

**MORPHOMETRIC CHARACTERISTICS OF NEURONS OF  
CEREBRAL CORTEX IN RATS UNDER ABDOMINAL AORTA  
NARROWING**

**\*Havryshchuk Yu. M. and Herasymyuk I. Ye**

I. Ya Horbachevskyi Ternopil State Medical University Ternopil.

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**\*Correspondence for**

**Author**

**Havryshchuk Yu. M.**

I. Ya Horbachevskyi

Ternopil State Medical

University Ternopil.

**SUMMARY**

The experiment, conducted on rats with abdominal aortic stenosis by means of light-optical microscopy and morphometric research methods, has shown that in the early period (up to 3 days of observation) there occur diverse morphofunctional reactions accompanied by subtotal or central chromatolysis in some neurons

whereas in others this process is characterized by complete disorganization connected with the appearance of protoplasm hyperchromatism. These changes occurred at the background of paravasal and pericellular swelling. Moreover, it should be noted that the phenomenon of chromatolysis as well as paravasal swelling was more characteristic of layer III pyramidal neurons, and hyperchromatism was characteristic of layer V neurons of cerebral cortex in rats. Morphometric study helped to find out the increase of morphometric parameters in layer III neurons and the decrease in layer V neurons of the cerebral cortex in rats. On the 7<sup>th</sup> day of observation the stabilization of the detected changes was recorded, and then their reverse development was observed. However, the full restoration of the structure of neurons and their morphometric characteristics did not occur even after 28 days of observation.

**KEYWORDS:** aortic stenosis, neurons, morphometry, swelling.

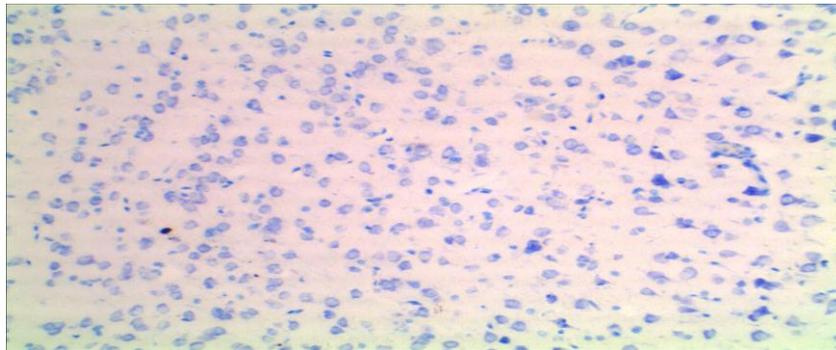
**INTRODUCTION**

There have been already established that acute cerebral circulation disorders can occur after surgical interventions in case of obliterating of aorto-femoral segment diseases. Moreover, the frequency of such complications is recorded at up to 2% of the operated patients.<sup>[1]</sup>

Therefore, the experimental study of the characteristics of morphological changes in the brain

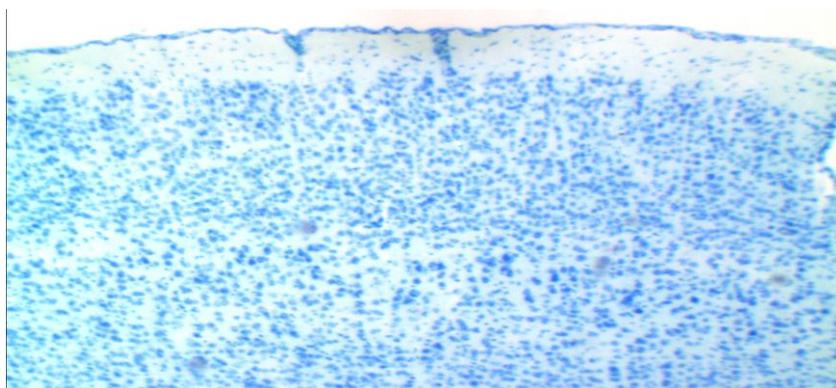
tissue at various disorders of the central circulatory dynamics can contribute to the prevention of adverse effects and improve treatment outcomes of occlusive diseases of great vessels. The results of modern scientific researches conducted in this area are descriptive for the most of its part. Whereas, in contrast, at this stage for the objectification of the received data the usage of quantitative characteristics of the structural organization of organs, tissues and the establishment of their dynamics in the pathological processes development become significant.<sup>[2, 3, 4]</sup> Therefore, morphometry in last decades is quite widely used in biomedical studies because it creates an opportunity for a comprehensive, in-depth and more detailed study of physiological and pathological processes, giving its adequate and logical explanation.<sup>[5]</sup>

**"Morphometric characteristics of neurons in the cerebral cortex in rats under abdominal aortic narrowing"**



**Hydropic neuron degeneration, pericellular swelling.**

**Figure 1 - Histological cut of the cerebral hemispheres cortex in rat in 7 days after abdominal aortic constriction. The color of toluidine blue by Nissl. x 180.**



**Thickening of the cerebral cortex layers by the intercellular spaces narrowing. Neurons hyperchromatism.**

**Figure 2 - Histological cut of the cerebral hemispheres cortex in rat in 28 days after abdominal aortic constriction. The color of toluidine blue by Nissl. x 180.**

**Study Objective:** to establish the nature and dynamics of morphological changes in neurons of the rats' cerebral cortex in abdominal aorta stenosis and to give them a quantitative description.

**Methods of Study:** Experiments were performed on 36 mature white rats of which 6 made up the control group, and the narrowing of the abdominal aorta just above its bifurcation at 2/3 in diameter by the original method was performed for the other 30 animals being under ketamine anesthesia.<sup>[6]</sup> The animals were resuscitated by intrapleural administration of large doses of concentrated thiopental sodium. All experiments were done by using "Work code with the use of experimental animals".

For histological examination, tissue particles from different parts of the brain were taken in the 1, 3, 7, 14 and 28<sup>th</sup> days from the start of the experiment, they were fixed in 10% solution of neutral formalin and 96 ° alcohol. Paraffin sections in thickness 5 - 8 microns were stained by hematoxylin and eosin as well as by toluidine blue after Nissl and tested for the light-optical level. Morphometric evaluation of the data was carried out using an eyepiece micrometer MOV-1-15 × as well as an eyepiece with grating. Thus, the area and perimeter of perikaryon, the diameter and area of the layer III and V pyramidal neurons of nucleus of cerebral hemispheres cortex (taking into account both nuclear-cytoplasmic ratio) were measured.

**Study Findings.** Giving models of disorders of the central and related to them cerebral hemodynamics, the most sensitive to such changes were layers III and V neurons of cerebral hemispheres cortex of experimental animals. So, on the first day of the experimental observations Nissl body (basophilic Nissl substance) responded particularly active and rapidly to these cells. Its structural changes in some neurons were shown as partially subtotal or central chromatolysis whereas others occurred in a form of complete disruption with the emergence of protoplasm hyperchromia. This has been accompanied by paravasal and pericellular swelling. Moreover, it should be noted that the phenomenon of chromatolysis as well as pericellular swelling were more characteristic of layer III pyramidal neurons, and hyperchromia of layer V neurons. All these changes progressed up to the 3<sup>rd</sup> day and kept to the 7<sup>th</sup> day of experimental observations (Fig. 1). The cytoplasm of neurons became more bleaching and their hyperchromic nuclei occupied the eccentric position in most cases.

Since the 7<sup>th</sup> day of the experiment, the stabilization of morphological condition of the components of cerebral cortex in rats was observed. Although, the dystrophy of cytoplasm neurons bleaching has continued to grow in part. However, even for the 14<sup>th</sup> day of observation, the characteristic point was to identify the signs of recovery of the structural building of cerebral cortex cells in experimental animals, which continued up to 28 day of the experiment.

The results of histological study had their morphometric confirmation. Firstly, it should be noted that at the same nuclei area, cytoplasm area (perikaryon) and V layer neuronal cell area of cerebral cortex in rats naturally prevailed over the equivalent indices of the third layer of nerve cells, accompanied by corresponding differences as well as in size of cytoplasmic-nuclear interrelations (Table. 1).

Modeling the abdominal aorta stenosis, the reaction of layer III and V neurons also differed. All area size indices of layer III neurons of the cortex grew progressively during the first three days of experimental observations. Their dynamics flattened out after it and the level of indices remained nearly unchanged until the 7<sup>th</sup> day of the experiment. The nuclei area of such neurons significantly increased ( $p < 0.05$ ) by 19%, the perikaryon area increased by 8% and the area of the entire cell increased by 11% compared to the same indicators of control animals. However, cytoplasmic-nuclear relationship decreased by 8%.

The dynamics of morphological changes of layer V neurons of the cerebral cortex was the opposite one during the same period of observation. The nuclei area of the given cells on the 7<sup>th</sup> day of observation decreased by 15%, the perikaryon area reduced by 5% and the area of the entire cell decreased by 8% compared with the control data. However, cytoplasmic-nuclear interrelations increased by 11%.

**Table 1. Morphometric parameters of layers III and V neurons of the cerebral cortex in rats in normal state and at different times after abdominal aortic constriction ( $M \pm m$ ).**

Observation time		Cell area	Nucleus area	Perikaryon area	Cytoplasmic-nuclear interrelations
Control	Layer III	182.82 ±4.55	58.26 ±2.76	124.57 ±2.09	2.16±0.09
	Layer V	191.70 ±4.01	58.62 ±1.91	133.08 ±2.23	2.28±0.05
1 day	Layer III	196.86 ±4.65	67.27 ±3.77	131.05 ±2.07	2.01±0.11

	Layer V	181.62 ±7.40	51.59 ±1.56*	130.03 ±6.02	2.58±0.04*
3 day	Layer III	200.49 ±4.94	68.71 ±3.96	131.79 ±1.30*	1.95±0.10
	Layer V	175.86 ±7.16	49.13 ±2.10*	126.73 ±5.29	2.59±0.05*
7 day	Layer III	204.38 ±5.87*	69.01 ±2.33*	135.38 ±2.16*	1.97±0.06
	Layer V	176.08 ±3.86*	49.95 ±1.96*	126.14 ±1.97	2.54±0.07*
14 days	Layer III	196.83 ±5.01	65.89 ±4.44	130.94 ±2.16	2.03±0.13
	Layer V	177.34 ±6.27	52.11 ±2.51	125.23 ±3.94	2.41±0.06
28 days	Layer III	190.64 ±4.38	61.62 ±4.07	129.01 ±2.16	2.14±0.14
	Layer V	179.22 ±5.96	55.57 ±2.67	123.65 ±3.68	2.24±0.06

Notice: \* –  $p < 0,05$

The attention was also drawn to the fact that the layer V neurons of the cerebral hemispheres cortex in rats reacted faster and stronger. Significant reduction of their area was observed after the 1<sup>st</sup> day of the modeling of the central hemodynamics disorders displayed by accurate growth of cytoplasmic-nuclear interrelations even despite a simultaneous decrease of the perikaryon area.

Since the 14<sup>th</sup> day of observation the recovery of morphometric parameters of cells of the cerebral cortex of experimental animals became a characteristic feature, which continued until the 28<sup>th</sup> day of the experiment. This has been accompanied by dehydration of brain tissue with thickening of cortical cells layers by reducing the intercellular spaces as well as by hyperchromatism (Fig. 2). However, full recovery didn't occur. This was confirmed by the fact that even in the final stage of the experimental observations moderate paravasal and pericellular swelling continued to be as evidenced by the results of the undertaken study.

Thus, changes of morphological parameters, revealed in the process of experiment, may be an indication that in layer V cells of cerebrocortical brain hemispheres in rats occur dystrophic processes that manifest in most neurons atrophy of this group and pyknosis, while in layer III pyramidal cells, by contrast, most processes occur indicating the increased activity of cells in the background of some hyperhydration, which should ensure their adaptation and compensatory regeneration under the conditions of the modeling of the central hemodynamics disorders. Similar changes were found by other researchers in experimental

modeling of cerebral circulation disorders.<sup>[7]</sup> As for the reasons for these differences, they can be connected with the differences of blood flow to different layers of cells of the cerebral cortex, and also with the fact that V layer neurons are more sensitive to hypoxia.<sup>[8]</sup>

## CONCLUSIONS

1. Stenosis of the lower abdominal aorta is accompanied by conspicuous morphofunctional changes on the part of the neurons of the cerebral cortex in rats.

2. Cells of different layers of the cerebral hemispheres cortex in rats respond differently to hemodynamic effects arising after stenosis of lower abdominal aorta. The dystrophic changes predominate the layer V cells whereas in layer III cells, by contrast, there are processes that indicate the increasing of their activity, which may be a manifestation of adaptation and compensatory regeneration.

**Prospects for further study:** Further studies will deeper reveal the mechanisms of remodeling of brain structures in occlusive lesions of the aorta and in the recovery period.

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