

Morphogenesis of lymph nodes in Muscovy ducks during early postnatal ontogenesis

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Received: 25.09.2020. Accepted: 29.10.2020

The dynamics of mass and linear parameters of lymph nodes of ducks is a direct reflection of structural and functional transformations of their lymphatic parenchyma. The peculiarities of quantitative dynamics of tissue components of peripheral lymphatic organs at early stages of postnatal ontogenesis are to a great extent determined by advanced growth rates of their absolute mass against the background of sharp increase of their antigenic stimulation intensity. Parenchyma of lymph nodes of newborn ducklings is characterized by relatively low degree of differentiation and is represented by diffuse lymphatic tissue with no pronounced signs of its division into separate functional zones. Internally, the lymphatic channel is represented by only two lymphatic sinuses - the central one, which is located in the central part of the organ and occupies a large relative area and a discrete edge sinus, which borders on the node capsule and has a much smaller relative area and, accordingly, is located at its periphery. The organ parenchyma is a diffuse cluster of stromal and lymphatic cells in the enlarged lymphatic vessel between the central (inner) and edge (outer) lymphatic sinuses, without signs of its division into cortical and brain matter. Among the lymphatic tissue of the lymph node, reticular stroma cells and the population of small lymphocytes have the largest relative amount.

Keywords: muscovy duck, lymph node, parenchyma, lymphatic sinus, reticular stroma.

Introduction

Lymph node is one of the most modern forms of development of lymphatic structures in vertebrate animals. That is why it is of great importance to study the morphogenesis peculiarities of the parenchyma morphogenesis of these organs, which are characteristic only for separate representatives of this class (species of waterfowl) in the bird. A number of scientific works (Berezina, 1988; Krasnikov, Keleberda, 2000; Melnik, 2003) are devoted to the study of the structure and regularities of morphogenesis of lymph nodes in birds, but most of the aspects of postnatal morphological organization of these organs are still controversial and not finally clarified. In birds, the lymphatic tissue is widely represented throughout the body and, in addition to the main lymphatic organs (thymus, spleen, Fabricia bag), finds itself in digestive organs, airways, eye envelopes, bone marrow, liver, kidneys, and other organs (Chomych et al., 2004, 2005; Kolich, 2004). Aspects of morphogenesis and morphofunctional transformations of peripheral lymphatic organs in birds are less studied, especially lymph nodes. There is no common opinion about the nature of the intra suture lymph in the structure of the intra suture lymphatic channel of birds, and there is no explicit evidence of structural-functional differentiation of the parenchyma of lymph nodes and, accordingly, the presence of morphofunctional integrated units - compartments and segments, typical for mammals.

The study of the evolution of lymphomyeloid and lymphatic tissues and their immunoclitinoid reactivity is necessary, first of all, to clarify objective criteria of the regularities of their morphofunctional organization (Roit, 2000; Mebius, 2003; Von Andriach, 2003; Seleznev, 2010). Evolutionary morphology using triple parallelism methods together with historical and system approaches allows to determine possible ways of evolution of animal organs and tissues, and also allows to trace their structural and functional transformations in phylogeny (Mempel, 2004; Maslianko, Vengrin, 2004; Krishtoforova, Khrustaleva, 1994). In vertebrate animals, cytotypes and organotypes of the stages of phylogenetic formation of lymphoid tissue and its immunoclitinoid reactivity have been studied in more detail, which is proved by the works of many authors (Borodin et al. 1985; Krasnikov, 2000; Gavrilin, 2002).

Another characteristic feature of the process of lymphatic tissue evolution is the appearance of lymph nodes in birds, but only in waterfowl representatives (Sugimura, Hashimoto, 1977; Berezina, 1998). Most researchers argue that geese and ducks have two pairs of lymph nodes: cervicothoracic nodes or lymph nodes in chest and neck that belong to the cervical lymph duct and lumbar duct or lumbar lymph nodes located in close proximity to abdominal aortic gonads. In the study of lymphatic tissue in different classes of birds, Florensov and Pestova (1990) distinguished in waterfowl species, among lymphatic formations five forms: lymphatic perivascular infiltration, lymphatic perivascular follicle, lymphatic plaque, non-incapsulated and encapsulated node. The node has no sinus, as the author believes, because the lymph vessels entering the parenchyma of the node do not

branch, and fall into a large lymph vessel, which runs along the node in the center or a few from the side. The parenchyma of such a lymph node is represented by a diffuse lymphatic tissue, which is located in the spaces between the lymphatic vessels, closer to which the formation of lymphatic follicles (lymph nodes), among which there are "light centers. The data on age-related transformations of bird lymph nodes typical only for waterfowl representatives of this class of vertebrates are especially scarce. To date, largely unknown regularities of postnatal transformations of the parenchyma reticular axis, changes in the ratio of diffuse and nodular components of the parenchyma, the dynamics of cellular composition of its individual sites.

Absence of basic data on the principles of peripheral lymphatic organs structure in birds is a limiting factor for wide application of modern immuno and cytochemical methods for deeper studies of specific features of their structural and functional organization. This fact will turn a special meaning for morphological substantiation of efficiency and expediency of using technologies of intensive artificial antigenic stimulation of organs of immunity of birds, it is easier connected with the use of "saturated" schemes of vaccination of young birds in conditions of industrial poultry farming.

Materials and methods

The research was carried out in the morphological research department of the research center of biosafety and ecological control of resources of agroindustrial complex of Dnieper State Agrarian and Economic University. The research material were the lymph nodes in chest and neck of clinically healthy ducks of muscovy breed. The poultry were grown in vivarium conditions, feeding was carried out according to the existing norms, prophylactic vaccinations and antiparasitic treatments were not conducted.

For the morphological studies by anatomical preparation we selected lymph nodes in chest and neck from 1-, 5-, 10 and 15-day Muscovy ducks ($n = 5$). Absolute mass of organs was determined by means of "Tehniplot-WTW" scales with an accuracy of 0.002 mg. Linear measures (length, width) of lymph nodes were determined with the help of a rod-circle and a ruler of centimeters with the price of division of 1 mm. To determine the peculiarities of the architectonics of the intra suture lymphatic channel of lymph nodes were carried out indirect and direct injection of pre-bar lymphatic vessels in the neck and head area with a suspension of black carcass on gelatin gel.

Native fixation and injection with suspension of the carcass of lymph nodes for microscopic studies was carried out in stages: first in 5% solution of neutral formalin during 5 days, then in 10% solution of neutral formalin during 10-14 days with subsequent storage of material in this solution during the whole period of morphological studies. Fixed material was washed in running water for 12:00, znevodnyuvaly in alcohols of increasing strength and kept in solutions of histological paraffin. Paraffin histological slices (5-7 μm for examination preparations and histological examination, 3-5 μm for cytological examination) were manufactured with the help of the MS-2 slide microtome. To preserve the integrity of histological slices and their better fixation on the slide, a solution based on animal blood plasma was used. The obtained histological slices were stained with hematoxylin Ehrlich and eosin; and azure II- eosin according to the generally accepted methods.

Peculiarities of localization within the parenchyma of organs and syntopy of functional zones of lymph nodes (cortical plateau, paracortical zone or complex of deep cortical units, lymph nodes, brain tractions) were shown using the technique of impregnation of frozen slices with nitrous-oxide silver by Foot. Frozen histological slices of lymph nodes with thickness of 10-20 μm were made on microtome-chryostat MK-25 at temperature 16-18 $^{\circ}\text{C}$ below zero. For the better fixation of lymph nodes, we used 4% aqueous gelatin solution. To prevent the destruction of the organ when cut on its surface, we applied the glycerine-gelatin mixture.

Histological preparations were studied using Olympus CH-20, CB-41 light microscopes (eyepiece 10x; lens 10x, 40x, 100x) and a biological stereoscopic MBS-10 microscope (with eyepiece 8x, from 4x to 7x). Quantitative morphological analysis of structural components was carried out using the "spot-count" method using point test systems (inserts) according to G.G. Avtandilov (3 measurements on 5 drugs of each group).

The relative area of tissue components was calculated by formula:

$$S = \frac{P_i}{P_t} \times 100 \%,$$

where S is the relative area of the structural component of the organ on the area of the whole histopreparation, %; P_i - the number of points falling on the structural component of the organ, pcs; P_t - the total number of points falling on the area of the whole histopreparation, pcs.

The absolute size of lymph nodes in the lymph node was determined with the help of the MBS-10 stereoscopic microscope and an insert scale embedded in the lens (8x, 7x). Percentage ratio between individual cells of the lymph node parenchyma (large, medium and small lymphocytes, plasma and reticular cells, macrophages and granulocytes) in individual functional areas of the lymph node parenchyma was performed by differential counting of 100 cells at thousands of times magnification using an immersion lens on 5 histological lymph nodes of each age group using the "Olympus CH-20" light microscope.

Statistical processing of data was performed using Statistica v. 10 software. The figures were done from histological preparations and their separate areas using a digital camera and a microscope "Leica DM 1000".

Results and Discussion

Changes in morphometric parameters of lymph nodes in early postnatal ontogenesis are primarily due to the quantitative dynamics of their immunocompetent structures. The dynamics of mass and linear parameters of lymph nodes of ducks during the first days of life is a mediocre reflection of structural and functional transformations of their lymphatic parenchyma. In daily

ducks, the absolute mass of lymph nodes in chest and neck does not exceed 0.003 ± 0.0001 g, and the relative mass (in relation to body weight) - $0.007 \pm 0.0001\%$. In the 5-day ducklings, the absolute mass of lymph nodes does not change significantly and remains at the level of daily. Relative mass decreases by 25%. In 10-day ducklings there was an increase in absolute weight and relative weight. Thus, the absolute mass increases by 1.33 times, its growth rate is 33.4%, and the relative mass increases by 1.17%.

The peculiarities of quantitative dynamics of tissue components of peripheral lymphatic organs at early stages of postnatal ontogenesis are to a great extent determined by advanced growth rates of their absolute mass against the background of sharp increase in intensity of their antigenic stimulation. Determination of the nature of age-related changes in the relative area of parenchyma and stroma of lymph nodes in muscle ducks during the first days of their life is necessary to find out the peculiarities of quantitative dynamics of the two main tissue components of organs during the most pronounced structural and functional transformations.

In newborn ducklings parenchyma of lymph nodes in chest and neck is a diffuse lymphatic tissue and its relative area is $50.72 \pm 0.44\%$. Stroma of lymph nodes of newborn ducklings is represented by a dense unformed fibrous fabric that consists of a capsule and a few trabecule, its relative area is $29.17 \pm 0.78\%$.

In the lymph nodes of 5-day ducklings increases the relative area of lymphatic parenchyma by 6.09%, against a background of a decrease in the relative area of connective tissue stroma by 2.43%. In the lymph nodes of 10-day ducklings nature of the dynamics of the relative area of lymphatic parenchyma and connective tissue stroma similar to changes in stromal-paranchymatous relationships in the lymph nodes of 5-day ducklings. The relative area of lymphatic parenchyma increases by 4.83%, and the relative area of connective tissue stroma, on the contrary, decreases by 4.20%.

In the lymph nodes of 15-day ducklings there is a decrease in the relative area of lymphatic parenchyma by 8.24%. The relative area of connective tissue stroma on the contrary increases by 3.81%. The implementation of the function of antigenal immunocytogenesis by peripheral lymphatic organs of mammals and poultry is performed by discrete or zonal principle (Gavrilin et al., 2017). Effective and antitylosynthetic lymphocytes are formed in isolated specialized areas of spleen parenchyma, lymph nodes and lymphatic structures of mucous membranes (Chomych, Mazyrkevich, 2011).

The formation of the zonal structure of the parenchyma of secondary lymphatic organs is one of the most informative morphological criteria for the formation of its immunobiological function in early postnatal ontogenesis. The parenchyma of lymph nodes of newborn ducklings at the tissue level of structural organization is characterized by a relatively low degree of differentiation and is represented by diffuse lymphatic tissue without any pronounced signs of its subdivision into separate zones, the relative area of which is $50.72 \pm 0.44\%$. Inside the node lymphatic channel lymph nodes of daily ducklings is represented by edge (subcapsular) and central lymphatic sinuses, the relative area of which is $5.99 \pm 0.53\%$ and $13.91 \pm 0.57\%$, respectively.

Starting from the 5th day of age, ducklings have a parenchyma distribution of lymph nodes, according to the signs of different lymphocyte density into two diffuse zones - cortical and brain (Fig. 1). Relative cortical area is $36.04 \pm 0.44\%$, and relative brain area is $20.77 \pm 0.42\%$.

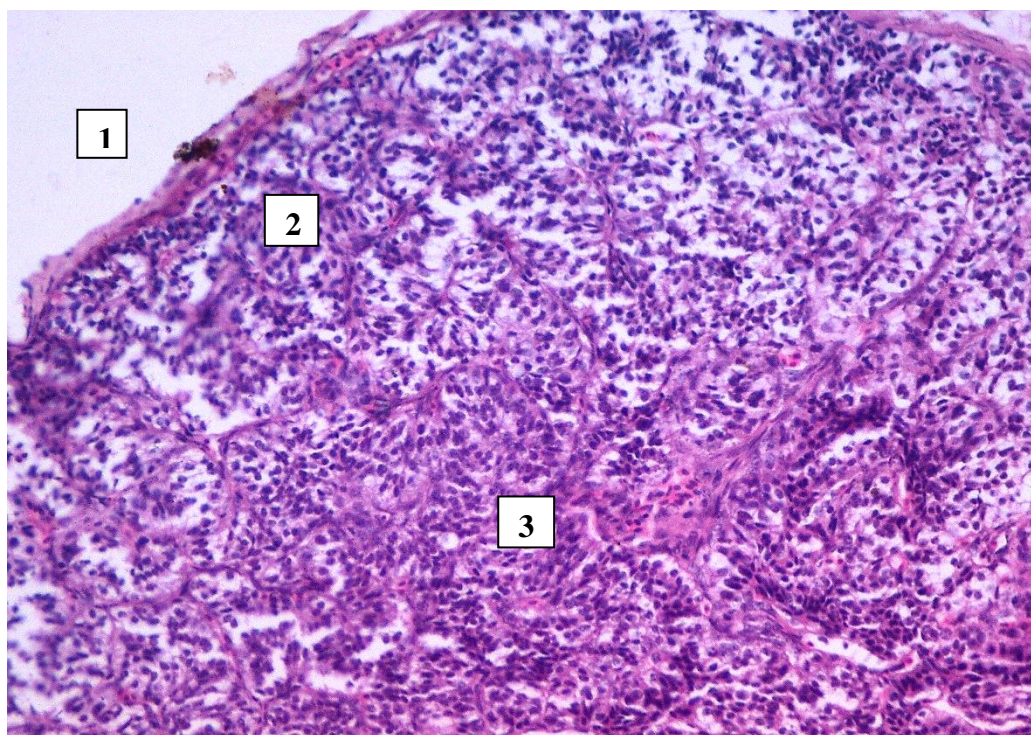


Fig. 1. Histological preparation of chest-lymph node of 5-day duck. Coloring with hematoxylin and eosin, $\times 400$. 1 - capsule; 2 - brain matter; 3 - cortical matter.

The total capacity of the intra suture lymphatic channel of 5-day ducklings decreases (by 9.45%). The relative area of the central lymphatic sinus decreases more significantly (by 7.68%). The relative area of the lymphatic edge sine decreases only (by 1.77%).

In the lymph nodes of the 10-day ducklings, the dynamics of the two main diffuse zones of parenchyma is characterized by a significant reduction in the relative cortical area (by 16.83%) with a simultaneous significant increase in the corresponding brain matter index (21.66%). The relative area of the inchoate lymphatic channel does not change significantly during this period, but the relative area of the central lymphatic sine tends to decrease, while the relative area of the marginal lymphatic sine increases. By the 15-day age of ducklings in the parenchyma of the lymph node there is a decrease in the relative area of both cortex and brain matter by 2.00% and 6.24%, respectively. The character of the dynamics of the intra suture lymphatic channel of the lymph nodes of ducklings up to 15-day-old remains unchanged, but the intensity of changes in the relative area of lymphatic sinuses is more significant. The relative area of the central lymphatic sinus decreases (by 3.94%), the relative area of the marginal sinus increases (by 3.29%), and the total capacity of the intra-node lymphatic channel decreases due to the redistribution of the relative capacity between the two lymphatic sinuses (by 0.65%).

Lymph nodes in chest and neck of Muscovy ducks are a local accumulation of lymphatic tissue in the lumen of the lymphatic vessel, resulting in one bringing and one remote lymph vessel. Connective tissue node lymph node is represented by a capsule, which is formed due to the thickening of the lymphatic vessel in the area of lymphatic clusters due to the development of loose fibrous connective tissue based on the outer and middle of their shells and a few, short, underdeveloped capsule trabecule, which are deepened only in the "surface", close to the capsule node "balls" of parenchyma. In microscopic studies of intra-node lumen it was found that the lymphatic channel of the lymph node consists of two lymphatic basins - the external (pidcapsular or edge lymphatic sinus) and the internal (central lymphatic sinus), which are combined by numerous intermediate sinuses.

The age features of histo-architectonics and histological changes in the parenchyma of lymph nodes of muscle ducks are primarily due to the peculiarities of the structure of the intra-node microcirculatory channel and the development of separate structural-functional zones of the organ parenchyma.

The parenchyma of lymph nodes of newborn ducks is characterized by relatively low degree of differentiation and is represented by diffuse lymphatic tissue without expressed signs of its subdivision into separate functional zones, the relative area of which is $50.72 \pm 0.44\%$ (Fig. 2).

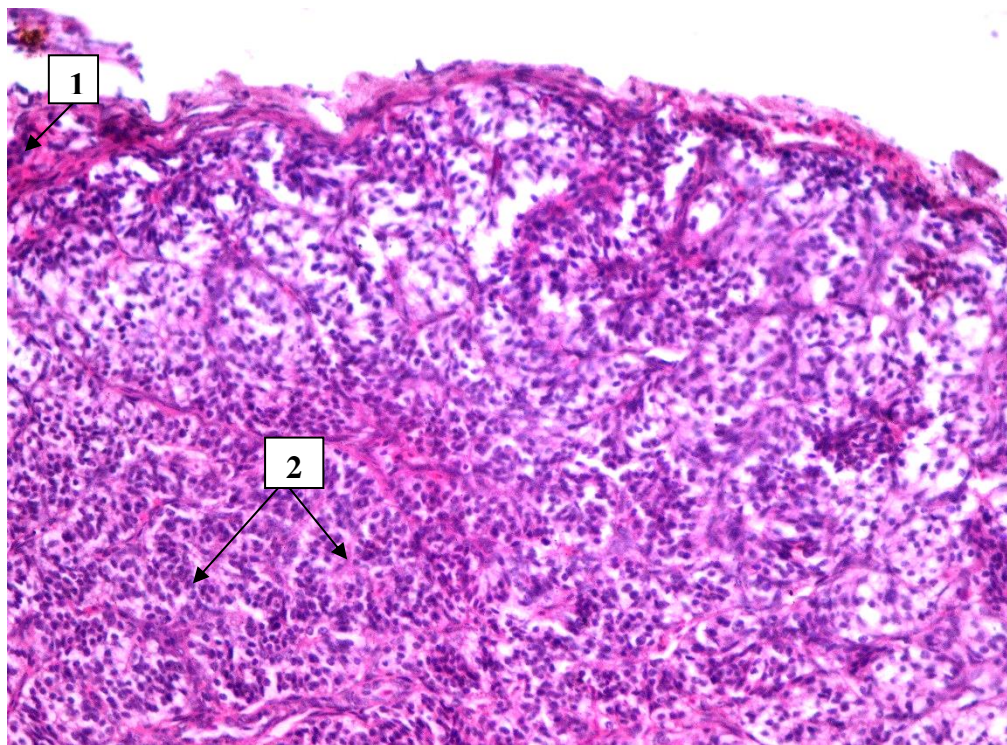


Fig. 2. Histological preparation of lymph nodes in chest and neck of a newborn duck. Coloring with hematoxylin and eosin, $\times 400$. 1 - capsule; 2 - diffuse lymphatic tissue.

Inside the node, the lymphatic channel is represented by only two lymphatic sinuses - the central one, which is located in the central part of the organ and occupies a large relative area ($13.91 \pm 0.57\%$) and a discrete edge sinus, which borders the capsule of the node and has a much smaller relative area ($5.99 \pm 0.53\%$), and, accordingly, is located at its periphery.

Architectonics of the reticular axis of the lymph node parenchyma of newborn ducklings is characterized by the formation of bundles of reticular fibers located mainly at the periphery of the node, and closer to its center - a net of thin reticular fibers, whose eyes are small and irregular, directed mainly to the central lymphatic sinus.

Up to the age of 5 days, ducklings differentiate the lymph node parenchyma into two diffuse zones: cortical and cerebral according to the signs of different lymphocyte density. Denser lymphocytes are located in the central zone of nodes along the central sinus, forming a cortical substance with a larger relative area ($36.04 \pm 0.44\%$) than in brain matter, which is formed at the periphery of the organ along the edge lymphatic sinus, where lymphocytes are located more sparsely and the relative area of the parenchyma is slightly smaller ($20.77 \pm 0.42\%$).

The intra-nodal lymphatic channel of the 5-day-old ducklings is also represented by edge and central lymphatic sinuses, but the total capacity of the sinuses decreases due to both central (up to $12.23 \pm 0.46\%$) and edge sinuses (up to $4.22 \pm 0.31\%$).

The reticular skeleton in the cortical matter of the lymph node of the 5-day ducklings is represented by a grid of short reticular fibers arranged tightly, which join each other and form irregular grids whose cells are narrow, with the majority of reticular fibers directed to the central lymphatic sinus.

In brain matter, the 5-day-old ducklings have relatively long reticular fibers, with a lower density, and when connected to each other they form irregular grids, but their cells are wider than in cortical matter. The location of reticular fibers in the brain matter of the lymph node of the 5-day ducklings is chaotic, but there are individual fibers that are perpendicular to the edge lymphatic sinus and node capsule. There are no clear boundaries between the diffuse zones of the lymph node parenchyma of the 5-day ducklings.

In the lymph nodes of 10-day ducklings histological architecture of the reticular axis, the structure of the intrasonic lymphatic channel and its total capacity does not change significantly. Characteristic changes are observed in the parenchyma of the lymph node, where there is a decrease in the relative area of the cortex (up to $19.21 \pm 0.51\%$), while the density of cells in the cortex increases markedly, with a simultaneous significant increase in the relative area of brain matter (up to $42.43 \pm 0.84\%$), without significant changes in the density of lymphocytes.

In the lymph nodes of 15-day ducklings characteristic changes are found in the structure of the intra-node lymphatic channel, there is a decrease in the relative area of the central lymphatic sinus (up to $8.09 \pm 0.25\%$) against the background of an increase in the relative area of the edge lymphatic sinus (up to $7.53 \pm 0.66\%$), while the total capacity of the lymphatic channel of the node decreases slightly, only by 0.69%. In the lymph node parenchyma, the 15-day ducklings have a more developed zone and occupy a larger relative area of the brain matter remains, but the decrease in the area of lymphatic tissue during this period occurs both in the cortical zone (up to $17.21 \pm 0.36\%$) and in the brain matter zone (up to $36.19 \pm 0.29\%$). Changes in the reticular axis of the lymph node parenchyma of 15-day ducklings are not significant, mainly due to the thickening of the reticular fibers, which are directed to the central lymphatic sinus, with the reticular fibers nets becoming more compacted (Fig. 3).

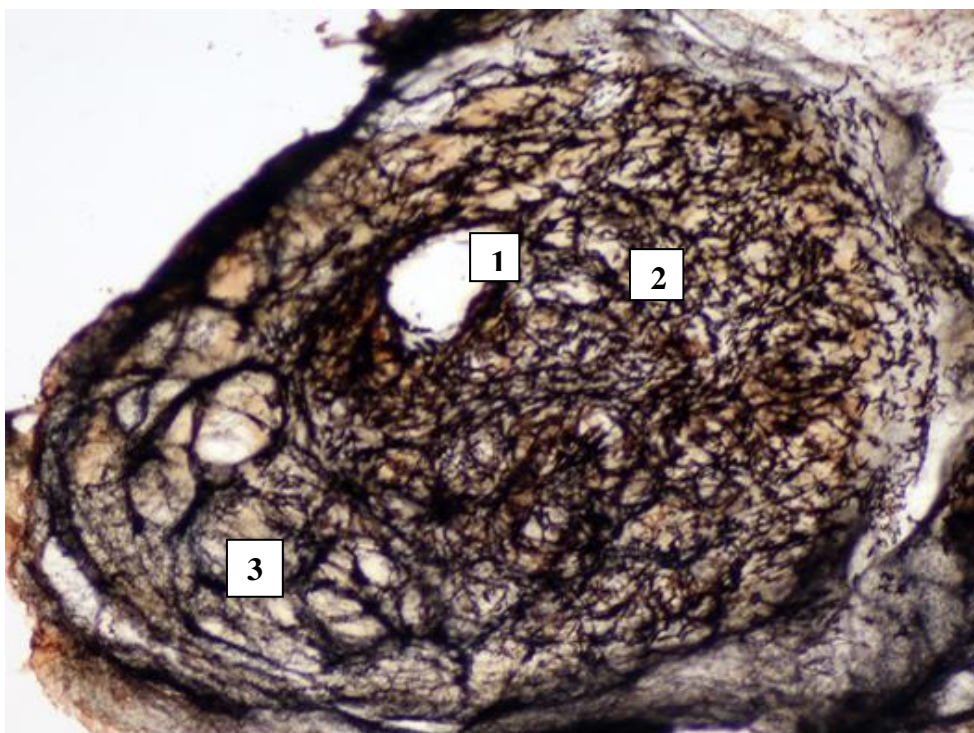


Fig. 3. Histological preparation of lymph nodes in chest and neck in 15-day duck. Coloring by nitrous-oxide silver, $\times 100$. 1 - central sinus; 2 - cortical matter; 3 - cerebral matter.

Histological changes in the architecture of the reticular axis of the lymph node parenchyma of muscovy ducks are also interconnected with the development of morphological features of AI of structural-functional specialization and are characterized by gradual formation of networks of reticular fibers characteristic for each individual functional zone of the lymph node. In this connection, newborn ducklings have bundles of reticular fibers at the periphery of the lymph node and irregular fine mesh networks of reticular fibers in the central zone of organs. Starting from the age of 5 days, the lymph node parenchyma is characterized by the formation of irregular reticular fiber nets both in the central and peripheral node zones. With age during the first three months of life, when the lymph node parenchyma is represented only by "diffuse" cortical and cerebral matter, reticle fibers at the periphery of the nodes are slightly thickened and characterized by a finer structure, and reticle fibers located closer to the center thicken, slightly liquefy and acquire greater curvature. Characteristically, most of the fibers that had a direction in relation to the central lymphatic sinus, as it is reduced, are lost and starting from the 15-day age of the ducklings there is a chaotic arrangement in both diffuse zones of the lymph node parenchyma.

The character of cell composition of the lymph node and its age dynamics are one of the most objective morphological criteria of the condition and regularities of the formation of immunological reactivity function in these organs (Berezina, 1998; Gavrilin, 2005). Moreover, the peculiarities of cell population development in various functional zones of nodes parenchyma in early postnatal ontogenesis are the reflection of the sequence of formation of cellular and humoral immunity reactions in the process of postnatal adaptation and specificity of interaction of animal organism with environmental factors (Krasnikov, 2000; Goralskiy, 2003).

The parenchyma of the lymph node of the daily ducklings is represented by a diffuse accumulation of stromal and lymphatic cells in the enlarged lymphatic vessel between the central (inner) and edge (outer) lymphatic sinuses, without any signs of its division into cortical and brain matter. Among the cells of lymphatic tissue of the lymph node, the greatest relative number of cells have the reticular stromas - $54.54 \pm 0.44\%$, the second largest number is the population of small lymphocytes, whose relative number is $30.30 \pm 0.49\%$. The relative number of average lymphocytes does not exceed 11.00% , large lymphocytes - 2.50% and granulocytes 2.00% . No plasma cells or macrophages are detected in the parenchyma of the lymph node of the daily ducklings.

From the age of 5 days, the ducklings' parenchyma of the lymph node shows the first signs of its structural and functional differentiation due to the concentration of lymphatic cells along the central sinus, which divides the parenchyma of the nodes into cortical and brain matter. The quantitative ratio of individual cell populations in the lymph node parenchyma of 5-day ducklings does not significantly change in comparison with the daily ratio (Fig. 4).

In the cortical matter of the lymph node in 10-day ducklings there was a 4.18% decrease in the relative number of reticular cells, a 1.03% decrease in the average lymphocyte, and a slight decrease in the relative number of large lymphocytes and granulocytes by 0.27% and 0.16% , respectively, whereas we registered a 5.64% increase in the relative number of small lymphocytes.

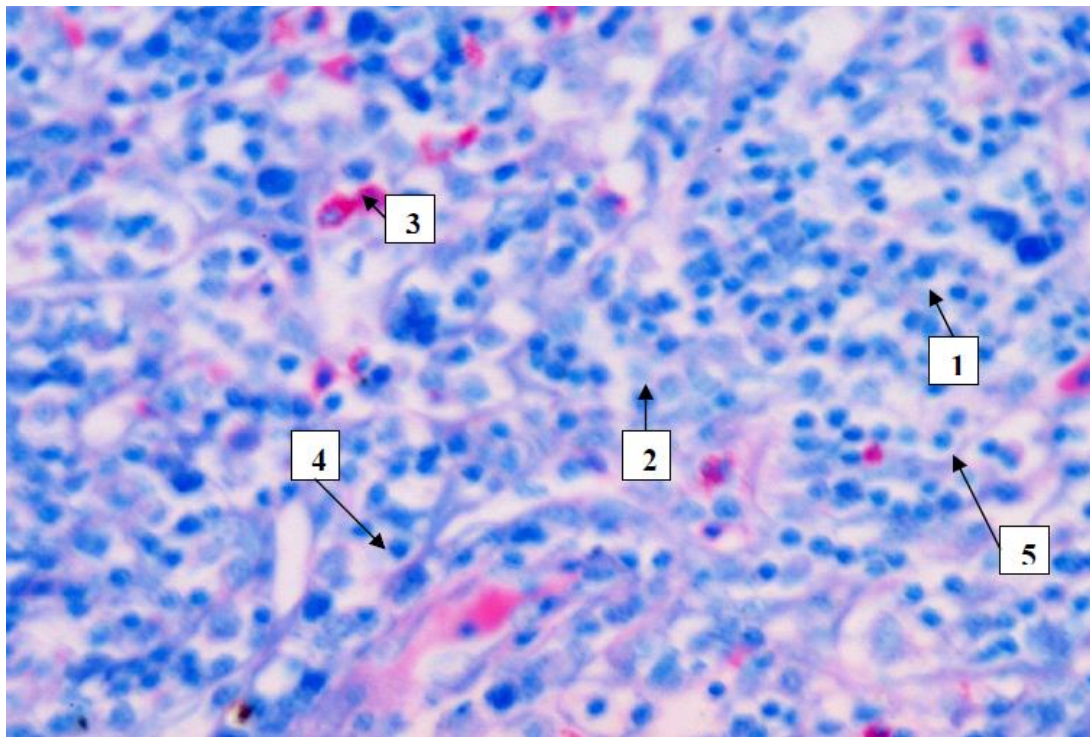


Fig. 4. Histological preparation of lymph nodes in chest and neck of 5-day duck (cortical substance). Coloring with azure II - eosin, $\times 1000$. 1 - small lymphocytes; 2 - medium lymphocytes; 3 - large lymphocyte; 4 - reticular cells; 5 - granulocytes.

In the brain matter of the lymph and conical node in 10-day ducklings, there was also a tendency to increase the relative number of small lymphocytes against the background of a decrease in all other cells. The relative number of small lymphocytes increased by 9.38% , a more significant decrease in the relative number was characteristic of reticular stroma cells by 4.44% , the proportion of medium lymphocytes, while decreasing by 1.37% , and the relative number of small lymphocytes and granulocytes by 0.36% and 0.21% , respectively. Plastic cells and macrophages in the lymph node parenchyma of the 10-day ducklings were also not detected.

The dynamics of cellular composition of the cortex of the 15-day ducklings' lymph node parenchyma was characterized by a significant decrease in the relative number of reticular cells, accompanied by an increase in the number of all other cellular components. The relative number of medium and small lymphocytes increased by 5.62% and 6.38% , large lymphocytes and granulocytes by 0.20% and 0.31% , respectively, while the relative number of reticular cells, on the contrary, decreased by 12.52% .

In the brain matter of the lymph node in 15-day ducklings, the dynamics of the cell composition also tends to reduce the number of reticular cells while increasing the content of all other cells compared to the cortical matter. The relative number of reticular cells decreased by 8.91% , medium and small lymphocytes by 3.88% and 4.68% , large lymphocytes and granulocytes by 0.21% and 0.13% respectively. No plasma cells or macrophages were detected in the parenchyma of 15-day ducklings.

Conclusions

In the parenchyma of cervical lymph nodes of newborn Muscovy ducks, the most numerous are cells of reticular stroma. The population of lymphatic cells is incomplete due to the absence of plasmocytes, and most of it is represented by small lymphocytes. Apart from plasma cells, no macrophages are found in the lymph node parenchyma. Populations of hematopoietic cells within the parenchyma of the lymph node in newborn ducklings are distributed in accordance with the structural-functional zonality of the peripheral lymphatic organs, which is typical for lymphatic tissue.

The first signs of zonal cytoarchitectonics in the parenchyma of the lymph node of muscle ducks appear in 5-10 day-old birds characterized by an increase in the number of small lymphocytes at the periphery of the parenchyma of the lymph node in its brain zone. Lymph nodes in chest and neck of Muscovy ducks are an accumulation of lymphatic tissue in the lymphatic space between two lymphatic pools - internal (central sinus or its rudiment) and external (discrete edge sinus), combined with numerous intermediate sinuses.

Lymph nodes of daily ducklings is a diffuse cluster of stromal and lymphatic cells in the enlarged lymphatic vessel, whose thickened walls form their capsule. The parenchyma of the nodes is localized between the central (inner) and edge (outer) lymphatic sinuses, without morphological signs of differentiation into structurally functional zones and, consequently, into cortical and brain matter. In newborn ducklings there is an intensive growth of lymphatic channel volume, accompanied by gradual reduction of central sinus and compensatory development of cortical and brain intermediate sinuses. Age-related changes in the cell composition of the parenchyma of lymph nodes in muscle ducks are characterized by a gradual increase in lymphatic cells and macrophages number along with a decrease of reticular cells of early postnatal ontogenesis ducklings due to populations of small lymphocytes in the cortical and cerebral matter of nodes.

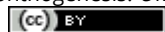
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Citation:

Gavrilina, O.G., Perotskaya, L.V., Alekseeva, N.V., Peretyatko, O.V. (2020). Morphogenesis of lymph nodes in Muscovy ducks during early postnatal ontogenesis. *Ukrainian Journal of Ecology*, 10(5), 266-273.



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