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MODERN POSSIBILITIES OF SOLVING THE PROBLEM OF DETERMINING THE DEGREE OF BLOOD LOSS IN FORENSIC MEDICAL PRACTICE

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Summary. During the forensic medical examination of a corpse in cases of acute blood loss, the most important issue for forensic medical experts is the determination of its amount. However, calculating the exact amount of blood lost is quite a difficult task. After all, a sufficiently accurate quantitative system for measuring the volume of blood in a corpse has not been developed, therefore, forensic medical experts in their calculations rely on well-known morphological signs of blood loss, which can often be quite subjective.

That is why the analysis of the methods proposed by world scientists is relevant, as well as the development of new, digital methods for determining the degree of blood loss, which could provide reliable scientifically based conclusions.

Keywords: forensic medicine, blood loss, methods of determination, diagnosis.

Introduction. Blood loss (BL) is often encountered in practical forensic medicine as a cause of death or as a contributing factor. According to the literature, the assessment of the risk to life and mortality is based on the calculation of the relative BL from the total amount of blood (TAB) [1]. Pathophysiologically, BL entails various consequences that, without medical assistance, ultimately lead to death. However, the question of degree of BL, which causes a fatal outcome, always remains debatable, as evidenced by modern literature [1-6]. The calculation of the relative BL (the amount of lost blood from the total volume in the human body) in relation to mortality is generally accepted in forensic medical practice: more than 33% of the TAB – BL is life-threatening; 50% – lethal [2]. However, even the calculation of the body's TAB can be quite difficult [3].

It is known that TAB can be divided into the volume of circulating blood and blood depot (spleen, liver and subpapillary skin plexus) [4]. Models for determining the physiological volume of human blood were proposed [1]: 77 ml/kg of body weight +/- 10% – for men and 65 ml/kg of body weight +/- 10% for women, which is primarily related with more adipose tissue in women. Also, the method of calculating TBV with increasing body weight is controversial. The reason is that adipose tissue has relatively few blood vessels. Some authors believe that age, sex, height, weight, and health condition also affect the total blood volume (for example: an increase in the TAB in severe varicose veins and and a decrease in cases of carcinoma, tuberculosis, leukemia, rheumatological diseases or other anemias). Also, it should be noted that the TAB depends on hormonal and climatic factors, as well as on the degree of physical training (increased of the TAB in athletes) [1, 4].

There are many rules and special formulas for evaluating the TAB. It is often calculated in general terms for most people – 5-6 liters. Scientists in modern studies demonstrate adapted formulas for calculating the TAB to body mass index [1, 7]. Non-linear scaling formulas are also used depending on the mass and constitution of the body of the deceased. The application of these nonlinear dependencies is especially relevant when calculating the TAB in cases of increased body weight.

For counting the amount of BL, its localization is also important. With external bleeding, the blood goes outside the body, which is manifested by clear signs of BL. With internal bleeding, blood accumulates in body cavities, which can cause additional local changes. For example: cardiac tamponade, intracranial

hemorrhage, or hemothorax can cause other mechanical causes of death before the development of fatal BL and its classic signs [2, 5].

The pathogenesis of BL consists in the development of hypovolemic shock with a further decrease in venous blood return, cardiac output, and a drop in blood pressure. Depending on the severity of bleeding, the peripheral resistance of blood vessels in the initial stages increases with the help of nervous and hormonal influences, which allows centralizing the residual blood volume. At the same time, blood depots are mobilized from the organs. Inflow of interstitial fluid and narrowing of venous vessels also increase venous return. However, subsequent loss of blood, fluid, and vascular mediators leads to hemostasis, thrombocytes and erythrocyte aggregation, and disseminated intravascular coagulation. Disturbance of micro- and macrocirculation leads to hypoxia and acidosis with irreversible disruption of cell function [7]. Such lack of blood circulation entails a disruption of the blood supply to the organs and systems of the body with the subsequent development of oxygen starvation. Death occurs as a result of paralysis of the respiratory center and cardiac contraction [7].

In cases of external bleeding, it can be difficult to estimate the amount of BL, because its traces on the corpse and around it can be misleading due to cleaning, moving the corpse, changing clothes, etc. [8].

The causes of BL can be different. Internal causes include gastrointestinal bleeding from ulcers, esophageal varices, tumors, ruptures of aneurysms or myocardial wall necrosis. Traumatic causes include road traffic accidents, falls from a height, stabbing, cutting and gunshot injuries. Blunt hard objects can also cause fatal BL. Most often, fatal BL is caused by damage to the main vessels, heart, or parenchymatous organs [9].

The diagnosis of bleeding is based on the identification of the amount of BL and, if possible, the source of its leakage. It should be noted that the localization of bleeding is important during morphological evaluation, since gastrointestinal bleeding can cause a significantly greater number of anemic manifestations than when localized in the respiratory tract [9].

The large amount of blood found in the cavities and internal organs of the corpse is not decisive for establishing the rate of BL, its multiplicity, as well as determining the duration of the terminal process [3]. BL from smaller vessels and/or vessels with lower pressure may continue for a long period of time and with significant volumes of more than 2L may not be lethal due to the development of compensatory processes in the body. And damage to large vessels in the immediate vicinity of the heart, such as the aorta, can lead to loss of pressure and decompensation, which can lead to death even with minor BL of about 500 ml.

Despite the great interest in this topic and significant technical development, forensic medical experts often rely on visual-descriptive methods in their conclusions, which are not accurate enough, but carry a significant amount of information about the degree of BL. Common morphological manifestations of acute BL include: paleness of the skin, mucous and serous membranes; slightly expressed livores mortis; acutely expressed rigor mortis; anemia of internal organs; reduction in size and shrinkage of the spleen; a small amount of blood in the vessels and cavities of the heart, ecchymosis in the internal organs and mucous membranes [9, 10].

Spot hemorrhages (ecchymosis) are a fairly frequent sign of BL, in particular, such manifestations in the endocardium of the left ventricle of the heart are called Minakov's spots. Their presence in the left ventricle is explained by the occurrence of higher rarefaction pressure during diastole compared to other parts of the heart [7]. More often, they are localized on the front wall and the base of the heart (under the mitral valve), there are both single point and multiple congestive hemorrhages up to 5.0 mm in size. Microscopic examination of heart preparations shows that hemorrhages in almost all cases are located directly under the endocardium and epicardium with spread to the myocardium [7].

According to the literature, quite often, along with subendocardial hemorrhages, there are also subpleural hemorrhages, which are mostly localized in the basal regions [7, 10]. Histologically, signs of pronounced dystrophic changes, microcirculatory disturbances and changes in the stroma are revealed

in the lungs (ruptures of the alveolar walls, compensatory expansion of the alveoli, accumulation of eosinophilic fluid in their lumen, pronounced fullness of arterioles and capillaries.

We would like to note that the assessment of relative BL during autopsy is negatively affected by a number of factors, such as a combination of internal and external BL, accumulation of blood in tissues by diffuse seepage, dilution of blood by other body fluids or intestinal contents, the impossibility of accurately determining the amount of blood [10]. In addition, the volume of blood loss may be small in the presence of concomitant diseases or injuries, which prematurely lead to decompensation of the condition and death, it would seem, with insignificant blood loss. There are also frequent cases of mechanical compression of vital organs, for example, cardiac tamponade, intracranial hemorrhage [11].

Also, interesting data are described in the work of Schorn M. N. that investigated the amount of postmortem BL at certain time intervals. The results showed the absence of a statistically significant correlation between age and the amount of BL, that is, the characteristics of the vessel walls (atherosclerotic changes, etc.) do not affect its amount [12]. In addition, the author notes that the cause of death also did not affect the results.

In order to ensure more accurate results, scientists searched for more objective methods of assessing the BL degree. Thus, it was proposed to use an immunohistochemical reaction with primary antibodies to hemoglobin and fibronectin for the study of livores mortis. In the dermis, they showed moderately pronounced expression of hemoglobin and fibronectin. The obtained signs can be used as additional forensic medical criteria for postmortem movement or changes in the position of the corpse in the stage of stasis in cases of death due to BL.

Many scientific works are dedicated to establishing the degree of BL by determining the dry blood residue and converting it to liquid blood. Based on the morphological changes of drying blood spots, a method of quantitative determination of blood volume for the needs of forensic examination has been patented [2, 6]. Scientists have described in detail the dynamics of blood evaporation and the features of its transition into sol-gel. According to their data, erythrocytes are a dispersed phase, and plasma is an aqueous phase. After coagulation and deposition of fibrin, the blood forms a gel-like structure that has certain characteristics during evaporation. Scientists have established that the shape and size of the blood pool affects the rate of evaporation. In addition, areas of drying do not occur uniformly, both in the center and at the edges of the basin, while some areas may remain gel-like [2].

Worthy of attention is the work of Yalanska L. O., who developed methods for determining the volume of BL on clothing, from wound surfaces and from hemorrhages in muscles and fatty tissue [13]. These methods are based on the mathematical analysis of macro- and microscopic signs of the blood supply of internal organs, using a qualitative approach, followed by the development of special test tables [14].

An interesting work, in our opinion, is a description of the technique of X-ray transverse imaging using a three-stage algorithm for measuring the diameter of the right pulmonary artery, the cross-sectional area of the main pulmonary artery, and the volume of the right atrium, which allows obtaining a volume sample of data [3]. The authors argue that quantitative postmortem cross-sectional imaging may provide a reliable objective method for assessing the issue of fatal hemorrhage in forensic medicine.

Despite the large number of works and proposed methods for determining the degree of BL, experts often face difficulties in diagnosis. Most of them consist in the fact that experts base their conclusions on anemia of internal organs, evaluation of the color of organs and skin, determination of the volume of BL by measuring extravasal blood, inside the body or outside on clothing items, etc. Unfortunately, all these signs do not provide sufficiently reliable results that would satisfy the judicial and investigative bodies [15].

In our opinion, research of the possibilities of laser polarization diagnostics of human biological tissues for quantitative determination of the degree of BL is a promising direction. These methods have proven themselves well in use for the needs of forensic medical examination, in particular for the differentiation of anemic and plethoric biological tissues [16].

Conclusions. Therefore, the existing information about BL and all generally accepted classical methods, based on the use of morphological, immune-histochemical methods, cannot fully satisfy the questions posed in the forensic medical examination. Analyzing the obtained data, we consider it necessary to search for modern methods of determining the forensic medical criteria of BL. In order to solve this problem, we suggest testing the method of polarization microscopy of biological tissues for accurate determination of BL.

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СУЧАСНІ МОЖЛИВОСТІ ВИРІШЕННЯ ПРОБЛЕМИ ВИЗНАЧЕННЯ СТУПЕНЯ КРОВОВТРАТИ В СУДОВО-МЕДИЧНІЙ ПРАКТИЦІ

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Резюме. При проведенні судово-медичної експертизи трупа у випадках гострої крововтрати найважливішим питанням для судово-слідчих органів є визначення її кількості. Однак, підрахунок точної кількості втраченої крові є досить складним завданням. Адже, не розроблено достатньо точної кількісної системи вимірювання об'єму крові в трупі, тому, судово-медичні експерти в своїх підрахунках опираються на загальновідомі морфологічні ознаки крововтрати, що часто можуть бути досить суб'єктивними.

Саме тому, актуальним є аналіз запропонованих світовими науковцями методик, а також розробка нових, цифрових методів визначення ступеня крововтрати, які могли б забезпечити надійні науково-обґрунтовані висновки.

Ключові слова: судова медицина, крововтрата, методи визначення, діагностика.

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