

USC 591.4: 591.441: 597/599**MORPHOLOGICAL FEATURES OF THE SPLENIC RED PULP****Ph.D. in Biological Sciences, associate professor, Dunaievskia O. F.**

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The spleen is an important peripheral organ of the sanguification and immune defense. In vertebrates and humans, it is formed by the support-contractile apparatus, as well as by the white and red pulps. The red pulp consists of the soft splenic cords, reticular stromal systems, and sinuses, including vascular structures. The relative area of red pulp is an important test criterion of the organ. It takes from 48,95% to 84,3% in the vertebrates, and from 71,4% to 83,6% in humans. It depends on the class, type, race, sex, breed, the age of animals, or the person's age and physiological state. The indicator of red pulp's relative area is used as a biomarker in the environment bioindication. Any change of its values indicates the changes of the environmental conditions. Determination of the morphological standards in the organs and tissues according to the animals' age, species, and breed aspects is used in the prevention of diseases, effective treatment, and getting the high-quality food. The test criteria of the spleen are important while studying the effect of pharmacological drugs, conditions of animal sustentation and feeding. Determination of splenic morphometric parameters is of the great practical importance, particularly in surgery, laboratory diagnostics, and development of the medical measures.

Keywords: spleen, morphology, fish, frogs, birds, mammals, human.

Spleen belongs to the peripheral organ of the sanguification and immune protection; it is presented in all vertebrates. In the fish, the main function of the spleen is to deposit the blood; in the amphibians and

reptiles, it is the sanguification; in the birds – lymph formation. The mammal and human spleen have the greatest functionality. It performs the functions of filtration, cleansing, sanguification, immune and blood depositing. Accordingly, the spleen carries the extramedullary hematopoiesis, synthesizes the substances of different groups, and takes part in metabolism. Any loss of spleen or its structural damage leads to significant disorders of the immune system [1].

As it was mentioned, the spleen consists of support-contractile apparatus and pulp. There are distinguished the white pulp and red pulp (RP). The RP performs these important functions: (1) it controls the state and destruction of the old, damaged red blood cells and platelets, (2) deposits to the mature blood cells, (3) ensures the phagocytosis of foreign particles, (4) provides the maturation of lymphoid cells and (5) converting monocytes to macrophages, and (6) produces the Factor VIII (Willebrand's Factor) of the endothelial cells [2].

Moreover, the spleen consists of the soft splenic cords (Cords of Billroth), the reticular stroma, which is filled with blood cells, and the sinuses system that is located between the cords [3; 4]. The RP includes three types of vascular structures – the thin arterial capillaries, sinusoids, and pulp's veins. All of these vessels are supported by the reticular stroma, which forms the splenic (or pulp's) cords (i.e. Cords of Billroth) and is distinguished by the presence of extracellular proteins: the fibronectin, laminin, vitronectin, tenascin, collagens of the III and IV types. Pulp's cords compose of connective tissue, which is represented by the fibroblasts, collagen, and elastic fibers [5]. Reticular cells and fibers network form a so-called 'filtration beds' that allow, depending on the location, to filter selectively the red blood cells, platelets, and granulocytes [5]. The RP of the spleen is a very dynamic compartment which exchange cells with other organ components intensively [6]. There are red blood cells, neutrophils,

megakaryocytes, macrophages in the loops of the reticular fibers; the major place of the lymphocytes is taken by the subpopulation of CD8+ cells [3]. Reticular stroma is an actively supporting structure. Here are the processes of cell migration, their interaction, representation and processing of antigens, proliferation of B-lymphocytes and their differentiation. Components of the intercellular matrix that are produced by the reticular cells play an important role in cell-cell interactions, such as the interaction of lymphocytes with antigen-presenting and endothelial cells [3]. Macrophages, which are located in RP, use the vascular cell adhesion molecules 1 (VCAM-1) for the maintenance of hematopoietic stem cells. Therefore, the spleen can act as the cell regulation of certain stem cells [7].

The endothelium of splenic veins is smooth, its basement membrane is continuous. There are also anastomoses between pulp's arteries as well as arteries and veins in the capsule of the spleen. Speaking about the mammals, there are much fewer sinusoids, which lie in the spleen, in the horses, cats, and mice. This spleen is of "without sinusoid" type. However, it is present, but mostly is located around the ellipsoids and acts more openly in the blood supply of the organ. Due to the insufficient venous sinuses in the spleen of "without sinusoid" type, the flowing blood enters directly through the pulp veins. The mice, cats, and horses consist of the veins, which are thin-walled, with the large orifices and a thin discontinuous basal membrane. Pulp's veins often are close to the trabeculae, and, by entering them, become trabecular veins. The walls of pulp's veins in the animals, which are presented in the "without sinusoid" type of RP, as opposed to "sinusoid" ones, provide a little resistance to the blood flow through these large openings [5].

The volume of RP in the spleen of animal differs and depends on the class. Thus, the relative area of RP is 48,95% in the chicken [8], up to 83,81% in the dogs [9], and 84,3% in the rats [10] (see the table). The

relative area of RP changes during the ontogenesis and has sex differences. For example, in hamsters' males, it decreased from 95,5% (10-day-old) to 65,6% (270-day-old); in females – from 96,4% (10-day-old) to 67,6% (270-day-old) [11].

Table 1.

Relative RP area of the vertebrates' spleen (%)

Animal species	RP	Animal species	RP
Fish [12]	70,82±10,8	Dog [9]	83,81 ± 1,24
Frog [13]	80,67±6,5	Rabbit [16]	76,45±3,78
Dove*	73,30±8,6	Pig [17]	78,87±2,36
Chicken *	78,30±1,9	Rat [18]**	79,43
Chicken [8]	48,95	Mouse [3]	49,6±2,0
Goose [14]	74,81±6,8	Cattle [19]	73,47±0,9
Duck [14]	57,12±6,0	Sheep [20]	69,99 ± 1,03
Horse [15]	78,94 ± 4,39	Cat [21]	75

* own research (the rock dove, the chicken)

** according to the other sources [22], this value reaches 72,1%

In the sheep, there is a clear age trend to the decrease of the RP relative area. Thus, in the 3-months sheep, it was 90,64%; in 9-months – 87,48%; 12-months – 85,66%; 18-months – 82,99%; 20-months – 79,8%; 24-months – 76,44%; 28-month – 69,99%; and it reached 68,56% in the 30-months sheep [20]. In quail, the relative RP area was 32,7% in the first day after hatching; then it was declining slightly to 26,15% at the age of 70 days with a further increase to 32,73% at the age of 294 days [23]. In the fish, there was an in-order and in-family difference in terms of RP relative area. The RP of Caspian roach took over 80% of the spleen [24], while the catfish's RP did not exaggerate 72% [12].

There were also admitted the breed's features of spleen's morphometric parameters, particularly in pigs [17; 25].

Each class of vertebrates has different histological architectonic of the spleen RP. Here are some of them. There are sinusoids and diffusely located melanomacrophagocytes in the fish's RP, which form melanomacrophagocytious centers [12]. In the frog, the pigment cells create the melanomacrophagocytious clusters. They often topographically related with sinusoids [13]. In the rabbits, the RP ellipsoids are absent; instead, there was recorded an extensive network of venous sinuses [16]. Pig's venous sinuses are absent. At the same time, there are many sinusoidal capillaries among their blood vessels [17].

The RP in histological sections of human spleen takes from 71,4% (in children) to 83,6% (in old age). Relative area indicator depends not only on the age but also on the physiological state of the body. The lymphocytes locate singly or in groups of 3-5 cells. There are also macrophages and blood corpuscles in a large quantity. Stroma of RP is formed by the reticular cells and reticular fibers, which continue in the reticular frame of arteries lymphoid sheaths, lymphoid nodules, ellipsoids, connective trabeculae, and reticular structures that surround the venous sinuses. The venous sinuses of RP are located in different areas, surrounded by a few reticular fibers as well as by the isolated reticular and smooth muscle cells. Around the venous sinuses walls, there are numerous macrophages, lymphocytes, erythrocytes, and leukocytes. Macrophages always locate in the intervals between the venous sinuses together with blood cells. During the postnatal ontogenesis, venous sinuses are expanding in 2,3-2,5 times, from 18,5 microns in the early childhood to 42,5 microns – in the elderly [26]. Venous sinuses are thin-walled vessels with the irregularly shaped anastomoses. The sinuses bespread the endothelial cells of unusual fusiform. Between these cells, there are the narrow slits (of 0,5 – 3 μm) [27].

The study of morphological features of the human and animal spleen has theoretical and practical value. Morphological study of the phylogenetic

area allows determining the mechanisms of organism's adaptation to the environmental conditions, as well as the impact on taxonomic groups of animals. Morphophysiological features of animals set the environmental conditionality in the nature of family forms and deepen their response. The study of environmental assessment of environmental quality is essential, too; it allows revealing the extent and intensity of the pollutants' impact, tracing the dynamics of ecosystem degradation in time and space. The immune system of the fish is labile, which allows usage of the immunological parameters of fish in monitoring the ecological state of water systems, including such values as absolute weight, relative weight, and relative area of spleen pulps [28]. It is successfully used the modern and perspective method of biological indication and identified natural reactions of animals are often extrapolated to humans for such an integrated assessment. Marsh frog (*Rana ridibunda P.*) meets all requirements imposed on bioindicators. Morphological parameters of the spleen serve as these biomarkers. There are the results of research, which show a significant decrease in the relative weight of the spleen in mature individuals of *R. ridibunda P.*, living in streams that are contaminated with heavy metals [29]. It is necessary to determine the morphological standards of organs and tissues in the animal according to the age, species, and breed aspect in order to prevent the disease and supply the effective treatment, got the high-quality food. The study of morphometric features of the animals' spleen is needed for the development of test criteria to the organ, which will be subsequently used while studying the effect of pharmacological agents, environmental factors, animal sustentation and feeding. Determination of morphometric parameters of human spleen is of great practical importance, particularly in surgery, laboratory diagnostics, and development of the medical measures.

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