Some features of the structural and morphological reorganization of the myocardium in hypothermic lesions. Prospects for further study

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Abstract. This article presents a review of the literature on the structural reorganization of the myocardium in conditions of exposure to low temperatures. Currently, a large number of studies are devoted to the study of the effect of low temperatures on the heart muscle of humans and animals. The main place in these studies is given to the diagnosis and differential diagnosis of general hypothermia when this type of death is combined with various intoxications, diseases and other conditions. However, despite the large number of published works to date, the study of the thanatogenesis process as a result of exposure to low temperatures from hypothermia remains a complex and poorly studied process. The accumulated knowledge allows us to conclude that there are no specific signs found in all 100% of deaths from hypothermia. Any symptom characteristic of hypothermia, at least in isolated cases, occurs with other causes of death. At the moment, morphological changes occurring in the nuclei of cardiomyocytes remain practically unexplored.

Keywords: hypothermia, cold injury, myocardial injury.

The problem of cold injury is currently very relevant and socially significant, due to its high share in the structure of causes of death. More than 30,000 people die from cold injury worldwide every year [25].

In the Russian Federation, at least 20,000 people die from this type of injury every year, which is about 65% of the total number of deaths in the world as a result of exposure to low temperatures. The share of death from cold injury in the structure of causes of violent death in Russia is about 5.5-7.0%, and in some regions of the Siberian Federal District it reaches a level of at least 11% [17]. The high share of cold injury in the structure of causes of death is associated

with the peculiarities of the climate (Russia is a country with a relatively cold climate, this is due to the fact that about 64% of the total area of the country belongs to the polar territories), a high level of ethylization of socially unadapted layers of society, as well as individual characteristics of the organism (decrease in resistance to low temperatures, decrease in overall resistance of the organism, etc.) [8, 25].

At present, a large number of studies are devoted to the study of the effect of low temperatures on the human and animal organism. The main place in these studies is given to the diagnosis and differential diagnosis of general hypothermia when this type of death is combined with various intoxications, diseases and other conditions. However, despite the large number of published works to date, the study of the thanatogenesis process as a result of exposure to low temperatures from hypothermia remains a complex and poorly studied process.

The main method for diagnosing death from hypothermia is the morphological method. [20]. At the moment, a huge number of morphological changes (both macro- and micromorphological) are known that can be detected in the study of deaths from low temperatures, but most of them are low-specific, and therefore cannot be fully used. [6,7,20].

The effect of the cold factor on the human and animal organism causes various functional and morphological changes in tissues. These changes depend on a huge number of factors of the external and internal environment and in some cases are fatal. A special condition for maintaining vital activity under the action of low temperatures is an increase in the blood supply to tissues and organs, which primarily depends on the functional activity of the myocardium.

At the moment, it has been found that it is precisely the adequate blood supply to organs and tissues, which can be carried out only with prolonged adequate functional activity of the myocardium, is one of the important conditions for survival in conditions of low temperatures. [21]. In this case, certain functional changes develop in the cardiovascular system in the form of the following stages: compensation and decompensation. The stage of compensation (the development of tachycardia, an increase in the level of systolic and diastolic blood pressure, an increase in cardiac output, an increase in peripheral resistance). Stage of decompensation (bradycardia, decreased blood pressure, decreased cardiac output, arrhythmias. Most often, death occurs as a result of ventricular fibrillation or the development of progressive bradycardia turning into asystole [1]. The fact of a direct connection between the above-mentioned changes and the effect of low temperatures on the body was proved by T. Tveita only in 1994. [25].

Most researchers described only single, separate morphological changes occurring in organs during hypothermia, without revealing the sequence of their appearance and the relationship [15].

In a macroscopic examination of the cardiac muscle of persons who died from hypothermia, some authors noted: an increase in the heart in the volume of predominantly left sections, thickening of muscle tissue, the formation of a reddish-brown tint, the appearance of a shine, overflow of blood in the left ventricle, the appearance of lighter blood in the left atrium and ventricles [nine]. Chudakov A.Yu. (2000) in his studies noted only a pronounced expansion of the cavity structures of the heart, the formation of a huge number of clots, mostly in the left sections [19].

For the first time, systematically and consistently, a detailed study of microscopic changes arising in the myocardium Asmolova N.D., Rivenson M.S. [3].They were able to identify the following microscopic changes that occur in the parenchyma, stroma and microvasculature of the myocardium:

- Changes in cardiomyocytes: swelling (edema) of muscle fibers with the phenomena of myolysis: uneven clearing of the cytoplasm, formation of optical voids, loss of striation; tight fit of muscle fibers to each other, indistinctness of their boundaries, the formation of muscle layers; the appearance of the phenomena of karyopycnosis or, on the contrary, swelling and enlightenment, the nuclei of muscle fibers are pycnotic, hyperchromic or swollen, light, with coarse or melted chromatin; many nuclei are deformed;

- Disturbances of microcirculation, in most cases arising precisely in places of edema of cardiomyocytes: pronounced uneven filling of arteries with blood, thickening of arterial walls due to edema and swelling, pronounced plethora of capillaries and venules, segregation of blood into components;

- Changes in the stroma: compression of the connective tissue stroma of the myocardium, the appearance of the phenomenon of erasure of its borders, basophilia; coarsening and basophilia of the perivascular stroma; development of hyperchromia, karyopycnosis, striae in the nuclei of connective tissue cells;

- Formation of overcontraction bands [3].

The above changes in the opinion of Asmolova ND and Rivenson M.S. (1982) allow us to talk about the frequency of occurrence of the above structural changes in the myocardium in more than 90 percent of cases and are fundamentally different from the changes occurring in the myocardium during death from coronary heart disease and alcohol poisoning [3].

In turn, Weil S.S. (1959) noted the following changes: the appearance of multiple hemorrhages in the myocardium, the "clear" state of the capillaries [4].

Research conducted by E.M. Koludarova. (1999, 2005) allow us to talk about reactive changes in the vascular bed: expansion of venules, arterio-arteriolear vasoconstriction, venous-venular congestion, the occurrence of stasis and sludge-phenomenon. In addition, the following parenchymal-stromal changes were identified: the formation of a homogeneous cytoplasm, vacuolization, areas of metachromasia according to Selye and Gendaygain, the presence of zones of intracellular edema, the disappearance of glycogen, the appearance of signs of both relaxation and contractures of I-II degrees in cardiomyocytes. [15,16].

Research results of Asmolova N.D. (2008) talk about the occurrence of the above changes in case of sudden death from complications of coronary heart disease. But with death from coronary heart disease, these signs are expressed evenly, and edematous changes occurring in the parenchymal – stromal structures are insignificant [3].

Analyzing the research results of Koludarova E.M. (2005), it can be concluded that the studies did not give any fundamentally new results. Thus, today, many of the above signs of morphological changes are not very informative, it is extremely difficult to objectify [15].

It should be noted that further research by Asmolova N.D. and Rivenson M.S. (2008) made it possible to find out the following features:

- fuchsinophilic degeneration, the phenomena of granular-lumpy decay of cardiomyocytes are found only in death from complications of ischemic heart disease;

- formation of layers of cardiomyocytes, their edema occurs mainly in cold injury;

- edema of the connective tissue structure predominates in deaths from acute alcohol poisoning [3].

Some authors note the appearance of foci of fuchsinophilia in the heart of those who died from cold injury [11].

The diagnosis of death from hypothermia was given in her research by Filippenkova E.I. (2011). Analyzing the results of her research, it can be concluded that the Asmolova – Rivenson sign is not constant and specific for death from hypothermia [10].

At the moment, there is an opinion that these changes are primarily associated with hypoxic damage to cardiomyocytes. This judgment is confirmed by the results of research conducted by V.P. Desyatov. (1981), Chudakov A. Yu. (2000), Kapustin A.V. (2000) [7,9,13]. The results of research conducted by L.A. Sumbatov (1980) suggest that many cardiomyocytes remain intact despite the effect of low temperatures [19].

Studies conducted by A.V. Kapustin are of great practical importance. (2000) Based on the results of these studies, it was concluded that the severity of morphological changes occurring in tissues, the frequency of their occurrence is largely determined by the process of thanatogenesis [13].

Thus, microscopic changes have different diagnostic significance: some are noticeable are more common in certain nosological forms and can be considered characteristic (but not specific) for them; others occur with many causes of death, but more often with certain causes, therefore, are rated as relatively informative; still others indicate only the immediate cause of death (acute heart failure, ventricular fibrillation or asystole) or its rate; the fourth occur with equal frequency for any cause, mechanism and rate of death and should not be taken into account in histological diagnosis. However, among the nosological forms studied by Kapustin A.V. (2000) based on this approach, hypothermia is not entered.In addition, the value of its results is reduced by the lack of statistical analysis - the main means to assess the very frequencies of occurrence of signs on which their diagnostic value depends.

At the present stage of development of medical knowledge in the field of thermal injuries, great importance is attached to the study of morphological changes occurring apparatus of cells. However, at the moment, the described morphological changes occurring in the nuclei of cardiomyocytes during hypothermia are rather scarce. Particularly noteworthy are the results of studies conducted by I.P. Bobrov. et al. (2019), who showed that the effect of the cold factor has a damaging effect on the nuclei of liver cells in experimental animals, while pronounced morphological changes are noted: a decrease in the number of binuclear hepatocytes, a decrease in the morphometric parameters of nuclei, an increase in the proportion of heterochromatin in the nucleus, a decrease in INDNA and a decrease in the number of nucleoli, with the occurrence of nucleolar segregation phenomena [5,6]. These studies confirm the importance and practical orientation of further study of morphological changes occurring in the nuclei of cardiomyocytes.

Thus, the pathomorphological picture of the heart muscle in hypothermia has been described, but the diagnostic and differential diagnostic significance of its elements, as well as their relationship with the variants of thanatogenesis, are unclear. The accumulated knowledge allows us to conclude that there are no specific signs found in all 100% of deaths from hypothermia.Any symptom characteristic of hypothermia, at least in isolated cases, occurs with other causes of death. In the future, the study of morphological changes occurring under the influence of low temperatures in the area of intercellular junctions and nuclei of cardiomyocytes is of scientific interest.

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