MORPHOMETRIC PARAMETERS OF THE SPLEEN IN THE EARLY ANTENATAL PERIOD OF DEVELOPMENT

Zayniddinov Og‘abek Farxod o‘g‘li
Pediatrics Faculty, 4th year, Group 434
zayniddinovogabek186@gmail.com
O‘razdurdiyeva Muqaddas
Faculty of General Medicine, Group 328
muqaddasorozdurdiyeva@gmail.com
Egamberganova Mohimjon Mahmudjon qizi
General Medicine, Group 328
mohimjonmohmudjonovna@gmail.com
Ikromova Shahlo Anvarovna
Pediatrics, Group 204
ikromovash727@gmail.com
Muxammadjonov Lochinbek
Faculty of General Medicine No. 1, Group 322
Lochinbekmuxammadjonov05@gmail.com
Samarkand State Medical University,
Samarkand, Uzbekistan

Abstract. In the study of spleen specimens from embryos and fetuses, at the 5th–6th week a primary splenic rudiment was identified within the dorsal mesogastrium. By weeks 8–9, distinct red and white pulp precursors became recognizable, with early lymphocyte populations appearing in the periarteriolar sheaths. By weeks 11–12, the spleen demonstrated well-formed trabecular framework, sinusoidal vasculature, and primary lymphoid follicles. Two peaks of active lymphocyte proliferation were established: at 18–20 weeks and at 27–28 weeks of embryogenesis, coinciding with intensification of extramedullary hematopoiesis and expansion of the white pulp compartment.

Key words: spleen, antenatal period, splenic morphometry, lymphoid organ, hematopoiesis, fetal development, white pulp, red pulp.

The relevance of the topic.

Knowledge of the developmental processes of the human immune and hematopoietic systems during embryogenesis is essential for establishing the timing of morphofunctional formation of immune competence, as well as for elucidating the etiology of fetal immunodeficiency states and determining strategies for their correction. In the embryological context, the spleen is one of the earliest

lymphohematopoietic organs, serving simultaneously as a site of extramedullary hematopoiesis during fetal life and as a primary lymphoid filtering organ [2, 4]. It functions as both a producer of lymphoid and myeloid cells during the antenatal period and as a regulator of immune responses within the systemic circulation [2, 3]. Alongside the thymus and lymph nodes, the spleen contributes critically to the homeostatic balance of the "mother–placenta–fetus" system, with its maturation reflecting the broader immunological adaptation of the developing organism [1, 3, 6]. The lympho-hematopoietic system of the fetus, including the spleen, serves as an adaptation constant for assessing fetal viability and immune readiness. Disruptions in splenic morphogenesis are associated with congenital immunodeficiency, susceptibility to perinatal infections, and hematological disorders of the newborn. The above considerations confirm that the study of morphofunctional changes in the fetal spleen represents one of the most pressing problems of general biological and clinical medicine.

The purpose of the study:

to study the dynamics of morphological changes in the spleen in the early antenatal period of development, and to determine the timing of morphofunctional formation of the splenic white and red pulp compartments.

Materials and methods.

The research material comprised spleen specimens obtained from 8 embryos and fetuses following medical termination of pregnancy, and from 14 stillborn fetuses that had developed under physiologically normal conditions and died as a result of birth trauma. Gestational age was determined using the date of the mother's last menstrual period and the crown-rump length of the fetus, calculated with reference to standard biometric tables. Following histological processing, paraffin sections of the organ were stained with hematoxylin-eosin and azure II-eosin. The microanatomical organization of splenic compartments was examined; the white pulp-to-red pulp area ratio (WP:RP index) and the total area of lymphoid follicles were determined. Statistical analysis was performed using the Material Vision software package. Results are expressed as arithmetic means with standard error of the mean ($M \pm m$); group differences were evaluated using Student's t-criterion (t). Differences were considered statistically significant at $p < 0.05$.

The results and their discussion.

It is well established that the human spleen originates during the 5th week of intrauterine development as a mesenchymal condensation within the dorsal mesogastrium, in close proximity to the developing stomach and pancreas. At week 5–6 of intrauterine development, the splenic rudiment presented as a compact mass of undifferentiated mesenchymal cells, rich in mitotically active elements. No distinct vascular or lymphoid architecture was yet identifiable.

From week 7 onward, progressive vascularization of the splenic primordium was observed. Sinusoidal channels began to form, lined by flattened endothelial cells, and early erythropoietic foci were identified within the vascular spaces, confirming the onset of extramedullary hematopoiesis. The organ grew predominantly through proliferation of mesenchymal stromal cells and expansion of the sinusoidal network.

At weeks 8–9, a clear distinction between developing red pulp and white pulp precursors became apparent. Periarteriolar lymphoid sheaths (PALS) were recognized as clusters of small lymphocytes surrounding central arterioles, representing the earliest white pulp differentiation. Simultaneously, erythropoiesis and early myelopoiesis were prominent within the red pulp cords.

By week 10, the trabecular framework of the spleen was established, with distinct fibromuscular trabeculae extending from the capsule into the parenchyma and carrying trabecular arteries and veins. The capsule itself consisted of dense collagen fibers with interspersed smooth muscle cells.

By weeks 11–12, the spleen demonstrated all its characteristic structural components: a well-formed capsule and trabeculae, a clearly delineated red pulp with venous sinusoids and splenic cords (of Billroth), and developing white pulp with primary lymphoid follicles. Blood vessels of the cortical and trabecular types were well defined. During this period, organ growth occurred both through continued proliferation of the reticuloendothelial stroma and through active expansion of periarteriolar lymphoid tissue.

From week 14 onward, secondary lymphoid follicles with germinal centers began to appear, and the marginal zone between red and white pulp became increasingly distinct. The WP:RP index rose progressively, reflecting the expanding immunological role of the organ relative to its hematopoietic function.

Two peaks of marked increase in lymphoid follicle number and area were established. The first occurred at 18–20 weeks of embryogenesis, associated with a sharp rise in lymphocyte proliferation within the PALS and primary follicles. The second, more pronounced peak was recorded at 27–28 weeks of gestation. During this period, a rapid increase in total white pulp area was observed, alongside a relative deceleration in red pulp expansion. The WP:RP index at 19–22 weeks of gestation was 0.79, rising to 1.12 at 27–28 weeks. At 27–28 weeks, the total area of lymphoid follicles reached 13.1% of total splenic area, compared to 5.6% at 19–22 weeks. After 27–28 weeks, the follicular content of the spleen stabilized, while red pulp hematopoiesis gradually diminished in preparation for postnatal bone marrow dominance.

Conclusion.

The period of 5–12 weeks of gestation can be characterized as a critical stage of spleen development. Its criticality lies in the fact that during this interval the organ establishes its fundamental structural organization: a capsule and trabecular skeleton,

a sinusoidal vascular network supporting active extramedullary hematopoiesis, and the earliest lymphoid compartments in the form of periarteriolar lymphoid sheaths and primary follicles. Blood vessels such as central arterioles and trabecular sinusoids are well defined by week 12. Epithelial-to-mesenchymal interactions drive the initial stromal framework, while hematopoietic progenitor cells seed the red pulp from the circulation. The established peaks of lymphoid follicle proliferation (18–20 and 27–28 weeks of embryogenesis) reflect successive waves of immune maturation, leading to a sharp increase in white pulp area at the expense of red pulp hematopoietic tissue, and signifying the progressive immunological competence of the fetal spleen.

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