SCHOLASTIC:
Journal of Natural and Medical Education
Volume 2, Issue 5, Year 2023 ISSN: 2835-303X
https://univerpubl.com/index.php/scholastic

Structurally-Morphological Development of the White Rat Thymus in Postnatal Ontogenesis

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Article Information

Received: March 15, 2023
Accepted: April 13, 2023
Published: May 6, 2023

Keywords
thymus; immune system; morphology; postnatal ontogenesis..

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 for the implementation of 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 describes the external features of the thymus structure, internal structure, and cellular composition.

The thymus is the central or primary organ of the lymphoid (immune) system. As is known, its main functions are to ensure the maturation and differentiation of thymocytes, the integration of various populations of thymocytes and macrophages for the implementation of immune responses. The morphofunctional state of the central organ largely determines the activity of secondary (peripheral) structures of immunogenesis and the severity of protective reactions of the entire body.

Currently, knowledge of the structural features of the organs of the immune system and determination of the beginning of differentiation of immunocompetent cells in different stages of ante-and postnatal periods of ontogenesis is limited. It allows us to understand the processes of formation of immunological functions characteristic of these organs.

Research objective The aim of the study was to study the dynamics of formation of the microanatomic organization of the thymus gland in white rat pups in the antenatal and early postnatal periods of development. The conducted studies allow us to better understand the patterns of structure and development of organs of immunogenesis, allowing us to standardize morphological data in the process of physiological ontogenesis.

In all mammals, the thymus is located in the mediastinum. In humans, it is located in the anterior part of the upper mediastinum. The body of the sternum, sternohyoid and sternohyroid muscles, parietal pleura are attached to its ventral surface, and the pericardium, trachea, aortic arch, internal jugular and brachiocephalic veins, and recurrent laryngeal nerve are attached to the dorsal surface. 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 (when the right and left lobes merge) to five, which was confirmed in the XX century. Nevertheless, it is believed that the main variant of the structure of the human thymus is its two-lobed organization. Rats also have the most common thymus, which consists of two lobes. At the same time, the thymus consisting of three lobes was found in adult rats in 4.3% of cases, and such a variant of the organ structure was found in newborn rats 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 cortical and medulla and divide the parenchyma into lobules of various sizes. Blood vessels and nerves pass through these partitions. Traditionally, two parts are distinguished in the thymus lobule: the cortical substance (cortex) — dark, with a dense arrangement of lymphoid cells (thymocytes) and the brain substance — lighter, in which there are significantly fewer thymocytes, but reticular epithelial cells are well defined; thymic bodies are also detected here. 90 % cellular composition of the thymus it is represented by thymocytes. There is no consensus in the literature on structural and functional zones in thymus lobules. Some authors distinguish four zones within the lobule: 1-external subcapsular zone, 2-internal cortical zone, 3-medullary substance, 4-perivascular connective tissue [1], others describe three zones: cortical, cortical-cerebral and medullary [2]. Some authors define four zones in the thymus lobule: subcapsular, internal cortical, medullary (medulla) and intralobular perivascular spaces. However, in more recent studies, five zones were identified in the thymus lobule: three in the cortical substance (subcapsular, central zone of the cortex and border with the medulla) and two in the medulla (zone bordering the cortex and central) [3]. 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 [4]. In this section, under conditions of a specific microenvironment, proliferation occurs and the initial stages of maturation of prethymocytes that have migrated here from the bone marrow pass.

In the inner cortical zone, which is formed by a broad-layered network of reticular epithelial cells, antigen-independent thymocyte differentiation ends, autoaggressive thymocytes are selected and eliminated, and mature autolerant cells migrate to the medulla or leave the thymus in the cortical-medullary zone [5]. Thymocytes of the inner cortical zone account for up to 80 % of all thymus a lymphocytes and are characterized by the presence of T10, CD2, CD5, CD7, CD1, CD3, CD4, and CD8 antigens [6]. In the medulla of the thymus, antigen-dependent maturation of thymocytes is carried out. This zone is formed by a dense network of epithelial reticulocytes, and its cells are small in size. Thymic bodies are also defined here. Thymocytes of this zone have the morphology of medium and small lymphocytes, have a high degree of differentiation, the ability to react to blast transformation, they are characterized by antigenic signs of helpers, killers and suppressors. From here, they enter the bloodstream and thymus-

dependent zones of the secondary organs of the immune system [7]. Thymic corpuscles (TT), which are defined in the medulla, are formed from reticular epithelial cells layered on top of each other (RE) with hyaline grains in the cytoplasm and dystrophically altered nuclei. Further, necrosis and calcification of the center of the forming thymic body sequentially occur. TT can be detected even after complete replacement of the thymus lobule with adipose tissue [8]. There is an opinion that TT serve as stimuli for RE and cause accelerated proliferation, an increase in the size of the thymus and its colonization by lymphocytes [9]. In addition to thymocytes of various degrees of maturity and RE, 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. Mast cells, granulocytes, plasmocytes, and APUD cells can be detected in the thymus, and basophils can be detected in the interlobular connective tissue [10]. The formation of the thymus in ontogenesis occurs earlier than other organs of the lymphoid system and endocrine glands. In humans, the germ of an organ in the form of paired epithelial strands is detected at the 4th week of intrauterine development [11]. In the early stages of development, paired strands of multilayered epithelium surround mesenchymal cells thought to migrate from the neural crest. From these cells develop a capsule, interlobular septa and reticular tissue of the thymus [12]. At the initial stage of development, the epithelial rudiment of the thymus in the cervical part has a lumen — the thymopharyngeal duct, which later, as a rule, undergoes obliteration. In rats, epithelial rudiments of the thymus located on the sides of the pharynx are detected on the 12th-13th day of intrauterine development, and this period is defined as the period of" dense rudiment " [4, 13], which subsequently, as a rule, undergoes obliteration. In rats, epithelial rudiments of the thymus located on the sides of the pharynx are detected on the 12th-13th day of intrauterine development, and this period is defined as the period of" dense rudiment " [13]. Further, during 14-16 days of prenatal ontogenesis, mesenchyme and blood vessels are introduced into the epithelial lining of the organ, RE differentiation occurs, and the organ is populated with lymphocytes [4]. During 17-19 days 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 thymic lobules and differentiation of the parenchyma into the cortex and medulla continue. The first lymphoid cells in the epithelial bud 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 RE and lymphoblasts, and the content of medium and small lymphocytes is low. By the time of birth, the number of small and medium lymphocytes increases, a well-formed subcapsular zone consisting of 5-6 rows of cells is determined, and mast cells appear in the perivascular spaces and interlobular connective tissue [13].

During the first month of postnatal life, the process of forming new lobules in the rat thymus slows down. The subcapsular zone is preserved only at the top of the lobules, and the rest of the length is populated by small lymphocytes and disappears. In the lobules of the organ, the growth of the brain substance continues, in which TT is formed, their small number is a specific feature of rats [2]. After birth, both in the cortical substance and in the medulla, the number of small lymphocytes increases, while the number of medium and lymphoblasts decreases [4, 13,

14]. Thus, the formation of the main structures of the thymus occurs in humans at the 17th week of intrauterine development, and in rats it continues in the postnatal period of ontogenesis.

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