanamüller, Pirkko Riipinen, Kaisa Riala, Eero Paloneva and others [9] investigated all cases of suicide by hanging during 1988–2013 (N=851) in the northern province of Oulu. Using ICD death certificates and diagnoses from the Finnish hospital discharge register, they focused on gender differences in suicide, mental health, and physical condition. Male victims were more likely to be intoxicated or drink alcohol; female victims were more likely to have somatic or mental hospitalization [9].

On the importance of taking into account, the mental state of suicides is noted in the work of scientists Arsenault-Lapierre G., Kim C., Turecki G. [10], who studied 3,275 suicides, of which 87.3 % were diagnosed with a mental disorder before their death. In addition, large gender differences were identified. Thus, the diagnosis of problems with organic disorders, personality disorders and childhood disorders were more common among male suicides, while affective disorders, including depressive disorders, were less common among men. Geographical differences were also present in the relative proportion of psychiatric diagnoses among suicides [10].

Researchers Starkuviene S., Kalediene R., Petrauskienė J. [11] from Lithuania conducted a large-scale epidemiological study of suicides by hanging. They studied 8,324 suicides (6,864 men and 1,460 women) committed between 1993 and 1997 and 7,823 suicides (6,455 men and 1,368 women) during 1998–2002. Of all the registered suicides in Lithuania during 1993–2002, hanging was the most common method. Hanging was prevalent among men, the elderly, villagers and people with low levels of education. Logistic regression analysis showed that gender, place of residence and education,

independently of other factors, had the strongest influence on the choice of hanging as a method of suicide between 1993 and 2002. Age had only a minor effect, and marital status had no significant influence on the choice of hanging in order to commit suicide [11].

Researchers from Turkey Taktak S., Kumral B., Unsal A., Ozdes T., Buyuk Y., Celik S. [12] conducted a study of 4,549 cases of hanging in 1979–2012, revealed at the Institute of Forensic Medicine in Istanbul, Turkey. 4,502 cases of hanging of suicidal origin were identified and evaluated in terms of demographic characteristics, type of material used for ligature, internal manifestations in the neck, toxicological and microscopic studies. Of these suicides, 3,295 (73.2 %) were men and 1,207 (26.8 %) were women. The average age of the victims was 37.8 years. The incidence of suicidal ideation in women has approximately doubled with age in women. According to them, 1,424 victims committed suicide at home, and 441 of them in prisons and indoors. Alcohol in the blood of all autopsies was tested, the results were positive for 687 (15.3 %) people. Active drugs were detected in 108 (2.4 %) victims: 70 (1.5 %) of them were antidepressants, 20 (0.5 %) of them were analgesics/anti-inflammatory/antihistamines and 18 (0.4 %) of which are antipsychotic. In the study of psychoactive substances in the blood and urine, none of these substances was detected in 4,146 victims. However, the blood and urine of the victims contained sedative-hypnotic-anxiolytic drugs 74 (1.6 %), cannabinoid 16 (0.4 %) and opioid 12 (0.3 %). Psychoactive substance studies were not performed for 243 victims [12].

The study of suicides by hanging should also take into account cultural and religious differences between countries, which may affect the causes of suicide, the age, sex and social status of victims of these types of suicides.

Suicide cases among certain age groups, especially young people, should also be carefully studied.

For example, Australian scientists Kosky R. J. and Dundas P. [13] conducted a study to identify factors associated with deaths from hanging among young people in Queensland, Australia. They studied the results of coroner reports of all deaths due to the hanging of people under the age of 25 in Queensland in 1995 and 1996. All cases were recorded as suicides. Most of them were men, and a quarter were natives. Half of the deaths occurred in regional or rural areas. Unemployment, personal loss, mental illness, and alcohol use were possible factors. Early warning signs were the onset of uncharacteristic behaviour and suicide threats [13].

A study by scientists S. H. Bhosle, N. P. Zanjad, M. D. Dake, H. V. Godbole [14], which related to cases of hanging among adolescents, was performed on 51 cases of death of adolescents due to hanging, autopsies of which were performed by the Department of Forensic Medicine of the State Medical College of Dr. Shankarrao Chavan, Nanded, Maharashtra (India), since January 1, 2001 to December 31, 2010. In this study, death by hanging among adolescents was most often suicidal in nature (96.08 %), and there were only two (3.92 %) deaths by accidental hanging. Factors that predispose and cause suicide were domestic disputes, exam stress, physical and psychological illness.

A study conducted by German scientists Mosek D. P., Spermhake, J. P., Edler, C. [15] examined all cases of asphyxia in children and adolescents (aged 0 to 21 years) among the cases of autopsy and analysis of cases of the Hamburg Legal Medical Department from 1998 to 2017. These cases were analyzed retrospectively with special emphasis on how often the external signs of asphyxia were completely absent. Among 249 cases of lethal asphyxia: 170 (68 %) – accidents, 35 (14 %) – suicide and 33 (13 %) – murder. Most of the cases concerned boys. Adolescents and young people aged 15–21 represented the main age group. Drowning was the leading mechanism of asphyxia. Younger age was associated with less frequent detection of external signs of asphyxia at postmortem external examination. Petechial hemorrhages were the most common visible external signs of asphyxia. In 35 (14 %) cases, there is no external evidence of asphyxia [15].

Scientists from Finland emphasize the need for a more systematic approach to the diagnosis of asphyxia. According to them, mechanical asphyxia has the highest percentage of methods of killing. After a thorough study of archival cases for the period 1983–2012, the circumstances under which it can be stated that the murder itself took place were revealed. They also indicate a high percentage of official negligence and incompetence of researchers [16].

A group of researchers from Slovakia and the Czech Republic carefully studied cases of fractures of the hyoid bone and laryngeal bones during hanging. During his study, 178 cases were found to have a total fracture rate of 72.5 % (129 cases) with the highest frequency at the lateral location of the node. Isolated fractures of the thyroid cartilage 33.7 % (60 cases). The dependence of the frequency of fractures with the age of the dead was statistically proved. They also stressed the need to expand the diagnosis and not just focus on the fact that it is a mechanical neck injury [17].

Scientists from the American Academy of Forensic Sciences suggest a new type of asphyxia – positional. Indicate that in the positional type of asphyxia, the identified dead were in a position where adequate breathing is impossible. They also emphasize that it is necessary to more carefully examine the corpse at the place of its discovery and record not only documents, but also take photos of the corpse, this can be crucial in determining the cause of death [18].

Researchers from Turkey examined the bodies and made a differential diagnosis of deaths from asphyxia or trauma in the presence of chest and abdominal injuries due to traffic collisions and accidents at work. Establishing asphyxia as the cause of death was indicated, that in the presence of severe injuries to make a differential diagnosis is extremely difficult [19].

The problem of differences in interpretation in the classification of types of mechanical asphyxia was addressed in Canada. Their scientists proposed their classification, which divided asphyxia into 4 main types – asphyxia, strangulation, mechanical asphyxia and drowning. At the same time, shortness of breath combines a lack of oxygen in the environment, a confined space. Strangulation includes hanging, loop strangulation, strangulation by hands. Mechanical asphyxia – positional asphyxia, asphyxia due to injury [20].

Researchers from the Italian University of Genoa have studied the problem of differential diagnosis in SUDEP (sudden unexpected death in epilepsy), when death occurs against the background of completely healthy organs. They found that an average of 1.16 cases of SUDEP per 1,000 patients with epilepsy. They put forward two main hypotheses that death occurs because of seizures due to asphyxia or acute cardiovascular failure of the reflexogenic type. However, at the same time it is emphasized the lack of diagnostic signs and the need to develop an international standard of the research. A promising area of research using immunohistochemical and genetic methods was proposed [21].

4. Conclusions

Thus, the cited works of foreign physicians indicate the presence of contradictory and unresolved issues regarding the differential diagnosis of mechanical asphyxia with other types of death, the lack of a uniform classification of types of asphyxia. Emphasis is also placed on the relevance and feasibility of expanding diagnostic capabilities, the use of immunomorphological techniques for forensic research, including the diagnosis of the viability of the asphyxiation caused by mechanical obstruction of external respiration.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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