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The State of the Structure of the Brain Cortex at Different Times of the Postmortal Period after Massive Blood Loss and Blood Loss Complicated by Hemorrhagic Shock

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Authors' contributions

This work was carried out in collaboration between both authors. Author JZE developed the research, conducted statistical analysis, wrote a protocol and wrote the first draft of the manuscript. He directed the search for literature. Author ISI supervised the analysis of the study. Both authors read and approved the final manuscript.

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ABSTRACT

Determine the time of death based on these characteristics.
Aims: The aim of the study was to identify the features of changes in the structure of the cerebral cortex in different periods of the post - mortem period after massive blood loss and blood loss complicated by hemorrhagic shock, and to determine the age of death based on these data.
Study Design: Cross-sectional study.
Place and Duration of Study: Department of Medicine and Department of Forensic Medicine 2020 between.
Methodology: The structures of the cortex from the Brodman sixth field of the large hemispheres of the brain were studied from 73 corpses of individuals who died from massive blood loss (MB) - 61 and blood loss complicated by hemorrhagic shock -12. The study of corpses with MB (group 1) was carried out in the period: 6-8 h (26), 8-10 h (6), 10-12 h (4), 12-14 h (6), 14-16 h (12), 16-24 h (5), 24-28 h (2) postmortem period. Research of corpses after hemorrhagic shock (group 2) were

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carried out after 6-8 hours (3), 12-14 (3), 18-20 (2), 24-28 (4). Histological preparations of the brain were first examined qualitatively, then quantitatively. Quantitative study of structures was carried out by the point method according To G. G. Avtandilov, the digital material was statistically processed by the Student – Fisher method.

Results: Thus, at death from massive blood loss, as the post-mortem period increases, there is an increase in structural changes in cortical neurons,as well as an expansion of pericellular space. The vascular component of the cerebral cortex is also involved in destructive processes associated with an increase in the postmortem period, and an increase in perivascular spaces is observed.

Conclusion: Comparative analysis of the data obtained showed that in the postmortem period after hemorrhagic shock (group 2), destructive changes in the cerebral cortex appear earlier and are more pronounced than in the case of death from massive blood loss (group 1). Similar expansion of perineuronal and perivascular spaces in the cerebral cortex reflects the persistence of thanatogenesis manifestations in different periods of the post-mortal period after death from massive blood loss and hemorrhagic shock.

Keywords: Massive blood loss; hemorrhagic shock; brain; postmortal period; thanatogenesis.

1. INTRODUCTION

The undoubted urgency of the problem of blood loss and shock has led to studies of its manifestations in the body. Numerous studies on this issue are devoted to the study of changes in the brain (B). This is due to the earliest brain damage under conditions of hypoxia caused by blood loss. [1,2,3]. In forensic practice, the origin of blood loss is most often noted damage with sharp objects, often blood loss occurs in blunt trauma with damage to parenchymal organs. [4]. In the process of forensic medical examination of corpses of persons who died from blood loss and hemorrhagic shock (HSh), it is required to establish and substantiate the main and immediate causes of death, to determine the duration of the dying process and the period of its onset [5].

2. MATERIALS AND METHODS

The structures of the cortex from the Brodman sixth field of the large hemispheres of the brain were studied from 73 corpses of individuals who died from massive blood loss (MB) – 61, blood loss complicated by hemorrhagic shock -12. Among the dead men 55, women-18, the age of victims from 20 to 61 years. In all cases, blood loss was caused by stab wounds to internal organs and blood vessels. The volume of internal blood loss in the dead ranged from 2500 to 4500 cm3, in addition, external blood loss was observed in all cases. No alcohol or drugs were found in the blood of the victims. The duration of hospital stay for victims of hemorrhagic shock was 9 ± 4.2 hours. Transfusion therapy (Blood and blood substitutes, colloids and crystalloids) in the volume from 1500 to 6100 ml was performed for the victims of hemorrhagic shock.

The study of corpses with MB (group 1) was carried out in the period: 6-8 h (26), 8-10 h (6), 10-12 h (4), 12-14 h (6), 14-16 h (12), 16-24 h (5), 24-28 h (2) postmortem period. Studies of corpses after HSh (group 2) were carried out after 6-8 hours (3), 12-14 (3), 18-20 (2), 24-28 (4).

The material for a special histological study was taken from the cortex and the underlying white matter (field 6 according to Brodman). The pieces are fixed in 10% neutral formalin, passed through an alcohol battery, filled in paraffin and stained with: hematoxylin and eosin, Mallory and Nissl methods. Histological preparations of the brain were first examined qualitatively, then quantitatively. Quantitative study of structures was carried out by the point method according To G. G. Avtandilov, the digital material was statistically processed by the Student – Fisher method.

3. RESULTS AND DISCUSSION

In 6-8 hours after MB (group 1), changes in neurons of the ischemic type are observed in the surface layers of the cerebral cortex of the large hemispheres of the brain. The nuclei of these cells are pycnotic, located eccentrically. The processes of neurons are thin and long, i.e. they are viewed at a great distance from the cell body. There are narrow pericellular spaces around many neurons and gliocytes. 8-10 hours in the neurons are caryopycnosis, edema is expressed around the neurons. Around 10-12 hours of neurons are located in the expanded pericellular space (PCS). The nuclei of many neurons are light, in some cavities there are no neurons, and the number of oligodendrocytes in them is increased to 3-5, then (12-14 hours) it is joined

by a hydropic swelling of neurons, an expanded PCS is located around the neurons. 14-16 hours in some neurons, the nuclei are not determined as a result of karyolysis. The neuropil is swollen, and gliocytes are absent in some areas. After 16-24 hours, neurons exposed to hydropic dystrophy are more common in the deeper layers of the cortex, karyocytolysis is also noted, and there is expanded PCS around many neurons. Subsequently, karyolysis and shrinking of the nerve cell are determined (24 hours or more). Thus, at death from MB, as the post-mortem period increases, there is an increase in structural changes in cortical neurons,as well as an expansion of PCS.

The vascular component of the cerebral cortex is also involved in destructive processes associated with an increase in the post-mortem period, and an increase in perivascular spaces (PVS) is observed.

Changes in blood vessels after 6-8 hours are manifested by dystonia, PVS is expanded. Often PVS appears in one side of the vessel. Then (after 8-10 hours) they are replaced by a structural breakdown of the wall. 10-12 hours of the brain, perivascular edema is strongly pronounced. Brain, large, medium and small arteries in states of moderate spasm, perivascular edema is strongly pronounced. The lumen of the vessels contains a small amount of blood corpuscles. As a result, its layers are not contoured (12-14 hours).14-16 h. medium and small caliber arteries have a slit-like lumen. The structure of the vessel wall is not clearly defined. Initially, 16-24 hours large, medium and small arteries of the cerebral cortex in states of spasm to a greater extent than in the previous study period. There is an expanded PVP around the vessels. The lumen of some vessels is not detected. The vessel walls are loosened, and only single endothelial cells are present. At the end of this period, postmortem changes lead to the destruction of the vessel wall layers, PVS is also more pronounced, after that (24 hours or more) the complete destruction of the entire vessel occurs, and PVS is broad.

As the post mortal period increases, the PCS area increases (6-8 h-1,15±0,09; 8-10 h-1,23±0,1; 10-12 h-1,38±0,11; 12-14 h-2,06±0,14; 14-16 h-2,31±0,22; 16-24 h-2,81±0,28; 24-28 h-3,56±0,20), and the size of neurons decreases (6-8 h-2,81±0,27; 8-10 h-2,65±0,1; 10-12 h-2,48±0,10; 12-14 h-1,93±0,17; 14-16 h-1,68±0,20; 16-24 h-1,25±0,11; 24-28 h-1,06±0,06).The same changes are observed when studying the vascular component. The area of the PVS becomes larger as the post moral period increases(6-8 h-3,58±0,29; 8-10 h-3,96±0,32; 10-12 h-4,19±0,36; 12-14 h-5,75±0,50; 14-16 h-5,94±0,54; 16-24 h-7,94±0,39; 24-28 h-11,8±0,57), and the area occupied by the vessel in this space decreases(6-8 h-6,58±0,27; 8-10 h-6,46±0,27; 10-12 h-6,27±0,25; 12-14 h-5,69±0,71; 14-16 h-5,18±0,59; 16-24 h-3,35±0,12; 24-28 h- 0,8±0,1).

The relationships between nerve and vascular structures and their surrounding spaces are clearly defined when calculating relative values. It was found that as the post-mortem period increases, the relative areas of PCS and PVS increase, and the size of the structures located in them (nerve and vascular) decreases.

Thus, as the post mortal period increases, the relative sizes of PCSP increase in comparison with neurons (Fig. 1).

As the postmortem period increases, the relative areas of the PVS increase, and the sizes of the vascular structures in them decrease (Fig. 2).

At HSh (2 group) after 6-8 hours, there are hydropic changes in neurons, which are more pronounced after 12-14 hours, and karyolysis also occurs in them. After 18-20 hours of the post-mortem period, these changes are accompanied by edema of the neuropil and around the gliocytes, and after 24 hours, signs of neuronal cytolysis occur. The number of gliocytes is increased, they are located in close proximity to neurons, often in the perineuronal space.

In the intracerebral vessels, the initial changes are manifested by morphological signs of atony (6-8 hours of the postmortal period), then endothelial edema is noted (12-14 hours). In the subsequent periods of the postmortem interval, vascular layers are destroyed (18-20 hours) and the entire vessel is destroyed (24 hours or more). These data indicate that in comparison with changes in group 1 at death from HSh, as the postmortem interval increases, there are more significant changes in the structures of neurons and intracerebral vessels.

In the cerebral cortex of cadavers of individuals who died from HSh, as the post-mortem period increases, the PCS increases, while the area of neurons located in this space decreases. The total area occupied by PCS and neurons increases.

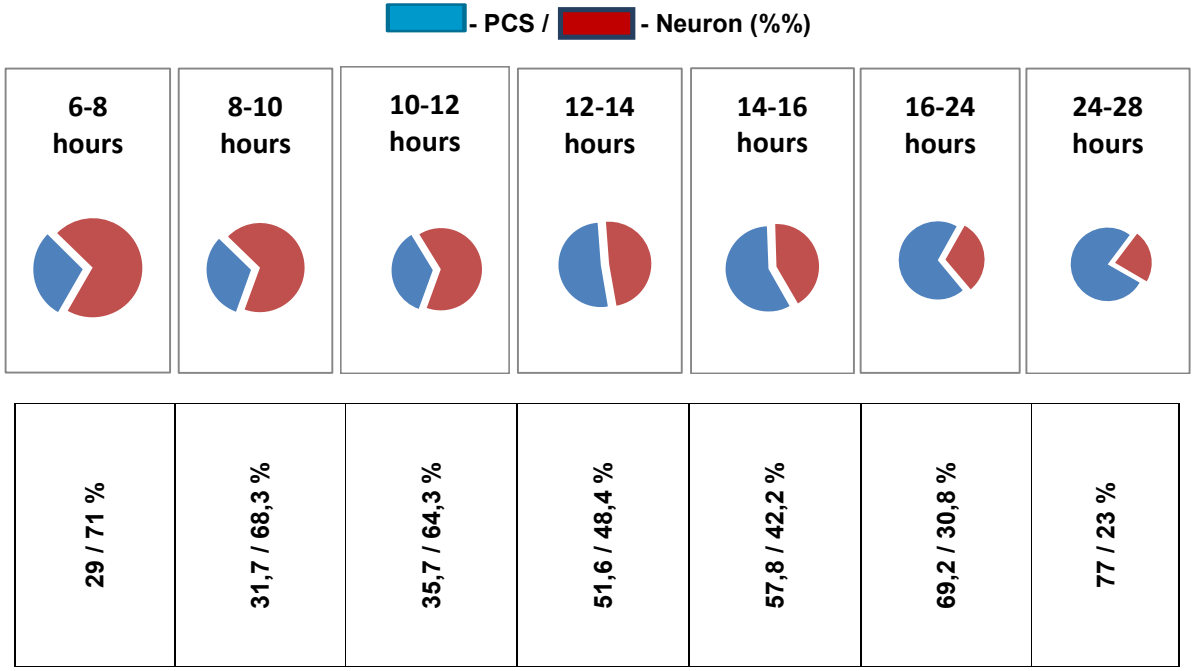

Fig. 1. An increase in the ratio of PCS to neurons in the dynamics of the post mortal period after MB in the cortex of the cerebral hemispheres

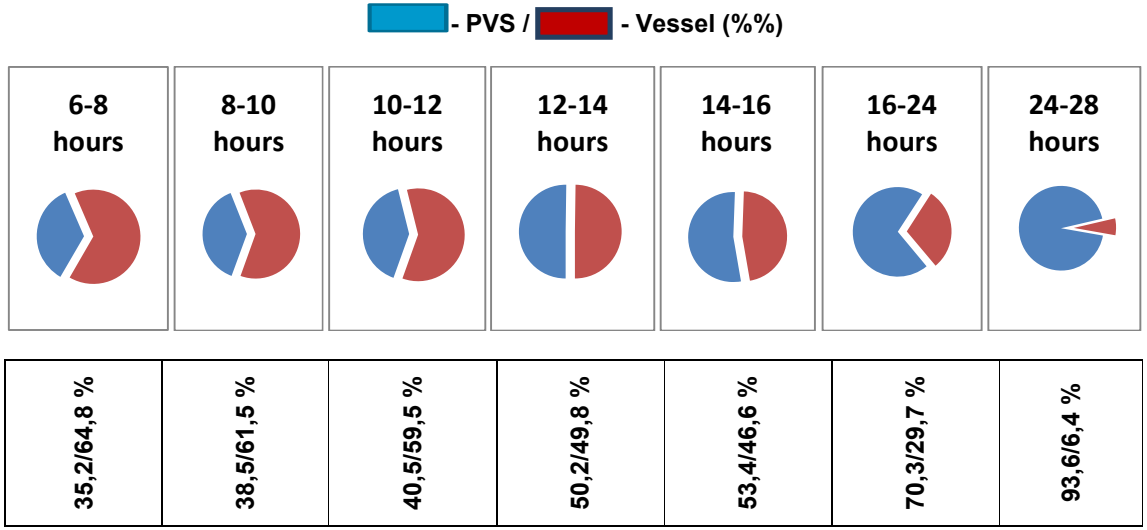

Fig. 2. Ratio of PVS and vessel in the cerebral cortex with MB in the dynamics of the postmortem period

The greatest changes in PCS are observed after 12-14 hours (2,7±0,3) of the post-mortem period, it becomes almost 2 times more than after 6-8 hours (1,41±0,15) of the study. In subsequent periods, the PCS increases slightly with an increase (18 h-3.5 ± 0.44) 24 hours (4,12±0,20) after death. The area occupied by neurons is also significantly reduced during these periods (18 h-1,08±0,08; 24-28 h-0,88±0,13), i.e. after 12-14 hours of the post-mortem period, its decrease (1,5±0,19) is gradual. Changes in the areas occupied by the PVS and the vessels lying in them occur in the same way. 12-14 hours after death, PVS becomes significantly higher (7.37 ± 0.72) than in the interval up to 6-8 hours (5.35 ± 0.24). In subsequent periods of the study, the area of PVP increases gradually (18-20 h - 8.69 ± 0.6; 24-28 h-10.38 ± 0.2), the area of the vessel also gradually decreases (18-20 h - 3.81 ± 0.81; 24-28 h-0.94 ± 0.34).

Currently, the study of thanatogenesis is carried out in conjunction with other important tasks for forensic medical examination [6]. When analyzing thanatogenesis, it is necessary to take into account the temperature features of postmortem cooling of human corpses, especially in cases of death from mechanical trauma [7]. In this regard, the study of the morphological criteria of organs, including the brain, at different times of the postmortem period has not lost its relevance. Morphological manifestations of autolysis in the brain are described [8]. Autolysis in the brain tissue is manifested by diffuse karyolysis (paling and loss of clarity of the core contours until complete disappearance), chromatolysis (paling and dissolution of the Nissl substance) and cytolysis (similar changes in the cytoplasm). At a certain stage of autolysis, the cell nuclei swell, increase in size, they appear clear, and chromatin condenses in the area of the nuclear membrane and nucleolus. Autolysis of neurons can also be manifested by karyopycnosis - changes in the nucleus, in which it decreases in size, becomes homogeneous and intensely basophilic. These changes are explained by the fact that the core shell is torn and the liquid content is released into the cytoplasm. In addition, postmortem autolysis pales and gradually dissolves the gliocyte nuclei, develops pycnosis of the capillary endothelial nuclei, hemolysis of the contents of larger vessels and exfoliation of their endothelium [9].

Forensic histological examination of internal organs is supplemented by the measurement of the main microscopic structures of internal organs. Histomorphometric studies are among the promising areas of study, both thanatogenesis and the prescription of death [10].

We found that the morphology and morphometric parameters of the neural and vascular structures of the cerebral cortex in people who died from MB and HSh differ depending on the post-mortem period. After death from MB, as the post-mortem period increases, there is an increase in structural changes in cortical neurons. The vascular component of the cerebral cortex is also involved in destructive processes associated with an increase in the prescription of death.

At death from HSh in the early postmortem period, gliocytes are located in close proximity to neurons, often in the perineuronal space. The increased content of gliocytes in HSh reflects the lifetime of their appearance. As the post-mortem period increases, the number of gliocytes becomes smaller, but they do not completely disappear. Apparently, compared to neurons, they are more susceptible to autolysis. Morphometric indicators reflect the processes of increasing the area of the PCS, as well as a decrease in the relative size of the neurons located in them. In the intracranial vessels of the initial changes are manifested by morphological signs of dystonia, and then marked swelling of the endothelial cells.

In the subsequent terms of the postmortem interval, the destruction of the vessel layers and the destruction of the entire vessel occurs. Therefore, at death from HSh in the postmortem period, autolysis processes begin earlier and are more pronounced than at death from MB. This is due to the presence of ischemic changes in neurons and blood vessels preceding death from HSh and edema of brain tissues. It was noted that iatrogenic hyperinfusion, which was manifested in severe edema of the brain and other organs, was the most common of the important iatrogenic complications in thanatogenesis [11]. In addition, these changes appear earlier and to a greater extent in the postmortem period after HSh. Thus, the destructive processes of neurons and blood vessels in the brain in the postmortem period after MB and HSh occur with a certain regularity, which allows us to determine the approximate age of death by these signs.

4. CONCLUSION

Comparative analysis of the data obtained showed that in the postmortem period after HSh

(group 2), destructive changes in the cerebral cortex appear earlier and are more pronounced than in the case of death from MB (group 1). This may be due to the presence of ischemic changes in neurons and blood vessels preceding death from HSh. Pronounced changes in the size of PCS and PVS are probably due to brain edema due to the use of infusion therapy. Similar expansion of perineuronal and perivascular spaces in the cerebral cortex reflects the persistence of thanatogenesis manifestations in different periods of the postmortal period after death from MB and HSh.

These data can be taken into account both when assessing the thanatogenesis of MB and HSh, and to clarify the age of death after these conditions.

CONSENT

It is not applicable.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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