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Structural and Functional Features of the Thymus Under Some Impacts

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Abstract: The article is devoted to the study of the protective and compensatory mechanisms of the thymus, that is, the study of its adaptive reactions to antigenic and non-antigenic effects. These changes are based on the structural and functional response to stress.
Key words: thymus, antigenic and non-antigenic stimulation, infectious process.

Relevance. The thymus, being the central organ of the immune system, takes an active part in the adaptive reactions of the body under various influences [11, 12, 14, 45, 46, 55]. Its close relationship with the nervous, endocrine, and other body systems determines the leading role of the thymus in maintaining body homeostasis [2, 4, 5, 6, 26, 50]. As is known, the thymus has a pronounced endocrine function associated with the synthesis and secretion of a number of hormones. It has been established that the functional activity of the thymus is closely related to the endocrine system, primarily to the adrenal cortex [13, 33, 34]. Other hormones produced by the hypothalamus and pituitary gland also have a significant effect on the organ [5, 55]. All this allows us to conclude that the thymus is one of the leading links that ensure the body's homeostasis in physiological and pathological conditions [3, 7, 8, 9, 53, 54].

Hence, the great interest in the study of structural and functional rearrangements of the thymus under various experimental influences and pathologies is understandable [11, 25, 26]. Until now, the issues of the structural and functional development of the thymus in the period of early postnatal ontogenesis, when the immune system of the newborn, as well as the whole organism, remains immature [1, 2, 6, 11, 25]. In addition, the issues of the influence of extragenital pathology of the mother, in particular, diseases of the hepatobiliary system, on the development of offspring remain relevant today [10, 16, 18, 20, 21, 24, 37, 38, 39, 51, 56], in the pathogenesis which, one of the main mechanisms of pathological effects is the occurrence of autoimmune processes, on the structural and functional formation of the organs of the immune system of the offspring, including the thymus [15, 17, 19, 22, 23]. An analysis of literature data shows that structural and functional rearrangements in the thymus under the influence of various stress factors are generally of the same type [25, 26, 27, 55]. Thus, various effects of a non-antigenic nature (hypo- and hyperthermia, hypoxia, etc.) during the first day cause an increase in the mass of the thymus and the number of cells in them [7, 8, 11, 13]. At the same time, the severity of morphological changes depends on the nature of stress factors, the duration and frequency of their action. In the future, depending on the nature of the impact, morphological changes in the thymus can progress, or, on the contrary, normalize.

Consequently, the impact of non-antigenic stress factors in the early period is accompanied by certain adaptive rearrangements in the thymus. In the development of which, the interaction of the

thymus with other organs of the endocrine system plays a significant role [5, 6, 11]. During this period, morphological changes in the thymus can be considered as one of the manifestations of the general adaptation syndrome [1, 5]. An increase in the level of glucocorticosteroids plays a certain role in reducing the mass of the thymus and the density of distribution of cells in it under stress. It is believed that under the influence of glucocorticosteroids there is an increase in the migration of T-lymphocytes from the thymus, causing a decrease in the mass of the organ [13, 25].

Of considerable interest is the study of structural and functional rearrangements in the thymus under various antigenic influences and infectious processes [2, 3,]. This is due to the fact that the thymus plays a regulatory role in the development of the immune response to antigens of tissue, bacterial, or artificial origin [30]. Under antigenic action, structural and functional changes in the thymus are distinguished by a certain dynamics of the course, which corresponds to the stages of the formation of the body's immune response. The early period of antigenic exposure is characterized by a stereotyped thymus reaction, similar to that under the influence of stress factors. Thus, when animals are immunized with ram erythrocytes, a decrease in the mass of the thymus and the number of cells in it is observed on the first day [31, 32]. Subsequently, morphological rearrangements develop in the thymus, the nature of which depends on the type of antigen and the frequency of exposure [32, 34]. Repeated immunizations of guinea pigs with various vaccines lead to the development of a certain reaction in the thymus, covering the entire cell population of the organ [43]. At the same time, after the first immunization, the content of reticular cells significantly increases, and repeated immunization leads to a decrease in the number of these cells to control values. The number of macrophages throughout remains elevated. The number of lymphoblasts after the first immunization initially decreases, and by 24 hours increases. Repeated immunization is accompanied by a persistent decrease in the number of lymphoblasts [32, 44].

Changes in the cellular composition of the thymus during antigenic exposure are accompanied by ultrastructural rearrangements of its cells. Thus, when rats were injected with hemolytic streptococcus, an increase in the number of lysosomes in macrophages, hyperplasia of organelles and secretory vacuoles in reticuloepithelial cells was found [42]. The initial periods of antigenic exposure are characterized by pronounced ultrastructural changes in the vascular cells of the thymus microvasculature [44]. They manifest themselves in the form of activation of endothelial cells, thinning of the basement membrane and the disappearance of its fibrillar components, which indicates a change in the permeability of the thymus vascular wall under the action of antigens. It is believed that ultrastructural changes in the thymus in the early period of antigenic exposure are nonspecific in nature and are a response to the action of a stress factor. Subsequently, some specific ultrastructural rearrangements develop in the thymus, covering both thymocytes and cells of the thymic microenvironment. Antigenic effects lead to significant changes in intracellular metabolism in the thymus [5, 6]. They are expressed in an increase in the activity of redox enzymes in reticuloepithelial cells and macrophages. In addition, the metabolic activity of thymocytes and vascular epithelial cells increases significantly. All this is accompanied by an increase in the number and intensification of degranulation of tissue basophils [7, 8, 11, 25]. The nature of structural and functional adaptive rearrangements in the thymus largely depends on the type of antigen used for immunization. Immunization of mice with a cell suspension of a heterogeneous spleen is accompanied by the development of a systemic transfer reaction in the thymus [55]. It is revealed in the form of intensive destruction of thymocytes of the cortical substance, which is accompanied by increased phagocytosis of thymocytes by macrophages. The process of phagocytosis proceeds most intensively in the cortico-medullary zone of the organ and gradually spreads deep into the cortical substance. On days 3–5 of immunization, there is an

increase in the mitotic activity of lymphoblasts in the subcapsular zone, which is subsequently replaced by inhibition of mitosis in these cells [6, 13, 54].

Immunization of animals with various antigens of a bacterial nature is characterized by certain structural and biochemical rearrangements of lymphocytes migrating from the thymus. At the same time, the biochemical composition of lymphocyte membranes changes, which is accompanied by ultrastructural changes in cells in the form of an increase in the number of ribosomes and lysosomes. According to the author, the activation of lymphocytes migrating from the thymus is associated with an increase in the functional activity of the epithelial cells of the organ under the influence of the antigen [47, 48, 49, 52].

The foregoing shows that by now a sufficient number of works have accumulated that illuminate the structural and functional aspects of the thymus reaction during immunization of the body with one or another antigen. However, the analysis of the literature shows That similar studies of the thymus during the development of an infectious process in the body are few and contradictory [11, 55].

The infectious process has always been considered from the standpoint of the relationship between macro- and microorganism [55]. On the other hand, the microorganism was sometimes assigned a decisive role, in connection with which the approach to understanding this problem seemed very one-sided. This approach mainly consisted in studying the virulence of the microorganism, adapting the pathogen to the ability to hematogenous dissemination, etc. Attempts were repeatedly made to serological, biochemical, physicochemical characteristics of the infectious process, and at the same time, the role of the microorganism itself in this process was completely overlooked [12, 13, 30, 31].

At present, the immunological characterization of a number of infectious diseases has been quite widely and fully developed, and the role of the immune system in the infectious process is being studied [28, 29]. However, the problem of the reaction of immune organs to infectious agents, morphological and functional characteristics of the state of these organs during the infectious process began to be taken into account by researchers relatively recently [35, 36, 40, 41, 42].

The role of the thymus in the infectious process is indisputable [11]. A number of authors have shown that the infectious process is accompanied by a certain dynamics of structural and functional rearrangements of the thymus, which reflect the essence of the adaptive relationship between the macro- and microorganism [12, 13]. The study of the thymus in experimental tuberculosis revealed that in the initial period of the infectious process there is a pronounced decrease in the number of thymocytes in the cortical substance, which is accompanied by an increase in their death. Further morphological changes in the thymus depend on the nature of the development of a specific process in the lungs. The growth of destructive changes in the lungs is accompanied by a progressive involution of the thymus, and the limitation of the pathological process is characterized by a gradual increase in the number of thymocytes in the cortex. A similar relationship between the nature of the course of experimental tuberculosis and structural changes in thymus cells was established during electron microscopic studies. Infection of mice with a pathogenic strain of Fracisella tularensis is accompanied by a decrease in thymus mass and a decrease in the number of cortical thymocytes. The decrease in the number of thymocytes in this case proceeds in parallel with an increase in the concentration of glucocorticosteroids in the blood plasma and the destruction of thymus-dependent zones of the peripheral organs of the immune system. The authors believe that changes in the thymus in the dynamics of the infectious process are most pronounced in old animals compared to young mice. Similar changes in the thymus of white mice were also found in the dynamics of experimental listeriosis infection. Similar changes in the

thymus of white mice were also found in the dynamics of experimental listeriosis infection [24, 26, 27].

Thus, to date, there are numerous works devoted to the structural and functional bases of the thymus reaction under antigenic influences. At the same time, most of them present the results of morphological studies of the thymus during immunization with one or another antigen. Only a few works are devoted to the study of the thymus in the dynamics of the infectious process, although immunological changes in many infections are covered quite widely.

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