

UDC: 616.33-413-005.1-005.4-085

DOI: 10.15587/2519-4798.2022.256461

STRUCTURAL CHANGES OF BRAIN VESSELS IN CARDIOSURGERY PATIENTS WITH POSTOPERATIVE STROKE

Dmytro Mankovskyi

Hypoxic-ischemic lesions of the brain of cardiac surgery patients as a leading factor in stroke have been studied. The importance of prolonged thrombosis, embolism, which exacerbate the general degenerative changes in the central nervous system is recognized.

The aim of the research – to study the morphological changes of the vessels of the brain of cardiac surgery patients with postoperative stroke on the background of hypoxic-ischemic complications.

Materials and methods. Pieces of cerebral vessels were subjected to microscopic examination. Histological sections were stained according to Van Gieson.

Results and their discussion. The study of the structure of the vessels of the brain of persons who were in the group intact to neurological pathology control, showed the presence of anatomical and functional changes that are fully consistent with the sex-age norms of postnatal human ontogenesis.

The drugs of the clinical observation group contained signs of pathological changes characteristic of hypoxic-ischemic disorders. It is obvious that their appearance and intensification contributed to the development of ischemic stroke. Structural and functional changes mainly concerned the vascular walls, their layers, paravascular spaces, the blood system as a liquid phase, in fact. Endothelial layer with signs of desquamation. Endothelial cells are characterized by signs of hyperchromia of the nuclei, the shift of the latter in the direction of one of the poles of the cells, the appearance of heterochromatin. Contacts between cells are weakened, defects are visible in the surface layer. Perovascular edema, which is formed in the case of increased permeability, leads to a certain isolation of individual vessels from the surrounding tissues, followed by the development of hypoxia. Defects of the wall layers lead to the activation of the migratory properties of platelets, encourage the appearance of megakaryocytes, erythrocyte thrombi, which are in close contact with the endothelial layer of blood vessels. On histological specimens, brick-red blood clots abundantly cover the damaged inner layer of vascular walls, sometimes completely filling their openings. Over time, defects in the layers of the walls are accompanied by thrombosis, inflammation, edema.

Conclusions. Hypoxic-ischemic brain lesions in cardiac surgery patients play a leading role in stroke. Priority is given to hypoxia, which contributes to ischemia, trophic disorders, atrophy, necrosis, necrobiotic changes. The latter are the organic basis of pathogenetic patterns of focal cerebral infarction (with progressive destruction of brain cells, its vessels, the development of prolonged thrombosis, embolism, increased general degenerative changes in the central nervous system)

Keywords: brain, blood vessels, structural changes, thrombosis, embolism, cardiac surgery, stroke

How to cite:

Mankovskyi, D. (2022). Structural changes of brain vessels in cardiosurgery patients with postoperative stroke. ScienceRise: Medical Science, 2 (47), 57–60. doi: <http://doi.org/10.15587/2519-4798.2022.256461>

© The Author(s) 2022

This is an open access article under the Creative Commons CC BY license hydrate

1. Introduction

The development of hypoxic-ischemic brain lesions in cardiac surgery patients as an integral leading factor in stroke is not limited to the occurrence of local pathology [1–3]. The structural and functional profile of the latter has a systemic character, which is characterized by the appearance of a number of interrelated processes and phenomena in the chain “neurocyte-capillary-glia” [4]. The role and importance of hypoxia, ischemia in the clinical-morphological / pathogenetic pattern of stroke has long been beyond doubt [5]. Their consequences (atrophy, necrosis, necrobiotic changes) contribute to the formation of focal heart attacks, with progressive de-

struction of brain cells and blood vessels. Prolonged thrombosis and embolism exacerbate general degenerative changes in the central nervous system, in some ways engaging a vicious circle where ischemia triggers a cascade of structural disorders, which in turn trigger several interrelated physiological responses [6]. Under the influence of regenerative factors of the hearth of the infarction are organizations with the formation of a framework of collagen fibres in areas of former necrosis, slow stimulation of vasogenesis. These phenomena are a solid basis for changes in the ultrastructure of cells of the walls of brain capillaries (swelling, hyperplasia, karyorexis, karyopyknosis, hyperchromatosis of endothelial nuclei), cor-

tical neurons (vacuolation of the cytoplasm with the appearance of lysosomal inclusions, lysosomal inclusions). Structural changes of the astro-glial component (swelling of the processes, destruction of the granular and agranular endoplasmic reticulum), which develop in the logistic algorithms of organic relationships [4], greatly contribute to these processes. Subsequently, glia cells accumulate in the foci of pathological foci under conditions of their trophic sufficiency. Then the meaning of ischemia receives a double clinical and morphological interpretation. On the one hand, it induces marked decompensation of cortical zones of localization of sensorimotor analyzers in the hemispheres of the brain [7–9]. In the future, this causes the corresponding functional disorders in patients. On the other hand, structural disorders determine the trends in the development of compensatory processes, confirming the considerations of stimulating the adaptive potential in conditions of extreme loads of the central nervous system [7]. Given the latter, the study of the structural profile of the vessels of the brain of cardiac surgery patients with hypoxic-ischemic lesions, stroke, including, seems quite appropriate.

The aim of the research. To study the morphological changes of the vessels of the brain of cardiac surgery patients with postoperative stroke on the background of hypoxic-ischemic complications.

2. Materials and methods

The study was conducted based on the Department of Intensive Care for Adults of the State Institution “Heart Institute of the Ministry of Health of Ukraine” from June 2021 to May 2022.

Microscopic (histological / cytological) examination was performed on pieces of main and microvessels of the brain, 0.5 cm³ in size, healthy subjects, which were a control group, intact (IC, n=12) regarding neurological pathology and hypoxic-ischemic complications in persons with cardiac surgery (clinical comparison groups, CC, n=18). The basic volume of research inevitably included materials of retrospective analysis of thanatological follow-up data from the author's own archives. Biopsy material / necropsies were obtained under surgical / sectional prosector conditions. Pieces of vessels were separated from the surrounding substance and branches, washed in running water, subjected to fixation for at least 24 hours in 12 % formalin solution in phosphate / sulfate buffer (pH=7.0–7.2), at room temperature t°=18–20 °C in glass-ceramic desiccators). The material was dehydrated in solutions of alcohols of increasing concentration (from 30° to absolute), poured into paraffin / celloidin (according to the purpose and objectives of the study). From the obtained blocks (microtome MC-25), made a series of histological sections with a thickness of 5–10 μm. The sections were stained in the traditionally most popular and at the same time quite accessible methods (hematoxylin and eosin, according to Van Gieson). Histological / cytological analysis of the structure of the vessels of the brain was performed in stages. The light optical system of the Lieca microscope (Germany) (×100; ×300; ×600; ×1350) was used for this purpose. Comparison of control and clinical samples was performed in a comparative aspect. Areas with foci of inflammation, hemorrhage, heart attacks, reparative and regenerative phenomena

were subject to close study. The results were recorded with the help of the author's registration card of the research. Evaluation of morphologically similar microscopic features was performed in total. The generalized results were reduced to a unified scheme.

3. Research results

The study of the structure of the vessels of the brain of individuals who were in the group intact to neurological pathology control, showed the presence of anatomical and functional changes that are fully consistent with the variants of the sex-age norm of postnatal human ontogenesis. The vessels were in accordance with the natural topography, contained generous branches, had clear outlines that moderately contrasted with the substance of the brain. The openings of the latter had the shape of an oval, circle, slit. The native preparations separated for further research were quite strong to the touch, were characterized by appreciable elasticity, and were not subject to the pressure of tensile tension. The walls did not contain seals, calcifications, were not marked by the presence of signs of tumor development, tumors. Shell ruptures, bundles, and other integrity defects were not observed. Adventitia completely covered the vascular trunk, seemed contrasting, marked. Phenomena of paravasal hemorrhages, the appearance of foci of inflammatory processes, the development of destructive-degenerative reactions, necrosis are absent. Phenomena of thrombosis, stasis, defects of wall layers, diapedesis of erythrocyte cells in the paravasal space were not detected throughout the experimental session. Swelling, proliferation of the glial component is absent. Epidural, subdural hematomas were not observed. Numerous capillaries were located peripherally, were represented on both lumbar and longitudinal sections. The presence of thrombosis, stasis, hemorrhage in the latter is rejected.

Vascular preparations obtained in the case of examination of CGs contained signs of pathological changes characteristic of hypoxic-ischemic disorders [5, 6]. It is obvious that their appearance and intensification contributed to the development of ischemic stroke. Structural and functional changes mainly concerned the vascular walls, their layers, paravasal spaces, the blood system as a liquid phase, in fact. The walls of native vascular preparations are hard to the touch, fragile, brittle, fragile. Even at a slight increase, their stratification is noticeable, defects of integrity at long intervals of the length of the separated part of the drug. The openings of the bed are mainly represented by longitudinal slits, in some cases free of blood cells. Fixed and stained preparations of microvessels are contrasting, clear, chromatophilic. The walls of the vessels are twisted, between each of the layers of the walls there are free spaces in the form of slits. Endothelial layer with signs of desquamation. Endothelial cells are characterized by signs of hyperchromia of the nuclei, the shift of the latter in the direction of one of the poles of the cells, the appearance of heterochromatin [4]. In contrast to drugs of the IC group, the contacts between the cells in the vessels of the CG sections are weakened, defects are visible in the surface layer. Perovascular edema, which is formed in the case of increased permeability, leads to a certain isolation of individual vessels from the surrounding tissues, followed by

the development of hypoxia. Thus, there are additional reasons for the deterioration of the structure of the vascular wall. Exfoliated endothelial cells hang in the inner space of microvessels, sometimes accumulate in the form of conglomerates. The latter form the ground for the formation of short-lived emboli, characterized by oval, round shapes, moderate contrast. Vasodilation is not a causative factor for the formation of tubules, such as classical emboli. Another specific feature of endothelial cells is the signs of increased hydration, associated with a gradual increase in intracellular edema, to the point of melting of the laminar edge of cytoplasmic membranes, which is considered a factor in fluid access from the subendothelial space. Obviously, this is the reason that leads to a massive release of histamine. In this connection, the microvesiculation noted in separate groups of drugs plays a role of the protective reaction focused on elimination and utilization of the excess of the liquid of the substances dissolved in it from fabric in blood. On the other hand, microvesiculation leads to pathological formation of pores in the endothelium, which significantly changes its barrier properties, increases the permeability of cell membranes [2, 4, 10]. Thus, these processes contribute to the depletion of membrane potential / reserve and obviously inhibit the protective response of microvesiculation in the endothelium.

Defects of the wall layers lead to the activation of the migratory properties of platelets, encourage the appearance of megakaryocytes, erythrocyte thrombi, which are in close contact with the endothelial layer of blood vessels. On histological specimens, brick-red blood clots abundantly cover the damaged inner layer of vascular walls, sometimes completely filling their openings. Over time, defects in the layers of the walls are accompanied by thrombosis, inflammation, edema. There is a formation of a kind of vicious circle, in which hypoxic-ischemic processes contribute to the development of structural disorders, and the newly formed structural changes increase the ischemia of tissues. Against this background, there is an increase in infiltration of the vascular spaces by polymorphic cell pool, mainly lymphocytes, a small number of macrophages, eosinophils.

In the immediate vicinity of the damaged areas are numerous platelets, megakaryocytes with signs of sequestration. Angiospasm, stasis and, consequently, severe perivascular edema have been reported on some drugs. Substance of the brain in foci with edema in a state of necrosis. It is obvious that the latest facts contributed to the development of the clinical picture of hypoxia, severe acidosis. The observed pathogenetic picture of ischemic stroke may have contributed to the strengthening of vascular insufficiency, which was exacerbated by blockage of cerebral circulation [5]. Changes in the adhesive properties of erythrocytes, probable changes in the blood coagulation system led to the appearance of microthrombi in blood vessels, contributed to the violation of the trophism of the surrounding tissue, the development of microbiotic processes. One of the assumptions is the fact that hyperaggregation of erythrocytes contributes to a sharp increase in the content of free erythrocyte aggregates-microthrombi in the blood. They in most cases lead to total / partial blockage of blood supply in the microcirculatory tract, reducing the number

of actively functioning capillaries and arterio-venular anastomoses, which further contributed to the development of sclerotic changes in surrounding tissue structures [2]. One of the most available facts confirming our conclusions is thrombosis of cerebral vessels [5, 6, 10, 11] of the vertebro-basilar basin, fronto-parietal angles of both hemispheres. That is, the occlusion of the main vessels, in the end, caused further progressive damage to the tissue of the cerebral hemispheres.

4. Discussion of research results

The work carried out and the fixation of the obtained results were able to reveal the following advantages: in the sectional study of hypoxic-ischemic lesions of the brain of cardiac patients it is possible to clearly detect morphological changes in the body. However, the disadvantage of this study is that the study is conducted in the post-mortem period.

The study of the structural dominants of stroke as a solid element of the evidence base of the morbid psychotype of cardiac surgery patients with postoperative hypoxic-ischemic disorders is currently a priority [1, 2, 3]. The latter is largely due to the lively issues of unresolved issues of patient-oriented strategy of neurological support of cardiac surgery patients, persistent contradictions in the tactics of management of this category of patients, frequency and clinical polymorphism of postoperative complications (strokes, encephalopathies, dysfunction, neuroses, neuritis, severe cognitive dysfunction, transient ischemic attacks, etc.) [6, 7]. Preoperative preparation of patients, transoperative management of patients; issues of application, anesthesia; prevention of complications and persistent disabilities, prognosis of working capacity and further quality of life, sometimes social psychoadaptation - all this requires specialists to have a deep and comprehensive understanding of the leading components of the nosological prototype, the basic criteria of morphological patterns of the disease. Given the latter, the role and importance of morphological diagnosis of clinical manifestations among a wide range of complications of cardiac surgery is clearly growing. One of them is a stroke. Its current socio-medical specifics include the predominance in the pathomorphosis of neurotic disorders of somatized versions, which encourage a prolonged course of the disease; resistance to the most proven therapies; development of both temporary and permanent disability. Somatic suffering is a powerful psycho-traumatic factor, the potentiated secondary neurotic disorders negatively neutralize the somatic matrix of the body, creating the basis for the development of mutual encumbrance syndrome [2]. Thus, a thorough solution to this problem lies in the field of basic research of structural and functional profile of stroke, its morphological design, determination of current macromicroscopic dominants, which are promising criteria for diagnostic systems / algorithms of complications in cardiac surgery patients with postoperative hypoxia and hypoxia.

Study limitations. Carrying out of research on section material does not give a chance to observe revealing of features at change of structure of blood vessels of a brain of cardiac surgery patients with postoperative stroke in dynamics.

Prospects for further research. In the next steps of the study, it is planned to use current morphological dominants of stroke as evidence criteria for substantiating the morbid psychotype of cardiac surgery patients with postoperative hypoxic-ischemic complications in order to further improve patient-oriented strategy of neurological support.

5. Conclusions

Hypoxic-ischemic lesions of the brain of cardiac surgery patients play a leading role in stroke. Its structural and functional potential is systemic in nature, marked by a cascade of interconnected phenomena. Priority among them is hypoxia, which contributes to ischemia, trophic disorders, atrophy, necrosis, necrobiotic changes. The latter are the organic basis of pathogenetic patterns of focal cerebral infarction (with progressive destruction of brain cells, its vessels, the development of prolonged

thrombosis, embolism, increased general degenerative changes in the central nervous system).

Conflict of interests

The author declares there is no conflict of interest.

Financing

Funding for the organization, conduct and receipt of research results is not provided.

Acknowledgments

The author pays tribute to the bright memory of prof., doctor of medicine A. F. Yakovtsova is a former head and honorary professor of the Department of Pathological Anatomy of the Kharkiv National Medical University of the Ministry of Health of Ukraine for invaluable advisory assistance in performing morphological fragments of work.

References

1. Feigin, V. L., Roth, G. A., Naghavi, M., Parmar, P., Krishnamurthi, R., Chugh, S. et. al. (2016). Global burden of stroke and risk factors in 188 countries, during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *The Lancet Neurology*, 15 (9), 913–924. doi: [http://doi.org/10.1016/s1474-4422\(16\)30073-4](http://doi.org/10.1016/s1474-4422(16)30073-4)
2. Costa, M. A. C. da, Gauer, M. F., Gomes, R. Z., Schafranski, M. D. (2015). Risk factors for perioperative ischemic stroke in cardiac surgery. *Revista Brasileira de Cirurgia Cardiovascular*, 30 (3), 365–372. doi: <http://doi.org/10.5935/1678-9741.20150032>
3. Demikhov, O., Dehtyarova, I., Rud, O., Khotyeev, Y., Kuts, L., Cherkashyna, L. et. al. (2020). Arterial hypertension prevention as an actual medical and social problem. *Bangladesh Journal of Medical Science*, 19 (4), 722–729. doi: <http://doi.org/10.3329/bjms.v19i4.46632>
4. Torianyk, I. I., Kolesnyk, V. V. (2014). Morfologichnyi dysayn ishemichnogo insultu. *Visnyk morfologii*, 2, 37–42.
5. Mankovsky, D. S. (2021). Tserebralnyi krovoobih ta faktory ryzyku formuvannia hipoksychno-ischemichnykh urazhen holovnoho mozku u kardiokhirurhichnykh patsientiv pry vykorystanni shtuchnoho krovoobihu. *Vitchyzniana nauka – perspektyvy ta innovatsii*. Kyiv: «Kyivskyi medychnyi naukovyi tsentr», 22–26.
6. Todurov B.M., Kuzmych I.M., Tarabrin O.O. (2015). Porushennia funktsii tsentralnoi nervovoi systemy pislia operatsii zi shtuchnym krovoobihom u patsientiv z nyzkoiu fraktsiieiu vykydu livoho shlunochka. *Clinical Anesthesiology and Intensive Care*, 2, 82–90.
7. Rubinshteyn, S. (2019). *Osnovy obschey psikhologii*. Saint-Petersburg: Piter, 720.
8. An, N., Yu, W.-F. (2017). Difficulties in Understanding Postoperative Cognitive Dysfunction. *Journal of Anesthesia and Perioperative Medicine*, 4, 87–94. doi: <http://doi.org/10.24015/japm.2017.0010>
9. Spoelstra, S. L., Schueller, M., Hilton, M., Ridenour, K. (2014). Interventions combining motivational interviewing and cognitive behaviour to promote medication adherence: a literature review. *Journal of Clinical Nursing*, 24 (9-10), 1163–1173. doi: <http://doi.org/10.1111/jocn.12738>
10. Johnson, W., Onuma, O., Owolabi, M., Sachdev, S. (2016). Stroke: a global response is needed. *Bulletin of the World Health Organization*, 94 (9), 634–634A. doi: <http://doi.org/10.2471/blt.16.181636>
11. O'Neal, J. B., Billings, F. T., Liu, X., Shotwell, M. S., Liang, Y., Shah, A. S. et. al. (2017). Risk factors for delirium after cardiac surgery: a historical cohort study outlining the influence of cardiopulmonary bypass. *Canadian Journal of Anesthesia/Journal Canadien D'anesthésie*, 64 (11), 1129–1137. doi: <http://doi.org/10.1007/s12630-017-0938-5>

Received date 14.12.2021

Accepted date 18.01.2022

Published date 31.03.2022

Dmytro Mankovskyi, PhD, Senior Researcher, Department of Diagnosis of Myocardial and Main Vascular Pathology, Neurologist, Intensive Care Unit for Adults, State Institution “Heart Institute of the Ministry of Health of Ukraine”, Bratyslavskaya str., Kyiv, 5 A, Ukraine, 02166

E-mail: mds.anest7777@gmail.com