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The State of Perivascular and Pericellular Spaces in the Cerebral Hemispheres of Individuals with Death from Hemorrhagic Shock

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Abstract **Relevance of the research problem:** The study of various aspects of hemorrhagic shock remains an urgent problem of medicine to date. Brain morphological study at the General Staff have established of tanatogenetic significant changes in its structure. **Objective:** To study the state of pericellular and perivascular spaces in the IV-ventricle of the brain in persons who died from hemorrhagic shock. **Materials and methods:** Investigated field 6 from the region of the cerebral cortex and the white matter adjacent to it from 12 corpses of persons who died in the hospital with a clinically established diagnosis of hemorrhagic shock caused by knife wounds of internal organs and blood vessels. In the blood and urine of these individuals, ethyl alcohol was not detected. The duration of hospital stay of such victims was 9±4.2 hours. **Results of the study:** In the cortex of the hemispheres and the white matter of the hemorrhagic shock of people adjacent to it, people who died from hemorrhagic shock, there is a moderate spasm of intracerebral arteries of large and medium caliber. **Conclusions:** In the case of a single lesion of peripheral vessels in the thanatogenesis in hemorrhagic shock, neurons and intracerebral vessels are equally involved, and in case of multiple damage, the role of damage to intracerebral vessels increases.

Keywords Brain, Perivascular space, Pericellular space, Hemorrhagic shock

1. Relevance of the Research Problem

The hemorrhagic shock is an extreme degree of the above hemodynamic and metabolic disorders resulting from severe blood loss. It is a type of hypovolemic shock and requires a number of conditions for development: the interval of time for the development of the body's responses; inadequate tissue perfusion; disorders of cell metabolism; the potentially lethal nature of the injury [3]. The study of various aspects of hemorrhagic shock (HSh) remains an urgent problem of medicine to date [1, 3]. Morphological studies of the brain in hemorrhagic shock allowed us to establish significant changes in its structures [2]. However, a forensic assessment of changes in the nervous and vascular structures of the brain according to the state of the perivascular and pericellular spaces in HSh has not yet been carried out. The expansion of these spaces in pathological conditions is considered as perivascular and pericellular edema [4].

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2. Objective

To study the state of pericellular and perivascular spaces in the IV-ventricle of the brain in persons who died from hemorrhagic shock.

3. Materials and Methods

Investigated field 6 (Brodman) from the region of the cerebral cortex and the white matter adjacent to it from 12 corpses of persons who died in the hospital with a clinically established diagnosis of HSh caused by knife wounds of internal organs and blood vessels. In the blood and urine of these individuals, ethyl alcohol was not detected. The duration of hospital stay of such victims was 9 ± 4.2 hours. All victims were transfusedtherapy in the amount of from 1000 to 6150 ml. In 5 cases, HSh was caused by damage to the heart and main vessels (aorta and pulmonary trunk), in the remaining 7 cases, blood loss occurred due to damage to peripheral vessels and internal organs (except the heart). By the number of injuries: single injuries - 4 cases, multiple injuries - 8 cases. In all cases, the injury was accompanied by internal and external blood loss. Brain pieces are fixed in 10% neutral formalin, passed through an alcohol battery,

embedded in paraffin and painted: with hematoxylin and eosin, according to Van-Gieson and Mallory. Histological preparations of the brain were first investigated qualitatively, then quantitatively. The state of perivascular and perivascular of spaces (edema) was investigated by the point method according to G.G. Avtandilov. For mathematical data processing, the Student's – Fisher method was used with the determination of the arithmetic mean M, the mean error of the relative values, and the coefficient of confidence of the difference t.

4. Results of the Study

In the cortex of the hemispheres (field 6) and the white matter of the brain of people adjacent to it, people who died from hemorrhagic shock, there is a moderate spasm of intracerebral arteries of large and medium caliber. They determine the content consisting of either loosely arranged erythrocytes with a large number of leukocytes and plasma admixture, or of fresh non-deformed erythrocytes, separated by narrow gaps from the vessel wall. At the same time, the arteries of small calibers resemble tissue cords with slit-like gaps, they show little signs of erythrocyte aggregation and plasma coagulation. Expanded perivascular space and a rarefaction of the brain tissue are noted around them.

For an objective characterization of the state of the structural components of the cerebral hemispheres (field 6), morphometric parameters were used for HSh. A study of pericellular (PCE), perivascular (PVE) edema and white matter edema was performed.

A study of the severity of edema in the cerebral hemispheres of brain showed that with HSh caused by injury of the heart and great vessels the edema is more pronounced in the white matter than in the cortex (table 1).

Table 1. The severity of pericellular and perivascular edema in hemorrhagic shock in the cerebral hemispheres (%)

Type of blood loss	The multiplicity of injuries	Cerebral cortex		White matter edema
		PCE	PVE	
HSh (heart and great vessels)	single	5.2 ± 0.59	4.8 ± 0.69	16 ± 0.92
	Multiple	6.0 ± 0.64	5.1 ± 0.96	13.6 ± 0.64
HSh (peripheral vessels)	single	8.4 ± 1.66	8.4 ± 1.51	15 ± 0.81
	multiple	7.8 ± 0.98	14 ± 1.55	14.4 ± 0.94

With a single damage to the heart and main vessels of the PCE, there is a little more PVE, with multiple injuries, this difference increases. In the case of a single injury with damage to the peripheral vessels of both the PCE and PVE, they are more pronounced than with damage to the heart and the great vessels. Multiple injuries with damage to peripheral vessels are also accompanied by high values of PCE and PVE. It should be noted that the edema of PCE and PVE spaces in the cortex of the brain big hemispheres in individuals of this group of observations is greater than in the white matter.

In order to determine the degree of expression of one or another type of edema in the cerebral cortex of the brain with various lesions, the ratio of PCE/PVE. was determined. It turned out that this ratio is different in different groups. With a single lesion of the heart and arterial vessels, the proportion of PCE increases, since the PCE/PVE equals 1.1. In the case of multiple injuries, it is also more than air defense [1]. The ratio of PCE and PVE indicates that with HSh caused by damage to the heart and great vessels, there is a greater damage to the nervous tissue compared to the vessels. In a single wound of peripheral vessels, edema in the cerebral cortex is most pronounced, but the ratio of PCE/PVE is 1.0. In the case of multiple injuries, the proportion of air defense increases, it becomes almost 2 times larger than the CST, the ratio of PCE/PVE is 0.6. Consequently.

Puffiness of the substance of the brain occurs due to a violation of the process of blood circulation in its vascular system due to the prevalence of dystonia, as well as a violation of the rheological properties of blood [2]. At present, it is believed that cerebral edema is a common phenomenon, its research often has a forensic value. It is believed that edema is always more pronounced in the white matter of the brain than in gray, which is associated with its structural features [1]. In our studies, we also observed a greater degree of puffiness of the white matter, compared with gray, but only with HSh caused by injury to the heart and great vessels.

5. Conclusions

We have found that by the volume of the PCE and PVE in the cortex of the cerebral hemispheres it is possible to determine the role of the nervous tissue and the vascular component in thanatogenesis in HSh. It differs depending on the type of damaged vessels, as well as the frequency of injuries. When death from HSh caused by a single and especially multiple damage to the heart and great vessels, the defeat of neurons prevails in thanatogenesis. In the case of a single lesion of peripheral vessels in the thanatogenesis in HSh, neurons and intracerebral vessels are equally involved, and in case of multiple damage, the role of damage to intracerebral vessels increases.

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