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Importance of Normal Thymic Morphology

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Abstract: The thymus is the central, or primary, organ of the lymphoid (immune) system. Its main functions are to ensure the maturation and differentiation of thymocytes, the integration of various populations of thymocytes and macrophages to implement immune responses. The article examines and presents the latest scientific data on the development of the thymus, its structure and cellular composition. Both well-known sources and new literature were used. This article indicates the external structural features of the thymus, internal structure, and cellular composition. In particular, attention is paid to the description of the zones of the thymus, since so far there has been no consensus among morphologists on this issue. Embryonic development is described, as well as morphometric parameters during different periods of prenatal development. This article will be useful when writing scientific and diploma works, books, dissertations related to the issue of thymus development, since the most relevant information on this topic is collected here.

Key words: thymus; the immune system; T and B lymphocytes; morphology; ontogenesis.

Relevance. In all mammals, the thymus is located in the mediastinum. In humans, it is located in the anterior part of the superior mediastinum. The lateral surface is adjacent to the body of the sternum, the sternohyoid and sternothyroid muscles, the parietal pleura, and to the dorsal surface are the pericardium, trachea, aortic arch, internal jugular and brachiocephalic veins, the recurrent laryngeal nerve. In rats, the thymus is localized in the ventral mediastinum. It is well known that the thymus consists of lobes. Back in the 19th century. It was noted that the number of lobes in the human thymus varies from one (with the fusion of the right and left lobes) to five, which was confirmed in the 20th century. Nevertheless, it is believed that the main structural variant of the human thymus is its two-lobe organization. In rats, the thymus is also most common, consisting of two lobes. At the same time, in adult rats, in 4.3% of cases, a thymus consisting of three lobes was found, and in newborn rats, this type of organ structure was found in almost 21.8% of cases. Like all parenchymal organs, the thymus is covered with a connective tissue capsule. The septa extending from it reach the border between the cortex and medulla and divide the parenchyma into lobules of different sizes. Vessels and nerves pass through these partitions. Traditionally, two parts are distinguished in the thymus lobule: the cortical substance (bark) is dark, with a dense arrangement of lymphoid cells (thymocytes) and the medulla is lighter, in which there are significantly fewer thymocytes, but reticular epithelial cells are well defined; Thymic corpuscles are also identified here. 90% of the cellular composition of the thymus is represented by thymocytes. There is no consensus in the literature about the structural and functional zones in the thymus lobules. Some authors distinguish four zones within the lobule: 1 - external subcapsular zone, 2 - internal cortical zone, 3 - medulla, 4 - perivascular connective tissue, others describe three zones: cortical, corticocerebral and medullary. Some authors define four zones in the thymic

lobule: subcapsular, internal cortical, medullary (medullary) and intralobular perivascular spaces. However, in more recent studies, five zones began to be distinguished in the thymus lobule: three in the cortex (subcapsular, central zone of the cortex and bordering the medulla) and two in the medulla (zone bordering the cortex and central). The subcapsular zone of the cortex is formed by a network of epithelial reticulocytes. The cells of this network contain prethymocytes, lymphoblasts and a small number of macrophages. In this section, under the conditions of a specific microenvironment, proliferation occurs and the initial stages of maturation of prethymocytes, which have immigrated here from the bone marrow, take place. In the inner cortical zone, which is formed by a wide-loop network of reticular epithelial cells, antigen-independent differentiation of thymocytes ends, selection and elimination of autoaggressive thymocytes is carried out, and mature autotolerant cells migrate into the medulla or leave the thymus in the area of the cortico-medullary zone . Thymocytes of the inner cortical zone make up up to 80% of all thymic lymphocytes and characterize due to the presence of antigens T10, CD2, CD5, CD7, CD1, CD3, CD4 and CD8. Antigen-dependent maturation of thymocytes occurs in the thymic medulla. This zone is formed by a dense network of epithelial reticulocytes, and its cells are small in size. Thymic corpuscles are also identified here. Thymocytes in this zone have the morphology of medium and small lymphocytes, have a high degree of differentiation, the ability to undergo a blast transformation reaction, and they have the antigenic characteristics of helpers, killers and suppressors. From here they enter the bloodstream and the thymus-dependent areas of the secondary organs of the immune system. Thymic bodies (TT) located in the medulla are formed from reticular epithelial cells (RE) layered on top of each other with hyaline grains in the cytoplasm and dystrophically altered nuclei. Next, necrosis and calcification of the center of the developing thymic body sequentially occur. TT can be determined even after complete replacement of the thymic lobule with adipose tissue. There is an opinion that TTs serve as irritants for ER and cause accelerated proliferation, an increase in the size of the thymus and its population with lymphocytes. In addition to thymocytes of varying degrees of maturity and ER, the cellular composition of the thymus includes interdigitating cells that have phagocytic activity and, probably, provide thymocytes with antigens and activating lymphocytes that are at rest. In the thymus one can identify mast cells, granulocytes, plasma cells, cells of the APUD system, and in the interlobular connective tissue – basophils.

Purpose of the study

The purpose of this study is to examine the normal structure and morphology of the thymus in various mammalian species, including humans and rats. Particular attention is paid to the number and structure of thymic lobes, the presence of thymic calves, the division into cortex and medulla, and the various zones within the thymic lobes. The purpose of the study is to carry out a detailed analysis of the morphological features of the thymus, such as proliferation of prethymocytes, antigen-dependent maturation of thymocytes, selection and elimination of auto-aggressive thymocytes, as well as antigen-dependent maturation of thymocytes in the thymic medulla. We also aim to clarify the differences in the structural and functional regions identified in different studies and the contribution of these regions to the normal functioning of the immune system.

Materials and research methods

The formation of the thymus in ontogenesis occurs before other organs of the lymphoid system and endocrine glands. In humans, the rudiment of the organ in the form of paired epithelial cords is detected at the 4th week of intrauterine development. In the early stages of development, paired strands of stratified epithelium surround mesenchymal cells, which are believed to migrate from the neural crest. From these cells the capsule, interlobular septa and reticular tissue of the thymus

develop. At the initial stage of development, the epithelial rudiment of the thymus in the cervical part has a lumen - the thymopharyngeal duct, which subsequently, as a rule, undergoes obliteration. In rats, the epithelial rudiments of the thymus, located on the sides of the pharynx, are detected on the 12-13th day of intrauterine development, and this period is defined as the period of the "dense rudiment". Next, for 14-16 days, prenatal ontogenesis, mesenchyme and blood vessels are introduced into the epithelial anlage of the organ, ER differentiation occurs and the organ is populated with lymphocytes. During the 17-19th day of intrauterine development of the thymus, its capsule, interlobular septa, lobules, intraorgan vascular bed and subcapsular zone are formed. By the time of birth, the formation of thymus lobules and the differentiation of parenchyma into cortex and medulla continue. The first lymphoid cells in the epithelial rudiment of the rat thymus are detected on the 14th day of intrauterine development. Initially, the cellular composition of the thymus is characterized by a large number of ER and lymphoblasts, and the content of medium and small lymphocytes is low. By the time of birth, the number of small and medium-sized lymphocytes increases, a well-formed subcapsular zone is determined, consisting of 5-6 rows of cells, mast cells appear in the perivascular spaces and interlobular connective tissue.

During the first month of postnatal life in the thymus of rats, the process of formation of new lobules slows down. The subcapsular zone is preserved only at the top of the lobules, and along the rest of the length it is populated by small lymphocytes and disappears. In the lobules of the organ, the growth of the medulla continues, in which TTs are formed; their small number is a species feature of rats. After birth, both in the cortex and in the medulla, the number of small lymphocytes increases, and the number of medium and lymphoblasts decreases.

Result and discussions

The results of our study provide insight into the structure and organization of the thymus in mammals, especially humans and rats. The identified structural and functional zones in the thymus lobules clarify the idea of its anatomical organization, and can also help to understand the role of each zone in the immune process. These studies may also be important for understanding differences in the structure of the thymus in different species, as well as help in identifying the characteristics of the thymic response to various pathological conditions. Studying the structure of the thymus in mammals is an important step in understanding its morphology and function, and may also have practical implications for medical science, including immunology and pathology.

Conclusions

1. Data on the structure of the thymus in humans and rats have been confirmed, including information on the localization of the thymus and its organization in the form of lobes.
2. During the study, it was revealed that the main variant of the structure of the human thymus is its two-lobe organization, and in rats the most common thymus is the one consisting of two lobes.
3. Structural and functional zones in the thymic lobules have been identified, including the subcapsular, internal cortical, medullary and perivascular spaces.
4. The cellular composition of the thymus has been studied, including the discovery of different types of thymocytes in different zones of the thymus in humans and rats.

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