THE LYMPHATIC SYSTEM AS A KEY MORPHOLOGICAL BASIS OF THE BODY'S PROTECTIVE MECHANISMS

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Annotation. The immune system (IS) plays a critical role in the body's adaptation to adverse endogenous and exogenous factors, as it is essential for maintaining immune homeostasis and, consequently, the adaptive potential of the body (APO). This function is realized through the coordinated interaction of various immunocompetent organs, including lymph nodes (LNs)—both visceral and peripheral (somatic). This paper proposes a novel algorithm for studying functional immunomorphology of lymph nodes, based on the assessment of five tissue-level parameters and the calculation of three derived coefficients. This new methodological approach enables an objective and precise evaluation of the structural and functional state of lymph nodes under both normal and pathological conditions. In turn, this evaluation reflects the immune status and the overall level of the body's adaptive potential.

Key words: lymph nodes, functional immunomorphology, morphometry, novel research algorithm.

At the present time, she has found out in detail many of the features of anatomy and physiology in all structures of the lymphatic system, which now makes it possible for clinicians to actively search for ways to correct disorders of blood circulation and lymph outflow. In modern lymphology there are many controversial issues concerning the structure of endothelial cells, basement membrane, lymphatic capillaries and postcapillaries, organization, valves of lymphatic vessels and

lymphangions. There is still no clear explanation of the reasons for the different number of lymph nodes in different regions and around organs.Thus, the statement that the lymph nodes are characterized by the fact that 5-7 lymphatic vessels enter the lymph node, and only one lymphatic vessel leaves the lymph node [7] is unfounded. Numerous studies of renowned lymphologists confirm that the number of inflowing and outflowing lymphatic vessels in lymph nodes varies from 2 to 8.

Thelymphnodes — the most numerous organs of immunogenesis [1]. Their number in an adult is about 460, and the total weight is about 1% of the body weight (500-1000 g) [6]. This is three to five times the mass of the largest solitary organ of the IS - the spleen.

Thelymphnodes carry out two main functions - immune and drainage-detoxification [3], which makes it possible to classify these organs as IS and the lymphatic system [11]. The drainage function is performed mainly by the medullary substance of the LN, the immune function belongs to the cortex, where three separate structural and functional units are distinguished: 1) lymphoid follicles (LF), 2) interfollicular zone, or cortical plateau (CP) and 3) the inner cortex, or paracortical zone, paracortex (PC) [2].

The cellular composition of Lf is dominated by B-lymphocytes, which, upon antigenic stimulation, undergo blast transformation and subsequent differentiation into plasma cells, forming light (germinal) centers (HC) of Lf [8]. In this case, the primary Lf turns into a secondary one, which documents the presence of an immune response of the humoral type [7].

On the contrary, the population of T-lymphocytes is localized in the CP and PC [2,7,9], the expansion of which indicates an increase in the immune response of the cell type [4; 1]. A mixed type of immune response is observed with a reactive change in all immunocompetent LN structures [4].

Therefore, the morphological development of these components of the LN

parenchyma reflects the level of functional immune activity of these immune system organs [14].

The statement [1] that connective tissue in humans, all bones, muscles, ligaments, fascia and aponeuroses do not have their own lymphatic drainage, does not correspond to the results of our studies and contradicts the data of other authors [5; 6]. Also controversial is the idea that all lymphatic vessels, with the exception of the thoracic duct, have almost the same diameter [1]. Due to this, it is impossible to determine to which generation a particular lymphatic vessel belongs.

Literature data and our long-term observations refute this information. So, the diameter of the lymphatic vessels is extremely variable: in the ventricle it is 67-113 microns, in the small intestine - 27-945, in the liver - 67-1700, in the heart - 67-1080, in the lung - 40-1600, in the ovary - 40 -160, in the periosteum of the ribs-120-150, in the articular capsule-40-160, in the peritoneum-60-180, in the fascia-25-115, in the aponeurosis-45-175 microns. [8, 15]

Although lymphology is 400 years old, however, there are currently controversial issues on the anatomy of the lymphatic system. For example, in [10] it is noted that lymphatic capillaries begin blindly in the interstitial spaces of all organs and tissues. The exception is the brain and spinal cord, where the function of the lymphatic system is to a certain extent performed by the cerebrospinal fluid system. However, according to our data [5], there are 28 such organs, not 2.

So far there are no reliable data on the timing of the completion of the adaptation of lymphatic capillaries to the action of unfavorable factors, on the peculiarities of their reaction at various tissue and cellular levels, the degree of reversibility of these changes, etc. The solution of controversial issues in the field of studying the lymphatic system gives excellent results in clinical lymphology. Already, fundamental studies of the regularities of the structure of the lymphatic system contribute to the successful development of the endolymphotropic direction

in the treatment of many diseases. [4; 11]

According to qualifications [12], "blind" lymphatic capillaries are divided into 3 groups: 1st group - capillaries have smooth contours and narrowed orifices, clavate and finger-shaped; 2nd group - capillaries are found in serous integuments with blind processes directed towards the mesothelium (they participate in the resorption of intraperitoneal fluid), the mouths of such capillaries are wide; 3rd group - the capillaries have a predominantly spherical shape, they have a narrow mouth. Often found in pathology, edema, hypoxia in the elderly.

In modern conditions, when new technical means are widely used (ultrasound, computed tomography, endoscopy, laparoscopy, radionuclide diagnostics, etc.), accurate data are needed on the individual parameters of the size of the lymph nodes, their shape, syntopy with arteries, veins, nerves, ducts of glands, lymphatic collectors, trunks and ducts.

In recent years, some authors [13; 14] have raised the issue of the lymphatic postcapillary [15], identified in the initial part of the lymphatic vessel "lymphatic postcapillary", which has a valve, in contrast to lymphatic capillaries. The valve in the lymphatic postcapillary is formed by a fold consisting of endothelial cells without connective tissue [14]. It is argued that the presence of connective tissue is a prerequisite for the valve, and the protrusion of endothelial cells into the lumen of the lymphatic capillary is not a prerequisite for the isolation on this basis of a new structural formation in the form of a "lymphatic postcapillary". We do not share the opinion that the lymphatic postcapillaries have elements of smooth muscles [2] found in the literature, and we did not find myocytes in the thickness of the walls of the postcapillaries. According to our data, smooth myocytes are found starting from the lymphatic vessels [8-11].

We cannot agree with the statement [16] that: Lymph is a liquid that is contained in the blood and makes up oxygen and nutrients to cells. Having received

toxins in return, lymph is removed from the tissues in the veins and lymphatic vessels. However, lymphatic vessels are extremely fragile: they are prone to internal rupture, and can also be easily damaged as a result of external influences, which leads to a disruption in the flow of lymphatic fluid. The lymphatic fluid is rich in protein and rather thick.

It is now generally accepted that lymph is a liquid located in the lumen of the lymphatic bed. Lymph (from Latin - clean, transparent spring water, moisture) is a biological fluid of complex composition and function, located in the lumen of lymphatic capillaries, lacunae, networks, postcapillaries, vessels, collectors, nodes, trunks and ducts. It is not necessary to identify tissue, intercellular and other types of fluids (cerebrospinal, cavity, synovial, etc.) with lymph. So, according to [11] “With a closed circulatory system, blood is not a liquid medium surrounding the cells. This role is played by tissue (intercellular) fluid - lymph. Small vessels (lymphatic capillaries) with walls of unilamellar epithelium open directly into the intercellular space and lymphatic vessels, hence it is subdivided into tissue lymph and vascular. [13] Notes that "... in the intercellular gaps, lymphatic fluid circulates, which brings nutrient material for the cells of the Malpighian layer and carries away metabolic products from the epidermis." In such cases, it is advisable to consult a qualified lymphologist.

For a clear understanding of what lymph is and how it is formed, knowledge of the theories of lymph formation is necessary [12]. It should be borne in mind that the presence of many such theories speaks of the complexity and laboriousness of the study of this issue and the need for a comprehensive analysis of different theories, which, in fact, complement and enrich each other.

Since 2015, information has appeared in mythology that there are lymphatic capillaries and blood vessels in the dura mater and human brain. Until that time, it was written everywhere that there were no elements of the lymphatic channel in the

brain and spinal cord and in their membranes.

A group of scientists from Finland and the USA claims the existence of lymphatic capillaries and blood vessels in the dura mater (DM) of mice, humans and monkeys.

Daniel Reich (Maryland) using MRI imaged lymphatic vessels (LS) in the dura mater. The author used staining and showed the presence of lymphatic vessels in the dura mater. CSF from the brain goes to the cervical lymph nodes (here is a link to these discoveries: ne.Zimpho, 2018, No. 2, p.9).

A sensation in 2015 was the publication in the journal Nature of a study by Jonathan Kipnis and co-authors on the structural and functional characteristics of the lymphatic vessels of the central nervous system.

These structures have all the molecular characteristics of lymphatic endothelial cells, they are able to carry immune cells from the cerebrospinal fluid and are connected to the deep cervical lymph nodes. The unique arrangement of these vessels may have hindered their discovery to date, thereby contributing to the dominance of the long-standing concept of the absence of a lymphatic vascular system in the central nervous system.

Conclusion. Currently, there are controversial and variable issues in the field of lymphology. The question is unclear why not all organs have lymphatic capillaries. There are large discrepancies about the structure of lymphatic capillaries (isolation, openness, lymphatics, prelymphatics, etc.). It has not been established how many regional lymph nodes are needed for each organ, etc.

Thus, the proposed new morphometric approach to the study of the functional immunomorphology of LN makes it possible to objectively and accurately assess the structural and functional state of the organ both in normal conditions and in pathological conditions, which reflects the immune status and the general level of APO.

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