Gavrilina Olena
Gavrilin Pavel

MORPHOGENESIS OF GASTRIC TISSULAR COMPONENTS AND IMMUNE STRUCTURES IN PIGLETS

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Reviewers:

O. P. Melnyk – Doctor of Science (Veterinary medicine), Professor, Head of the Department of Anatomy and Histology of Animals, National University of Life and Environmental Sciences of Ukraine

I. V. Yatsenko – Doctor of Science (Veterinary medicine), Professor, Head of the Department of Veterinary and Sanitary Expertise and Forensic Veterinary Medicine, Kharkiv State Zooveterinary Academy

Gavrilina Olena, Gavrilin Pavel

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The monograph analyzes the problem of postnatal morphogenesis of tissue components, immune structures and lymphatic vessels of the stomach of piglets. It is established that the degree of differentiation and specialization of the main structures of the stomach wall in newborn piglets depends on their body weight (conformity of newborn piglets body weight to the breed standard). The results of analysis of the age-related changes of the main components of the porcine stomach wall in early postnatal ontogenesis are presented. The features of growth and development of immune structures of piglets gastric mucosa, lymphatic vessels and gastric lymph nodes during postnatal adaptation are interpretated.

For scientists, lecturers and post-graduate students in the field of veterinary medicine, biotechnology and biology.

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Introduction

Complication of ecology all over the world stipulates decreased autarcesis in animals and human. Mammals are under an especially strong negative impact of the up-to-date ecology during the prenatal period of ontogeny which is related with disorders in mother-placenta-fetus system. As a consequence animals are born with various prenatal growth and development. At the same time morphological underdevelopment is the most typical for the digestive apparatus and immune formations and that stipulates disorders of their functions after the first-second feeding with mother's colostrum which is an optimal source of energy for animals during the neonatal period of life. The current situation concerning reduced viability of newborn animals requires a more detailed research of tissue components of tubular digestive organs and their immune structures taken in conjunction with organism prenatal growth and development. The purpose of this research consists in improving the livestock safety.

Providing people with high-quality products of animal origin is possible only in case of an effective management in all livestock sectors including pig breeding [1–4]. But influence of negative environmental factors affects adversely growth and development of animals and this leads to decrease of their immune resistance [5–9]. These factors have the strongest negative impact on the organism of newborn animals and in particular on the organism of piglets with unfinished morphofunctional status and the situation is also complicated through biological peculiarities of their maturity when born [10–15].

Structural incompleteness of tissue components in organs of newborn animals animals on the one hand stipulates a high level of adaptability and on the other hand it stipulates insecurity to influence of various environmental factors. Practically all systems of newborns have a certain functional and morphological incompleteness and some of these systems just start their functioning for the first

time [16–22]. In newborn animals feed ingredients affect primarily digestive organs and stomach taking a certain place among these organs. Colostrum is delivered to the stomach of piglets not later than few minutes after birth. And in view of this fact structures of stomach coats in newborn piglets must be sufficiently structurally and functionally mature in order to provide ingestion of nutrients as well as to prevent penetration of foreign proteins to lymph and blood.

During the neonatal period of ontogeny an intensive morphogenesis of stomach tissue components in mammals takes place. Morphological changes of this organ are first of all stipulated by substances coming with feed (particularly protein substances stimulating transformation of tissue components and immune formations of its coats) [29–32]. But peculiarities of structural organization of tissue components as well as dynamics of their formation in stomach wall coats in piglets are not sufficiently covered in scientific literature.

Stomach secretory function undergoes changes according to the age as well as depending on the general state of the organism [33–37]. But in comparison with a significant number of works about peculiarities and functions of stomach in newborn children [27, 38–44], morphology of tissue components of various parts of stomach wall in animals has been much less studied.

Researchers have not reached a consensus on structural peculiarities of immunogenesis organs providing full-rate immunity of animals during their neonatal period of life [45–50]. Digestive organs are characterized by intensively developed lymphoid structures integration of which with boundary tissues represents the basis of organism barrier reactions [45, 51–58]. Stomach lymphatic vessels in combination with regional lymph nodes not only perform a drainage function but also exercise control over presence of foreign substances in lymph and neutralize these substances [59–64]. But scientific literature sources contain almost no information about peculiarities of stomach immune formations in neonatal piglets.

Section 1. Literature review

1.1 Structural and functional peculiarities of monogastric stomach in mammals

The digestive apparatus of mammals is constructed on the principle of a channel. When moving along this channel nutrients are split by means of enzymes into simple compounds and get into lymph and blood. Stomach takes its definite place among digestive organs. Being a connective link between the external environment and the organism it performs not only cumulative, digestive and transport function but also a protective function performing the role of a selective barrier on the way of feed stuffs [51, 54, 66–70].

The monogastric stomach is a characteristic of the most mammals. It is presented as a elongated pouch with the lower convex border (major curve) and the upper incurved border (lesser curvature). Stomach consists of its cardiac part, pyloric part and fundus. According to the structure of the stomach mucous membrane (mucosa) there are three types of stomach: esophageal (glandless) stomach, esophageal-intestinal (combined) stomach and intestinal (glandular) stomach. Pig has stomach of esophageal-intestinal type with a diverticulum on the external surface of its cardiac part [32, 71].

Analysis of performed researches shows that results of immunomorphological studies as well as information about contents of nucleic acids and mucopolysaccharides in gastric mucosa in animals and human prevail in scientific literature [72–82]. A large number of works are devoted to study of stomach wall structures in pathology [83–98] and in experiment under influence of exogenous and endogenous factors [52, 99–101], while peculiarities of its age-related morphology remain much less informative. In the predominant

part of morphological studies structural peculiarities of stomach of laboratory animals and wild animals are revealed [102–113].

1.1.1 Tissue components of stomach wall coats

Stomach wall consists of four coats: mucous membrane (mucosa), submucous layer (submucosa), muscular coat and serous membrane (serosa) [114, 115, 116]. Mucous membrane (mucosa) is marked by an uneven surface with folds, areas and pits [117]. V.V. Shchedrunov et al. [118] note that in human mucosa folds of various sizes are directed from the edge of the stomach to its pyloric part. Areas have a diameter from 1 to 6 mm and include glands and their excretory ducts (ductus excretorius). According to the authors there are about 3 million pits and glands are open to these pits. Average thickness of gastric mucosa in adult humans is about 1 m [119], and its area is about 526–825 sq. cm [120]. According to M.R. Neura, H.A. Padykula [121] there are about 3.5 million pits and 15 million glands.

Epithelium of gastric mucosa is subdivided into surface epithelium, pit epithelium and glandular epithelium [119]. Surface epithelium and pit epithelium are represented as single-layer cylindrical (columnar) glandular epithelium [116, 122–124]. And according to T.A. Lukina and O.V. Chistiakova [125] in humans these gastric epithelium cells are of a cubic or irregular rounded shape with eccentrically located nuclei. Epithelium cells of gastric fundus in humans have a low nuclear cytoplasmic ratio and an increased weight of cytoplasm; and according to the authors this is related to their special protective function [123].

Cells of surface epithelium and pit epithelium are characterized by positive result of periodic acid Schiff reaction and this fact has been confirmed by a number of authors [51, 77, 126, 127]. This structure of epithelium is typical for many vertebrates. When studying stomaches of lower vertebrates R.Kh. Niyazova [126] came to a conclusion that gastric fundus epithelium of these lower

vertebrates is generally similar with that of mammals and that few differences consist in larger dimensions, sharply delineated boundaries and deeper gastric pits.

Lamina propria of the gastric mucosa (lamina propria mucosae) includes glands with thin layers of loose fibrous connective tissue among these glands. There are three types of gastric glands: cardiac glands, fundic glands (proper gastric glands) and pyloric glands; all these glands consist of variously expressed isthmus, neck and and main part represented as body and fundus [114, 115].

Fundic glands prevail in the stomach. According to V. V. Shchedrunov et al. [118], there are about 3.5 million of fundic glands in human stomach. Fundic glands are simple and unbranched (sometimes slightly branched) glands. They include cells of five types: main and parietal exocrinocytes, cervical mucocytes, endocrynocytes and undifferentiated cells [115, 116, 128, 129]. The share of parietal cells is 12 %, the share of gland mucous cells is 43 %, the share of main cells is 40 %, and the share of endocrine cells is 4 % [130]. V. A. Samsonov [131] defined that ratio index of main and parietal cells in healthy humans may vary between 1 and 1.9.

Y. R. Matsuk [132] determined that fundic glands in stomach of dogs are direct with predominance of main cells. In rabbits these glands are wavy with predominance of parietal cells. In the fundic part of cats' stomach A. L. Liskovich [133] determined parietal cells in the area of body and neck of glands; and in guinea pigs parietal cells are evenly dispersed throughout the area of glands.

Ts. G. Masevich [134] pointed out that in the area of gland necks in the fundus of human stomach parietal and mucous cells prevail. Form of parietal cells is irregularly rounded, these cells are located singly, predominantly in the neck and body of glands and their lesser number is presented in end sections (fundus). According to the author in quantitative sense main cells are located opposite to parietal cells: their greater number is located in end sections

of glands and lesser number is presented in the neck. Amount of connective tissue in the area of main glands is not significant: it is presented in form of very thin layers located between glands.

According to H. F. Helander [26] in case with humans main cells are located in the basal part of fundic glands. They cover bottom of glands and take 26 % of mucosa weight. The cells are trapezium-shaped and have polarity typical for all exocrine cells (with nucleus located at the base). With age density of main cells in mucosa is decreased but activity of pepsin is preserved on the same level [130]. According to the author this phenomenon can be explained by the fact that with age the pool of "undifferentiated" cells is not changed and with the course of time they take over secretion of pepsinogen.

A greater part of isthmus is taken by parietal cells secreting hydrochloric acid. Their form resembles trapeziform with a broad basis located on the basal membrane. Unlike other epithelial cells their nuclei are located in the center of the cell. The most parietal cells are mononuclear cells but binuclear and even multinuclear samples are not rare. Volume of binuclear cells is twice the volume of mononuclear cells. Parietal cells are twice fewer than the main cells. It has been proved that they are less resistant to impact of various pathological agents and so changes in secretion of hydrochloric acid appear much earlier than disorders in pepsin production [135]. I. A. Zalizniak [30] pointed out that in white rats parietal cells have the largest volume on the 5th day of life. In the result of morphometry of main gastric glands in healthy humans V. V. Shchedrunov et al. [118] determined the average index of cell number (132–174). J. T. Tehver [71] insisted that the number of parietal cells in pigs is increased towards the pylorus.

In 20 % of healthy humans parietal cells can be determined not only in fundus but also in the pyloric part of stomach. When studying gastric parietal cells it was determined that they appear starting from the 13th week and are localized in the fundic part as well as in

the pyloric part and by the start of the third trimester they usually disappear from the pyloric part. But this process does not occur in case with each fifth fetus [24, 28].

According to data presented by I. A. Morozov [136] topographic peculiarities of parietal cells depend on the level of their differentiation. The least differentiated ("young") cells are located in 100–120 microns from the surface of mucosa; cells with the highest level of activity are located deeper (in 400–500 microns) and cells with signs of destruction are located in the depth of the glands. Hellander H. F. et al. [120], Coulton G. R., Firth A. [137] on the contrary found the most functionally active parietal cells in upper sections of glands. Functioning parietal cells differ from resting ones by increased secretory surface. In dogs this secretory surface is increased four to tenfold; in rats it is increased by 60 % and in humans it is increased by 76 % in comparison with the period of rest. Secretory surface of highly located cells is by 40 % larger that that of basal cells. So, we can make a conclusion about adverse relationship with the level of basal secretion: in case with dogs it is low and in case with humans and rats it is comparatively high [28].

When performing comparative analysis of gastric glands in vertebrate animals Kh. R. Rakhmanov et al. [138] pointed out that the body and bottom of gastric glands in lower vertebrates are lined with cells of a single parietal-peptic type (unlike mammals).

Mucous (additional) cells in the neck of glands are located in all parts of gastric mucosa. These cells are smaller than surface epithelial cells, their nuclei are round and located in the basal part [139, 140]. During the recent years interest in cervical mucous cells as well as in multifunctional cells has increased. So, with a help of in situ hybridization it was determined that they produce spasmolytic polypeptide (which stimulates migration of cells and re-epithelization) as well as pancreatic secretory trypsin inhibitor (which suppresses activity of proteases and destruction of destruction epidermal growth

factor, stimulating cell proliferation and gastrin gene expression suppressing secretion of hydrochloric acid) [124].

In histological structure of stomach in children of the first months and years of life G. I. Dorofeyev and V. M. Uspenskiy [141] determined a number of peculiarities: main cells are small and low; parietal cells have irregular form; surface epithelium penetrates deeper into the glands; there are few typical goblet cysts.

In the cardiac part and pyloric part of stomach pits are deep and occupy almost half the thickness of mucosa [114]. Glands are located relatively rarely, especially in the cardiac part where Lamina propria mucosaeis more developed. There are few parietal cells in cardiac glands as well as in pyloric glands and main cells are absent at all [115].

Cardiac glands are tubular branched and wavy glands. They are the most developed in pigs and take 1/3–2/5 of the entire gastric mucosa surface [71]. Mucosa of cardiac part of stomach in pigs has a smooth velvety surface, grayish-pink coloring and the smallest thickness (0.5–1 mm).

O. O. Shestuk [95] pointed out that pyloric glands are presented as a branched system of epithelial tubes ending in terminal portions which are defined by the author as acini.

The lesser curvature of stomach in piglets is characterized by presence of non-squamous multi-layer flat epithelium as well as glandular epithelium [142]. Researches performed by a number of authors [143–145] confirm that the lesser curvature is functionally more active than other parts of stomach. K. M. Bykov [144] formulated a proposition conforming that the lesser curvature of stomach is the start place of signals regulating activity of secretory cells in the entire stomach. A. G. Khripkova et al. [145] pointed out that epithelium of the lesser curvature contains the biggest amount of crude protein and chlorides and it is also characterized by the highest activity of cholinesterase, adenosine triphosphatase,

succinate dehydrogenase and cytochrome oxidase. N. P. Barsukov [143] underlined that young parietal cells can be first determined on the 11th week of human intrauterine life nowhere but at the bottom of pits of the lesser curvature of stomach.

According to A. L. Liskovich [133], in Lamina propria mucosaein cats well developed fibrous structures of connective tissue and smooth muscle cells separate glands with powerful bundles. In case with guinea pigs glands on the contrary densely adjoin each other and lamina muscularis. In all parts of cat's stomach between lamina propria and lamina muscularis the author defined a collagen membrane which starts at the place where esophagus enters the stomach and runs up to the duodenum.

Lamina muscularis includes three layers formed by the smooth-muscle tissue: internal and external circular layers and the middle (longitudinal) layer.

Submucous layer of stomach (submucosa) is presented as loose fibrous unshaped connective tissue containing a big amount of elastic fibers and cellular elements. It includes arterial and venous plexuses, network of lymphatic vessels and submucous nervous plexus [116, 119, 146, 147].

Muscularis propria of the stomach includes three layers formed by smooth muscle cells: external layer (longitudinal), middle layer (circular) and internal layer (oblique).

The most scientific works dedicated to age-related structural peculiarities of stomach in animals and human describe processes of aging [148, 149], while data about stomach of newborns are much less informative.

But unlike adults newborn organisms have their own specific structures, patterns of growth and development [29]. It has been proved that stomach secretory function in children undergoes changes according to the age as well as depending on the general state of the organism. Especially significant changes of stomach

functions and developmental delay of its glandular apparatus can be observed in case of aplasia and are presented as persistent suppression of glandular secretion and delayed evacuation of contents [34, 33]. According to a number of authors [23, 150] stomachs of newborn children is characterized by relatively thin walls great roundness and smooth lines especially in places of transition of one part to another. Motor function and secretory function of stomach in newborns are the most studied in case with children [33, 29, 151]. Data received by N. P. Piatnitskiy and N. S. Malanyina [34] prove that the less mature the organism of a newborn child is the lower gastric secretion indexes are.

G .I. Dorofeyev and V. M. Uspenskiy [141] pointed out that during the first year of children's life gastric fundus is weakly developed (its length takes 1/4 of the total length of stomach in comparison with 1/3 of the total length in adults).

In newborn children thickness of gastric mucosa grows from fundus to pylorus where it reaches the maximum [148]. Epithelial lining is formed by multinuclear cells and more rarely by mononuclear cells. Lamina propria of the mucosa consists of a tender fibrous connective tissue diffusely infiltrated with lymphocytes.

When analyzing gastric peculiarities of newborn rats Z. S. Khlystova and Z. I. Lobanova [152] noted that mucosa of gastric fundus is folded and takes 1/3 of the total thickness of the stomach wall.

By the moment of birth the process of differentiation of gastric glandular apparatus is still far from being complete. The first parietal cells (the cells which are already formed) are unable to provide acid reaction of gastric juice. A number of authors [31, 153, 154] studied physiological peculiarities of age-related patterns concerning motor and functional activity of stomach and small intestine in pigs. These authors prove that the period of gastric juice achlorhydria in pigs is a vitally important process which promotes absorption of immune bodies coming with mother's colostrum. During this period of life

gastric juice is not proteolytically active but it can actively coagulate caseinogen of colostrum and milk and the whey formed (containing albumins and globulins) is evacuated to the intestine where these proteins are no doubt absorbed into blood. Functional peculiarities of stomach during the neonatal period of ontogenesis prove that it has a weak barrier function [29], and this in its turn contributes to occurrence of digestive tract diseases [4, 92, 155–157].

A. S. Nariadchikova [158] pointed out that newborn children do not have many glands in their gastric mucosa and that existing glands are located at a significant distance from each other. Pyloric part is the first area where gastric pits become deeper. Structure of gastric mucosa in this part of stomach looks especially incomplete [24].

According to A. F. Ryzhykh and L. K. Khabibullina [159] by the birth of a calf density of its fundic glands becomes increased due to formation of new glands, by means of introduction of surface epithelium (located between two gastric pits) to th underlying tissue (subiculum) as well as due to cells of gland neck.

Gastric glands of a newborn child contain a significant amount of indifferent cellular elements which are especially numerous at the bases of glands [24]. Parietal cells appear to be less resistant to impact of various pathogenic agents [139, 136].

According to data presented by Z. S. Khlystova and Z. I. Lobanova [152] formation of fundic glands is going on after birth of baby rats. The authors registered formation of fundic glands at the basis of mucosa pits, in places of accumulation of indifferent cells with high mitotic activity. In newborn rats fundic glands are lined with indifferent cells, parietal cells and singular mucous cells secreting neutral and acidic acid glycosaminoglycans.

I dogs the number of parietal cells is intensively increased during the first 12 weeks of postnatal life when their density in relation to the unit of mucosa volume reaches a more or less definitive level [71].

Many scientific works are devoted to studying gastric walls of mammals during the prenatal period of ontogenesis [44, 143, 160–162].

In case with pig fetuses the first parietal cells appear approximately at the age of 75 days, in sheep fetuses — at the age of 3 months, and in domestic bull fetuses — at the age of 4 months [163–165]. And the first main cells in mucosa of the fundic part in baby rats were determined by Z. S. Khlystova and Z. I. Khlystova and Z. I. Lobanova [152] only by the 15th day of life.

According to L. K. Khabibullina [166], the number of parietal cells in abomasum of newborn calves is increased: the average number of these cells per one fundic gland of 9-month-old fetuses is 5–7 and in 12-day-old calves this number is 20–25 cells. At the same time their diameter is also growing. They are located singly and their greatest number is presented in the central part of the gland.

Lamina muscularis consists of 4–7 raws of smooth muscle cells and an argyrophilic stroma [27]. The submucous layer includes a loose connective tissue with multiple cellular elements. According to O. V. Volkova and R. M. Pekarskiy [24], gastric muscularis propria of a newborn child is developed moderately except for the pylorus where it is the thickest. T. A. Bokov [27] noted that in newborn children the internal layer of muscularis propria is the thickest in the pyloric part and during the period of early infancy it becomes more than 2 times thiner. G. N. Alexandrov and G. Y. Talash [167] pointed out that in human fetuses the external muscular layer has an expressed syncytial structure. In the pyloric part it is 8–10 times thicker than in the fundus area. Researches performed by N. L. Kornesul et al. [168] and I. V. Vilkova [41] proved that in children from the moment of birth and till the age of one month old width reduction of bundles of smooth myocytes and stromal interlayers of muscularis propria is the most intensive. Serous membrane (serosa) is presented as a loose fibrous connective tissue of insignificant thickness located along stomach walls.

So, analysis of literature devoted to tissular peculiarities of walls in various parts of stomach proves that up to date there is a significant amount of information concerning structural features of stomach in newborn children and laboratory animals. There is no information about structure of surface epithelium and pit epithelium, presence of parietal cells, thickness of mucosa layers, submucous layer, muscularis propria and serosa in one-day-old piglets with various body weight. Patterns of morphogenesis of these structures in newborn animals have not been defined. Correlative relationships between tissue components of stomach wall coats in newborn piglets have not been determined

1.1.2 Stomach wall immune structures

Location of gastric mucosa as a border structure coming into contact with various substances (many of which are antigens) determines development of immune structures ensuring a sufficiently effective mechanism of local protection. Close integration of local lymphoid tissue with borderline tissues (and first of all with epithelial tissue) constitutes the basis of protective-barrier reactions of the organism which prevent penetration of foreign substances into the internal environment [50, 169–172].

After birth alongside with the development of glandular apparatus an active hystogenesis of stomach wall protective components is taking place (these are such components as intraepithelial lymphocytes, diffuse lymphoid tissue, lymph nodules, lymphatic vessels and gastric lymph nodes) [24]. Lymphoid tissue takes almost 1/4 of the total weight of digestive tract mucosa [173].

During the resent years many works have been devoted to the structure and functions of digestive tract lymphoid tissue predominantly in the small intestine [174–183].

Lymphocytes located between epithelial cells are the first to contact antigens presented in contents of the digestive tract. According to data presented by L. I. Aruin and O. L. Shatalova [51], in the

area of gastric fundus more than 52 lymphocytes are accounted for 1,000 epithelial cells, and in the pyloric part of stomach the respective number of lymphocytes is 59. Intraepithelial lymphocytes in stomach are localized in basal sections of epithelial layer, they are surrounded with a typical light limbus. Researches performed by the authors [184] show that the fundic part as well as the pyloric part contain solitary Intraepithelial lymphocytes the most of which are located on the level of nuclei of epithelial cells or deeper and are surrounded with a typical light limbus.

Data presented by Y. V. Modestova [185] confirm that there are significantly fewer lymphocytes among epithelial ells of gastric mucosa in comparison with their number in the small intestine (in small intestine their number varies from 100 to 300 cells per 1,000 enterocytes. L. I. Aruin and O. L. Shatalova [184] explain these differences by the fact that stomach epithelium only comes into contact with various antigens located in its gaps. And in the small intestine active absorption of nutritional substances is also taking place and due to this fact relatively large particles can penetrate through the epithelial cover.

M. N. Marsh [56] determined that 90 % intraepithelial lymphocytes are activated or transformed and that bear evidence of their immunological activity. Number of these cells is 9–20 % of the number of epithelial cells and according to the author their total weight is almost equal to the weight of pancreas [173].

Intraepithelial lymphocytes do not undergo dystrophic changes in the epithelium and do not migrate to the lumen of the organ [56, 186]. According to A. G. Babayeva [187] and A. P. Douglas, A. P. Weetman [173] their location between cells characterized by intensive renewal gives an opportunity to admit that intraepithelial lymphocytes take part in regulation of this renewal. This supposition of the authors is based on the proved phenomenon of immunological regulation of regeneration processes as well as on the fact that lymphocytes transfer regeneration information.

L. I. Aruin and O. L. Shatalova [184] established direct relationship between the number of IELs and the rate of epithelial cell renewal in stomach and small intestine. It is more intensive in small intestine than in stomach and greater number of intraepithelial lymphocytes in intestine can be explained by this fact. Intraepithelial lymphocytes are localized near miotically dividing cells at the bottom of pits. And according to the authors this fact proves participation of intraepithelial lymphocytes in regeneration processes [184].

The most researches intraepithelial lymphocytes have been performed when examining jejunum and ileum. There are only few separate works devoted to this matter when examining duodenum and stomach (in normal conditions as well as in pathology) [122, 188].

According to K. A. Zufarov and K. R. Tukhtayev [170] intraepithelial lymphocytes differ from stromal lymphocytes and belong to small lymphocytes. They have clear cytoplasm with multiple ribosomes and polyribosomes. Nuclei of cells are usually of an irregular shape and have several pits. The shape of lymphocytes themselves is to a significant extent defined by short pseudopodia with a help of which they adhere closely to cytoplasm of epithelial cells.

The specific localization of intraepithelial lymphocytes suggests that among all immune structures they are the first to meet various antigens located in the lumen of the digestive tract [184]. But many authors [134, 189–191] think that normally infiltration of gastric mucosa with lymphocytes is quite insignificant. The up-to-date classification of chronic gastritis forms presupposes that normal mucosa do not have the slightest infiltration. L. I. Aruin et al. [139] came to a conclusion that this peculiarity is typical only for fundic mucosa of the stomach. And as for the pyloric part, according to the authors plasmatic cells and lymphocytes are presented almost in every bioptic sample.

Lamina propria cells of the gastric mucosa are presented as fibroblasts, reticular cells, mast cells, plasmatic cells, lymphocytes

of various maturities. Neutrophils, eosinophils, basocytes, macrophages are also presented. Lymphocytes of various maturities are the most numerous cells in the gastric mucosa; they are presented throughout the stroma of the mucosa and in some places they form accumulations [119].

A typical peculiarity of immune formations of the digestive tract organs consists in availability of lymphatic noduleslocated in the loose connective tissue of mucosa as well as in the submucous layer. Mature lymphatic nodules consist of the basis (including the germinal center and the adjacent periphery — mantle), the crown and the cupola [54].

Structural peculiarities of lymphatic nodules of the stomach wall in dogs are described in the work by V. M. Koltoniuk and S. I. Boltrukevich [192]. The authors pointed out that the biggest lymphatic nodules (diameter from125 to 525 micron) are located in the wall of the cardiac part of stomach. Towards the pyloric part size of lymphatic nodules, especially their maximal dimensions gradually decrease. Alongside with clearly contoured lymphatic nodules, in the dog's stomach wall the researchers also determined diffuse lymphoid tissue (especially in the area of bottom of glands in the fundic part of the organ).

According to N. F. Bambuliak [193] gastric lymphoid formations in newborn piglets are located mainly in the Lamina propria mucosaeand in the submucous layer. Immature lymphatic nodules are located predominantly in the fundic part and as a rule they have fuzzy boundaries. According to the author accumulations of the diffuse lymphoid tissue are the most significant in the diverticulum and at the transition of the pyloric part of the stomach to the duodenum. N. F. Bambuliak pointed out that in newborn piglets germinal centers are not presented in anylymphatic nodules. Morphologists do not have a common opinion on this matter. Some authors point out that germinal centers inlymphatic nodules are registered yet

before the birth [54], and some other state their appearance only some days or even months after birth [17, 176, 178, 194–197].

According to L. I. Aruin et al. [184], there are only few lymphatic nodules in gastric mucosa of humans. These nodules are usually located in the pyloric part and do not contain germinal centers.

Researchers can not also come to consensus concerning organotopic peculiarities of gastric lymphatic nodules. Some researchers [48, 198] came to a conclusion that stomach wall saturation with lymphoid tissue decreases as approaching to the duodenum. And V. V. Kostyrkina [199], on the contrary registered the strongest saturation with lymphatic nodes in the wall of the pylorus. The largest number of works is devoted to lymphoid formations at the transition of the esophagus to the stomach as well as at transition of the stomach to the duodenum [199, 200].

In the stomach of pigs the greatest density of lymphatic nodules is presented in the cardiac part at the very border with the esophagus. Their number in the cardiac part of the stomach in a four month old piglet is 5,000. It is quite often that lymphatic nodules are located not far from the fundus, the pyloric part and in the diverticulum [193, 48]. According to the authors an intensive formation of lymphatic nodules occurs only after taking pigs away from their sow i. e. during the period of the strongest possibility to identify these nodules.

Scientific literature sources represent quite a complete description of lymphoid structure peculiarities in stomaches of laboratory animals [52, 75, 100, 138, 152]. I. G. Kaliniuk et al. [201] pointed out that in sexually immature rats lymphoid structures of the gastric mucosa are completely formed. The diffuse lymphoid tissue is formed by chains of lymphoid cells which are located parallel to the lamina muscularis of the gastric mucosa as well as between the glands. Lymphoid pre-nodules and lymphatic nodules have an oval, triangular or band-like shape in all parts of the stomach. Density

of plasmatic cells taking part in humoral immunity in lymphoid structures of gastric mucosa in rats is high in all age groups of these animals; and according to the authors [152] this fact proves an intensive functional activity of the lymphoid tissue during the entire period of postnatal ontogenesis.

Up to date the interest of researchers to the lymphatic system as a component of the immune system has increased significantly; and that is related with development of curative lymphology, lymphotropic therapy, lymphosorption and lymphostimulation [202–206]. The most works are devoted to describing ultrastructural organization of the lymphatic system [207, 208, 209, 210]. Age-related changes of lymphatic vessels in stomach of human and some other mammals have been described sufficiently [158, 211, 212]. At the same time researches devoted to describing macro- and microanatomic peculiarities of lymphatic flow in the stomach of piglets are quite insignificant [213, 214].

In the stomach networks of lymphatic capillaries are localized in the mucosa, the submucous layer, muscular coat and serosa. V. S. Revazov et al. [215] defined two lymphatic plexuses in human stomach — a deep plexus (submucosal) and a surface plexus (subserosal) which are used for moving lymph. According to data presented by D. A. Zhdanov [211], L. V. Chernshenko and A. A. Sushko [216], M. G. Fedosenko et al. [217] these networks are closely related to each other and have common lymphatic discharging vessels which are a single entity from the functional point of view. In addition to that V. S. Revazov [218] came to a conclusion that in all parts of the stomach wall lymphatic capillaries and plexuses have close anatomic and topographic relationships with networks of blood capillaries, arteries and veins. V. N. Balashev [59] determined interglandular sinuses in the stomach wall of rabbits; networks of lymphatic capillaries of the mucosa, the submucosa, the muscular coat and the serosa start from these interglandular sinuses.

Y. G. Ostroverkhov [219], L. V. Chernyshenko and A. A. Sushko [216] defined two networks of lymphatic capillaries in the gastric mucosa of human: the surface network and the deep network. The deep (subglandular) network is located not far from the bottom of gastric glands; it is localized on the lamina muscularis. The surface network of the mucosa (overglandular) is located on the level of the neck section of glands. According to V. N. Balashev [59] lymphatic system of gastric mucosa in mammals starts from interglandular sinuses — blind capillaries located between glands; and his point of view is also shared by other authors [211, 220, 221].

L. V. Chernyshenko and A. A. Sushko [216], Y. G. Ostroverkhov [219] prove that all lymphatic vessels of mucosa are capillaries with walls are formed only of endothelium. V. S. Revazov et al. [215] noted the direct contact between cells of gastric glands and lymphatic capillaries and suggested that these cells take part in absorption and transportation of hormones produced by endocrynocytes.

Y. M. Yanenko [222] determined relatively large lymphatic vessels in the fourth stomach of the sheep; these lymphatic vessels form network in form of cells with multiple capillary capillary anastomoses thanks to which they penetrate to lamina muscularis and in some cases to the submucous layer.

D. A. Zhdanov [211] and V. N. Balashev [59] have come to a consensus that on the lesser curvature of human stomach in the mucosa and in the submucous layer networks of lymphatic capillaries are denser than in other parts of the stomach; according to the researchers it can be explained by the fact that the most intensive secretion is taking place here in response to action of physiological stimuli.

L. V. Chernyshenko and A. A. Sushko [216] denote that the submucosal network of lymphatic vessels of the human stomach consists of a single layer. According to these scientists it is formed by lymphatic vessels of two types. Lymphatic vessels of the greater diameter form a wide-meshed network with a close-meshed network in it.

The authors also define two ways for outflow of lymph from the submucous network: a short one (direct) and a long one (indirect).

V. A. Bizhokas [213] defined lymphatic vessels of the 1st order, the 2nd order and the 3rd order in the submucous layer of the stomach in gilts and adult pigs. At the same time lymphatic vessels of the 2nd order and the 3rd order form vascular bundles with arterial and venous trunks. Lymphatic capillaries in the connective-tissue interlayers between bundles of oblique, circular and longitudinal muscular fibers are oriented with longitudinal axes of their meshes parallel to muscle bundles.

According to data presented by L. V. Chernshenko and A. A. Sushko [216] think that there are no lymphatic vessels directly connected with muscle fibers. Each of the three muscle layers of the stomach wall (in the connective tissue around bundles of muscle cells) includes lymphatic vessels and anastomoses between them. V. Y. Chumakov et al. [50], Y. M. Yanenko [222] (when examining the muscularis propria of the fourth stomach of the sheep) determined a network of lymphatic capillaries in the longitudinal layer and the circular layer.

Architectonics of subserosal plexuses of excurrent lymphatic vessels and capillaries of the network has its local peculiarities. D. A. Zhdanov [211] pointed out that in the fundic part of the stomach in humans loops are large and have a polygonal form and in the lesser and greater curvatures they are elongated and smaller. In pyloric part of the stomach the network consists of very thin lymphatic vessels which are elongated. Y. G. Ostroverkhov [219] considers that the surface layer of lymphatic capillaries is poorer and consists of rare loops which may be intermittent.

According to Z. I. Rakhman [223] in the fundic part of the human stomach loops of the subserosal network are stretched parallel to its edge. In the left part of the greater curvature they are located obliquely from left and upwards as well as downwards and

to the right; and at the same time in the right part of the greater curvature meshes of the subserosal lymphatic network have the opposite arrangement.

L. V. Chernshenko and A. A. Sushko [216] explain intensive development of lymphatic networks in the subserous layer by availability of a great amount of anastomoses with lymphatic vessels of other layers of the stomach wall. According to data presented by V. A. Bizhokas [214] in gilts and adult pigs the largest networks of lymphatic capillaries are located in the middle third of anterior and posterior walls of the stomach. The size of these networks decreases towards edges of the organs.

Many authors determine finger-shaped capillaries which resemble outpouching of the lymphatic vessel wall. A. I. Sviridov [224], Leak L. V. [225, 226] thinks that these are blind capillaries. R. S. Orlov et al. [227], A. V. Borisov [228] supposes that these are growing capillaries or newly formed capillaries.

Up to date there are doubts whether lymphatic vessels of the stomach and the duodenum in human and animals are connected. Y. G. Ostroverkhov [219] rejects relations of the surface network of lymphatic capillaries in the pyloric part of the stomach and the duodenum in humans. D. A. Zhdanov [211], L. S. Bespalova [229], O. I. Melnik et al. [230] consider that lymphatic capillaries and lymphatic vessels of all layers of the stomach transfer to the similar capillaries and lymphatic vessels of the first section of the duodenum. L. V. Chernyshenko and A. A. Sushko [216] explain weakened penetration of injected masses from lymphatic vessels and the submucosal layer of the stomach to the respective networks of the esophagus and the duodenum by changes in histological structure of their mucosa and submucous layer which is also reflected on the form of lymphatic networks.

According to V. V. Revazov [221], the side where lymphatic vessels of the abdominal section of the esophagus enter the stomach

jointly with the cardiac part of the stomach represents a single fragment of lymph drainage as well as from the pylorus and the duodenum to regional lymph nodes.

Due to simultaneous execution of drainage function, barrier and filtration function and immunological function unique mechanisms of mechanical and biological lymph filtration as well as mechanisms of lymphocyte migration were organized in lymph nodes [61, 231, 232, 233, 210]. The up-to-date concept determining peculiarities of structural and functional organization of lymph nodes in mammals is based on specialization of various parts of lymph node parenchyma as well as on their consolidation into functional segments or compartments [234–238].

Among multiple works devoted to studying the lymphatic system data concerning structural peculiarities and topography of gastric lymph nodes in mammals (especially of the neonatal period of life) are quite poor and sometimes contradictory. The most works are devoted to peculiarities of structural and functional organization of lymph nodes in conditions of experimental pathology [239, 240, 241].

Age-related peculiarities of lymph node architectonics have been most thoroughly studied in humans and laboratory animals [242–246]. V. G. Motalov [246] pointed out that with age amount of connective tissue in lymph nodes of humans is increased, medulla dominate over cortex zone, the number of lymphatic nodules is decreased which is consistent with the result of researches performed by D. A. Zhdanov [211] and S. S. Vinogradova [247].

There is also a quite significant amount of informative information concerning peculiarities of topography and hystoarchitectonics of lymph nodes in the multi-chambered stomach of ruminants [248].

By the moment of birth the process of differentiation of the internal structure of lymph nodes in ruminants is not simultaneous. V. Y. Lipchenko et al. [243] determined that large nodes as well as

lymph nodes with a well-developed vascular bed are the most differentiated. According to data presented by Y. I. Borodin et al. [61] the most rapid growth of lymph nodes in humans occurs next after birth when plasmatic cells and well-formed germinal centers appear in these nodes. A sign of functional maturity of the immune system peripheral organs consists in presence of lymphatic nodules in them (especially with germinal centers) [249, 250, 251, 252, 253].

According to some authors [254, 255, 256] germinal centers in lymphatic nodules appear soon after birth when the organism of a newborn meet the ambient environment and is subjected to influence of antigens. According to K. S. Kabak et al. [257] there are no lymphatic nodules with germinal centers in lymph nodes of newborn puppies. But V. A. Florensov [258] pointed out that germinal centers of lymphatic nodules in human fetuses appear already by the 5th month of prenatal development and by the 9th moth they are registered in all lymph nodes. This fact is consistent with results of researches performed by other authors [259–262].

A. A. Buyanov et al. [17] observed a clear separation of medulla and cortex zone as well as primary lymphatic nodulesin mesenteric lymph nodes of 10-day old piglets. And in 20-day old piglets the authors determined also lymphatic nodules with germinal centers where macrophages, reticular and plasmatic cells can be determined.

The connective-tissue framework of a lymph node is presented as a capsule with a neck thickening and trabecules and their cortex zone and medulla form parenchyma of the organ Capsule with hilar thickenings and trabecules form the main carcass of a lymphatic node which performs demarcation function and support function [263–265]. Depending on the development of the capsular-and-trabecular apparatus and the lymphoid parenchyma Y. I. Borodin et al. [61] determined 3 types of lymph node histological structure: fragmentary, compact and intermediary.

Relative area of the connective-tissue stroma is significantly more developed in somatic lymph nodes in comparison with visceral lymph nodes [266, 267, 268]. So, M. R. Sapin and N. O. Bartosh [269] pointed out that in mesenteric lymph nodes relative area of the cortex zone varies widely (26–63 %), and in iliac lymph nodes this variation is not so wide (26–40 %). T. R. Korabliova [270] determined the maximal relative area of the cortex zone in lymph nodes of the jejunum caudal zone (43 %) and the minimal relative area of the cortex zone belongs to lymph nodes of the duodenum (34 %).

According to S. S. Vinogradova [247] (who studied structure of the connective-tissue framework in case with various groups of lymph nodes in humans) the thickest capsule was determined in surface inguinal nodes (up to 355 microns), and the thinest capsule was determined in deep cervical nodes (not more than 104 microns) and some mesenteric lymph nodes (7–14 microns). When studying lymph nodes of some laboratory animals (dogs, cats, rats) A. I. Gazizova and Zh. K. Alkeyeva [271] determined that the thinest capsule is typical for splenic lymph nodes, a thicker one — to gastric lymph nodes, pancreatic lymph nodes and hepatic lymph nodes and the thickest one — to ileocecal lymph nodes. L. P. Goralskiy [272] determined that relative area of the cortex zone of lymph nodes is more developed in sheep (over 55 %), and medulla is more developed in horses (over 68 %).

Data determining peculiarities of the reticular framework of lymph nodes in mammals are quite poor [273, 274]. Reticular tissue being a type of connective tissue performs the support function and the function of a microenvironment for lymphoid elements. Architectonics of reticular fibers in various structural and functional zones of lymphatic zones is unequal [172, 275]. In the cortex area of a lymph node networks of reticular tissues are woven-like and in paracortex zones they are honeycomb-like, and in Billroth's

strand they are felt-like, and in lymphatic nodes they are evenly coarse-grained. Y. Y. Vyrenkov et al. [231] pointed out that amount of reticular tissues is decreased in the direction from cortical sinuses to medullary sinuses. And according to the authors in portal sinus reticular tissues are found rarely.

So, analysis of researches performed by many authors shows that peculiarities of immune structures of the stomach are to a larger extent described in humans, laboratory and wild animals. In production animals these researchers are rare. Data concerning presence and structure of lymphatic nodules in newborn mammals in the stomach wall as well as in lymph nodes are contradictory. Data determining peculiarities of the reticular framework of lymph nodes in mammals are quite poor. Data concerning studying structural and functional peculiarities of gastric lymph nodes in pigs are quite disaggregated and contradictory. There is almost no information about structural peculiarities of immunocompetent structures in various parts of the stomach wall in piglets**.** Until now no complex researches of tissue components and immune structures of gastric coats in piglets during their neonatal period have been performed (researches determining morphogenetic relations between glandular and protective formations in the stomach).

Section 2. Main trands, materials and methods of research

Morphogenesis of tissue components of the stomach wall and its immune structures in piglets during the neonatal period (piglets of Poltava meat breed — PM-1) have been researched.

One-day old pigs (according to indexes of bodyweight and other body articles they were divided into three groups) as well as 5-, 10- and 20-day old piglets were chosen for the research (table 2.1). The total number of researched animals is 30 (n = 5).

For researching gastric lymph vessels in piglets intratissual injections to lymph capillaries and lymph nodes were made (china ink on the 3 % aqueous gelatin solution) as well as Impregnation of the intrinsic lymphatic bed of an organ by the Ranvier method [276] with further preparation and manufacturing of total cleared specimens.

Morphometry of lymphangions was performed with a help of MBS-10 microscope with standard ocular inserts [277].

Volume of lymphangions was calculated according to the formula (A. V. Borisov, 1984; cited according to V. Y. Chumakov [278]):

$$V = Ш^2 \cdot Д/2,$$

where V — volume of lymphangion; Ш — width of lymphangions;
Д — length of lymphangion.

Valve index was calculated according to the formula (V. Y. Chumakov [278]):

$$КИ = К/Д,$$

where К — he total number of valves; Д — length of the vessel in mm.

For histological researches sections of the stomach wall in cardiac part, pyloric part, fundus and lesser curvature were selected (tables 2.2; 2.3).

Table 2.1 – Dynamics of body weight and linear parameters of some body articles in piglets

Indexes / Age (days), group		Body weight, g	Cv, %	Height at the shoulder, mm	Cv, %	Chest girth behind the shoulder blades, mm	Cv, %	Head length, mm	Cv, %	body length, mm	Cv, %	Tail length, mm	Cv, %
I	I	1454.00 ± 46.54	7.15	199.80 ± 3.66	4.10	235.20 ± 3.81	3.62	107.80 ± 2.59	5.38	269.00 ± 5.62	4.67	90.00 ± 2.48	6.18
	II	1144.00 ± 45.01**	8.79	191.40 ± 2.73	3.19	222.20 ± 5.00*	5.03	102.60 ± 2.18	4.75	246.80 ± 6.28*	5.69	84.80 ± 4.39	11.59
	III	812.00 ± 18.50**	5.10	168.80 ± 2.33**	3.08	197.20 ± 4.91*	5.57	100.20 ± 2.97	6.63	217.00 ± 3.39**	3.49	71.80 ± 1.42*	4.44
5		1926.00 ± 147.09***	17.07	202.20 ± 5.56**	6.15	241.60 ± 4.36**	4.21	114.8 ± 3.44*	6.70	278.20 ± 6.43***	5.79	82.80 ± 4.17	11.27
10		2934.00 ± 237.58*	18.10	227.80 ± 9.40	9.23	262.80 ± 12.84	10.93	120.20 ± 3.56	6.63	296.60 ± 14.04	10.58	99.40 ± 7.89	17.73
20		4458.00 ± 168.35**	8.44	229.20 ± 3.33	3.25	281.80 ± 12.93	10.26	126.00 ± 6.95	12.34	303.20 ± 6.19	4.72	102.60 ± 4.28	9.33

Note: * — $p < 0.05$; ** — $p < 0.01$; *** — $p < 0.001$

Table 2.2 – Study materials

Material	Age of piglets, days				Total
	1	5	10	20	
Stomach: – cardiac part	15	5	5	5	30
– fundus	15	5	5	5	30
– pyloric part	15	5	5	5	30
– lesser curvature	15	5	5	5	30
Gastric lymph nodes	15	5	5	5	30
Total:	**75**	**25**	**25**	**25**	**150**

Table 2.3 – Distribution of material according to applied methods of research

Methods of research:	Number of specimens (units) for age groups of animals (days)				
	1	5	10	20	Total
Stomach					
1. Morphometry	15	5	5	5	30
2. Whole specimens	15	5	5	5	30
3. Histological:					
– hematoxylin and eosin	300	100	100	100	600
– congo red and hematoxylin	180	60	60	60	360
– caustic silver impregnation	180	60	60	60	360
Intra-stomach lymphatic vessels					
4. Intratissual injection	9	3	3	3	18
5. Preparation	9	3	3	3	18
6. Cleared specimens	27	9	9	9	54
7. Whole specimens	9	3	3	3	18
8. Morphometry	27	9	9	9	54
Gastric lymph nodes					
9. Preparation	15	5	5	5	30
10. Histological:					
– hematoxylin and eosin	75	25	25	25	150
– caustic silver impregnation	27	9	9	9	54
Total:	**888**	**296**	**296**	**296**	**1776**

Material was fixed in 5 % aqueous neutral formalin solution at a temperature t = +4 °C, and then in 10 % solution where it was stored during the entire period of researches. Bits of organs were washed in running water during 1–2 days with further preparation of histotopograms (thickness of 25–30 microns) on the freezing microtome MK-25 M [279]. Temperature in the freezing chamber of cryostat was maintained on the level of –15 … –18 °C. Bits of organs were fixed on the object holder table. After the block was leveled glycerin-gelatin mixture (gelatin — 3 g, glycerin — 20 ml, water — up to 100 ml) was brought to the frosted plate. After preparation a slice from the microtome knife with a help of preparation needle was placed to the object glass. Then the slices were dried on object glasses at room temperature during 14–30 days. Glycerin-gelatin mixture before staining was removed by means of careful immersing of slices to warm water (up to 40–50 °C). After being washed in water the slices were stained with hematoxylin and eosin according to the generally accepted method [280].

For determining reticular tissues slices of the stomach wall and lymph nodes were impregnated with caustic silver (lunar caustic) according to Foot's method [280, 281].

For staining histological slices with Congo red bits of the organs were embedded in paraffin according to the generally accepted method [280]. Slices (thickness 5–10 microns) were prepared in a sliding microtome.

Investigation of histotopograms was performed with a help of a stereoscopical microscope (MBS-10) "Biolam-LOMO" with a binocular adjustment АУ-12УЧ2 and МВІ-6. Quantitative microscopic analysis was performed with a help of eyepiece micrometer МОВ-1–15^{x} and ocular insert with a measuring scale according to G. G. Avtandilov's method [277]. Calibration of ocular inserts was performed with a help of object micrometer. Quantitative analysis of lymph node structural components was performed with a help of

"point counting" method with a help of ocular test inserts. Relative area of tissue structures was calculated according to the following formula:

$$V_{vi} = P_i / P_t \cdot 100\,\%,$$

where V_{vi} — relative area of the structure in volume of the organ, %; P_i — number of points on the structure (items); P_t — total number of points of the test system on the tissue specimen, items.

Statistical processing of the received numerical (digital) data was performed on personal computer with a use of standard software packages MS Excel and NCSS 2000. Difference between indexes of average values was considered statistically reliable at the following values: * – $p < 0.05$; ** – $p < 0.01$; *** – $p < 0.001$. Variation coefficient was determined between tissue components of stomach wall in various parts of the stomach and piglet body weight [282].

Photographing histotopograms and whole specimens was performed with a help of microscopes Olympus CX 21, MBI-6 and MBS-10 with a use of digital camera "Samsung Digimax V 700".

Section 3. Research results

3.1 Structural peculiarities of tissue components of the cardiac part of the stomach in piglets

The wall of the stomach consists of four coats and each of these coats has its structural and functional peculiarities. Under the mucosa submucous coat (submucosa) is located, then muscular coat and serous coat are located.

Mucosa of the cardiac part of the stomach has a velvety surface with pits and rare folds. The pits are deep and they take almost half of mucosa thickness. Surface epithelium and pit epithelium of the gastric mucosa is single-layer columnar epithelium. Borders of epithelial cells are clear; their nuclei are oval or more seldom round and are located basally. Epithelium height is various and depends on the part of the stomach as well as on the body weight and age of animals. Cardiac glands are simple tubular branched and wavy glands. They are relatively rare and are localized in the lamina propria of the gastric mucosathe gastric mucosa which in its turn is presented as a loose connective tissue including thin collagen, elastic and reticular fibers as well as microvasculature and cellular elements. Cardiac glands have parietal cells in their composition.

3.1.1 One-day old piglets

Depth of gastric pits in piglets with body weight corresponding to the breed standard is 63.04 ± 5.94 microns (fig. 3.1). The pits are wide and it is often that ducts of two glands open to the same pit (fig. 3.2). In one day old piglets with body weight higher than the breed standard depth of mucosa pits in the cardiac part of the stomach is 12.26 % higher (in case of high variability Cv = 54.39 %).

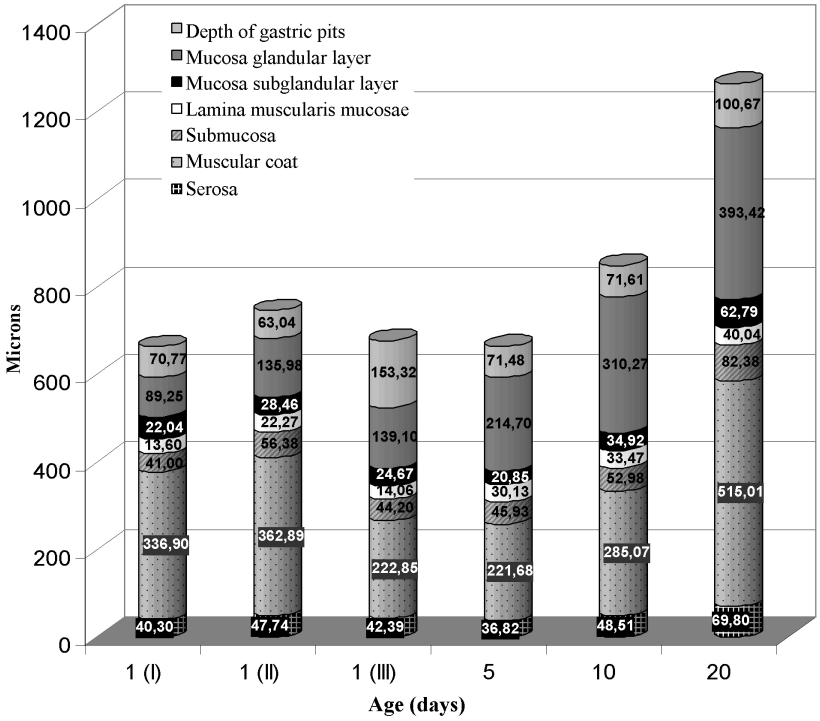


Fig. 3.1 Dynamics of tissue components in the cardiac part of the stomach in piglets

In this part of gastric mucosa glands are wavy with expressed interlayers of interglandular loose connective tissue which is especially typical for one day old piglets with body weight exceeding the breed standard (fig. 3.3). Pits of the cardiac part of the stomach are the deepest in one day old piglets from Group III (fig. 3.4). These pits are 143.21 % (in case of significant variability — Cv = 141.10 %) than in piglets with body weight corresponding to the breed standard. Gland-pit ratio in animals from Group II is moderate (1 : 0.46), and in animals from Group I it is narrow (1 : 0.79), and in animals from Group III it is wide (1 : 1.10), and that bear evidence of almost equal thickness of the mucosa glandular layer and depth of gastric pits in these animals (table 3.1).

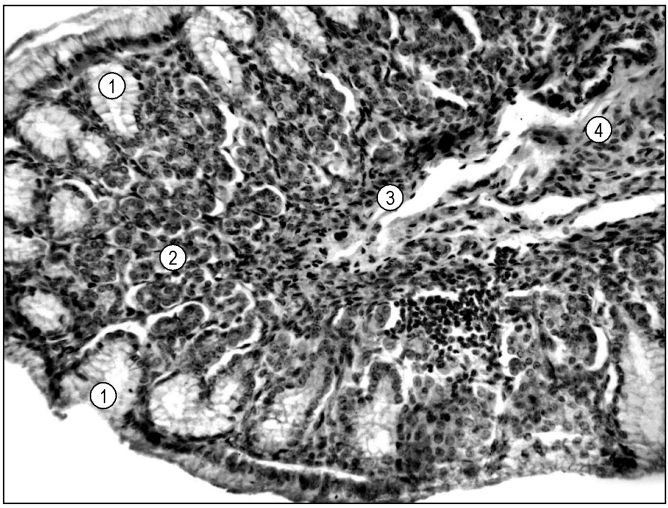


Fig. 3.2 Histological specimen of the cardiac part of the stomach in piglets (one day old, Group II). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — pits; 2 — glands; 3 — lamina muscularis of the mucosa; 4 — submucosa

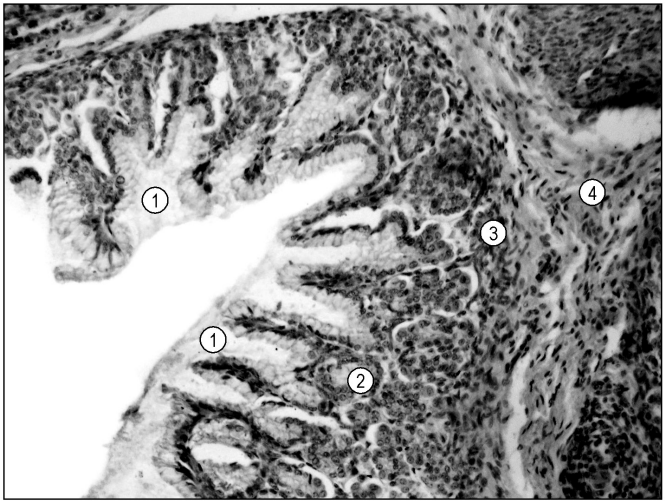


Fig. 3.3 Histological specimen of the cardiac part of the stomach in piglets (one day old, Group I). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — pits; 2 — glands; 3 — lamina muscularis of the mucosa; 4 — submucosa

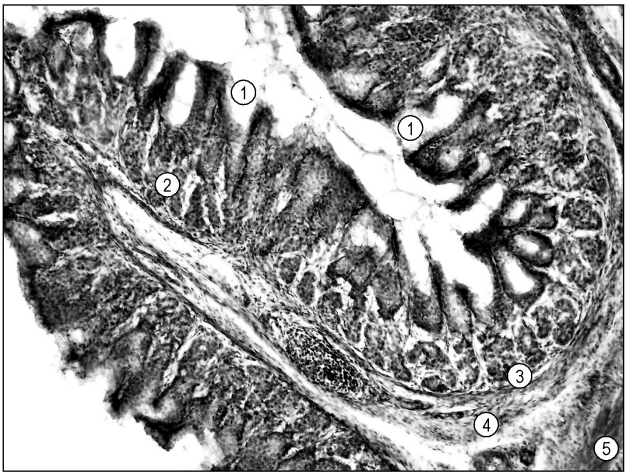


Fig. 3.4 Histological specimen of the cardiac part of the stomach in piglets (one day old, Group III). Hematoxylin and eosin, Olympus CX 21, ×100: 1 — pits; 2 — glands; 3 — lamina muscularis of the mucosa; 4 — submucosa; 5 — muscular coat (muscularis propria)

Table 3.1 – Dynamics of ratio between structures and coats of the cardiac part of the stomach wall in piglets

Indexes \ Age (days), group		1			5	10	20
		I	II	III			
Mucosa	1. Gland-epithelium	1:0.28	1:0.18	1:0.15	1:0.14	1:0.13	1:0.10
	2. Gland-pit	1:0.79	1:0.46	1:1.10	1:0.33	1:0.23	1:0.25
	3. Glandular-subglandular	1:0.24	1:0.21	1:0.17	1:0.09	1:0.11	1:0.15
	4. Glandular-muscular	1:0.15	1:0.16	1:0.10	1:0.14	1:0.10	1:0.10
5. Mucosal-submucosal		1:0.15	1:0.16	1:0.09	1:0.09	1:0.08	1:0.10
6. Mucosal-muscular		1:1.25	1:1.06	1:0.49	1:0.47	1:0.46	1:0.62
7. Mucosal-serosal		1:0.15	1:0.13	1:0.09	1:0.07	1:0.07	1:0.08

Thickness of the mucosa glandular layer of the cardiac part of the stomach in one day old piglets from Group II is 135.98 ± 36.11 microns, and thickness of the subglandular layer is 28.46 ± 3.05 microns. At the same time glandular-subglandular ratio is wide (1 : 0.21), and that is due to greater thickness of the mucosa glandular layer. And in piglets from Group I the mucosa glandular layer is thiner (by 34.36 %), providing significant variations (Cv = 28.49 %), and the subglandular layer is also thiner (by 22.56 %) (Cv = 18.78 %), and glandular-subglandular ratio is significantly narrower (1 : 0.24), in comparison with the same ratio in animals from Group II. In one day old piglets from Group III the mucosa glandular layer is significantly thicker (by 2.29 %) with high variability (Cv = 45.72 %), and the subglandular layer is thiner (by 13.32 %) as well as its variability (Cv = 12.88 %) in comparison with the same indexes in Group II. This causes widened glandular-subglandular ratio (1 : 0.17) which bears evidence of a greater thickness of the mucosa glandular layer.

A similar trend is observed in morphometric characteristics of the lamina muscularis mucosae. Its thickness in piglets from Group II is maximal (22.27 ± 3.20 microns), and this causes a wide glandular-muscular ratio (1 : 0.16). And in one day old piglets from Group I lamina muscularis in the cardiac part of the stomach is 38.93 % thiner, and glandular-muscular ratio is narrower (1 : 0.15). Lamina muscularis mucosae in piglets from Group III is 36.86 % thiner and glandular-muscular ratio is the widest (1 : 0.10).

Thickness of submucous coat (submucosa) (56.38 ± 7.61 microns), muscular coat (tunica muscularis) (362.89 ± 88.52 microns) and serous coat (serosa) (47.74 ± 4.64 microns) of the wall in the cardiac part of the stomach is dominant in piglets with body weight corresponding to the breed standard. Mucosal-submucosal ratio (1 : 0.16) as well as mucosal-serosal ratio are wide (1 : 0.13), and mucosal-muscular ratio is narrow (1 : 1.06). In animals with body weight higher than the respective breed standard the gastric

submucosa is 37.51 % thiner (Cv = 36.08 %), as well as the muscular coat (7.16 % thiner) and serosa (15.58 % thiner) providing significant variations of indexes (Cv = 43.36 % and 19.58 %). Mucosal-submucosal ratio and mucosal-serosal ratio are wide (1 : 0.15), and mucosal-muscular ratio is narrow (1 : 1.25) due to increased thickness of the muscular coat. In this part of the stomach, in its muscular coat the following two layers are well expressed : the internal layer (oblique) and the external layer (longitudinal). In animals with body weight lower than the breed standard the submucosa is thiner (by 21.60 %), as well as the muscular coat (by 38.59 %) and serosa (by 11.20 %). Variability of the indexes is significant — Cv = 35.78–29.34 %. The muscular coat of the cardiac part of the stomach also includes an oblique layer and a longitudinal layer. Mucosal-muscular ratio in piglets with body weight lower than the breed standard is wider (1 : 0.49) and mucosal-serosal ratio is narrower (1 : 0.09) than in animals with body weight corresponding to the breed standard and that is due to the fact that mucosa and especially lamina muscularis mucosae are thiner.

In piglets from Group II height of the surface epithelium is 24.79 ± 2.08 microns, and height of the pit epithelium is 18.72 ± 0.88 microns (fig. 3.5). The glandular-epithelial ratio is wide (1 : 0.18). In piglets from Group I height of the surface epithelium in the cardiac part of the stomach is maximal (25.52 ± 2.90 microns with variations Cv = 18.61 %) among one day old animals. And height of the pit epithelium is slightly less (by 2.56 %, with Cv = 12.42 %) in comparison with piglets from Group II. The glandular-epithelial ratio is a bit narrower (1 : 0.28). Nuclei of epithelial cells have an elongated shape. In one day old piglets from Group III height of the surface epithelium and pit epithelium is less (by 14.84 % and by 13.46 % respectively) providing decreased coefficient of variability (Cv = 7.14 %), in comparison with Group II. Glandular-epithelial ratio in these animals is wide (1 : 0.15) in comparison

with their agemates from other groups and that is due to the lowest height of the surface epithelium.

In piglets from Group II diameter of glands is 27.73 ± 1.11 microns (table 3.2) and in piglets from Group I this diameter is larger (by 13.95 %) and in piglets from the group III it is smaller (by 23.15 %) providing insignificant individual variations (Cv = 7.80 %).

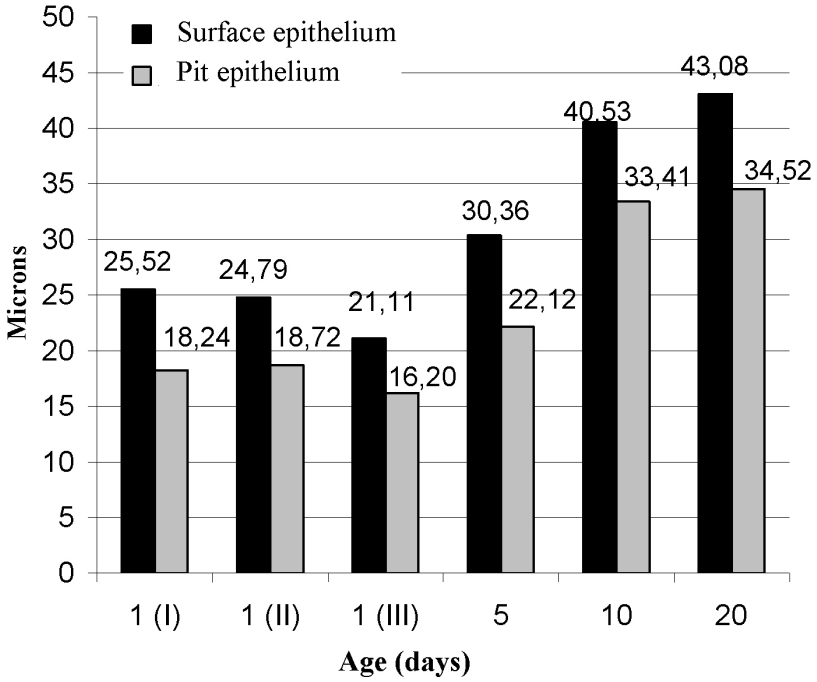


Fig. 3.5 Dynamics of the height of the single-layer columnar epithelium in the cardiac part of the stomach in piglets

Among all researched one day old animals the largest number of parietal cells (15.4 ± 0.40 items) within one cardiac gland providing insignificant variations (Cv = 5.81 %), was revealed in piglets from Group II. In animals from Group I this number is 29.87 % less, and in animals from Group III it is 49.15 % less.

When analyzing dynamics of the cardiac part of the stomach it was determined that the mucosa glandular coat is the thickest in

one day old piglets from Group III while in piglets from groups I and II it is thiner by 35.83 % and 2.24 % respectively. Pits of the cardiac part of the stomach are also the deepest in one day old piglets from the group III. And as for other morphometric indexes (thickness of the subglandular coat, the lamina muscularis mucosae, the submucosa, the muscular coat and the serosa, as well as the number of parietal cells) in the cardiac part of the stomach Group II appears to be dominating.

Table 3.2 – Dynamics of diameter of glands and number of parietal cells within one gland in the cardiac part of the stomach in piglets

Indexes / Age (days), group		Diameter of glands, micron		Number of parietal cells, units	
		M ± m	Cv, %	M ± m	Cv, %
1	I	31.60 ± 0.91	6.42	10.80 ± 0.37	7.75
	II	27.73 ± 1.11	8.95	15.40 ± 0.40	5.81
	III	21.31 ± 0.74**	7.80	7.83 ± 0.31***	9.61
5		35.18 ± 0.84***	5.37	16.40 ± 0.51***	6.95
10		38.69 ± 0.95*	4.81	17.80 ± 0.37	4.70
20		48.32 ± 2.05**	9.51	21.80 ± 1.06*	10.95

Note: * — $p < 0.05$; ** — $p < 0.01$; *** — $p < 0.001$

3.1.2 5-, 10- and 20-days old piglets

Depth of pits of the mucosa in the cardiac part of the stomach in 5-day old piglets is increased by 13.38 %, providing insignificant variability — Cv = 4.98 % in comparison with one-day old piglets with body weight corresponding to the breed standard. Alongside with this the gland-pit ratio is widened (1 : 0.33) and this fact indicates a significant increase of the mucosa glandular coat thickness, providing a less intensive increase of pit depth. Gastric pits are wide (fig. 3.6)

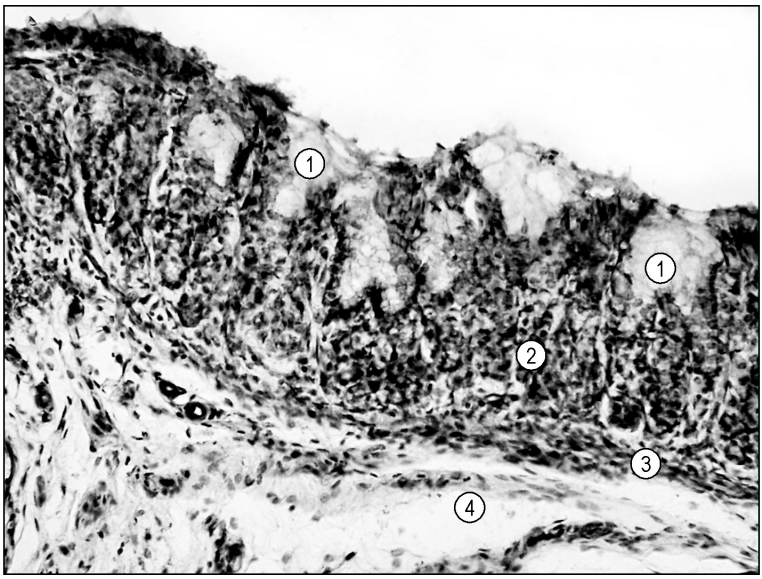


Fig. 3.6 Histological specimen of the cardiac part of the stomach in piglets (5-day old). Hematoxylin and eosin, Olympus CX 21, ×100: 1 — pits; 2 — glands; 3 — lamina muscularis mucosae; 4 — submucosa

Glandular coat of the gastric mucosa is also becoming thicker very intensively (by 57.89 %) (Cv = 5.03 %), its thickness exceeds the respective index in one-day old piglets from Group II; while the subglandular coat is decreased by 26.74 % (Cv = 6.10 %) which leads to a significant widening of the glandular-subglandular ratio (1 : 0.09). Thickness of lamina muscularis mucosae is increased by 35.29 %, while the submucosa is becoming 18.53 % thiner. This trend has an effect on the ratio between these structures. So, glandular-muscular ratio is widened (1 : 0.14) and mucosal-submucosal ratio remains on the same level (1 : 0.09). The muscular coat is decreased by 38.91 % and serosa is decreased by 22.87 % in comparison with one-day old piglets from Group II. At the same time mucosal-muscular ratio (1 : 0.47) and mucosal-serosal ratio (1 : 0.07) are widened. Two layers are expressed in

the muscular coat of the stomach: external layer (longitudinal) and internal layer (oblique).

Height of the surface epithelium as well as height of the pit epithelium of the cardiac part of the stomach in 5-day old piglets is increased (by 22.46 %; Cv = 4.35 % and 18.16 %; Cv = 5.88 %) in comparison with one-day old piglets from Group II. And at the same time glandular-epithelial ratio is widened up to 1 : 0.14.

In 5-day old piglets diameter of glands in the cardiac part of the stomach is increased (by 26.86 %) in comparison with one-day old piglets from Group II. And number of parietal cells within one cardiac gland of the stomach is increased by 6.49 %.

In 10-day old piglets depth of gastric pits remains practically unchanged in comparison with 5-day old piglets (fig. 3.7). Thickness of the mucosa glandular coat is increased by 44.51 % (Cv = 11.51 %) and that leads to widening of gland-pit ratio (1 : 0.23). Thickness of the mucosa subglandular layer is also increased (by 67.48 %; Cv = 9.27 %) while glandular-subglandular ratio becomes narrower (1 : 0.11). Thickness of the lamina muscularis mucosae in the cardiac part of the stomach is increased by 11.08 % and glandular-muscular ratio is widened (1 : 0.10). Thickness of the submucosa and the muscular coat is increased by 15.34 %, and by 28.59 % respectively. So, mucosal-submucosal ratio (1 : 0.08) and mucosal-muscular ratio (1 : 0.46) are widened. In this part of stomach the serosa is also thickened (by 31.74 %) providing insignificant variability (Cv = 6.48 %), but the mucosal-serosal ratio (1 : 0.07) remains wide.

In 10-day old piglets height of the surface epithelium is increased (by 33.49 %), and the height of the pit epithelium is increased (by 51.04 %) in comparison with 5-day old piglets, providing insignificant individual variations (Cv = 4.19 %). At the same time an insignificant widening of the glandular-epithelial ratio (1 : 0.13) is observed. Diameter of glands in the cardiac part f the stomach is increased by 9.97 % (Cv = 4.81 %).

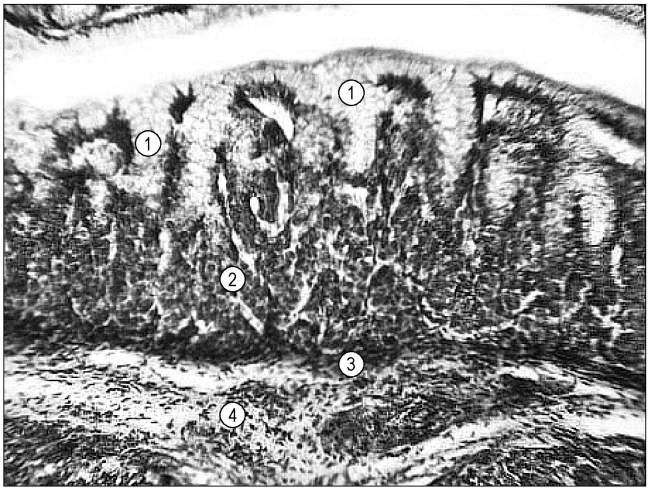


Fig. 3.7 Histological specimen of the cardiac part of the stomach in piglets (10-day old). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — pits; 2 — glands; 3 — lamina muscularis mucosae; 4 — submucosa

In 10-day old animals number of parietal cells within one cardiac gland of the stomach is increased by 8.53 %, providing insignificant variability (Cv = 4.70 %) in comparison with 5-day old animals.

Depth of pits in the cardiac part of the stomach is maximal in 20-day old piglets (fig. 3.8), and that leads to narrowing of the gland-pit ratio (1 : 0.25). At the same time thickness of the glandular coat is increased (by 26.79 %) providing insignificant variability (Cv = 10.25 %), in comparison with 10-day old piglets**.** Thickness of the mucosa subglandular layer is increased by 67.48 % and thickness of the lamina muscularis mucosae is increased by 19.63 %, while the glandular-subglandular ratio is narrowed (1 : 0.15). At the same time thickness of the submucosa is increased (by 55.49 %), and thickness of the muscular coat is also increased (by 80.66 %) in comparison with 10-day old piglets. Due to almost equal increase of the respective coats the mucosal-submucosal ratio (1 : 0.10)

remains narrow, and the mucosal-muscular ratio (1 : 0.62) remains moderate. Thickness of the serosa in the cardiac part of the stomach in 20-day old piglets is increased by 43.88 %, ant that leads to a certain narrowing of the mucosal-serosal ratio (1 : 0.08) in comparison with 10-day old animals.

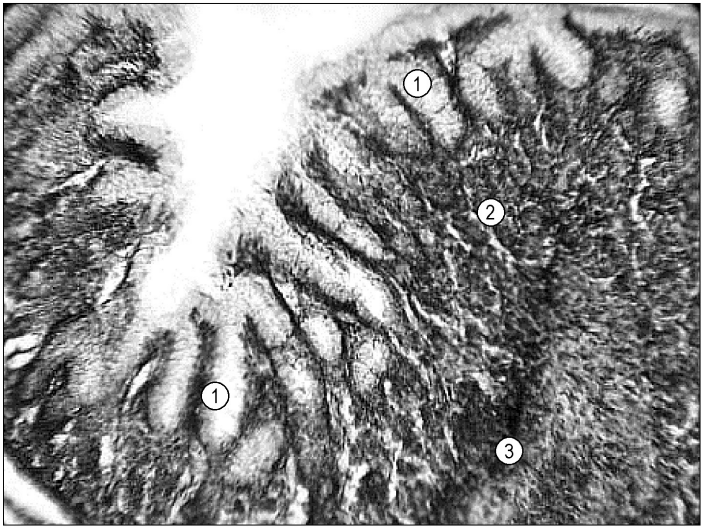


Fig. 3.8 Histological specimen of the cardiac part of the stomach in piglets (20-day old). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — pits; 2 — glands; 3 — lamina muscularis mucosae

In 20-day old piglets height of the surface epithelium and the pit epithelium in the cardiac part of the stomach reaches its maximal value (43.08 ± 0.13 microns and 34.52 ± 0.75 microns) providing an insignificant coefficient of variability (Cv = 0.70 and Cv = 4.88 %), which is manifested as a wide glandular-epithelial ratio (1 : 0.10).

Diameter of glands in the cardiac part of the stomach is increased (by 24.89 %; Cv = 9.51 %) in comparison with 10-day old piglets. Number of parietal cells within one cardiac gland of the stomach is increased (by 22.47 %) providing high variability (Cv = 10.95 %).

During 20 days of life thickness of all coats in the cardiac part of the piglet's stomach is increased. Depth of gastric pits 59.69 %, in comparison with one-day old piglets whose body weight corresponds to the breed standard. The gland-pit ratio is gradually widened reaching the level of 1 : 0.25. Thickness of the mucosa glandular layer is subjected to the most intensive increase (by 289.32 %) in the cardiac part of the stomach and this causes a wider (in comparison with other one-day old animals) glandular-subglandular ratio and a wider glandular-muscular ratio. Increased thickness of the gastric submucosa (by 46.11 %) in 20-day old piglets leads to an insignificant narrowing of the mucosal-submucosal ratio (1 : 0.10) in comparison with one-day old animals from Group II. Alongside with an intensive thickening of the glandular coat of the gastric mucosa in 20-day old piglets a significant thickening of the muscular coat (by 41.92 %) is taking place; and due to this fact the mucosal-muscular ratio is almost equal to the respective ratio in one-day old piglets (the group II). The gastric serosa is also thickened by 46.20 % and mucosal-serosal ratio is slightly narrowed in comparison with one-day old piglets whose body weight corresponds to the breed standard.

When analyzing ratio between wall coats of the cardiac part of the stomach in piglets it was determined that development of its structures is taking place asynchronously. Increased depth of gastric pits alongside with practically unchanged thickness of the glandular coat leads to narrowing of the gland-pit ratio (1 : 1.10) in one-day old piglets from Group III.

The glandular-subglandular ratio reaches its minimal value in 5-day old piglets due to reducing thickness of the mucosa subglandular layer as well as due to a certain increase of the glandular layer. An intensive growth of cardiac glands in 10-and 20-day old piglets alongside with a smoother thickening of the lamina muscularis mucosae leads to widening of the glandular-muscular ratio. Widening

of the mucosal-submucosal ratio is taking place during a period of up to 10 days. With aging a rapid thickening of the submucosa occurs and that leads to narrowing of the mucosal-submucosal ratio. According to the same scheme in 20-day old piglets the muscular coat becomes almost twice thicker, and this fact in its turn leads to narrowing of the mucosal-muscular ratio. And the mucosal-serosal ratio is widened more smoothly; but in 20-day old piglets an intensive growth of the mucosa alongside with a slower growth of the serosa leads to a certain narrowing of the mucosal-serosal ratio.

3.2 Structural peculiarities of tissue components of the gastric fundus in piglets

Mucosa of the gastric fundus in piglets is presented as flexuous folds located along the greater curvature of the stomach. 1–2 glands open to each pit of the gastric fundus. Fundic glands are simple tubular unbranched glands. Gland neck consisting of neck myxocytes, parietal and undifferentiated cells opens directly to a gastric pit. The body and the bottom of a gland include main cells, parietal cells and mucous cells. Glands are surrounded with thin interlayers of connective tissue of lamina propria mucosae.

3.2.1 One-day old piglets

In one-day old piglets from Group II depth of the gastric pits is 91.80 ± 18.82 microns (fig. 3.9). The pits are direct, their depth is the greatest in piglets from Group I (by 15.07 %) and the smallest in piglets from Group III (by 5.63 %), in comparison with animals whose body weight corresponds to the breed standard.

Fundic glands of the gastric mucosa in piglets are simple tubular unbranched or slightly branched (fig. 3.10, 3.11). The pits are comparatively shallow. Gland length is 2–3 times greater than depth of the pits. Fundic glands occupy the greater part of the gastric mucosa. In piglets from Group II thickness of the mucosa glandular layer is 228.54 ± 15.62 microns, while in piglets from Group I it is 0.35 % larger. Gland-pit ratio in piglets from Group II is moderate (1 : 0.46) as well as in piglets from Group I (1 : 0.46) (table 3.3).

In piglets with body weight lower than the breed standard glands are located at a large distance from each other. Epithelium is lower; its height is similar to the hight of cuboidal epithelium. Fundic glands are simple tubular unbranched (fig. 3.12).

In animals with body weight lower than the breed standard thickness of the mucosa glandular layer is 8.99 % less providing a high level of variability (Cv = 24.56 %), and this fact causes

a narrower gland-pit ratio (1 : 0.41) in comparison with pigs whose body weight corresponds to the breed standard.

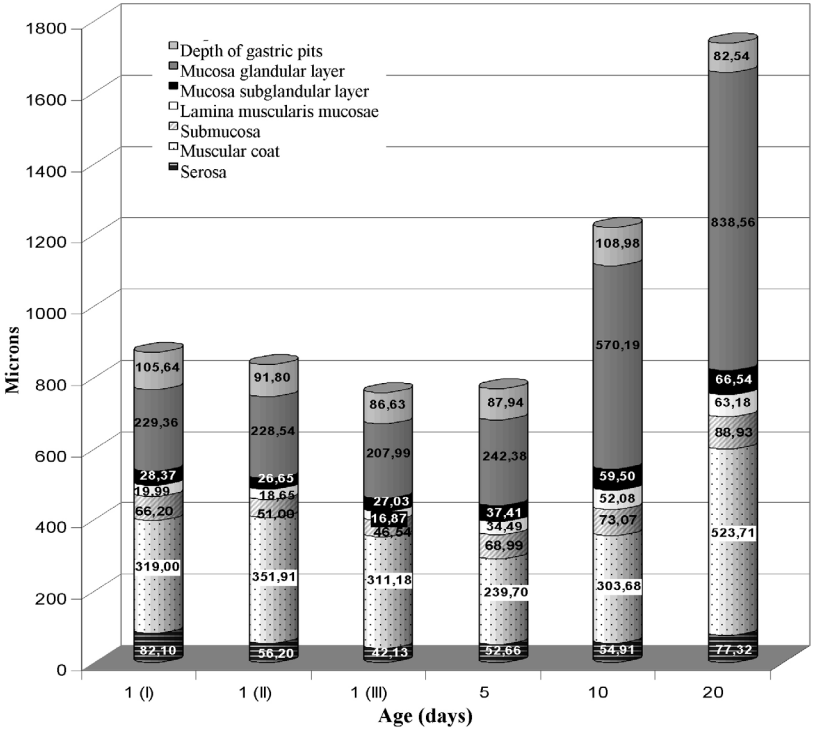


Fig. 3.9 Dynamics of tissue components of the gastric fundus in piglets

Thickness of the mucosa subglandular layer of the gastric fundus in one-day old piglets from Group II is 26.65 ± 3.62 microns and thickness of the lamina muscularis mucosae is 18.65 ± 2.67 microns. In piglets from Group I thickness of the mucosa subglandular layer is 6.06 % greater providing insignificant variations (Cv = 31.07 %), and lamina muscularis mucosae is also thicker (by 7.18 %) (Cv = 18.12 %). In piglets from Group II the glandular-subglandular ratio is wide (1 : 0.11), as well as the glandular-muscular ratio (1 : 0.08). At the same time the glandular-subglandular ratio and the glandular-muscular ratio in animals from Group I are wider (1 : 8.08 and 1 : 11.47

respectively). In one-day old piglets from Group III the mucosa subglandular layer is insignificantly thicker (by 1.42 %), and the lamina muscularis is thiner (by 10.61 %) in comparison with piglets from Group II and this fact alongside with a lesser thickness of the mucosa glandular layer causes analogously wide glandular-subglandular ratio (1 : 0.12) and glandular-muscular ratio (1 : 0.08).

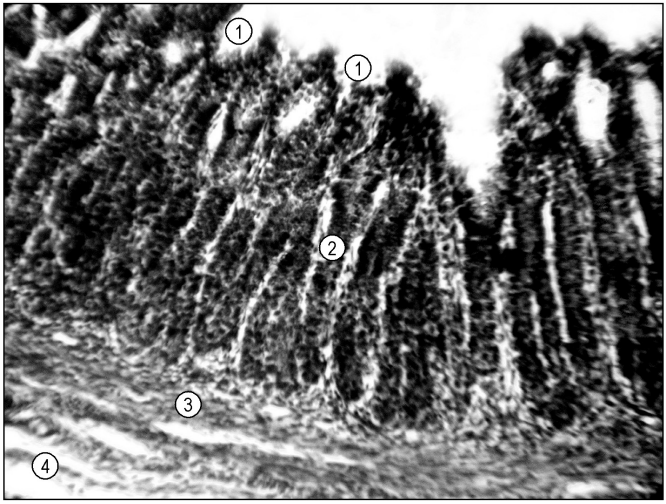


Fig. 3.10 Histological specimen of the gastric fundus in piglets (one day old, Group II). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — pits; 2 — glands; 3 — lamina muscularis mucosae; 4 — submucosa

Thickness of the funds submucosa in piglets with body weight corresponding to the breed standard is 51.00 ± 10.94 microns, and the mucosal-submucosal ratio is 1 : 0.10. In animals with body weight higher than the breed standard the gastric submucosa is 29.80 % thicker which causes insignificant narrowing of the mucosal-submucosal ratio (1 : 0.12). And in animals whose body weight is lower than the breed standard the gastric submucosa is 8.74 % thiner in comparison with piglets whose body weight corresponds to the breed standard; and mucosal-submucosal ratio remains unchanged (1 : 0.10) which can be explained through a lesser thickness of their gastric mucosa.

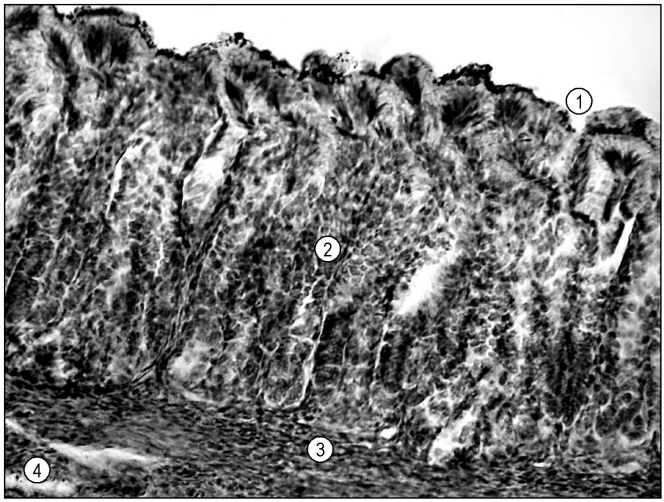


Fig. 3.11 Histological specimen of the gastric fundus in piglets (one day old, Group I). Hematoxylin and eosin, Olympus CX 21, ×100: 1 — pits; 2 — glands; 3 — lamina muscularis mucosae; 4 — submucosa

Table 3.3 – Dynamics of ratio between structures and coats of the gastric fundus wall in piglets

Indexes \ Age (days), group		1			5	10	20
		I	II	III			
Mucosa	1. Gland-epithelium	1:0.09	1:0.09	1:0.08	1:0.11	1:0.06	1:0.05
	2. Gland-pit	1:0.46	1:0.40	1:0.41	1:0.36	1:0.19	1:0.09
	3. Glandular-subglandular	1:0.12	1:0.11	1:0.12	1:0.15	1:0.10	1:0.07
	4. Glandular-muscular	1:0.08	1:0.08	1:0.08	1:0.14	1:0.09	1:0.07
5. Mucosal-submucosal		1:0.12	1:0.10	1:0.10	1:0.12	1:0.06	1:0.06
6. Mucosal-muscular		1:0.60	1:0.70	1:0.67	1:0.43	1:0.28	1:0.36
7. Mucosal-serosal		1:0.15	1:0.11	1:0.09	1:0.09	1:0.05	1:0.05

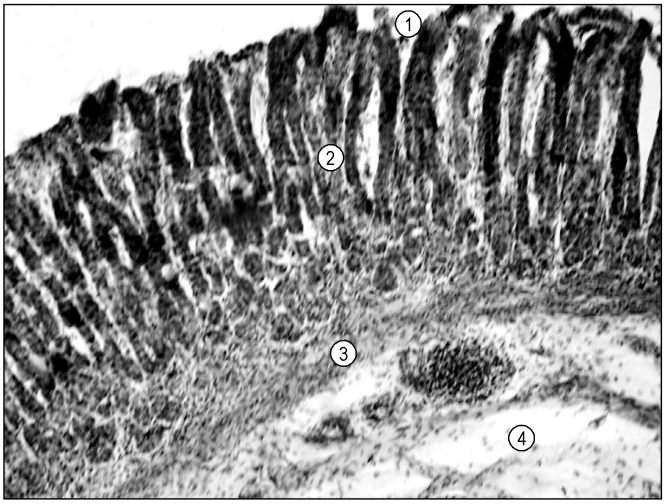


Fig. 3.12 Histological specimen of the gastric fundus in piglets (one day old, Group III). Hematoxylin and eosin, Olympus CX 21, ×100: 1 — pits; 2 — glands; 3 — lamina muscularis of the mucosa; 4 — submucosa

In one-day old piglets from Group II thickness of the muscular coat in the gastric fundus is 351.91 ± 87.79 microns, and thickness of the serosa is 56.20 ± 12.72 microns providing high variability (Cv = 55.78 % and Cv = 50.59 % respectively). The mucosal-muscular ratio in these animals is the narrowest (1 : 0.70), and their mucosal-serosal ratio is wide (1 : 0.11). Three layers are expressed in the muscular coat: the external layer (longitudinal) the middle layer (circular) and the internal layer (oblique). And in animals from Group I the muscular coat is 9.35 % thiner and the serosa is 46.08 % thicker than in animals from Group II. This morphometric characteristic causes a wider mucosal-muscular ratio (1 : 0.60) while the mucosal-serosal ratio is narrower (1 : 0.15). In piglets from Group III the muscular coat and the serosa are thiner (by 11.57 % and by 25.03 % respectively) in comparison with Group II. The mucosal-muscular ratio (1 : 0.67) and the mucosal-serosal ratio (1 : 0.09) are slightly wider.

Surface epithelium and pit epithelium of the stomach is single-layer columnar epithelium. In epithelial cells subdivision into apical part, light part of the cell and the basal part (where the nucleus is located) can be clearly seen. In piglets from Group II height of the surface epithelium is 21.49 ± 0.64 microns, and height of the pit epithelium is 18.44 ± 0.92 microns (fig. 3.13). The glandular-epithelial ratio is wide (1:0.09). Height of the surface epithelium (21.78 ± 1.36 microns; Cv = 10.42 %) as well as height of the pit epithelium (18.52 ± 0.93 microns; Cv = 11.24 %) in the gastric fundus in one-day old piglets are prevailing in animals from Group I, and their glandular-epithelial ratio is equal to the same ratio in piglets with body weight corresponding to the breed standard. Nuclei of epithelial cells have an elongated shape, they are located basally and the apical part of cytoplasm is transparent. In one day old piglets from Group III height of the surface epithelium and pit epithelium is less (by 18.24 % and by 30.15 % respectively) in comparison with animals from Group II. Epithelium of gastric pits is presented as cells with height similar to the height of cuboidal epithelium cells and their nuclei have a more rounded shape. The glandular-epithelial ratio in these animals is the widest (1 : 0.08) in comparison with their other agemates.

In piglets from Group II diameter of glands is 29.05 ± 0.27 microns while in animals from Group I this diameter is 22.61 % less and in animals of the group III it is 25.12 % less (table 3.4).

The greatest number of parietal cells (22.40 ± 0.24 items) within a single fundic gland is localized in piglets whose body weight corresponds to the breed standard. In fundic glands of piglets parietal cells are found not only in land isthmus. They are determined as separate groups located throughout the length of glands (fig. 3.14) In piglets from Group I parietal cells are 25.84 % than in animals from Group II. Parietal cells are located evenly throughout the length of the gland. Parietal cells are the least numerous

(12.80 ± 0.37 items) in one-day old piglets from Group III. In one-day old animals no secretory granules are determined in cytoplasm of parietal cells (fig. 3.15).

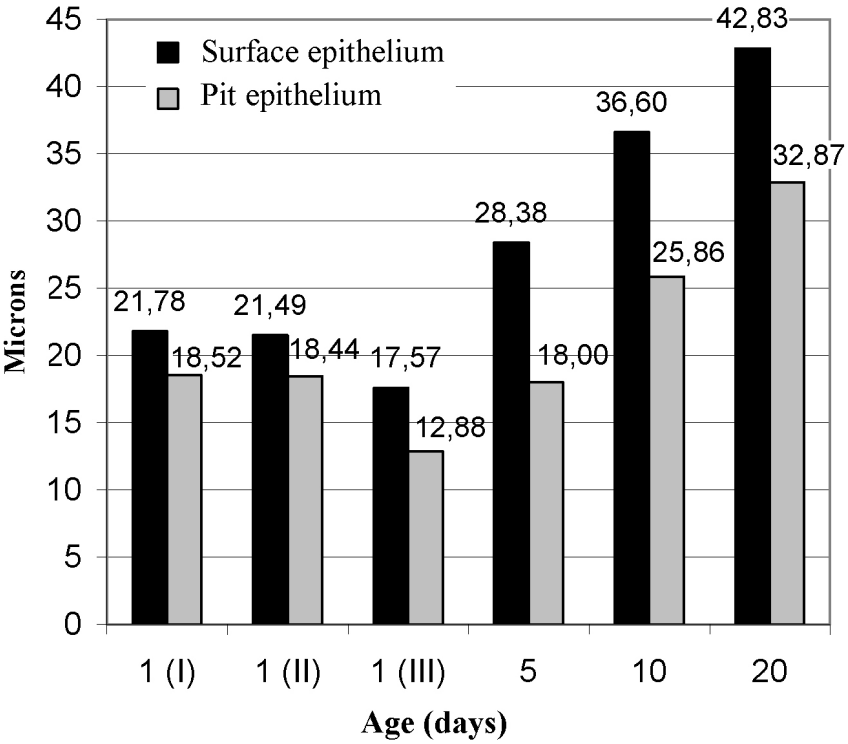


Fig. 3.13 Dynamics of the height of the single-layer columnar epithelium in the gastric fundus in piglets

When analyzing dynamics of the tissue components in the fundic part of the stomach wall it was determined that the mucosa glandular layer is the thickest in one day old piglets from Group I while in piglets from Group II it is only 0.35 % thiner. In piglets from Group III stromal components are dominant in the stomach wall. Morphometric characteristics of glandular structures and number of parietal cells appear to be dominating in the stomach wall of piglets whose body weight corresponds to the breed standard.

Table 3.4 – Dynamics of diameter of glands and number of parietal cells within one gland in the gastric fundus in piglets

Indexes / Age (days), group		Diameter of glands, microns		Number of parietal cells, units	
		M ± m	Cv, %	M ± m	Cv, %
1	I	22.48 ± 0.54	5.33	17.80 ± 0.37	4.70
	II	29.05 ± 0.27	2.10	22.40 ± 0.24**	2.44
	III	21.75 ± 0.66***	6.87	12.80 ± 0.37**	6.54
5		26.56 ± 1.16*	9.84	22.40 ± 0.11	8.11
10		34.02 ± 0.37**	2.45	22.80 ± 0.86	8.44
20		42.59 ± 2.04**	10.73	25.40 ± 0.51*	4.47

Note: * — $p < 0.05$; ** — $p < 0.01$; *** — $p < 0.001$

Fig. 3.14 Histological specimen of the gastric fundus in piglets (one day old, Group II). Congo red and hematoxylin, MBI-6, ×600: 1 — parietal cells

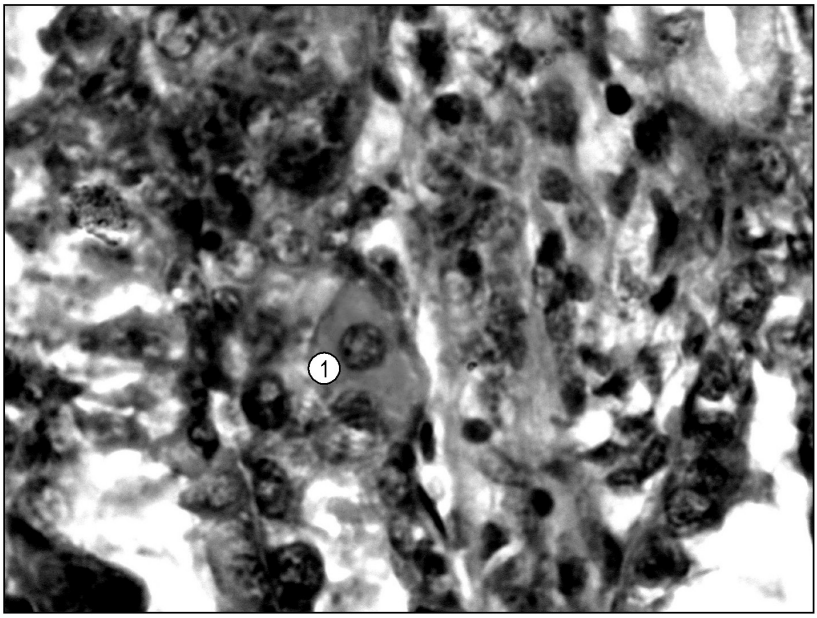


Fig. 3.15 Histological specimen of the gastric fundus in piglets (one day old, Group II). Congo red and hematoxylin, MBI-6, × 1350: 1 — parietal cell

3.2.2 5-, 10- and 20-days old piglets

In 5-day old piglets the pits are direct and shallow. The pit depth is decreased by 4.20 % (Cv = 19.76 %) in comparison with one-day old piglets whose body weight corresponds to the breed standard. The gland-pit ratio is widened (1 : 0.36).

In 5-day old piglets the mucosa glandular layer becomes 6.05 % thicker (Cv = 5.68 %). The glands are direct with a slightly branched bottom. Interlayers of the loose connective tissue are thin; glands are located in a more compact way (fig. 3.16). The mucosa subglandular layer is also increased (by 40.37 %) providing a significant variability (Cv = 22.31 %) and this fact causes narrowing of the glandular-subglandular ratio (1 : 0.15) in comparison with one-day old pigs from Group II.

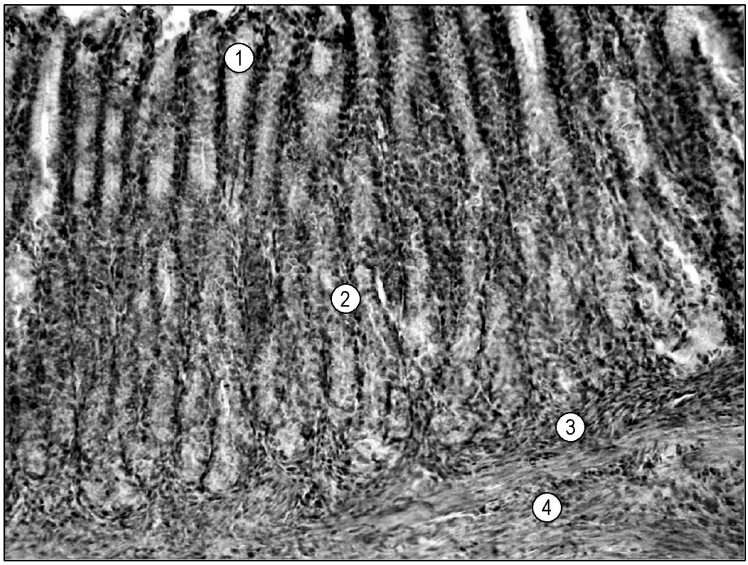


Fig. 3.16 Histological specimen of the gastric fundus in piglets (5-day old). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — pits; 2 — glands; 3 — lamina muscularis of the mucosa; 4 — submucosa

Lamina muscularis mucosae is clear and compact but its thickness in -day old animals is significantly increased (by 84.93 %) providing increase of variability (Cv = 31.26 %) in comparison with one-day old piglets whose body weight corresponds to the breed standard.

The gastric submucosa also becomes thicker (by 35.27 %; Cv = 23.83 %). This trend is expressed as narrowing of the glandular-muscular ratio (1 : 0.14) and mucosal-submucosal ratio (1 : 0.12).

A longitudinal layer and a cross layer are determined in the muscular coat of the stomach. Thickness of the muscular coat is decreased by 31.88 % (Cv = 30.27 %) and the serosa becomes 6.29 % thiner (Cv = 44.26 %), while the mucosal-muscular ratio and the mucosal-serosal ratio are widened (1 : 0.43 and 1 : 0.09 respectively).

Height of the surface epithelium in the gastric fundus of 5-day old piglets is increased by 32.06 %, providing insignificant coefficient

of variability (Cv = 3.01 %), and height of the pit epithelium is significantly decreased (by 2.38 %) (Cv = 3.70 %). In piglets of this age group as well as in piglets of other age groups the glandular-epithelial ratio is wide (1 : 0.11).

Diameter of glands in 5-day old animals is decreased by 8.57 %, and number of parietal cells within one fundic gland of the stomach remains unchanged in comparison with one-day old piglets from Group II.

In 10-day old piglets gastric pits are narrow and their depth is increased by 23.92 % (Cv = 9.33 %) in comparison with 5-day old piglets; and the gland-pit ratio is narrowed (1 : 0.19).

Glands are direct. The intraglandular connective tissue is presented slightly (fig. 3.17). An intensive thickening of the mucosa glandular layer is taking place (by 135.24 %; Cv = 10.06 %) and thickening of the subglandular layer is slightly less intensive (by 59.04 %; Cv = 13.97 %), and the lamina muscularis mucosae is thickened by 51.00 % (Cv = 7.33 %) in comparison with 5-day old piglets. So, glandular-subglandular ratio (1 : 0.10) and glandular-muscular ratio (1 : 0.09) are widened. The similar trend is observed in the process of development of other coats in the gastric fundus. So, thickness of the submucosa is increased by 5.91 % (Cv = 21.76 %), and the mucosal-submucosal ratio is widened (1 : 0.06). Alongside with this thickness of the muscular coat is increased (by 26.69 %) and the serosa is also thickened (by 4.27 %) and this fact causes widening of the mucosal-muscular ratio (1 : 0.28) and the mucosal-serosal ratio (1 : 0.05).

In 10-day old piglets height of the surface epithelium is increased by 28.96 %), and the height of the pit epithelium is increased by 43.66 % in comparison with 5-day old piglets. Alongside with this the glandular-epithelial ratio is widened (1 : 0.06). Diameter of glands in this age group of animals is increased by 28.08 % providing insignificant coefficient of variability (Cv = 2.45 %). Number of parietal cells within one gland is increased (by 1.78 %) providing insignificant coefficient of variability (Cv = 8.44 %).

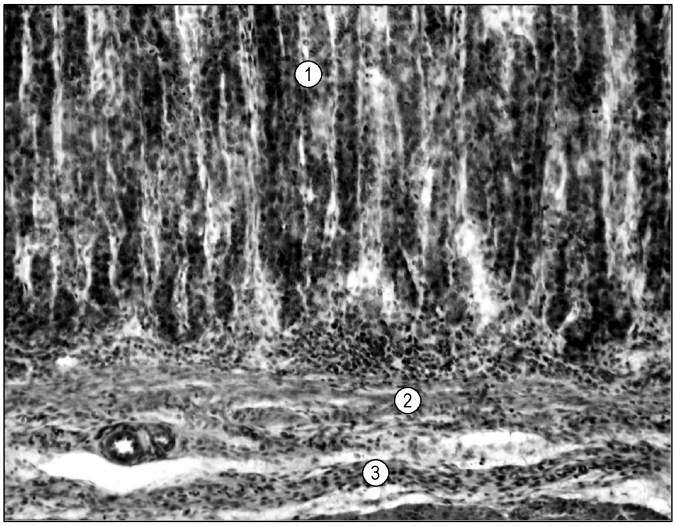


Fig. 3.17 Histological specimen of the gastric fundus in piglets (10-day old). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — glands; 2 — lamina muscularis mucosae; 3 — submucosa

In 20-day old piglets depth of pits in the gastric fundus is minimal (82.54 ± 6.15 microns, Cv = 16.66 %) among all animals studied. And the glandular layer of the organ reaches its maximal level of development: it is thickened by 47.06 % (Cv = 20.22 %) in comparison with 10-day old piglets. The intraglandular connective tissue is presented (fig. 3.18). Due to this fact the gland-pit ratio is widened (1 : 0.09).

Thickness of the subglandular layer is also increased (by 11.83 %, Cv = 13.53 %) and the lamina muscularismucosae is also thickened (by 21.31 %, Cv = 27.4 %), which is manifested as widening of the glandular-subglandular ratio (1 : 0.07) and the glandular-muscular ratio (1 : 0.07). The similar trend is observed in the process of development of other coats of the stomach. Thickness of the submucosa is increased to the least extend (by 21.70 %); and thickening of the muscular coat is maximal (by 72.45 %); and serosa is subjected to intermediate thickening (by 40.81 %). So, the mucosal-

submucosal ratio (1:0.06), as well as mucosal-serosal ratio (1 : 0.05) remain wide and the mucosal-muscular ratio (1 : 2.42) is narrowed due to an intensive thickening of the muscular coat. In 20-day old piglets height of the surface epithelium is increased by 17.02 %, and the height of the pit epithelium is increased by 27.10 % in comparison with 10-day old piglets. At the same time widening of the glandular-epithelial ratio (1 : 0.05) is observed. Diameter of glands in the gastric fundus is increased by 25.19 % and reaches the maximal value in comparison with other groups of researched animals. In 20-day old piglets number of parietal cells within one gland of the gastric fundus is increased by 11.40 % in comparison with 10-day old piglets and these cells are localized predominantly in the bottom part of glands (fig. 3.19). Secretory granules are determined in cytoplasm of these cells (fig. 3.20).

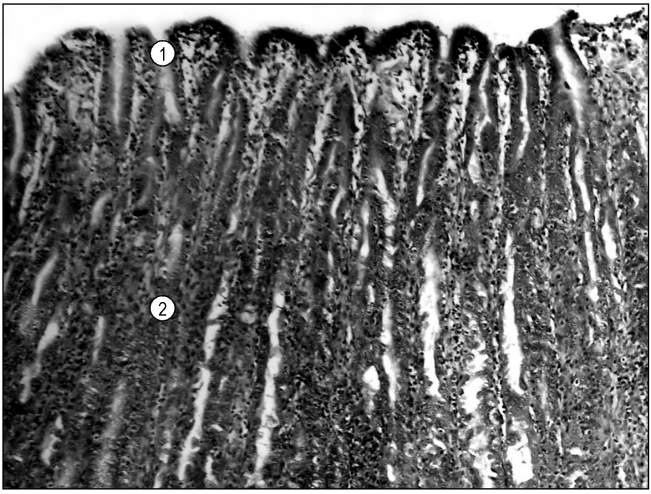


Fig. 3.18 Histological specimen of the gastric fundus in piglets (20-day old). Congo red and hematoxylin, Olympus CX 21, × 100: 1 — pits; 2 — glands

So, in the fundic part of the stomach in one-day old piglets morphometric parameters of gastric wall structures have the greatest thickness in Group I of piglets (excluding the muscular coat). With

aging in 5-day-old piglets the most layers of the mucosa and coats are thickened against the background of a lesser depth of pits and a thiner muscular coat of the stomach. An intensive thickening of the mucosa glandular layer (by 135.24 %) is taking place in 10-day old piglets and this process has a respective effect on ratios between the coats of the organ. In 20-day old piglets all coats of the stomach are thickened.

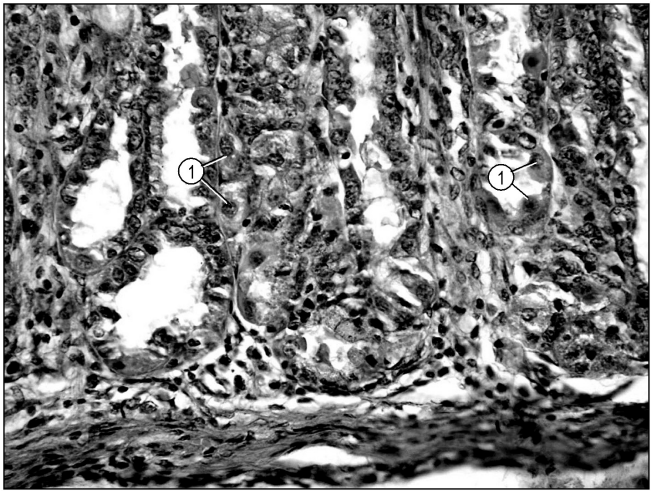


Fig. 3.19 Histological specimen of the gastric fundus in piglets (20-day old). Congo red and hematoxylin, MBI-6, ×600: 1 — parietal cells

During 20 days of life depth of gastric pits in piglets is decreased by 10.08 %, in comparison with one-day old piglets whose body weight corresponds to the breed standard. During this period of time the most intensive increase of the mucosa glandular layer is taking place (in 3.6 times). Significant changes are taking place in the glandular-subglandular ratio and mucosal-muscular ratio of the gastric fundus in piglets.

The glandular-epithelial ratio is gradually widened (excluding situation with 5-day old piglets) and that is due to a significant increase of the height of the single-layer columnar epithelium accompanied by a more gradual thickening of the mucosa glandular layer.

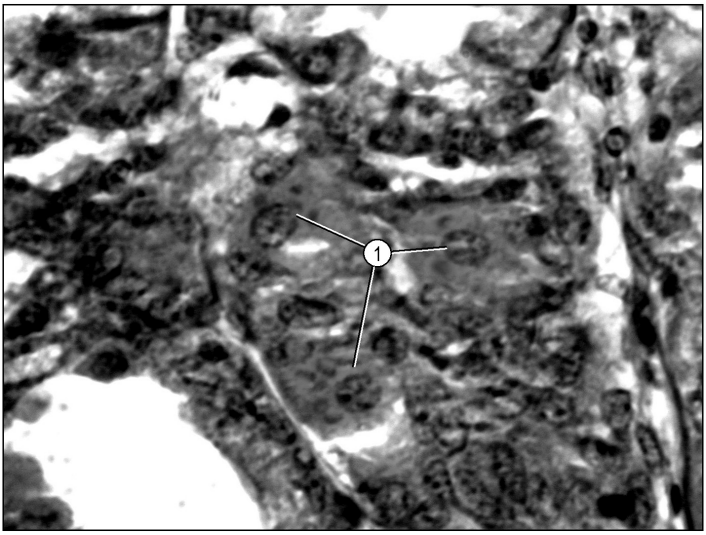


Fig. 3.20 Histological specimen of the gastric fundus in piglets (20-day old). Congo red and hematoxylin, MBI-6, × 1350: 1 — parietal cells

The gland-pit ratio is wider in one-day old piglets, and this fact is related with a greater depth of pits in regard to the glands. The glandular-subglandular ratio and glndular-muscular ratio are the narrowest in 5-day old piglets since alongside with an intensive thickening of the subglandular layer and the lamina muscularismucosae a more gradual increase of the mucosa glandular layer is taking place.

3.3 Structural peculiarities of tissue components of the pyloric part of the stomach in piglets

Gastric pits in in the pyloric part of the stomach are the deepest (their depth reaches half of the mucosa thickness, while glands are shorter. Glands are rarer in the lamina propria mucosae, they have wide lumens and are strongly branched. They have a well expressed long and arrow cervix. Pyloric glands consist mainly of myxocytes and we have not determined any parietal cells in their composition.

3.3.1 One-day old piglets

Depth of gastric pits in piglets from Group II is 116.74 ± 16.44 microns (Cv = 31.50 %) (fig. 3.21). In one-day old piglets from Group I the pits are deep (fig. 3.22). They are 6.97 % deeper than in piglets from Group II. In piglets from Group III the pits are the deepest (127.66 ± 2.11 microns), providing low variability (Cv = 3.70). They are 9.35 % deeper than in animals from Group II.

In comparison with fundic glands pyloric glands are more rare and have wide lumens between them (fig. 3.23). Themucosa glandular layer is the thickest (219.08 ± 19.11 microns) in piglets from Group II and the pit-gland ratio is 1:0.53 (table 3.5).

And in piglets from Group I thickness of the mucosa glandular layer is less by 14.46 % (Cv = 8.65 %) in comparison with piglets from Group II; and this fact causes a narrower gland-pit ratio (1 : 0.66).

In one-day old piglets with body weight lower than the breed standard the mucosa glandular layer in the pyloric part of the stomach is insignificantly thiner (by 0.18 %, Cv = 42.98 %) (in comparison with piglets whose body weight corresponds to the breed standard) while their gland-pit ratio is narrower (1 : 0.58). Glands are rarer (fig. 3.24). In piglets from Group II thickness

of the mucosa subglandular layer is 45.08 ± 2.80 microns with an insignificant coefficient of variability (Cv = 13.89 %). In one-day old piglets from Group I the mucosa subglandular layer is 9.51 % thiner (Cv = 28.73 %) in comparison with piglets from Group II. In piglets from Group III the mucosa subglandular layer is also 9.51 % thiner (Cv = 28.73 %). At the same time the glandular-subglandular ratio in piglets from Group II is wide (1 : 0.11) while in animals from the groups I and III it is slightly narrower (1 : 0.12) which is due to a lesser thickness of the mucosa glandular and subglandular layers.

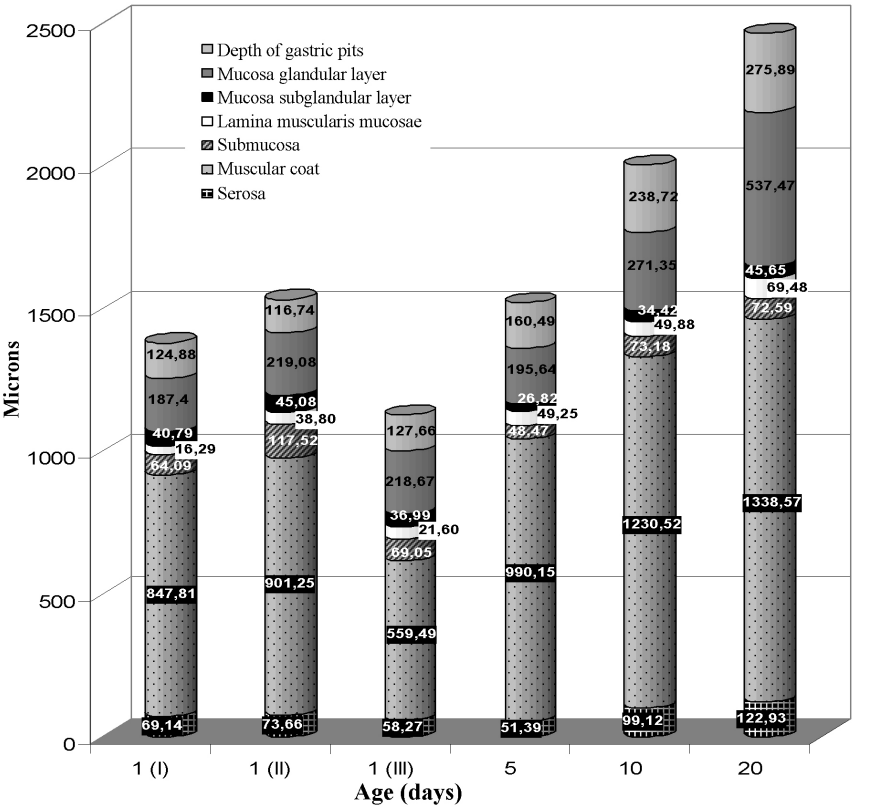


Fig. 3.21 Dynamics of tissue components of the pyloric part of the stomach in piglets

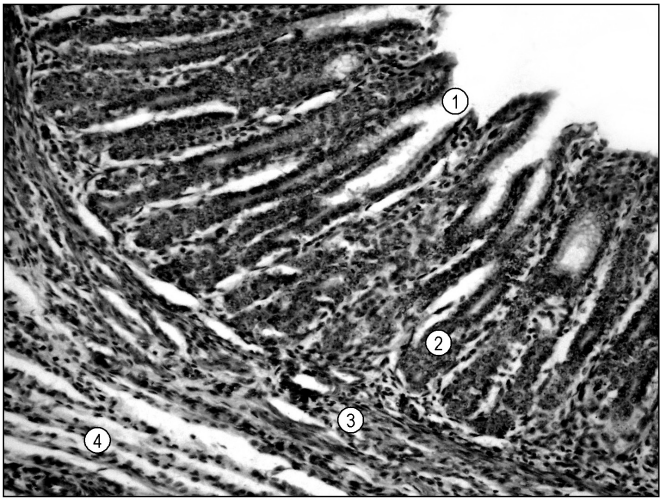


Fig. 3.22 Histological specimen of the pyloric part of the stomach in piglets (one day old, Group I). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — pits; 2 — glands; 3 — lamina muscularis of the mucosa; 4 — submucosa

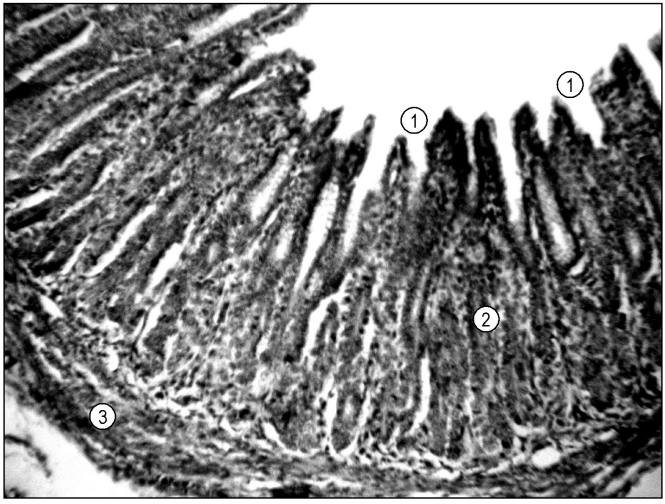


Fig. 3.23 Histological specimen of the pyloric part of the stomach in piglets (one day old, Group II). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — gastric pits; 2 — glands; 3 — lamina muscularis mucosae

Table 3.5 – Dynamics of ratio between structures and coats of the pyloric part of the stomach wall in piglets

Indexes \ Age (days), group		1			5	10	20
		I	II	III			
Mucosa	1. Gland-epithelium	1:0.10	1:0.09	1:0.09	1:0.12	1:0.12	1:0.07
	2. Gland-pit	1:0.66	1:0.53	1:0.58	1:0.82	1:0.87	1:0.51
	3. Glandular-subglandular	1:0.21	1:0.20	1:0.16	1:0.13	1:0.12	1:0.08
	4. Glandular-muscular	1:0.08	1:0.17	1:0.09	1:0.25	1:0.18	1:0.12
5. Mucosal-submucosal		1:0.12	1:0.20	1:0.12	1:0.10	1:0.08	1:0.05
6. Mucosal-muscular		1:1.67	1:1.56	1:1.01	1:2.05	1:1.51	1:1.05
7. Mucosal-serosal		1:0.13	1:0.12	1:0.10	1:0.10	1:0.12	1:0.09

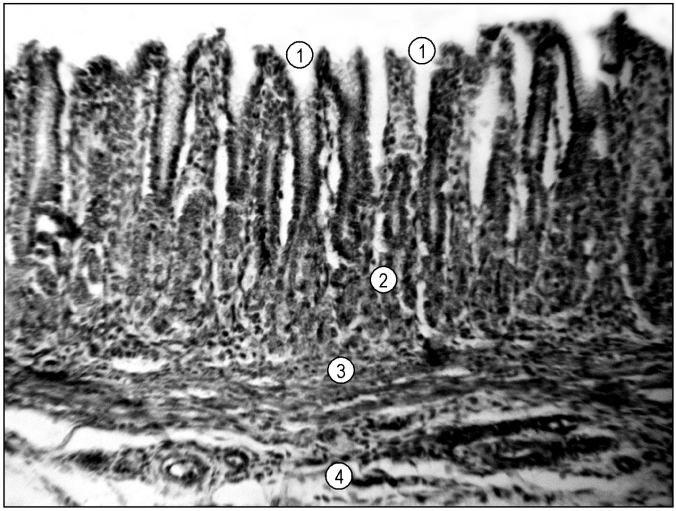


Fig. 3.24 Histological specimen of the pyloric part of the stomach in piglets (one day, Group III). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — gastric pits; 2 — glands; 3 — lamina muscularis mucosae; 4 — submucosa

In one-day old piglets from Group II thickness of the lamina muscularis mucosae maximal (38.80 ± 2.71 microns) and this fact causes the widest glandular-muscular ratio (1 : 0.17). Lamina muscularis mucosae in the pyloric part of the stomach in piglets from Group I is 58.01 % thiner, and the glandular-muscular ratio is wider (1 : 0.08) in comparison with piglets from Group II. And lamina muscularis mucosae in piglets from Group III is 44.32 % thiner and this results in a wider glandular-muscular ratio (1 : 0.09).

In piglets from Group I submucosa in the pyloric part of the stomach is 45.46 % thiner (Cv = 25.35 %), and the muscular coat is 5.92 % thiner (Cv = 39.98 %) in comparison with piglets from Group II. This trend results in a wider mucosal-submucosal ratio (1 : 0.12) and a narrower mucosal-muscular ratio (1 : 1.67). Analogous changes are typical for piglets from Group III. So, their submucosa is 41.24 % thiner (Cv = 18.84 %), their muscular coat is 37.92 % thiner (Cv = 32.92 %), and their serosa is 20.89 % thiner (Cv = 11.15 %) in comparison with one-day old piglets from Group II which results in a wider mucosal-submucosal ratio (1 : 0.12), a narrow mucosal-muscular ratio (1 : 1.01) and a narrow mucosal-serosal ratio (1 : 0.10).

In one-day old piglets from Group II height of the surface epithelium (20.58 ± 0.46 microns, Cv = 6.87 %) as well as height of the pit epithelium (15.80 ± 0.38 microns, Cv = 5.37 %) in the pyloric part of the stomach is maximal (fig. 3.25). At the same time the glandular-epithelial ratio is wide (1 : 0.09). In one-day old piglets from Group I amount of the surface epithelium in the pyloric part of the stomach is 4.13 % less (Cv = 20.60 %), and amount of the pit epithelium is 3.54 % less (Cv = 9.43 %) in comparison with piglets from Group II. And the glandular-epithelial ratio is a bit narrower (1 : 0.10). In piglets from Group III the surface epithelium is lower (by 3.83 %, Cv = 6.04 %), and the pit epithelium is also lower (by 12.15 %, Cv = 5.45 %) in comparison with piglets from Group II, while the glandular-epithelial ratio remains unchanged (1 : 0.09).

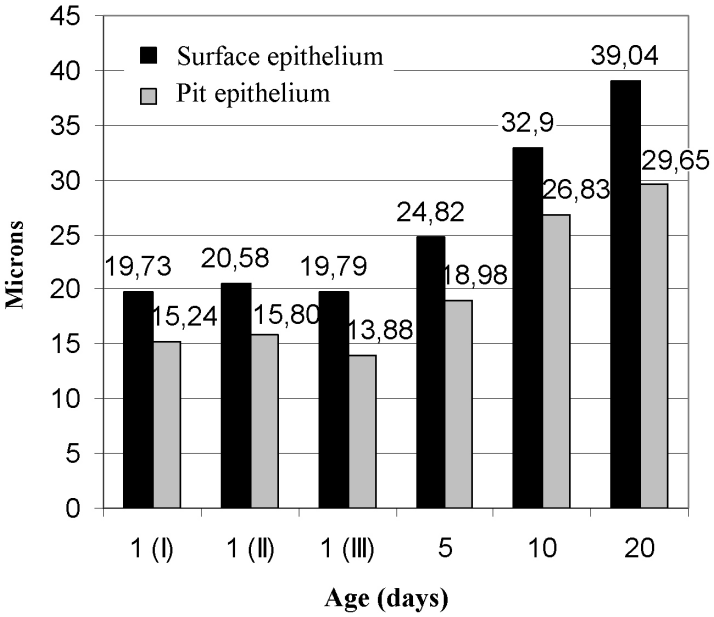


Fig. 3.25 Dynamics of the height of the single-layer columnar epithelium in the pyloric part of the stomach in piglets

Diameter of glands in the pyloric part of the stomach in piglets with body weight corresponding to the breed standard is 16.05 ± 0.30 microns (table 3.6). In piglets with body weight exceeding the breed standard diameter of glands in this part of the stomach is maximal (27.74 ± 1.44 microns; Cv = 11.62 %) and it exceeds the respective diameter in one-day old piglets (by 72.83 %). In piglets with body weight lower than the breed standard diameter of glands in the pyloric part of the stomach is 61.86 % less (Cv = 11.52 %).

When analyzing dynamics of tissue components of the stomach wall in the pyloric part of the organ it was determined that the mucosa glandular layer is the thickest in one-day old piglets whose body weight corresponds to the breed standard (219.08 ± 19.11 microns), while in piglets whose body weight is higher than the breed standard the mucosa glandular layer is 16.90 % thiner; and in piglets with

body weight lower than the breed standard it is 0.18 % thiner. Alongside with the thinest mucosa glandular layer one-day old piglets with body weight lower than the breed standard have the deepest gastric pits (127.66 ± 2.11 microns). As for other morphometric indexes of coats in the pyloric part of the stomach (thickness of the subglandular layer, lamina muscularismucosae, the submucosa, the muscular coat and the serosa) piglets from Group II with body weight corresponding to the breed standard appear to be dominating.

Table 3.6 – Dynamics of the diameter of glands in the pyloric part of the stomach in piglets (microns)

Indexes / Age (days), group		M ± m	Cv, %
1	I	27.74 ± 1.44	11.62
	II	16.05 ± 0.30***	4.24
	III	25.98 ± 1.33***	11.52
5		35.56 ± 0.83**	5.23
10		31.97 ± 1.39	9.74
20		29.20 ± 0.51	3.53

Note: ** — $p < 0.01$; *** — $p < 0.001$

3.3.2 5-, 10- and 20-days old piglets

In 5-day old piglets gastric pits in the pyloric part of the stomach become 8.53 % deeper in comparison with one-day old piglets whose body weight corresponds to the breed standard. Thickness of the mucosa glandular coat is decreased by 10.69 % (Cv = 6.34 %) and that leads to narrowing of the gland-pit ratio (1 : 0.82). Thickness of the mucosa subglandular layer in the pyloric part of the stomach is also decreased (by 40.50 %; Cv = 8.82 %) while the glandular-subglandular ratio becomes wider (1 : 0.13). Alongside with this the lamina muscularis mucosae is increased (by 26.93 %, Cv = 18.38 %) while the glandular-muscular ratio is narrowed (1 : 0.25).

In 5-day old piglets submucosa of the stomach becomes 58.75 % thiner (Cv = 7.75 %), and the muscular coat becomes 9.86 % thicker (Cv = 10.48 %) in comparison with one-day old piglets whose body weight corresponds to the breed standard. The mucosal-submucosal ratio (1 : 0.10) and mucosal-muscular ratio (1 : 2.05) are widened. And thickness of the serosa is decreased by 30.23 % (Cv = 8.44 %), and the mucosal-serosal ratio is widened (1 : 0.10).

In 5-day old piglets in the pyloric part of the stomach height of the surface epithelium is increased (by 20.60 %, Cv = 15.61 %), and height of the pit epithelium is also increased (by 20.12 %, Cv = 3.04 %). At the same time the glandular-epithelial ratio is widened (1 : 0.12). Also, diameter of glands in this part of the stomach is increased (by 121.55 %; Cv = 5.23 %) in comparison with one-day old piglets from Group II.

Depth of gastric pits in the pyloric part of the stomach in 10-day old piglets is increased by 48.74 % (Cv = 5.57 %) in comparison with 5-day old piglets. An intensive thickening of the mucosa glandular layer is taking place: it is 38.69 % thicker in comparison with 5-day old piglets (with an insignificant coefficient of variability — Cv = 4.34 %). The gland-pit ratio becomes a bit wider (1 : 0.87). The mucosa subglandular layer is increased by 28.33 % (Cv = 9.33 %) and the glandular-subglandular ratio is also widened (1 : 0.12). Thickness of the lamina muscularis mucosae in the pyloric part of the stomach is increased by 1.27 % (Cv = 2.27 %) and the glandular-muscular ratio is widened (1 : 0.18). In 10-day old piglets analogous changes in development of the pyloric part of the stomach are also taking place in other coats of the organ. So, the submucosa becomes 50.97 % thicker (Cv = 8.76 %), thickness of the muscular coat is increased by 24.27 % (Cv = 3.40 %), and the serosa is thickened by 92.87 % (Cv = 16.25 %). In its turn the mucosal-submucosal ratio is widened (1 : 0.08), while the mucosal-muscular ratio (1 : 1.51) and the mucosal-serosal ratio (1 : 0.12) become a bit narrower.

Height of the surface epithelium in the pyloric part of the stomach is increased (by 32.55 %, Cv = 4.74 %) and so does the hight of the pit epithelium (41.35 %, Cv = 3.34 %) in comparison with 5-day old piglets; and the glandular-epithelial ratio remains wide (1 : 0.12). Alongside with this diameter of glands is decreased by 10.09 % (Cv = 9.74 %).

Depth of gastric pits in the pyloric part of the stomach in 20-day old piglets is increased by 15.57 % (Cv = 5.64 %) in comparison with 10-day old piglets. Depth of the pits reaches the maximal value in comparison with animals of other age groups (fig. 3.26). But the gland-pit ratio is a bit narrower (1 : 0.51). An intensive development of the mucosa glandular layer is taking place. It is 98.07 % (Cv = 4.77 %) thicker than in 5-day old piglets. The mucosa subglandular layer becomes 32.62 % thicker and thickness of the lamina muscularis is increased by 39.29 % (Cv = 14.49 %).

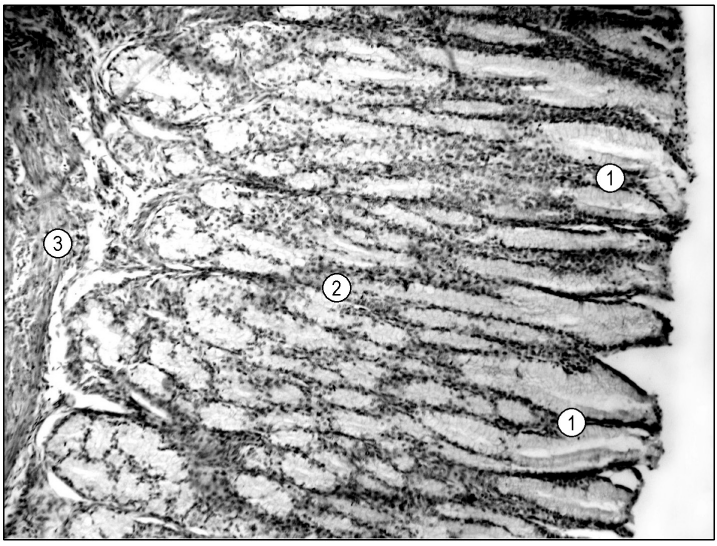


Fig. 3.26 Histological specimen of the pyloric part of the stomach in piglets (20-day old). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — pits; 2 — glands; 3 — lamina muscularis mucosae

The lamina muscularis mucosae consists of three layers: the internal and external layers (circular layers) and the middle layer (longitudinal layer). The glandular-subglandular ratio and glandular muscular are widened (1 : 0.08 and 1 : 0.12 respectively). And thickness of the submucosa is slightly decreased (by 0.80 %, Cv = 4.63 %) which leads to a certain widening of the mucosal-submucosal ratio (1 : 0.05). In 20-day old piglets the muscular coat of the stomach becomes 8.78 % thicker (Cv = 2.59 %) and thickness of the serosa is increased by 24.02 % (Cv = 7.35 %). At the same time the mucosal-muscular ratio (1 : 1.05) and mucosal-serosal ratio (1 : 0.09) are widened.

In 20-day old piglets the surface epithelium becomes 18.66 % higher, Cv = 7.11 %), and height of the pit epithelium is also increased (by 10.51 %, Cv = 8.51 %) and this fact causes widening of the glandular-epithelial ratio (1 : 0.07). Diameter of glands in the pyloric part of the stomach is increased by 15.09 % (Cv = 8.33 %) in comparison with 10-day old piglets.

During 20 days of life depth of mucosa gastric pits in the pyloric part of the stomach is increased by 136.32 %. The narrowest gland-pit ratio has been determined in 5-day old and 10-day old piglets (1 : 0.82; 1 : 0.87 respectively). An intensive thickening of the mucosa glandular layer is taking place (by 145.33 %) while thickening of the subglandular layer is insignificant (by 1.26 %), and in the result of this a gradual widening of the glandular-subglandular ratio is taking place. In 20-day old piglets the lamina muscularis mucosae is increased (by 79.07 %) in comparison with one-day old piglets whose body weight corresponds to the breed standard; and at the same time the submucosa is decreased (by 38.23 %). During 20 days of piglet's life the muscular coat of the stomach is increased (by 48.52 %) and so does the serosa (by 66.88 %).

So, in the pyloric part of the stomach in one-day old piglets with body weight corresponding to the breed standard coats of the organ are the thickest and the surface and pit epitheliums are the highest;

and diameter of glands is, on the contrary, the smallest. With aging gastric coats are thickened but the glandular and subglandular layers of the mucosa in 5-day old piglets are thiner than those in one-day old animals. Depth of gastric pits is almost equal to the thickness of themucosa glandular layer; an intensive growth of these pits is taking place in piglets by the age of 10 days. A rapid thickening of the muscular coat of the stomach (by 24.27 %) is also observed in this age group of piglets. By the 20th day of life an intensive growth of the gastric mucosa glandular layer (1.98 fold increase) alongside with a less expressed deepening of gastric pits (1.15 fold deepening).

When analyzing ratio between structures and coats of the stomach wall in the pyloric part of the organ it has been determined that the widest glandular-epithelial ratio and gland-it ratio are presented in 20-day old piglets which is due to an intensive increaseof the mucosa glandular layer. Glandular-subglandular ratio is gradually widened and the glandular-muscular is, on the contrary, narrowed in 5-day old piglets and then it is widened again. In one-day old piglets from Group II the submucosa of the stomach is the thickest which is due to a narrow mucosal-submucosal ratio. The mucosal-muscular ratio is the widest in 5-day old piglets (1 : 2.05) which is due to an intensive thickening of the muscular coat and a lesser thickness of the mucosain comparison with one-day old piglets. The mucosal-serosal ratio is wide and during 20 days of piglet's life its change is insignificant.

3.4. Structural peculiarities of tissue components of the lesser curvature of the stomach in piglets

Mucosa of the lesser curvature of the stomach in piglets is characterized by presence of multilayer flat non-squamous epithelial tissue. At the border with this epithelial tissue the single-layer columnar epithelium and tubular branched and wavy glands (structured according to the principle of cardiac glands) are localized. The glandless part of the stomach in form of a strip 10–15 mm wide is located along the lesser curvature of the stomach (from the diverticulum to the pyloric part).

3.4.1 One-day old piglets

At the border with the glandless part of the lesser curvature pits are wide and deeper and the mucosa glandular layer is thicker in comparison with those in the cardiac part of the organ (fig. 3.27).

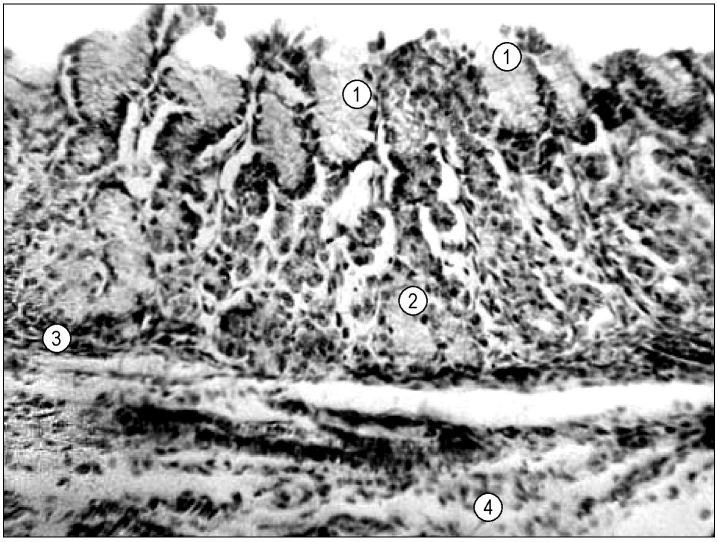


Fig. 3.27 Histological specimen of the lesser curvature of the stomach in piglets (one-day old, Group II). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — pits; 2 — glands; 3 — lamina muscularis of the mucosa; 4 — submucosa

Depth of gastric pits[1] in piglets with body weight corresponding to the breed standard is 89.82 ± 8.23 microns (fig. 3.28). In piglets with body weight higher than the breed standard gastric pits are 29.51 % deeper (Cv = 3.61 %). In piglets with body weight lower than the breed standard the gastric pits are the shallowest. They are 11.34 % shallower than in piglets from Group II.

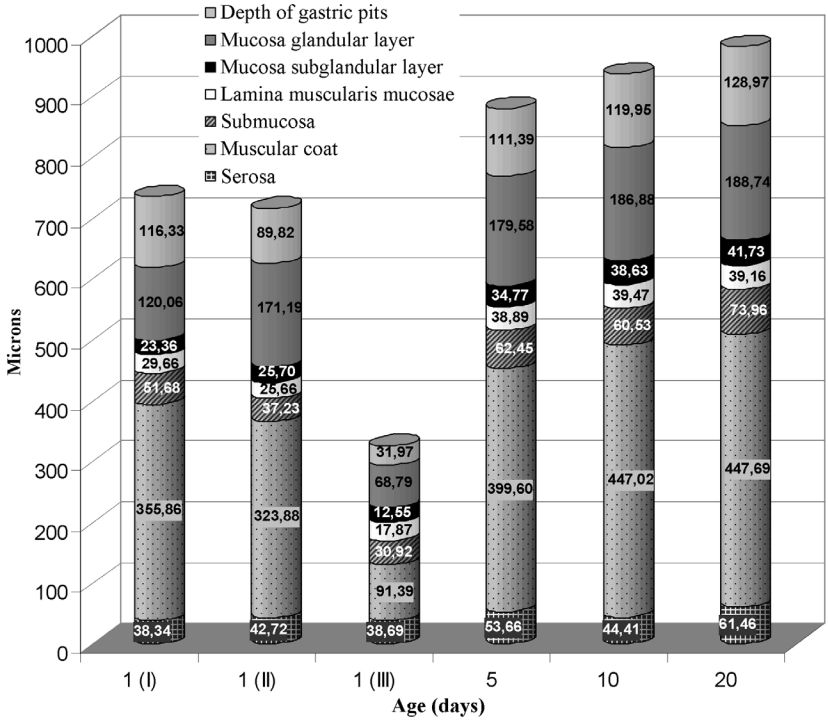


Fig. 3.28 Dynamics of the stomach wall tissue components at the border with the glandless part of its lesser curvature

The mucosa glandular layer of the stomach in piglets from Group II is 171.19 ± 7.67 microns, and the subglandular layer is 25.70 ± 2.83 microns and due to this fact the gland-pit ratio is moderate (1 : 0.52) and the glandular-subglandular ratio is wide (1 : 0.15) (table 3.7). The mucosa glandular layer in animals from Group I is, on

[1] here and hereinafter — at the border with the glandless part

the contrary, thiner (by 29.86 %), and the subglandular layer is also thiner (by 9.30 %), which results in thiner gland-pit ratio (1 : 0.96) and glandular-subglandular ratio (1 : 0.19).

Table 3.7 – Dynamics of ratio between structures and coats of the lesser curvature wall in piglets

Indexes / Age (days), group		1			5	10	20
		I	II	III			
Mucosa	1. Gland-epithelium	1:0.30	1:0.15	1:0.33	1:0.21	1:0.21	1:0.22
	2. Gland-pit	1:0.96	1:0.52	1:0.46	1:0.62	1:0.64	1:0.68
	3. Glandular-subglandular	1:0.19	1:0.15	1:0.18	1:0.19	1:0.20	1:0.22
	4. Glandular-muscular	1:0.24	1:0.14	1:0.25	1:0.21	1:0.21	1:0.20
5. Mucosal-submucosal		1:0.13	1:0.08	1:0.17	1:0.12	1:0.11	1:0.13
6. Mucosal-muscular		1:0.89	1:0.74	1:0.50	1:0.79	1:0.84	1:0.81
7. Mucosal-serosal		1:0.09	1:0.09	1:0.21	1:0.10	1:0.08	1:0.11

The mucosa glandular layer is thiner (by 59.81 %) in piglets from Group III, and the mucosa subglandular layer is also thiner (by 51.16 %) with significant coefficients of variability (Cv = 13.09 % and Cv = 16.24 %). This fact results in a wider gland-pit ratio (1 : 0.46) and a narrower glandular-subglandular ratio (1 : 0.19) in comparison with animals from Group II.

The lamina muscularis mucosae at the border with the glandless part of the lesser curvature of the stomach in animals with body weight corresponding to the breed standard is 25.66 ± 1.29 microns (Cv = 8.22 %), and the glandular-subglandular ratio is wide (1 : 0.14).

And in one-day old piglets from Group I the lamina muscularis mucosae is 15.58 % thicker (with insignificant level of variability — Cv = 15.78 %) in comparison with animals from Group II; and this

results in a narrower glandular-muscular ratio (1 : 0.24). The lamina muscularis mucosae in one-day old piglets with body weight lower than the breed standard is 30.35 % thiner (Cv = 12.46 %) in comparison with piglets whose body weight corresponds to the breed standard; and this fact is manifested as a narrower glandular-muscular ratio (1 : 0.25).

An analogous trend is observed during development of the submucosa and the muscular coat of the stomach. Their thickness in piglets from Group II is — 37.23 ± 3.47 microns and 323.88 ± 12.28 microns respectively.

At the same time the mucosal-submucosal ratio is wide (1 : 0.08) and the mucosal-muscular ratio is narrow (1 : 0.74). The lamina muscularis at the border with the glandless part of the lesser curvature of the stomach is presented as a massive circular layer (internal layer) and a less expressed longitudinal layer (external layer). And thickness the serosa in piglets of this group is 42.72 ± 3.93 microns, while the mucosal-serosal ratio is 1 : 0.09. In piglets with body weight higher than the breed standard the gastric submucosa is 38.81 % thicker with insignificant variability (Cv = 16.80 %) while the mucosal-submucosal ratio is, on the contrary, narrower (1 : 0.17). Also, at the border with the glandless part of the lesser curvature the muscle coat is 9.87 % thicker (Cv = 7.83 %) in comparison with one-day old piglets whose body weight corresponds to the breed standard, while the serosa is 10.25 % thiner (Cv = 16.06 %). This fact results in a wider mucosal-muscular ratio a wider (1 : 0.89) while the mucosal-serosal ratio remains unchanged (1 : 0.09). In one-day old piglets with body weight lower than the breed standard the gastric submucosa is 16.94 % thiner, the muscle coat is 71.78 % thiner and the serosa is 9.43 % in comparison with piglets whose body weight corresponds to the breed standard. The mucosal-submucosal ratio (1 : 0.17) as well as mucosal-serosal ratio (1 : 0.21) are wider, and the mucosal-muscular ratio is, on the contrary, narrower (1 : 0.50).

In piglets from Group II height of the surface epithelium is 26.64 ± 0.49 microns, and height of the pit epithelium is 20.37 ± 0.21 microns (fig. 3.29). The glandular-epithelial ratio is wide (1 : 0.15). In piglets from Group I height of the surface epithelium (36.08 ± 2.23 microns) as well as height of the pit epithelium (21.45 ± 0.37) of the lesser curvature is maximal in one-day old animals. In piglets from Group III height of the surface epithelium and pit epithelium is less (by 14.11 % and by 5.03 % respectively) in comparison with animals from Group II.

And the glandular epithelial ratio in piglets from groups I and III is narrower (1 : 0.30 and 1 : 0.33) in comparison with Group II. In piglets from Group II diameter of glands in the lesser curvature of the stomach is 20.33 ± 1.30 microns while in Group I this diameter is 42.20 % greater and in animals from the group III it is, on the contrary, 15.64 % less (table 3.8).

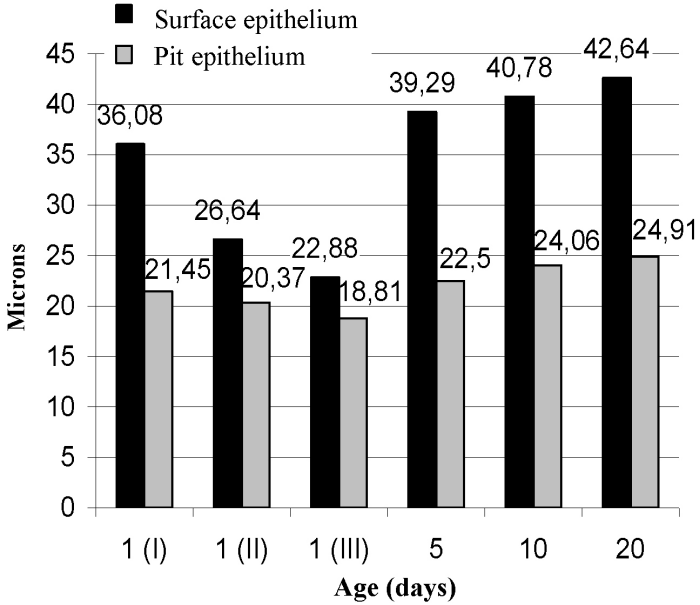


Fig. 3.29 Dynamics of the height of the single-layer columnar epithelium in the lesser curvature of the stomach in piglets

Table 3.8 – Dynamics of diameter of glands and number of parietal cells within one gland in the lesser curvature of the stomach in piglets

Age (days), group / Indexes		Diameter of glands, micron		Number of parietal cells, units	
		M ± m	Cv, %	M ± m	Cv, %
1	I	28.91 ± 0.49	3.82	2.83 ± 0.31	26.57
	II	20.33 ± 1.30	14.30	3.16 ± 0.31	23.77
	III	17.15 ± 0.92	12.04	1.80 ± 0.37*	46.48
5		18.10 ± 0.74	9.19	4.80 ± 0.37**	17.43
10		22.19 ± 0.71*	7.21	5.40 ± 0.24	10.14
20		25.54 ± 0.95*	8.33	7.16 ± 0.31***	10.50

Note: * — $p < 0.05$; ** — $p < 0.01$; *** — $p < 0.001$

The greatest number of parietal cells (among one-day old piglets) within a gland of the lesser curvature (3.16 ± 0.31 items) has been determined in one-day old piglets whose body weight corresponds to the breed standard.

And number of parietal cells within a gland of the lesser curvature in one-day old piglets from Group I is 10.44 % less than the respective number in Group II. The smallest number (by 43.03 %) of parietal cells (with significant variability — Cv = 46.48 %) has been determined in one-day old piglets from the group III.

At the border with the single-layer columnar epithelium in the lesser curvature of the stomach the glandless part is located; it is covered with stratified non-squamous epithelium. In one-day old piglets it is located from the diverticulum to the pyloric part of the organ.

The stratified non-squamous epithelium of the lesser curvature of the stomach is presented as the basal layer, the spinous layer and the surface (flat) layer. The basal layer consists of epithelial cells having a prismatic shape. In one-day old piglets from Group II the basement membrane is tortuous (fig. 3.31).

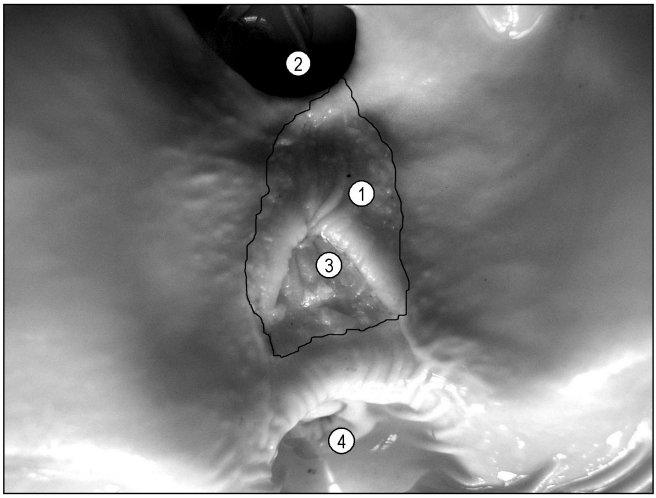


Fig. 3.30 Lesser curvature of the piglet's stomach (one-day old, Group II). Native specimen: 1 — glandless part; 2 — diverticulum; 3 — esophagus opening; 4 — duodenum opening

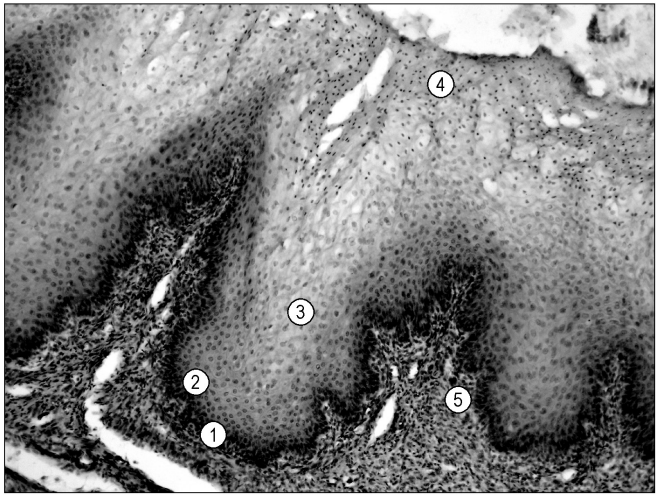


Fig. 3.31 Histological specimen of the lesser curvature of the stomach in piglets (one-day old, Group II). Hematoxylin and eosin, Olympus CX 21, ×100: 1 — basement membrane; 2 — basal layer; 3 — spinous layer; 4 — surface layer; 5 — lamina propria mucosae

In animals from Group I the stratified flat non-squamous epithelium is located on the tortuous basement membrane (fig. 3.32). In animals from Group III the basement membrane is analogous to that in one-day old piglets from Group II. The spinous layer is presented as cells of polygonal shape and the surface layer consists of flat cells. Epithelial stratum of the stratified flat non-squamous epithelium of the stomach in piglets from Group II includes 28–47 cell layers while in animals from Group I the number of these layers is 20–22, and in Group III the number of cell layers is 18–21.

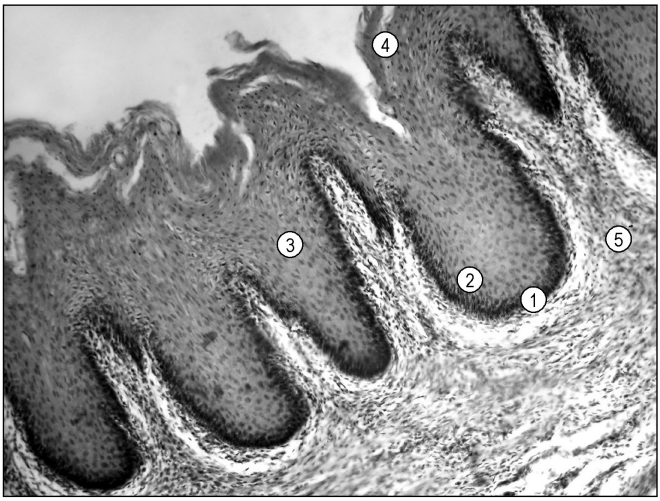


Fig. 3.32 Histological specimen of the lesser curvature of the stomach in piglets (one-day old, the group I). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — basement membrane; 2 — basal layer; 3 — spinous layer; 4 — surface layer; 5 — lamina propria mucosae

3.4.2 5-, 10-and 20-days old piglets

Gastric pits at the border with the glandless part of the lesser curvature of the stomach in 5-day old piglets are deeper by 24.01 % (Cv = 10.49 %) in comparison with one-day old piglets whose body weight corresponds to the breed standard. In these animals the glandular layer is slightly thicker (by 4.90 %) as well as the subglandular

layer (by 35.29 %). At the same time the gland-pit ratio (1 : 0.62) and the glandular-subglandular ratio (1 : 0.19) are narrowed. Thickness of the lamina muscularis mucosae is increased (by 51.55 %), the submucosa becomes thicker (by 67.74 %) and thickness of the muscular coat is increased (by 23.37 %) (with insignificant variability). The glandular-muscular ratio and the mucosal-submucosal ratio are narrowed (1 : 0.21 and 1 : 0.12 respectively). In 5-day old piglets at the border with the glandless part of the lesser curvature of the stomach the serosa is also thicker (by 25.60 %) and this fact results in narrowing of the mucosal-serosal ratio (1 : 0.10) in comparison with one-day old piglets whose body weight corresponds to the breed standard.

Height of the surface epithelium and the pit epithelium of the lesser curvature of the stomach is increased by 47.48 % and 10.45 % respectively; and the glandular epithelial ratio is narrowed (1 : 0.21). In 5-day old piglets diameter of glands is increased by 5.53 % (Cv = 9.19 %) in comparison with one-day old piglets whose body weight corresponds to the breed standard. Number of parietal cells within one gland of the lesser curvature of the stomach is increased by 51.89 % (Cv = 17.43 %).

The stratified flat non-squamous epithelium of the lesser curvature of the stomach in 5-day old piglets is presented as well developed basal layer, spinous layer and surface (flat) layer. The basement membrane is more tortuous than that in one-day old piglets from Group II (fig. 3.33). Epithelial stratum of the stratified flat non-squamous epithelium of the stomach in 5-day old piglets includes from 32 to 55 cell layers.

In 10-day old piglets depth of the gastric pits is changed insignificantly (it is increased by 7.68 %) in comparison with 5-day old piglets; and thickness of the mucosa glandular layer is also increased (by 4.06 %). Alongside with this insignificant narrowing of the gland-pit ratio (1 : 0.64) and the glandular-subglandular ratio (1 : 0.20) is taking place place.

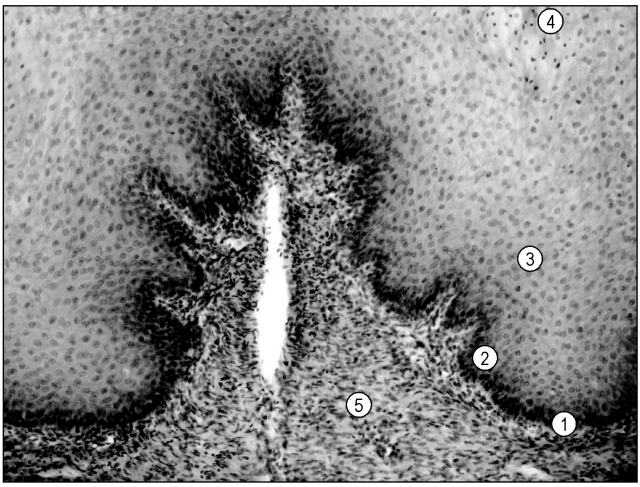


Fig. 3.33 Histological specimen of the lesser curvature of the stomach in piglets (5-day old). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — basement membrane; 2 — basal layer; 3 — spinous layer; 4 — surface layer; 5 — lamina propria mucosae

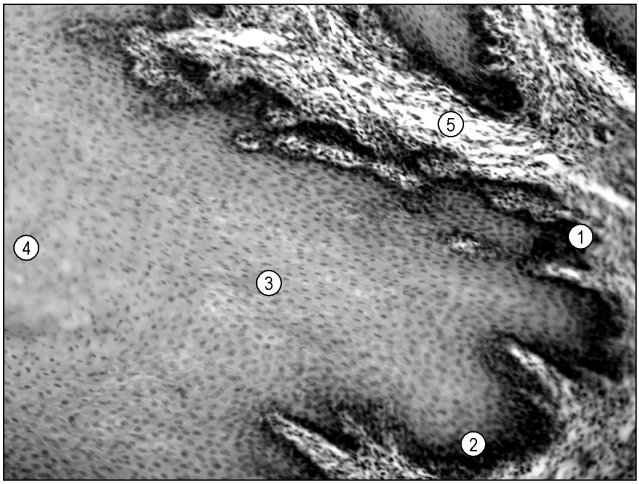


Fig. 3.34 Histological specimen of the lesser curvature of the stomach in piglets (10-day old). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — basement membrane; 2 — basal layer; 3 — spinous layer; 4 — surface layer; 5 — lamina propria mucosae

In 10-day old piglets thickness of the gastric mucosa subglandular layer is also increased (by 11.10 %) with insignificant coefficient of variability (Cv = 8.45 %). Thickness of the lamina muscularis mucosae in the lesser curvature of the stomach is increased by 1.49 % and glandular-muscular ratio remains unchanged (1 : 0.21). Thickness of the subglandular and muscular coats of the organ is increased while the mucosal-submucosal ratio is insignificantly widened (1 : 0.11), and the mucosal-muscular ratio is, on the contrary, narrowed (1 : 0.84). And thickness of the serosa is decreased by 17.23 % (Cv = 9.93 %) in comparison with 5-day old piglets while the mucosal-serosal ratio is slightly widened (1 : 0.08).

In 10-day old piglets, at the border with the glandless part of the lesser curvature of the stomach height of the surface epithelium and the pit epithelium is increased (by 3.79 % and by 6.93 % respectively). Diameter of glands is increased by 9.97 % (Cv = 4.81 %), as well as the number of parietal cells within one gland of the lesser curvature — by 12.50 % (Cv = 10.14 %).

The basement membrane of the stratified flat non-squamous epithelium of the lesser curvature of the stomach in 10-day old piglets is very tortuous (fig. 3.34). The epithelial stratum includes 35–58 cell layers.

In 20-day old piglets gastric pits at the border with the glandless part of the lesser curvature of the stomach are the deepest (128.97 ± 0.60 microns) among all other animals researched. Thickness of the mucosa glandular layer is increased insignificantly (by 0.99 %) in comparison with 10-day old piglets which results in insignificant narrowing of the gland-pit ratio (1 : 0.68). At the same time thickness of the subglandular layer is increased by 8.02 % (Cv = 5.12 %) and the glandular-subglandular ratio is narrowed down to 1 : 0.22). Glands are branched and wavy with expressed interlayers of the interglandular connective tissue (fig. 3.35).

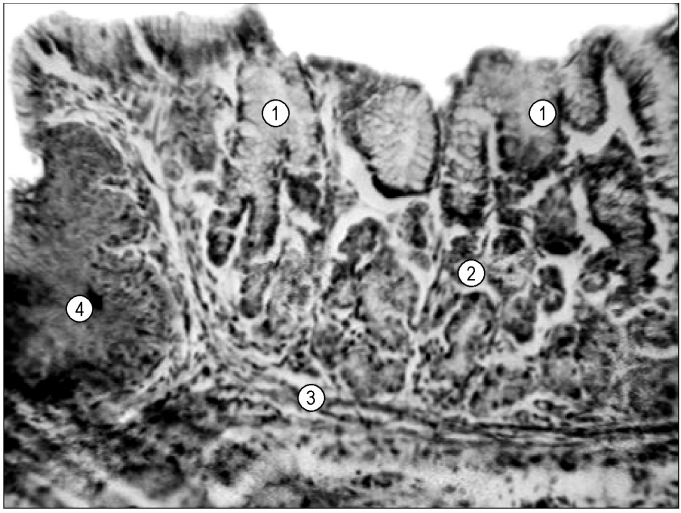


Fig. 3.35 Histological specimen of the lesser curvature of the stomach in piglets (20-day old). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — pits; 2 — glands; 3 — lamina muscularis mucosae; 4 — stratified flat non-squamous epithelium

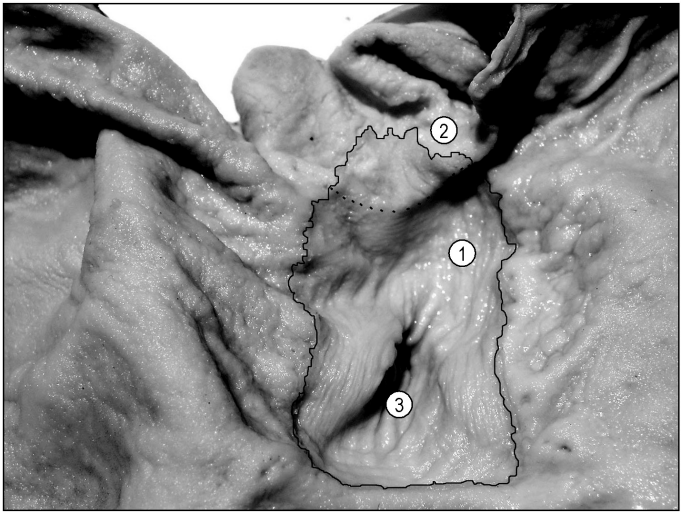


Fig. 3.36 Lesser curvature of the piglet's stomach (20-day old, Group II). Native specimen: 1 — glandless part; 2 — diverticulum; 3 — esophagus opening

In 20-day old piglets (in comparison with 10-day old ones) thickness of the lamina muscularis mucosae remains practically unchanged and this fact results in insignificant widening of the glandular-muscular ratio (1 : 0.20).

And thickness of the submucosa is, on the contrary, increased by 22.18 % (Cv = 6.78 %) while thickness of the muscular coat remains practically unchanged. The mucosal-submucosal ratio is narrowed (1 : 0.13) and the mucosal-muscular ratio is widened (1 : 0.81). Thickness of the serosa at the border with the glandless part of the lesser curvature of the stomach is increased by 38.39 % (Cv = 13.52 %) alongside with narrowing of the mucosal-serosal ratio (1 : 0.11).

In 20-day old piglets height of the surface epithelium is increased (by 4.56 %) and so does thickness of the pit epithelium (by 3.53 %) (lesser curvature of the stomach) while the glandular-epithelial ratio is insignificantly narrowed (1 : 0.22). Diameter of glands is increased by 15.09 % (Cv = 8.33 %) in comparison with 10-day old piglets. Number of parietal cells within one gland of the stomach is increased (by 32.59 %) with insignificant variability (Cv = 10.50 %).

The glandless art of the lesser curvature of the stomach takes 1/3 of the diverticulum and extends up to the pyloric part (fig. 3.36) The most tortuous basement membrane of the stratified flat non-squamous epithelium of the lesser curvature of the stomach has been determined in 20-day old piglets (fig. 3.37). The epithelial stratum includes 40–60 cell layers.

During 20 days of life morphometric parameters of all coats at the border with the glandless part of the lesser curvature of the stomach are increased. Depth of pits of the mucosa in in 20-day old piglets is increased by 43.58 % in comparison with one-day old piglets whose body weight corresponds to the breed standard. With aging the gland-pit ratio is narrowed down to 1 : 0.68. Thickness

of the mucosa glandular layer is increased by 10.25 % and it is the minimal one in comparison with other parts of the stomach. Thickening of the mucosa subglandular layer (by 62.37 %) results in insignificant narrowing of the glandular-subglandular ratio (1 : 0.22). During 20 days of piglet's life thickness of the lamina muscularis mucosae is increased by 52.61 %, and the submucosa becomes 98.65 % thicker in comparison with one day old piglets (Group II).

The glandular-muscular ratio and the mucosal-submucosal ratio in 20-day old piglets become slightly narrower. In addition to this the muscular coat and the serosa are thickened (by 38.22 % and by 43.86 % respectively).

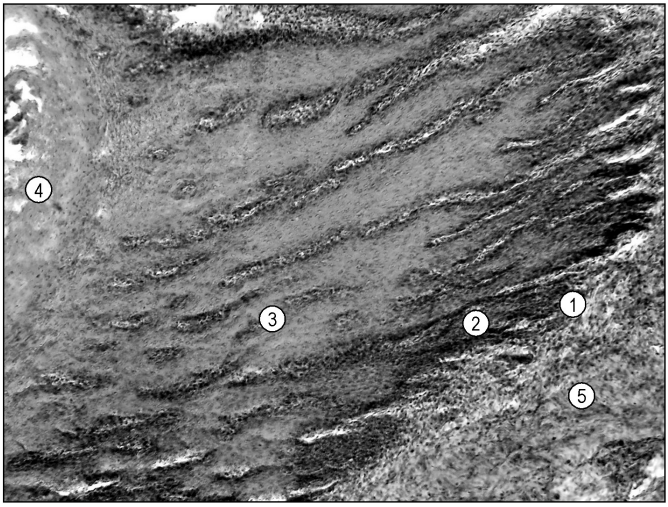


Fig. 3.37 Histological specimen of the lesser curvature of the stomach in piglets (20-day old). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — basement membrane; 2 — basal layer; 3 — spinous layer; 4 — surface layer; 5 — lamina propria mucosae

So, increase of all morphometric parameters in the lesser curvature of the stomach are determined already in 5-day old piglets which is also manifested during the following days (up to the 20th day of life). The stratified flat non-squamous epithelium includes three

layers; the basement membrane of these layers becomes more tortuous in piglets of older age. Epithelial stratum has the greatest number of cell layers in 20-day old piglets.

When analyzing ratio of structures and coats in the lesser curvature of the stomach in piglets it has been determined that variability of thickness values is more expressed in one-day old piglets with various body weights while starting from the age of 5 days index narrowing dynamics appear to be more gradual. 10-day and 20-day old piglets have the narrowest gland-pit and mucosal-submucosal ratios.

3.5 Gastric immune structures in piglets

3.5.1 Stomach wall lymphoid structures

Gastric mucosa contacting antigenic substances performs the function of a border structure between the external environment and the organism. Lymphoid formations in the stomach of piglets are presented as intraepithelial lymphocytes, diffuse lymphoid tissue and lymphatic nodules. Intraepithelial lymphocytes are localized in the basal part of epithelium or between epithelium and the lamina propria mucosae. Diffuse lymphoid tissue is located in the gastric mucosa and submucosa (diffuse lymphoid tissue is prevailing in the cardiac and fundic parts of the stomach). Lymphatic nodules are on various stages of formation and they are located singly or in pairs in the submucosa and the lamina propria mucosae; lymphatic nodules without germinal centers are presented as a homogeneous accumulation of oval lymphocytes. Lymphatic nodules with germinal centers include a crown (mantle).

In one-day old piglets in the cardiac part of the stomach the number of intraepithelial lymphocytes (IEL) per 1000 cells of surface epithelium and pit epithelium is 44.00 ± 1.78 units, while in animals from Group I this number is greater by 7.27 %, and in piglets from Group III it is, on the contrary, smaller by 13.63 % (table 3.9). The diffuse lymphoid tissue is localized in the interglandular stroma of the mucosa as well as in the submucosa of the organ. Height of lymphatic nodules of the cardiac part of the stomach in one-day old piglets with body weight corresponding to the breed standard is 89.06–140.89 microns and their width is 132.86–186.15 microns (table 3.10). Lymphatic nodules are usually localized in the gastric submucosa and have an oval form. Lymphatic nodules with germinal centers are absent. Reticular fibers of the basket of lymphatic nodules without visible fragmentation in

the center (fig. 3.38). And in one-day old piglets from Group I, in the cardiac part of the stomach lymphatic nodules are higher by 4.73–17.59 %, while the lower range of their width is 5.87 % smaller and the upper range is on the contrary larger (by 10.62 %) in comparison with animals from Group II. The funds of the stomach is the place where pear-shapedlymphatic nodules are localized. In one-day old piglets a preventive number of lymphatic nodules are on the pre-nodule stage of development without germinal centers and with indistinctly expressed connective tissue capsule (fig. 3.39).

Table 3.9 – Dynamics of the number of the intraepithelial lymphocytes per 1,000 cells of the surface epithelium and the pit epithelium of the stomach

Indexes / Age (days), group		Part of stomach						Lesser curvature[1]	
		Cardiac part		Fundus		Pyloric part			
		units	Cv, %	units	Cv, %	units	Cv, %	units	Cv, %
1	I	47.40 ± 2.73	12.86	45.00 ± 2.16	10.75	47.40 ± 3.58	16.89	44.20 ± 3.31	16.71
	II	44.00 ± 1.78	9.09	46.20 ± 2.26	11.01	48.60 ± 3.21	14.79	41.80 ± 4.04	21.60
	III	38.00 ± 2.19	12.86	41.00 ± 2.09	11.43	42.60 ± 3.18	16.71	40.40 ± 3.29	18.21
5		45.00 ± 1.76	8.73	50.20 ± 3.83	17.09	52.80 ± 3.59	15.22	47.60 ± 6.53	30.67
10		50.40 ± 0.92*	4.10	53.80 ± 3.70	15.39	57.20 ± 3.10	12.13	50.20 ± 4.49	20.01
20		51.20 ± 3.90	17.03	54.80 ± 3.24	13.22	59.20 ± 3.42	12.93	53.80 ± 3.78	15.76

Note: * — $p < 0.05$; [1] — at the border with the glandless part

Table 3.10 – Dynamics of linear parameters of lymphatic nodules in the piglet's stomach, microns

Indexes / Age (days), group		Part of stomach						Lesser curvature[1]	
		Cardiac part		Fundus		Pyloric part			
		height	width	height	width	height	width	height	width
1	I	93.28 – 165.68	125.05 – 205.92	91.25 – 202.94	150.38 – 192.72	80.30 – 103.24	72.43 – 115.34	50.44 – 78.26	148.16 – 166.85
	II	89.06 – 140.89	132.86 – 186.15	86.54 – 158.23	136.84 – 178.24	82.45 – 126.54	63.51 – 121.83	50.52 – 82.64	138.26 – 184.92
	III	73.23 – 125.68	105.26 – 156.72	65.32 – 99.34	142.64 – 168.50	57.08 – 96.82	60.72 – 111.92	46.34 – 76.26	120.54 – 151.23
5		99.87 – 212.42	146.52 – 215.93	96.36 – 118.26	186.15 – 248.93	92.48 – 146.85	125.81 – 186.54	58.86 – 94.43	140.15 – 236.85
10		115.54 – 237.25	126.36 – 232.87	124.21 – 301.51	206.87 – 356.44	118.26 – 185.46	198.15 – 246.17	61.32 – 102.51	165.92 – 386.27
20		141.62 – 310.98	264.26 – 392.74	146.72 – 336.48	268.74 – 498.72	121.58 – 205.15	231.00 – 308.24	75.48– 119.72	323.39– 518.30

Note: [1] — at the border with the glandless part

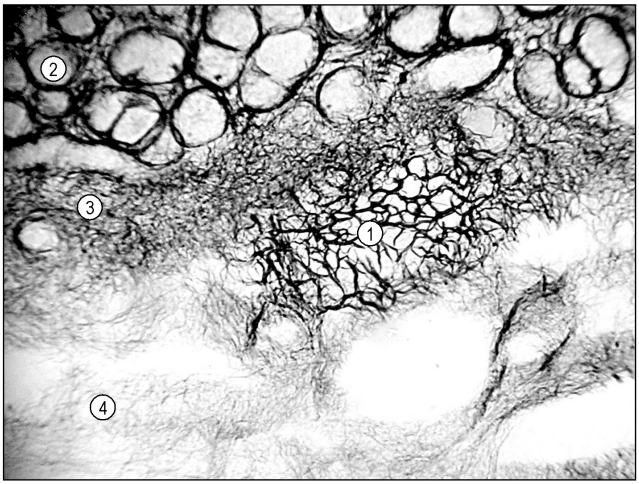


Fig. 3.38 Histological specimen of the cardiac part of the stomach in piglets (one day old, Group II). Caustic silver impregnation according to Foot's method, Olympus CX 21, × 100: 1 — reticular stroma of lymphatic nodules; 2 — glands; 3 — lamina muscularis mucosae; 4 — submucosa

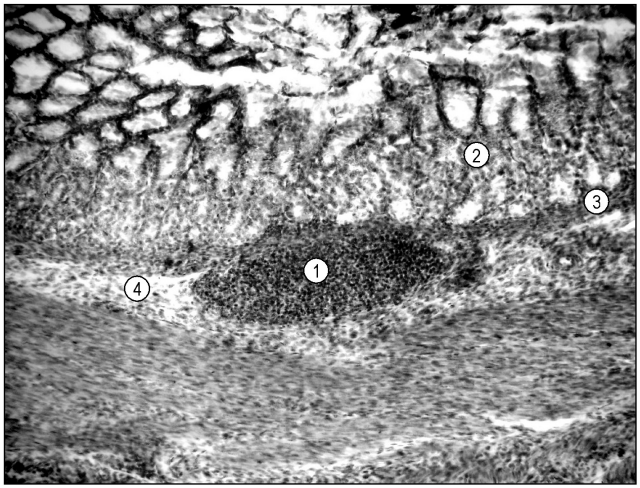


Fig. 3.39 Histological specimen of the cardiac part of the stomach in piglets (one day old, Group I). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — lymphatic nodules; 2 — glands; 3 — lamina muscularis mucosae; 4 — submucosa

The argyrophilic stroma of such lymphatic nodules is formed by round-shaped reticular fibers. In one-day old piglets with body weight lower than the breed standardlymphatic nodulesare lower and narrower. So, in the cardiac part of the organ lymphatic nodules are 17.77–10.79 %, lower and 20.77–15.80 % narrower in comparison with animals whose body weight corresponds to the breed standard.

In the gastric fundus of piglets from Group II number of intraepithelial lymphocytes per 1,000 epithelial cells is 46.20 ± 2.26, while in Group I this number is 2.59 % smaller, and in Group III it is 11.25 % smaller. The diffuse lymphoid tissue is located predominantly in the interglandular connective tissue and in the subglandular layer of the gastric mucosa. In piglets from Group II in the gastric fundus height of lymphatic nodules is 86.54–158.23 microns, and their width is 136.84–178.24 microns. Lymphatic nodules with germinal centers are presented in one-day old piglets with body weight corresponding to the breed standard. Such lymphatic nodules are characterized by thinning and fragmentation of reticular fibers in the center of the basket (fig. 3.40). They are absent in underdeveloped piglets (Group III). In the gastric fundus of one-day old piglets from Group I lymphatic nodules are wider (150.38–192.72 microns) and higher; and at the same time the upper range of height variations is subjected to more significant changes (91.25–202.94 microns). In piglets Lymphatic nodules in coats of the gastric fundus wall are also localized in the submucosa. As a rule they are located singly or (by way of exception) in groups of 2–4 units. Diffuse lymphoid tissue is located around lymphatic nodules and this lymphoid tissue forms the perinodular area. Lymphatic nodules in the gastric fundus of one-day old piglets have various structural organizations. The most of them are not clearly delineated and their capsule is barely visible. In the gastric fundus of piglets from Group I there are also lymphatic nodules with germinal centers. Networks of reticular fibers in the center of such

lymphatic nodules become thiner, rarer and are fragmented. Width of these nodules dominates over their height and in the result of this they have a shape elongated in width. In the gastric fundus of one-day old piglets with body weight corresponding to the breed standard and higher than the breed standard over 2.00 % of lymphatic nodules have germinal centers. And in one-day old piglets whose body weight is lower than the breed standard lymphatic nodules are shorter (by 24.52–62.77 %) and the lower range of their width is larger (by 4.23 %) providing that the upper range is lower (by 5.46 %).

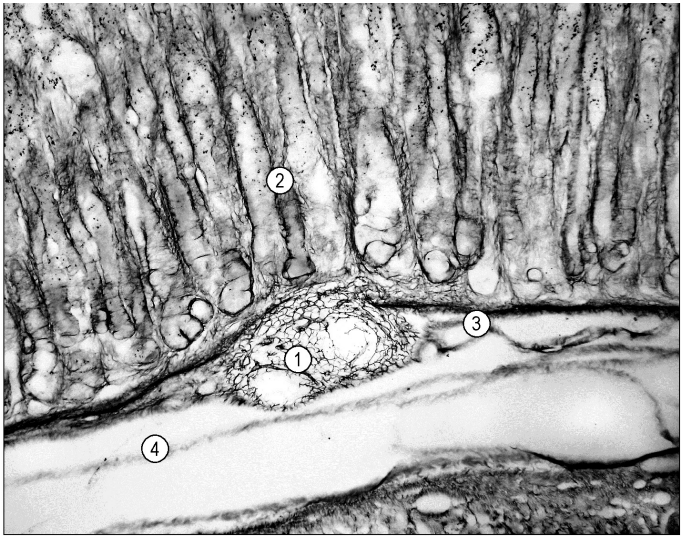


Fig. 3.40 Histological specimen of the gastric fundus in piglets (one day old, Group II). Caustic silver impregnation according to Foot's method, Olympus CX 21, × 100:
1 — reticular stroma of lymphatic nodules; 2 — glands; 3 — lamina muscularis mucosae; 4 — submucosa

In the pyloric part of the stomach of one-day old piglets the number of intraepithelial lymphocytes per 1,000 epithelial cells is maximal (48.60 ± 3.21 units) while in Group I they are 2.46 % fewer and in Group III they are 12.34 % fewer. The most of the diffuse lymphoid tissue are located in the glandular and subglandular

layers of the gastric mucosa. In the pyloric part of the organ in piglets with body weight corresponding to the breed standard height oflymphatic nodes is 82.45–126.54 microns and their width is 63.51–121.83 microns. One-day old piglets from Groups II and III have triangular-shaped lymphatic nodules (about 2.00 %) and their basis is adjacent to the submucosa. The lamina muscularis mucosae in places of its contact with lymphatic nodules is thinned and in some cases even interrupted and so, lymphocytes penetrate through it and they infiltrate their own lamina mucosae.

In one-day old piglets with body-weight higher than the breed standard Lymphatic nodules of the pyloric part of the stomach are lower (by 26.07–18.41 %) and narrower (by 14.04–5.32 %) in comparison with those in piglets whose body weight corresponds to the breed standard. In this part of the stomach lymphatic nodules without germinal centers and pre-nodules are localized and the diffuse lymphoid tissue is expressed intensively. Analogously, in the pyloric part and in the lesser curvature of the stomach in piglets with body weight lower than the breed standard linear parameters of lymphatic nodules are less than in animals whose body weight corresponds to the breed standard. Lymphatic nodules in piglets from Group III are localized in the gastric submucosa and they do not have germinal centers and in addition to this accumulations of the diffuse lymphoid tissue without noticeable rarefaction or compaction in the center.

In one-day old piglets from Group II at the border between the stratified flat non-squamous epithelium and single-layer cylindrical (columnar) glandular epithelium of the lesser curvature of the stomach the number of intraepithelial lymphocytes per 1,000 epithelial cells is 41.80 ± 4.04 units while in Group I his number is 5.74 % greater and in Group III it is 3.34 % smaller.

At the border between the stratified flat non-squamous epithelium and single-layer cylindrical (columnar) glandular epithelium of the lesser curvature of the stomach oval-shapedlymphatic nodules are

localized. In one-day old piglets from Group II their upper ranges of height and width are maximal in comparison with their other agemates (50.52–82.64 microns and 138.26–184.92 microns. In this age group of piglets lymphatic nodules located in pairs can be also met (fig. 3.41).

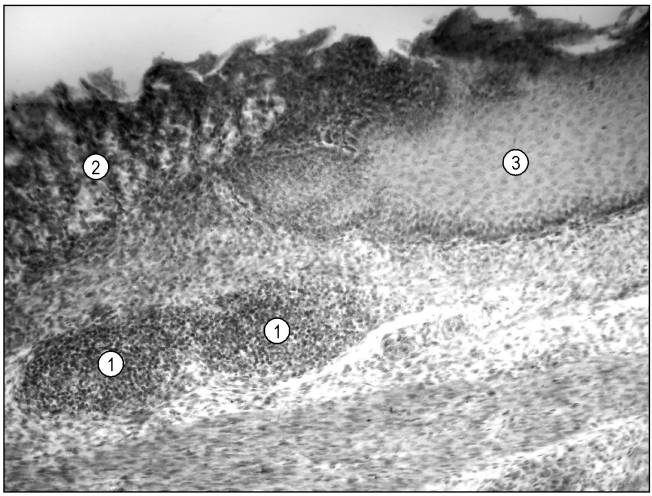


Fig. 3.41 Histological specimen of the lesser curvature of the stomach in piglets (one-day old, Group II). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — lymphatic nodules; 2 — glands; 3 — stratified flat non-squamous epithelium

They have a more rounded shape and are not connected by means of a common connective tissue capsule.

A regularity of permanent localization of lymphatic nodules of the lesser curvature of the stomach in one-day old piglets with body weight higer than the breed standard is the lesser curvature of the organ in places of transition from the stratified flat non-squamous epithelium to the glandular epithelium of the mucosa. Lymphatic nodules do not have germinal centers and are surrounded with a slightly expressed connective tissue capsule (fig. 3.42). Width of lymphatic nodules (148.16–166.85 micrones) dominates over their height (50.44–78.26 microns) and therefore they have an oval elongated shape.

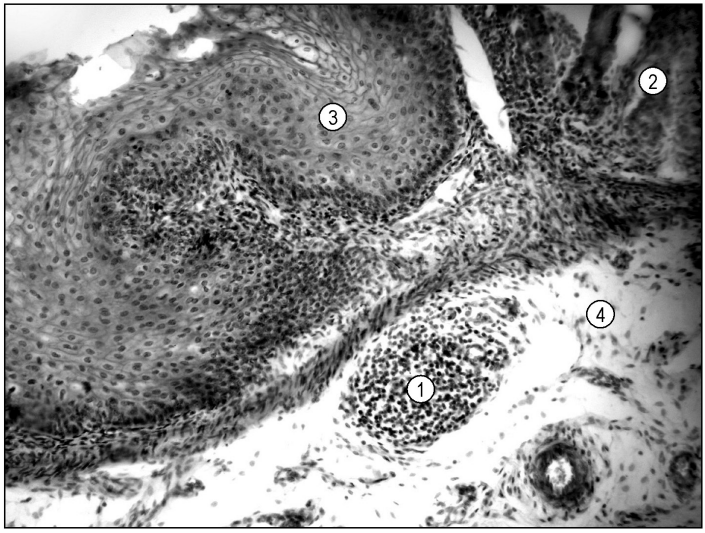


Fig. 3.42 Histological specimen of the lesser curvature of the stomach in piglets (one-day old, Group I). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — lymphoid nodule; 2 — glands; 3 — stratified flat non-squamous epithelium; 4 — submucosa

So, in one-day old piglets lymphatic nodules are localized in all parts of the stomach and have various levels of differentiation. Presence of germinal centers in lymphatic nodules already in one-day old piglets may indicate their morphofunctional formation which is typical for mature bearing kinds of animals. It should be pointed out that in animals with body weight lower than the breed standard lymphatic nodules with germinal centers are absent.

In the cardiac part of the stomach of 5-day old piglets number of intraepithelial lymphocytes per 1,000 epithelial cells is increased by 2.27 %, and in the fundus and the pyloric part this number is increased by 8.65 %, and at the border with the stratified flat non-squamous epithelium of the lesser curvature of the organ it is increased by 13.87 %, (in comparison with one-day old piglets from Group II). Amount of the diffuse lymphoid tissue is increased and it is localized in the mucosa as well as in the submucosa of the organ. In the

cardiac part of the stomach of 5-day old piglets height of lymphatic nodules is increased by 12.13–50.77 %, and their width is increased by 10.28–15.99 % in comparison with one-day old piglets whose body weight corresponds to the breed standard. The cardiac part of the stomach also includes lymphatic nodules which elevate the lamina muscularis mucosae. And in the fundus of the stomach of 5-day old piglets width of lymphatic nodules prevails over their height. At the same time the lower range of the height of lymphatic nodules is increased (by 11.34 %), and the upper range is decreased (by 25.26 %), and their width is increased (by 30.50–39.66 %). Lymphatic nodules (about 20 % of them) come into contact with the lamina muscularis mucosae elevating it.

In the pyloric part of the stomach of 5-day old piglets height of lymphatic nodules is increased by 12.16–16.05 % and their width is increased even more significantly (by 98.09–53.11 %. Lower and upper ranges of height (by 16.50–14.26 %) and width of lymphatic nodules are increased (by 16.50–14.26 % and 1.36–28.08 % respectively) is taking place in the lesser curvature of the stomach in 5-day old piglets. In the loose fibrous connective tissue around lymphatic nodules a significant number of lymphocytes is determined.

In the cardiac part of the stomach of 10-day old piglets number of intraepithelial lymphocytes per 1,000 epithelial cells is increased by 12.00 %, and in the fundus this number is increased by 7.17 %, in the pyloric part it s increased by 8.33 %, and at the border with the stratified flat non-squamous epithelium of the lesser curvature of the stomach it is increased by 5.46 %, (in comparison with 5-day old piglets). Amount of the diffuse lymphoid tissue is growing intensively, especially in the lamina propria mucosae of the organ (fig. 3.43). In the cardiac part of the stomach in 10-day old piglets height of lymphatic nodules is increased (by 15.69–11.68 %) while the lower range of their width is

decreased (by 13.75 %), and the upper range is, on the contrary, increased (by 7.84 %) in comparison with 5-day old piglets. Some lymphatic nodules break through the lamina muscularis of the gastric mucosa and penetrate its own lamina (fig. 3.44). But the most lymphatic nodules are located in the submucosa of the cardiac part of the stomach (fig. 3.45). The most intensive increase of height and width (by 28.90–154.95 % and by 11.13–43.18 %) of lymphatic nodules in 10-day old animals is determined in the fundus of the organ. Insignificant number of lymphatic nodules is already located in the lamina propria mucosae of the fundus and the pyloric part of the stomach.

In 10-day old piglets height and width of lymphatic nodules in the pyloric part of the organ are increased (by 27.87–26.29 % and by 57.49–31.96 % respectively) an in the lesser curvature their height and width are increased by 4.17–8.55 % and by 18.38–63.08 % respectively.

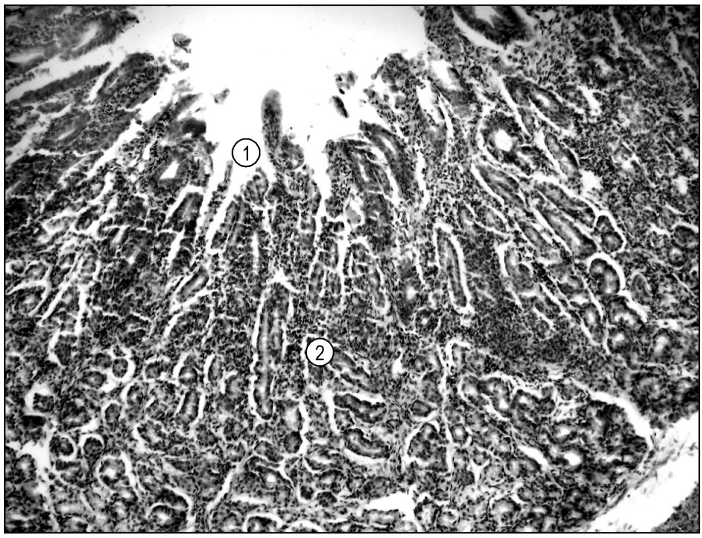


Fig. 3.43 Histological specimen of the pyloric part of the stomach in piglets (10-day old). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — pits; 2 — glands

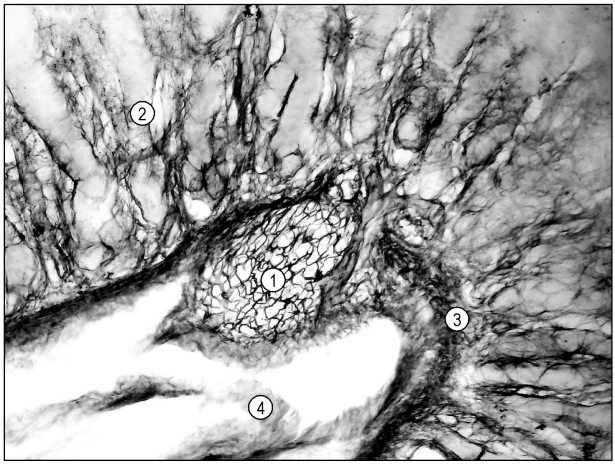


Fig. 3.44 Histological specimen of the cardiac part of the stomach in piglets (10-day old). caustic silver impregnation according to Foot's method, Olympus CX 21, × 100:
1– reticular stroma of lymphatic nodules; 2 — glands;
3 — lamina muscularis mucosae; 4 — submucosa

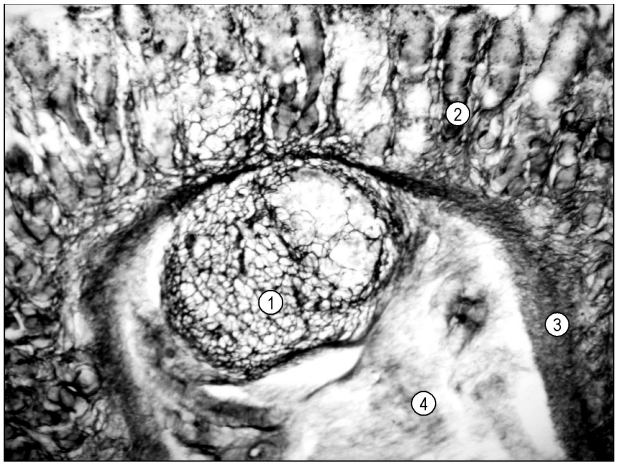


Fig. 3.45 Histological specimen of the cardiac part of the stomach in piglets (10-day old). caustic silver impregnation according to Foot's method, Olympus CX 21, × 100: 1 — reticular framework of lymphatic nodules with germinal center;
2 — glands; 3 — lamina muscularis mucosae; 4 — submucosa

In 20-day old piglets number of intraepithelial lymphocytes per 1,000 epithelial cells is increased insignificantly (by 1.58–7.17 %) in all parts of the stomach in comparison with 10-day old piglets. The diffuse lymphoid tissue is presented in the mucosa as well as in the submucosa of the organ and amount of this tissue is growing.

In 20-day old piglets further increase of lymphatic nodule linear parameters is taking place. So, their height in the cardiac part of the organ is increased by 22.57–31.07 %, and their width is increased by 109.13–68.65 % in comparison with 10-day old piglets.

Over 90.00 % of lymphatic nodules in the cardiac part of the stomach in 20-day old piglets are localized in the lamina propria mucosae, and stroma of these lymphatic nodules is formed by the reticular network which generates plexuses of argentophilic fibers between glands and under their bottom. For 20-day old piglets accumulations consisting of two and more lymphatic nodules (which are on various levels of development and may have a common capsule as well as a less developed individual capsule) are typical (fig. 3.46). Increase of upper and lower ranges of height of lymphatic vessels is taking place in the gastric fundus of 20-day old piglets. A greater number of lymphatic nodules is already localized in the lamina propria mucosae as well as between the glands. Lymphatic nodules with germinal centers are prevailing among them. But alongside with this there are some lymphatic nodules without germinal centers as well as lymphatic nodules on the initial stage of development. In the pyloric part of the stomach height of lymphatic nodules is increased by 2.80–10.61 % and their width is increased by 16.57–25.21 %. In 20-day old animals round-shaped and oval-shaped lymphatic nodules located in the lamina propria mucosae and between the glands are dominant (fig. 3.47, 3.48). In 20-day old piglets, in the lesser curvature of the organ lymphatic nodules are found even directly under the stratified flat non-squamous epithelium. Their height is increased by 23.09–16.78 %,

and their width is increased by 94.90–34.18 % in comparison with those in 10-day old piglets.

So, lymphoid structures of the stomach wall in piglets are presented by intraepithelial lymphocytes, the diffuse lymphoid tissue as well as by lymphatic nodules. A greater number of intraepithelial lymphocytes is determined in the pyloric part of the stomach of 20-day old piglets. The diffuse lymphoid tissue is localized in the lamina propria mucosae as well as in the submucosa of the stomach. The function of support and microenvironment for gastric lymphoid structures is performed by the reticular tissue. Alongside with lymphoid tissue differentiation a phased formation of argyrophilic stroma oflymphatic nodules is taking place. Formation of lymphatic nodule reticular baskets is taking place variously and do not have a distinct age-related dynamics.

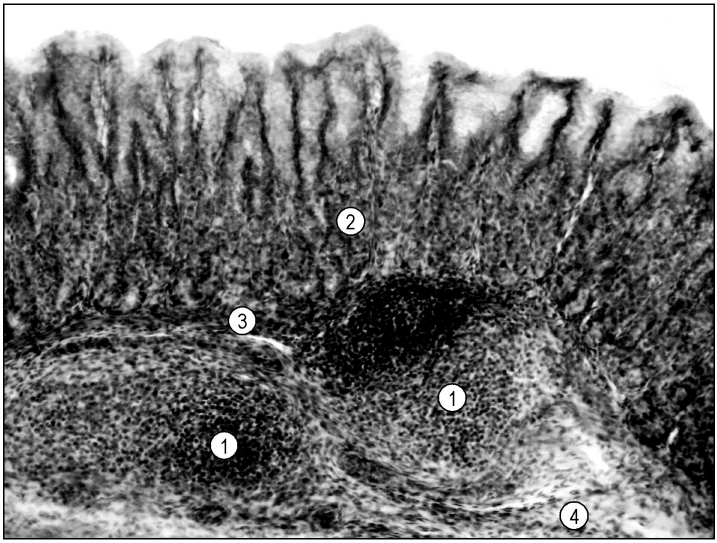


Fig. 3.46 Histological specimen of the pyloric part of the stomach in piglets (10-day old). Congo red and hematoxylin, Olympus CX 21, × 100: 1 — lymphatic nodules; 2 — glands; 3 — lamina muscularis mucosae; 4 — submucosa

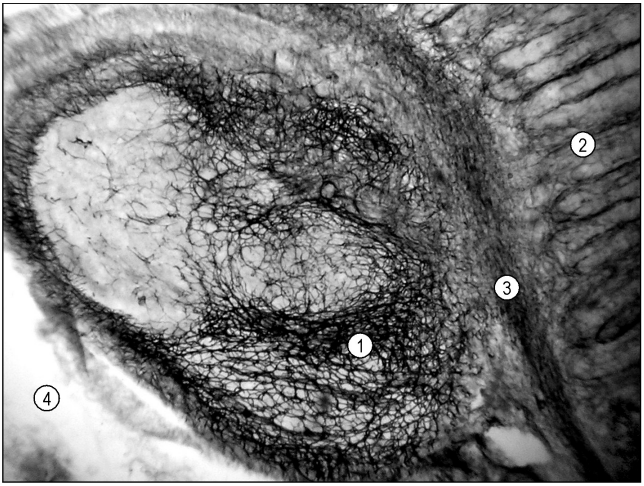


Fig. 3.47 Histological specimen of the cardiac part of the stomach in piglets (20-day old). caustic silver impregnation according to Foot's method, Olympus CX 21, ×100: 1 — lymphatic nodules; 2 — glands; 3 — lamina muscularis mucosae; 4 — submucosa

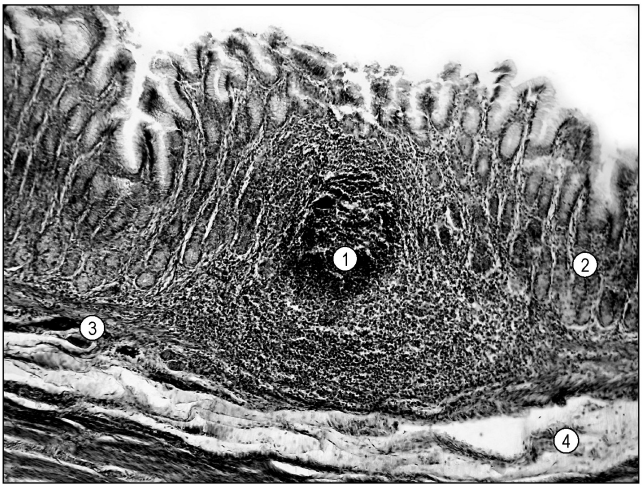


Fig. 3.48 Histological specimen of the pyloric part of the stomach in piglets (20-day old). Hematoxylin and eosin, Olympus CX 21, ×100: 1 — lymphatic nodule; 2 — glands; 3 — lamina muscularis mucosae; 4 — submucosa

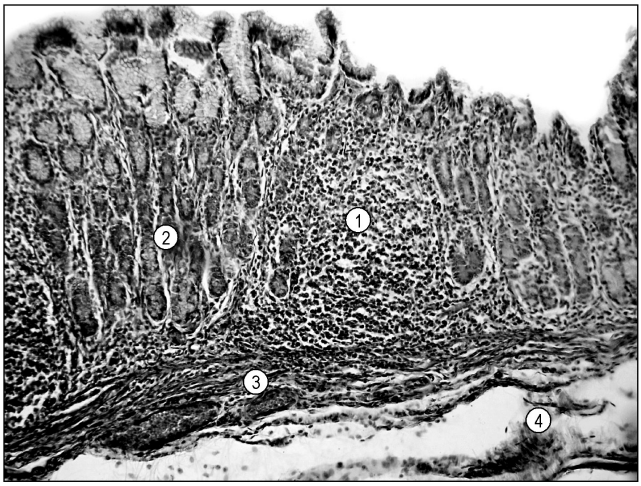


Fig. 3.49 Histological specimen of the pyloric part of the stomach in piglets (20-day old). Hematoxylin and eosin, Olympus CX 21, ×100: 1 — lymphatic nodule; 2 — glands; 3 — lamina muscularis mucosae; 4 — submucosa

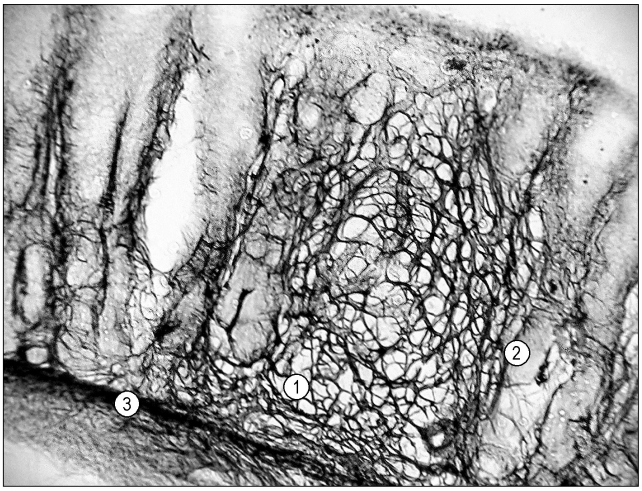


Fig. 3.50 Histological specimen of the pyloric part of the stomach in piglets (20-day old). caustic silver impregnation according to Foot's method, Olympus CX 21, ×100: 1 — reticular stroma of lymphatic nodules; 2 — glands; 3 — lamina muscularis mucosae

First in lymphatic nodules formed density of reticular fiber networks is increased; in the process of maturation these fibers are evenly rarefied and fragmented. In the stomach of one-day old piglets lymphatic nodules are located under the lamina muscularis mucosae in the loose connective tissue of the submucosa. Their shape varies from round to disc-like elongated. The greatest number of gastric lymphatic nodules in one-day old piglets is concentrated in the mucosa of its cardiac part and fundus; lymphatic nodules are rarer in the pyloric part; and the border with the glandless part of the lesser curvature of the organ is a permanent lace of their localization. Availability of germinal centers in lymphatic nodules already in one-day old piglets indicates a certain functional maturity of lymphoid tissue. In one-day old piglets lymphatic nodules are localized in the gastric submucosa while 90.00 % of lymphatic nodules in 20-day old piglets are presented in lamina propria mucosae of the organ. But number and dimensions of lymphatic nodules (primary ones and, particularly, secondary ones) is increased with aging.

In differentiation of gastric lymphatic nodules in piglets certain regularities have been revealed. One-day old piglets have accumulations of the diffuse lymphoid tissue, lymphatic nodules without germinal centers in the submucosa of the organ. Some of them are protruded into the lamina muscularis mucosae already in 5-day old piglets. With aging they penetrate through the lamina muscularis to the lamina propria (which is typical for 10-day old piglets) and then (20 days of life) they are also presented in the mucosa glandular layer.

3.5.2 Intra-organ lymphatic vessels

Penetration of foreign substances to the organism is prohibited by the lymphoid tissue of the stomach wall as well as by the network of lymphatic vessels with regional lymph nodes.

The intra-organ lymphatic system in the stomach of piglets is presented as capillaries, post-capillaries and lymphatic vessels. Networks of lymphatic capillaries are presented in all coats of the stomach wall.

Intra-organ lymphatic vessels are formed of plexuses of post-capillaries in the submucosa, the muscular coat and the serosa. Intra-organ lymphatic vessels anastomose abundantly with each other.

In one-day old piglets the gastric mucosa includes solitary lymphatic capillaries (especially in its glandular layer). But their greater number is presented in the mucosa of gastric fundus in piglets from Group II and Group I. The greatest number of lymphatic capillaries is presented in the mucosa forming folds which is also typical for the gastric fundus (fig 3.51). Lymphatic capillaries of the lamina propria mucosae anastomose with lymphatic capillaries in the lamina muscularis mucosae. In piglets from Group III relief of the mucosa is not expressed which coincides with a decreased number of capillaries in the lamina propria mucosae.

The lamina muscularis mucosae includes solitary lymphatic capillaries and post-capillaries which anastomose with the network of those in the submucosa. The lymphatic network of the submucosa is formed by capillaries, post-capillaries and lymphatic vessels with a small cross section (fig. 3.52).

The densest networks of lymphatic capillaries are located in the submucosa of the cardiac part of the stomach and in the gastric fundus.

This peculiarity of location of intra-organ lymphatic capillaries and lymphatic vessels is typical for one-day old piglets from Groups I and II. Looser networks of lymphatic capillaries are determined in the result of an intratissual injection of 0.1 % silver nitrate solution to gastric coats of piglets from Group III. In one-day old piglets from Groups II and I capillary network loops are predominantly oval or polygonal. For piglets from group III rare capillary networks with oval loops are typical.

The gastric submucosa also includes lymphatic vessels of the first order which merge together forming vessels of the second order and when they penetrate through the muscular coat their cross section is increased and they are located under the gastric serosa.

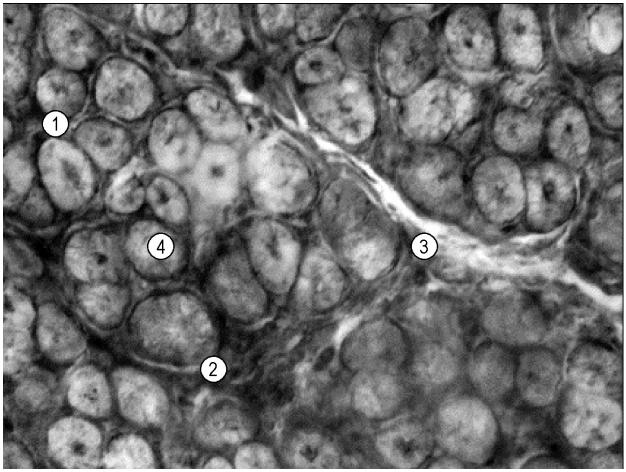


Fig. 3.51 Gastric fundus of a piglet (one day old, Group II). Caustic silver impregnation according to Ranvier's method, cleared specimen, Olympus CX 21, ×100: 1 — lymphatic capillary; 2 — lymphatic post-capillary; 3 — lymphatic vessel; 4 — bottom of glands

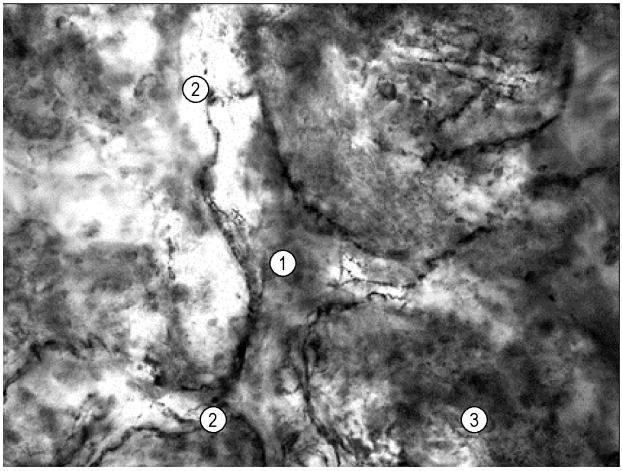


Fig. 3.52 Gastric fundus of a piglet (one day old, Group I). Caustic silver impregnation according to Ranvier's method, cleared specimen, Olympus CX 21, ×400: 1 — lymphatic vessel; 2 — valves; 3 — loose fibrous connective tissue of the submucosa

In the muscular coat of the stomach the network of lymphatic capillaries is localized in connective-tissue interlayers between bundles of muscle cells. They form loops of predominantly rectangular shape. Density of the networks is directly proportional to the development of the muscular coat of the respective part of the stomach as well as to the age of animals. The densest networks of lymphatic capillaries are located in the area of the lymphatic sphincter where several (3–5) lymphatic capillaries merge into post-capillaries and form lymphatic vessels. And as a rule these lymphatic vessels accompany blood vessels. Not far from the greater curvature of the stomach lymphatic vessels of the muscular coat merge with vessels of the submucosa. Capillaries of the oblique muscle layer are located in various planes and so they form narrow and long meshes and in the annular muscular layer they are oriented in the transverse direction in relation to the length of the stomach while in the longitudinal direction they are parallel to the long axis of the organ. Shape and dimensions of the capillary network depend on thickness of the loose connective tissue. In places where this loose connective tissue is thicker networks of lymphatic capillaries are denser and their diameter is wider.

In piglets under the gastric serosa lymphatic capillaries, post-capillaries and vessels are located; they form plexuses; shape and dimensions of these plexuses depend on their localization in various parts of the organ (fig. 3.54).

Loops of capillaries in the gastric fundus form oval networks; and it has been determined that these networks in one-day old piglets and newborn piglets are the largest in the middle third of the side walls of the organ. The densest network of subserosal plexuses of lymphatic capillaries and vessels is located in the area of diverticulum. Their loops have a polygonal shape while in the pyloric part of the stomach they have an elongated tetragonal shape and are parallel to the longitudinal axis of the organ. Lymphatic capillaries of

the subserosal plexus start either as blind finger-shaped protrusions or as closed networks of various shapes.

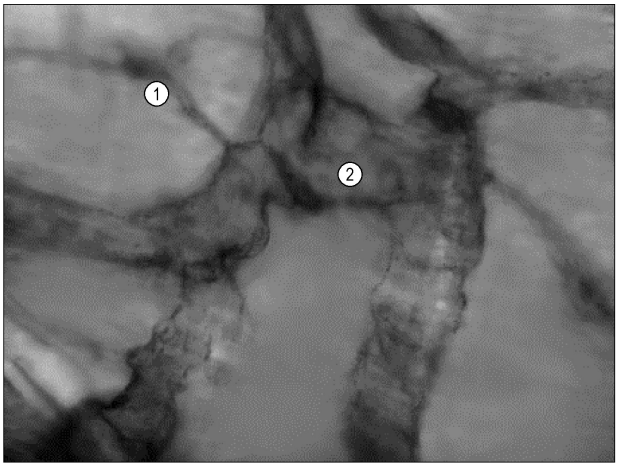


Fig. 3.53 Gastric fundus of a piglet (one day old, Group II). Caustic silver impregnation according to Ranvier's method, cleared specimen, Olympus CX 21, ×400: 1 — lymphatic post-capillary; 2 — lymphatic vessel

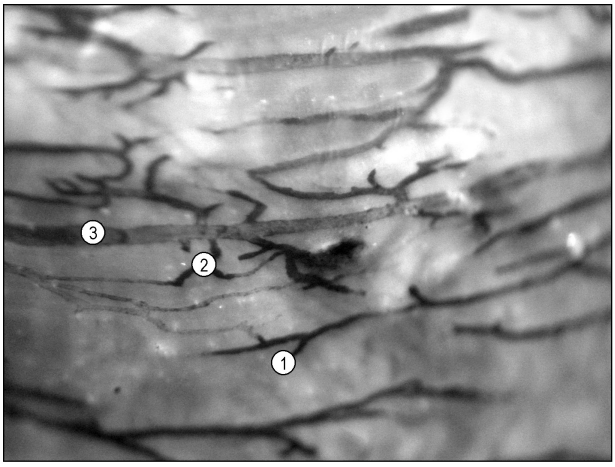


Fig. 3.54 Intra-organ lymphatic vessels of a piglet's stomach (one-day old, Group II). Injection of 3 % aqueous ink solution, native specimen MBS-10, ×32: 1 — lymphatic capillaries; 2 — lymphatic post-capillaries; 3 — lymphatic vessel

Networks of lymphatic capillaries give start to post-capillaries, and then lymphatic vessels are formed and in the cardiac part these vessels are directed to lymph nodes of the lesser curvature of the stomach. And in the fundus slightly tortuous lymphatic vessels reach 2/3 of the stomach cross section (similar to the cardiac part) and in the upper third they change their direction at an angle of 45° towards the diverticulum and after that they fall into gastric lymph nodes located in the lesser curvature (fig. 3.56). Networks of lymphatic capillaries from side walls flow into 12–15 vessels which are also directed to gastric lymph nodes.

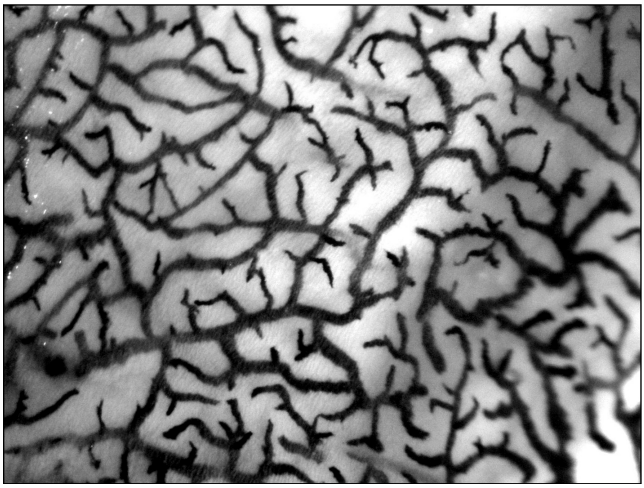


Fig. 3.55 Network of lymphatic capillaries of piglet's diverticulum (one-day old, Group I). Injection of 3% aqueous ink solution, native specimen MBS-10, ×32

The middle third of side walls of the stomach is the zone of lymphatic division (fig. 3.57) Vessels formed within the upper third and the middle third of side walls are directed to lymph nodes of the lesser curvature and vessels of the lower third are directed to the greater curvature of the stomach. Some lymphatic vessels located directly along the greater curvature of the stomach flow into pancreaticoduodenal and splenic lymph nodes.

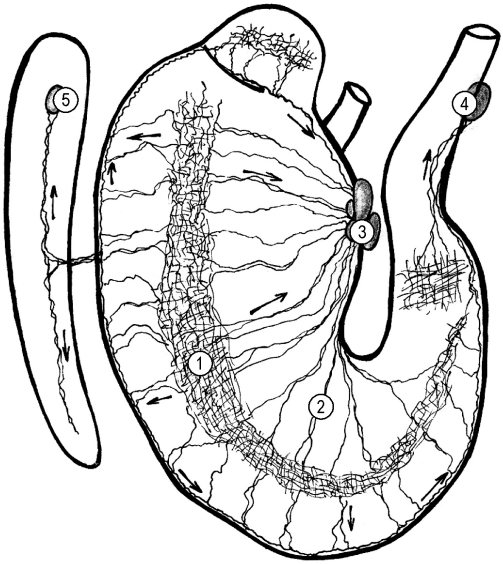


Fig. 3.56 Lymph nodes and directions of lymph outflow from the stomach wall in piglets (scheme): 1 — network of lymphatic capillaries; 2 — lymphatic vessel; 3 — lymph nodes of the lesser curvature of the stomach; 4 — pancreaticoduodenal lymph nodes; 5 — splenic lymph nodes

One of anatomic structural peculiarities of pig's stomach consists in presence of a blind protrusion (diverticulum) in the cardiac part. After injecting a contrast substance under the serosa in the area of the diverticulum we determined a network of lymphatic capillaries which appears to be the most expressed in its side walls.

In one-day old piglets it is weakly presented. Capillaries merge together and form post-capillaries which flow into 5–7 vessels and at the basis of the blind protrusion they form the main line going around the esophagus and flowing into lymph nodes of the lesser curvature of the stomach.

Our researches have shown that peculiarities of formation of lymphatic capillary networks as well as peculiarities of their location in coats of the stomach, sequence of their merging into post-

capillaries and formation of lymphatic vessels of the first order and the second order are typical for all coats in various parts of the stomach in one-day old piglets. An exception consists in the fact that in piglets with body weight lower than the breed standard networks of lymphatic capillaries are less presented.

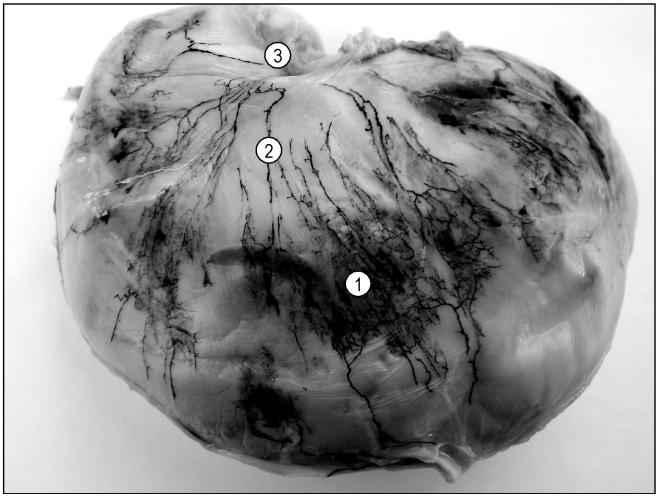


Fig. 3.57 Lymph flow of the stomach subserosal plexus in piglets (one day old, Group I). Injection of 3 % aqueous ink solution, native specimen: 1 — network of lymphatic capillaries; 2 — lymphatic nodules; 3 — gastric lymph nodes

In 5-, 10- and 20-day old piglets (with aging) architectonics of lymphatic capillaries, post-capillaries and lymphatic vessels does not change. Only their number and cross section are increased and this has an influence on density of lymphatic capillaries which acquire polygonal shapes (fig. 3.58).

In the lesser curvature of the stomach the number of lymphatic vessels is decreased, they acquire a greater cross section and prior to falling into gastric lymph nodes they form various variants of branching (fig. 3.59).

The most widespread variant of branching is presented as merging of lymphatic vessels into a common line with its further

falling into a gastric lymph node. This variant of lymphatic vessel branching in loose fibrous connective tissue (tissue located under the gastric serosa) is more typical for one-day old piglets (72–78 %). A significantly rarer variant (0.5–1 %) is a complex anastomotic connection of two lymphatic vessels which after merging are separated again with further merging into a common revehent lymphatic vessel.

In piglets of neonatal period the prevailing variants are direct inflow of revehent lymphatic vessels to a regional lymph node (43–48 %), as well as merging into a common vessel with further inflow to a lymph node (36–37 %). Other variants of inflow of revehent lymph vessels to a gastric lymph node are much less numerous (0.5–3 %).

Lymphatic vessels differ from capillaries in their shape as well as in their location. These peculiarities are related not only with complication of vascular units but also with their location in the stomach which is preserved with aging of animals.

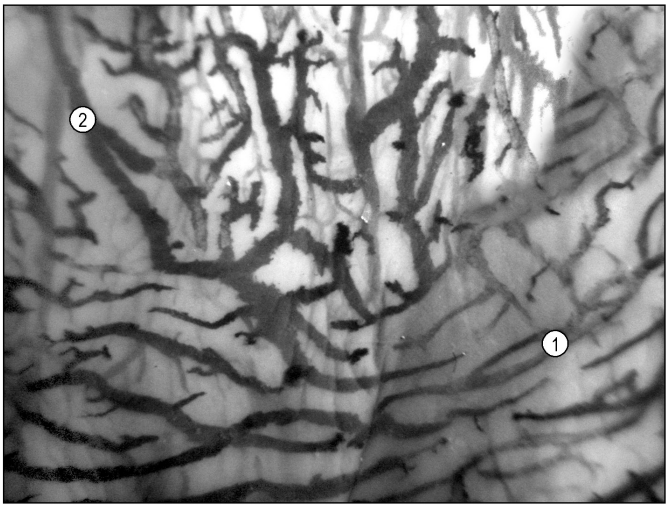


Fig. 3.58 Lymph flow of piglet's stomach (20-day old). Injection of 3 % aqueous ink solution, native specimen MBI-10, ×32: 1 — capillary; 2 — lymphatic vessel

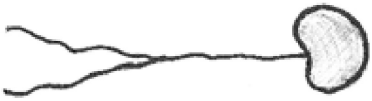
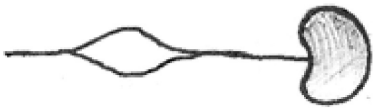
1.		Individual inflow of lymphatic vessels
2.		Merging of lymphatic vessels with further inflow
3.		Inflow of lymphatic vessels connected in the result of anastomosis
4.		Bifurcation of a lymph vessel not far from the place of its inflow
5.		Bifurcation with further merging into a common lymphatic vessel
6.		Double anastomotic connection of two lymphatic vessels
7.		Bifurcation of lymphatic vessels and their repeated merging before the inflow
8.		Plexuses of lymphatic vessels

Fig. 3.59 Variants of inflow of revehent lymph vessels to a gastric lymph node in piglets (scheme)

Lymphatic vessels consist of separate segments and have a clear appearance. So, lymphatic vessels in the pyloric part of piglet's stomach have shallower interceptions in the area of valves and their lymphangions have the greatest length with the smallest width (fig. 3.60).

Lymphatic vessels in the cardiac part of piglet's stomach have deeper interceptions and this contributes to their clearer view. Structure of lymphatic vessels in the fundus takes an intermediary position. But in this part of the stomach networks of lymphatic capillaries turning into post-capillaries with availability of valves. They, in their turn, bring lymph to intra-organ lymphatic vessels and then to revehent vessels going to gastric lymph nodes.

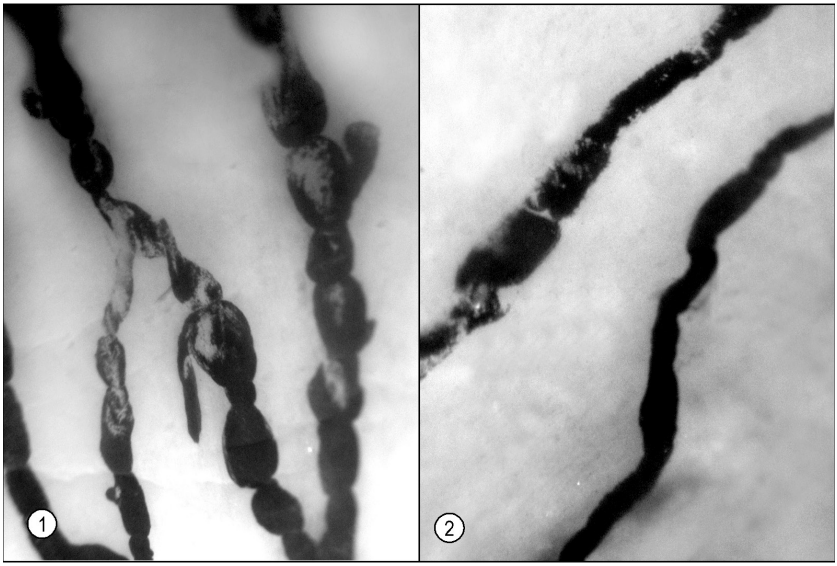


Fig. 3.60 Lymphatic vessels of the piglet's stomach (10-day old). Injection of 3 % aqueous ink solution, native specimen MBS-10, ×56: 1 — cardiac part; 2 — pyloric part

Valve segment or lymphangion is a structure-functional unit of the lymph flow. Lymphangion is a section of a lymphatic vessel between two valves. Distal valve belongs to one valve segment and proximal valve belongs to the next valve segment. Quantitative indexes of lymphangions in intra-organ lymphatic vessels of piglet's stomach are variated in wide ranges. Range of length, width and volume of lymphangions even in a certain lymphatic vessel appears to be quite variable (table 3.11). In one-day old piglets with body weight corresponding

to the breed standard n the cardiac part of the stomach length of lymphangeons is 0.35 ± 0.005 mm, their width is 0.12 ± 0.0003 mm, their volume is 0.002 ± 0.0005 mm^3, and the valve index is 5.71 with a high level of reliability of all indexes ($p < 0.01–0.001$). But in the cardiac part of the stomach lymphangeons are the longest in piglets from Group I reaching 0.83 ± 0.004 mm which is 137.14 % longer than in Group II and this results in a smaller valve index (2.40). And lymphatic vessel lymphangeons in the stomach of piglets with body weight higher than the breed standard are 8.33 % wider, and their volume is 250.00 % greater than in animals with body weight corresponding to the breed standard. Alongside with this in piglets from Group III lymphangeons are 28.57 % longer ($p < 0.001$) in comparison with animals from Group II; but in comparison with Group I they are 45.78 % shorter. Valve index of lymphatic vessels is less (4.44) in comparison with those in animals from Group II. In the cardiac part of the stomach in piglets from Group III width of lymphangeons is maximal ($p < 0.001$) among all one-day old animals researched and this results in their greater volume (by 25.00 %).

In one-day old piglets from Group II length of lymphatic vessel lymphangeons in the gastric fundus is 0.42 ± 0.08 mm; their width is 0.11 ± 0.02 mm, and their volume is 0.003 ± 0.0005 mm^3, with valve index equal to 4.76. In one-day old piglets from Group I lymphangeons are 26.19 % shorter but 18.18 % and their volume is 33.33 %, greater in comparison with animals from Group II. At the same time shorter lymphangeons result in a grater valve index (6.45) In the fundus of one-day old piglets from Group III lymphatic vessel lymphangeons are shorter (by 42.85 %) as well as narrower (by 36.36 %) with a larger valve index (8.33).

In the pyloric part of the stomach lymphatic vessel lymphangeons in piglets from Group II have a length of 0.45 ± 0.02 mm ($p < 0.001$), width of 0.05 ± 0.005 mm, volume of 0.0011 ± 0.0005 mm^3 and valve index equal to 4.44.

Table 3.11 – Dynamics of parameters of lymphatic vessel lymphangeons and valve index in the subserosal plexus of various parts of the stomach in piglets

Indexes / Age (days), group		Cardiac part				Fundus				Pyloric part			
		Length, mm	Width, mm	Volume, mm^3	VI	Length, mm	Width, mm	Volume, mm^3	VI	Length, mm	Width, mm	Volume, mm^3	VI
1	I	0.83 ± 0.004	0.13 ± 0.0003	0.007 ± 0.0007	2.40	0.31 ± 0.05	0.13 ± 0.08	0.004 ± 0.0004	6.45	0.63 ± 0.002	0.06 ± 0.0001	0.0012 ± 0.0003	3.17
	II	0.35 ± 0.005***	0.12 ± 0.0003***	0.002 ± 0.0005**	5.71	0.42 ± 0.08	0.11 ± 0.02	0.003 ± 0.0005	4.76	0.45 ± 0.02***	0.05 ± 0.005	0.0011 ± 0.0005	4.44
	III	0.45 ± 0.008***	0.24 ± 0.0007***	0.012 ± 0.0004***	4.44	0.24 ± 0.09	0.15 ± 0.03	0.003 ± 0.0007	8.33	0.29 ± 0.003***	0.05 ± 0.002	0.0007 ± 0.0006	6.89
5		0.57 ± 0.001***	0.23 ± 0.00025***	0.015 ± 0.0034	3.50	0.87 ± 0.05**	0.11 ± 0.01	0.005 ± 0.0007	2.29	0.59 ± 0.0025***	0.09 ± 0.0003***	0.0024 ± 0.0006	3.38
10		0.77 ± 0.010***	0.28 ± 0.0019***	0.030 ± 0.0018*	2.59	0.63 ± 0.05*	0.38 ± 0.05**	0.04 ± 0.01*	3.17	0.71 ± 0.006***	0.07 ± 0.0008***	0.0017 ± 0.0042	2.81
20		0.91 ± 0.002***	0.31 ± 0.00025***	0.087 ± 0.002***	2.19	0.90 ± 0.11	0.24 ± 0.02	0.02 ± 0.004	2.22	0.89 ± 0.005***	0.165 ± 0.00075***	0.012 ± 0.0058	2.24

Note: * — $p < 0.05$; ** — $p < 0.01$; *** — $p < 0.001$

In one-day old piglets from Group I lymphangeons are 40.00 % longer and 20.00 % wider in comparison with those in piglets from Group II. At the same time due to greater length of lymphangeons the valve index has a smaller value (3.17).

In the pyloric part of the organ in one-day old piglets from Group III lymphangeons are 55.17 % shorter ($p < 0.001$) with an almost equal width. At the same time the volume of lymphangeons is 36.36 % smaller and the valve index is greater (6.89).

So, morphological characteristics of lymphangeons in the stomach of one-day old piglets depend only on the part of the organ but also on the body weight. Morphometric indexes of intra-organ lymphatic vessels are dominant in the cardiac part and in the fundus.

In 5-day old piglets in the cardiac part of the stomach length and width of lymphangeons are significantly increased (by 62.85 % and 91.66 % respectively; $p < 0.001$) in comparison with one-day old animals whose body weight corresponds to the breed standard. These changes result in significant increase of lymphangion volume (by 650.00 %) and decrease of the valve index (3.50). In the cardiac part of the stomach in 10-day old piglets length of lymphangeons is increased by 35.08 % ($p < 0.001$) and their width is increased by 21.73 % ($p < 0.001$) in comparison with 5-day old piglets. At the same time volume of lymphangeons is increased by 100 % ($p<0.05$). And elongation of structure-functional units of lymphatic vessels leads to decrease of the valve index down to 2.59. Elongation (by 18.18 %; $p < 0.001$) and widening (by 10.71 %; $p < 0.001$) of valve segments are also taking place in lymphatic vessels of the cardiac part of the stomach of 20-day old piglets and this fact in its turn leads to significant increase of lymphangeon volume (by 190 %; $p < 0.001$) and to a certain decrease of the valve index (2.19).

In the gastric fundus of 5-day old piglets lymphangeons are elongated by 107.14 % ($p < 0.01$), and their width remains on the same level in comparison with one-day old piglets from Group II. And

their volume appears to be significantly greater (by 66.66 %), and the valve index is smaller (2.29) than in one-day old piglets with body weight corresponding to the breed standard. At the same time in the fundus of 10-day old piglets lymphangeons become shorter (by 27.58 %; $p < 0.05$), and their valve index is increased (3.17) in comparison with 5-day old piglets. And the width of lymphangeons is sharply increased and this fact has an influence on their volume. In the fundus of 20-day old piglets alongside with elongation of lymphangeons (by 42.85 %) their width is decreased (by 36.84 %) and this fact results in a significant decrease of their volume (by 50 %) and their valve index (2.22) in comparison with 10-day old piglets.

In the pyloric part of the stomach of 5-day old piglets structural changes of lymphatic vessels are analogous to those in the fundus. So, length of lymphangions is increased by 31.11 %, their width is increased by 80.00 % and their volume is increased by 118.18 %, with a decrease of the valve index (down to 3.38) in comparison with one-day old piglets whose body weight corresponds to the breed standard. In the pyloric part of the stomach of 10-day old piglets lymphangeons are 20.33 % longer ($p < 0.001$) than in -day old animals but 22.22 % narrower ($p < 0.001$) against the background of volume decrease (by 29.16 %) and a smaller valve index (2.81). In the pyloric part of the stomach of 20-day old piglets volume of lymphangeons is sharply increased due to a significant increase of all their linear parameters. So, length of lymphangions is increased by 25.35 %, their width is increased by 128.57 % and their volume is increased by 605.88 %, with an insignificant decrease of the valve index (down to 2.24).

During 20 days of life a significant increase of lymphangion parameters in all parts of the stomach is taking place (alongside with decrease of the valve index). The most significant widening of lymphangeons is taking place in the cardiac part and especially in the pyloric part; and the most intensive their elongation is taking place in the fundus.

So, components of the intra-organ lymphatic system in the stomach of piglets include: lymphatic capillaries, post-capillaries and vessels. Differences between the groups of newborn piglets are related with increase of morphometric indexes of lymphatic vessels and size of loops in the lymphatic network of the stomach alongside with increase of their body weight. Local peculiarities of the intra-organ lymphatic flow depend on the structure of tissue components in various parts of the stomach. In the process of morphogenesis of intra-organ lymphatic vessels in the stomach an intensive growth of lymphangeons is taking place which is possibly due to increase of their depositing ability. Structural peculiarities of intra-organ lymphatic vessels of the stomach consist in volume of lymphangeons and the valve index which is determined by the intensity of nutrient absorption in various parts of the stomach in piglets.

3.5.3 Lymph nodes

Intra-organ lymphatic vessels alongside with regional lymph nodes perform not only the drainage function but also perform immunological surveillance of the flow of substances entering the lymph.

Lymphatic vessels of the stomach walls enter predominantly gastric lymph nodes (95.00 %) and only partially splenic lymph nodes (2.00 %) pancreaticoduodenal lymph nodes (3.00 %). The group of lymph nodes (1–6 units) of the lesser curvature of the stomach is located along the left gastric artery. This variant of gastric lymph node syntopy is typical in 95.00 % of cases and in 5.00 % of cases their topography is insignificantly changed due to availability of additional lymph nodes located between the diverticulum and the esophagus or in side walls of the organ (fig. 3.61). Pancreaticoduodenal lymph nodes are oval shaped and are localized not far from the pylorus along the course of the pyloric artery. Splenic lymph nodes are located in the area of splenic hilum (hilus lienis) accompanying the splenic artery. Their number varies from 1 to 3.

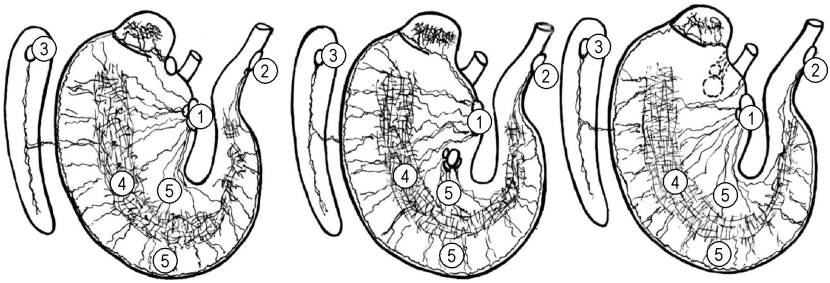


Fig. 3.61 Variants of location of gastric lymph nodes and lymphatic vessels (scheme): 1 — lymph nodes of the lesser curvature of the stomach; 2 — pancreaticoduodenal lymph nodes; 3 — splenic lymph nodes; 4 — network of lymphatic capillaries; 5 — lymphatic vessels

Lymph nodes consist of stroma (represented as a capsule with collar thickening and trabecules) and parenchyma (consisting of a cortex and medulla and paracortex located between them). Relative area of structural components of gastric lymph nodes in piglets is variable and depends on the body weight and age of animals. In group II of one-day old piglets relative area of the connective-tissue stroma of lymphatic vessels is 11.56 ± 0.92 % while in the lymphoid tissue it is 85.87 ± 0.86 % (fig. 3.62).

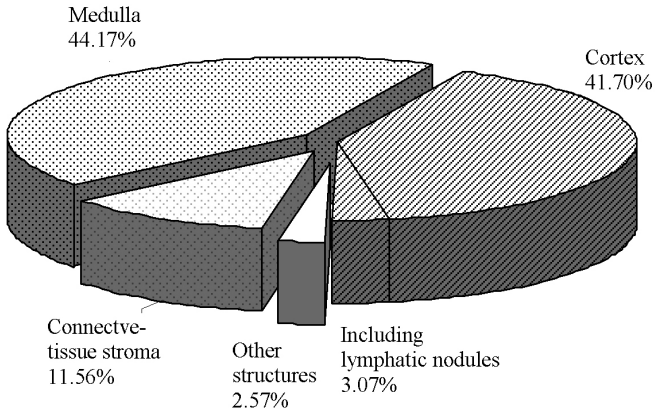


Fig. 3.62 Diagram of relative area of tissue components in gastric lymph nodes of piglets (one-day old, Group II)

Capsular trabecules are thin and long, they penetrate deep into the lymph node while hilar trabecules are thick, short and wavy (fig. 3.63). In the gastric lymph nodes relative area of the cortex takes 41.39 ± 4.56 %, and the medulla takes 44.17 ± 4.82 %. Round lymphatic nodules are determined in the cortex; their peripheral limbus is expressed weakly. In piglets from Group II their relative area reaches 3.07 ± 0.69 %, and relative area of those with germinal centers is 1.23 ± 0.08 %.

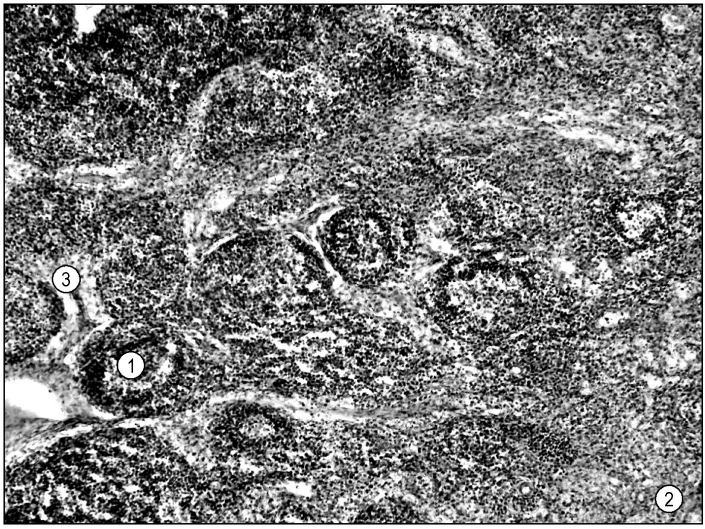


Fig. 3.63 Histological specimen of a piglet's gastric lymph node (one day old, Group II). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — lymphatic nodules with germinal center; 2 — medulla; 3 — trabecule

Architectonics of the reticular stroma depends on peculiarities of structure-functional area of gastric lymph nodes. In the cortex of a lymph node argentophilic fibers form networks of round-shaped loops (fig. 3.64). Reticular stroma of lymph cords is presented as a network of smaller loops. Around lymphatic nodules reticular fibers are compacted and form rings with large loops directly inside these rings; these loops have rarefactions in the center which is typical

for lymphatic nodules with germinal centers. Lymphatic nodules without germinal centers have a uniform fine-meshed network of argentophilic fibers.

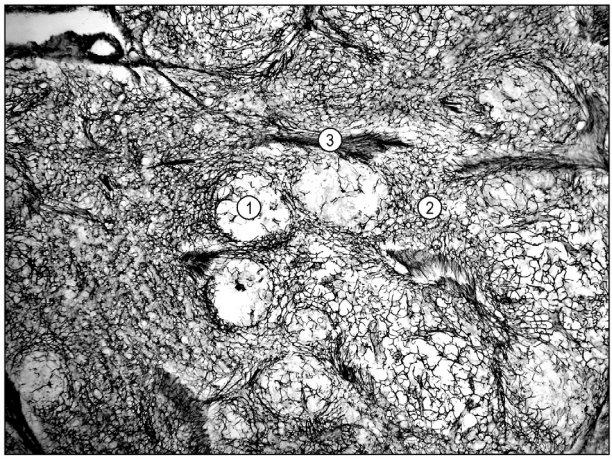


Fig. 3.64 Histological specimen of a piglet's gastric lymph node (one day old, Group II). Caustic silver impregnation according to Foot's method, Olympus CX 21, ×100: 1 — reticular stroma of lymphatic nodules with germinal center; 2 — reticular stroma of the diffuse lymphoid tissue in the cortex zone; 3 — trabecule

In one-day old piglets from Group I relative area of the connective-tissue stroma in a gastric lymph node is 1.58 % smaller (Cv = 9.83 %) in comparison with animals from Group II (fig. 3.65). The capsule is quite well-developed. Each lymph node has well-presented hilar trabecules as well as capsular trabecules. Capsular trabecules are not numerous, they are thin, unbranched, when they penetrate deep into parenchyma they do not reach hilar ones (fig. 3.66).

Diffuse lymphoid tissue in combination with lymphatic nodules located in the center of the organ form its cortex zone concentrated predominantly not far from hilar trabecules. Lymphatic nodules have an oval or (more rarely) round shape; some of them have an expressed peripheral limbus. 1.43 ± 0.03 % of them are nodules with germinal centers. Lymphoid tissue of gastric lymph

nodes in Group I is the most developed (87.65 ± 0.79 %) in comparison with other groups of one-day old piglets, and so is the cortex zone (45.10 ± 6.93 %). At the same time in gastric lymph nodes of one-day old piglets with body weight exceeding the breed standard the medulla takes 42.55 ± 7.12 % it is located on the periphery of lymph nodes and in some places it goes into cortex.

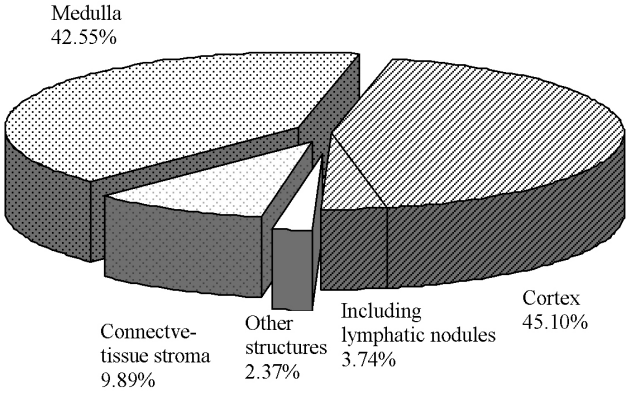


Fig. 3.65 Diagram of relative area of tissue components in gastric lymph nodes of piglets (one-day old, Group I)

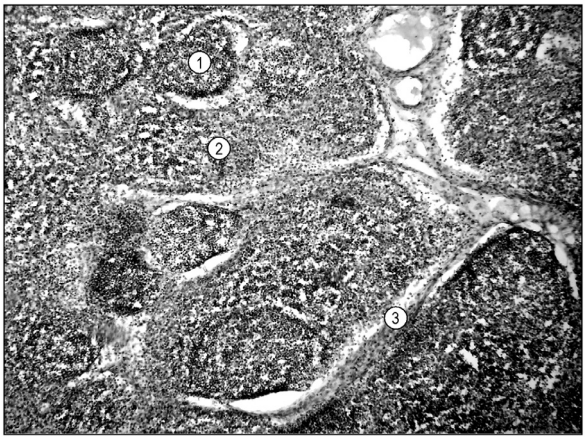


Fig.3.66 Histological specimen of a piglet's gastric lymph node (one day old, Group I). Hematoxylin and eosin, Olympus CX 21, ×100: 1 — lymphatic nodules; 2 — diffuse lymphoid tissue of the cortex; 3 — trabecule

Structure of reticular fibers of gastric lymphatic nodes in piglets from Group I corresponds to that in animals from Group II (fig. 3.67).

Relative area of the dense fibrous connective tissue (which forms the connective-tissue stroma of gastric lymphatic nodes) is 5.02 % greater in one-day old piglets from Group III (fig. 3.68); relative area of their cortex is smaller (4.48 %), and their medulla is 3.82 % greater (Cv = 5.92 %) in comparison with animals from Group II.

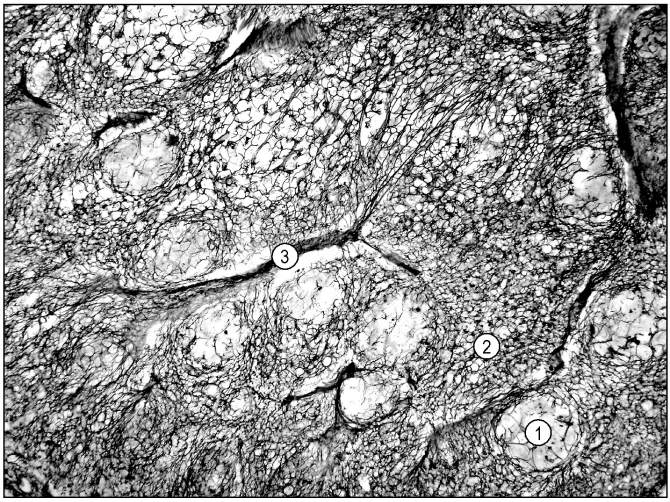


Fig. 3.67 Histological specimen of a gastric lymph node (one day old, Group I). Caustic silver impregnation according to Foot's method, Olympus CX 21, × 100: 1 — reticular framework of lymphatic nodules with germinal center; 2 — reticular framework of the diffuse lymphoid tissue in the cortex; 3 — trabecule

Relative area of tissue components is also accompanied by decreasing of lymphatic nodules and flatness of their peripheral limbus; but their form does not change significantly (fig. 3.69; 3.70). The total number of lymphatic nodules is smaller (by 0.55 %) and so is the total number of lymphatic nodules with germinal centers (by 0.31 %).

So, in one-day old piglets with a small amount of stromal structures in gastric lymph nodes parenchymatous components are prevailing.

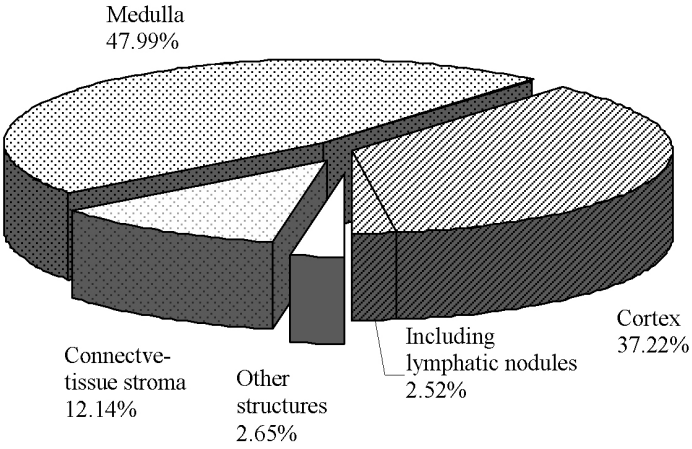


Fig. 3.68 Diagram of relative area of tissue components in gastric lymph nodes of piglets (one-day old, Group III)

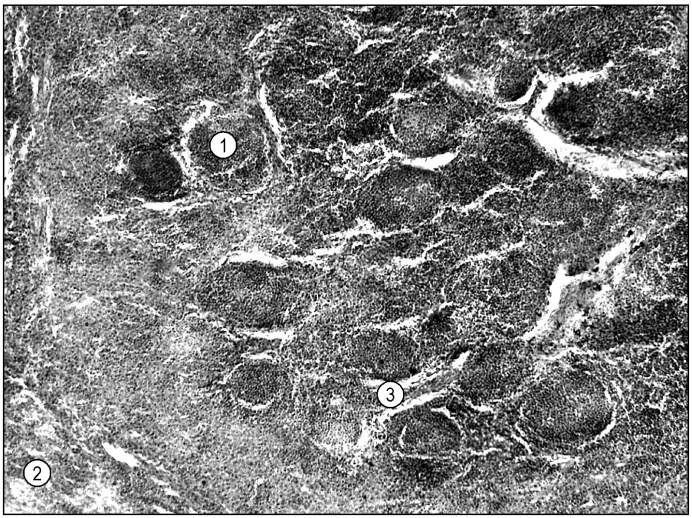


Fig. 3.69 Histological specimen of a piglet's gastric lymph node (one day old, Group III). Hematoxylin and eosin, Olympus CX 21, ×100: 1 — lymphatic nodule; 2 — medulla; 3 — trabecule

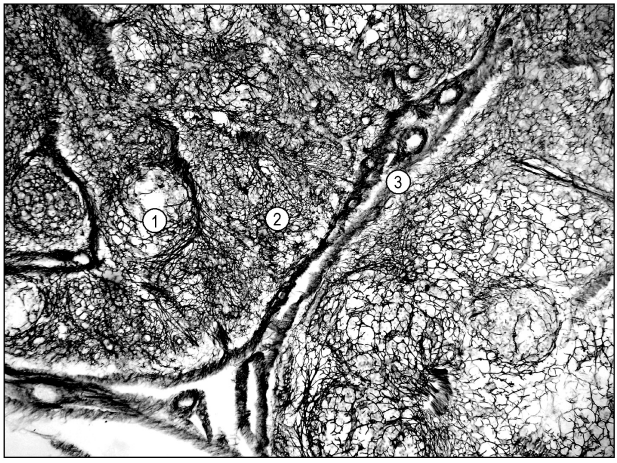


Fig. 3.70 Histological specimen of a gastric lymph node (one day old, Group III). Caustic silver impregnation according to Foot's method, Olympus CX 21, × 100: 1 — reticular framework of a lymphatic nodule with germinal center; 2 — reticular framework of the diffuse lymphoid tissue in the cortex; 3 — trabecule

With aging increase of the lymph node cortex is taking place against the background of reduction of the medullary and connective-tissue stroma of the organ. In newborn piglets (unlike one-day old piglets) relative area of the lymphoid tissue is increased alongside with decrease of the connective-tissue stroma. Relative area of the lymphatic vessel stroma in 5-day old piglets is decreased by 3.11 % with increasing coefficient of variability (Cv = 28.28 %) in comparison with one-day old piglets whose body weight corresponds to the breed standard (fig. 3.71). Hilar trabecules (which are usually much more massive than capsular ones) penetrate the parenchyma of the lymph node (fig. 3.72). They rarely border with capsular ones and have a branched structure resembling the shape of deer horns. Relative area of the lymphoid tissue is, on the contrary, increased (by 3.38 %) due to increase of the cortex of gastric lymph nodes (by 19.82 %; $p < 0.05$). Alongside with this relative area of lymphatic nodules is increased

(by 3.76 %), 4.36 ± 0.13 % of them ($p < 0.001$) are lymphatic nodules with germinal centers. And the medulla of the gastric lymph nodes in 5-day old piglets is decreased by 16.13 % ($p < 0.05$) in comparison with one-day old piglets from Group II. Coefficient of variability for all parameters of lymph node tissue components in piglets of this age group is high enough (Cv = 5.71–28.28 %).

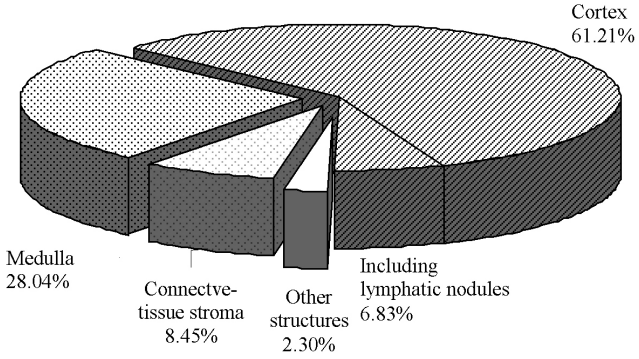


Fig. 3.71 Diagram of relative area of tissue components in gastric lymph nodes of piglets (5-day old)

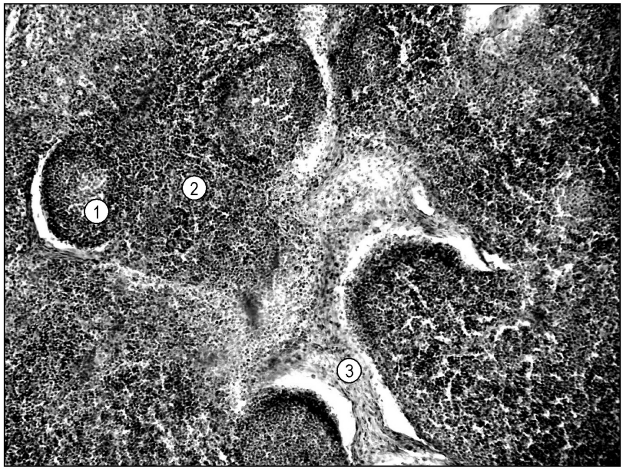


Fig. 3.72 Histological specimen of a piglet's gastric lymph node (5-day old). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — lymphatic nodules with germinal centers; 2 — diffuse lymphoid tissue of cortex; 3 — trabecule

In the cortex of a lymph node argentophilic fibers form networks with larger loops in comparison with one-day old animals (fig. 3.73). Loops of various sizes are also presented in baskets of lymphatic nodules: around the periphery they are covered with several layers of reticular fibers, and in germinal centers they are thinned and fragmented.

Fig. 3.73 Histotopogram of a gastric lymph node (5-day old). Caustic silver impregnation according to Foot's method, Olympus CX 21, × 100: 1 — reticular framework of a lymphatic nodule with germinal center; 2 — reticular framework of the diffuse lymphoid tissue in the cortex; 3 — trabecule

Alongside with such lymphatic nodules histotopograms show also lymphatic nodules being formed which are characterized by a dense network of reticular fibers.

In 10-day old animals stroma of gastric lymph nodes is decreased (by 1.03 %) in comparison with 5-day old piglets (fig. 3.74). Capsular trabecules are not numerous, they penetrate deep into lymph nodes and are not branched. Chilar trabecule are very strong and slightly branched. Greater part of the lymphoid parenchyma is localized in the cortex which is increased by 14.40 % in comparison with 5-day old piglets; at the same time relative area of the gastric lymph node

medulla is sharply decreased (by 12.55 %; Cv = 15.73 %). Lymphatic nodules are large, round-shaped or oval-shaped; they have a well expressed peripheral limbus (fig. 3.75). Relative area of lymphatic nodules with germinal centers is increased by 1.98 % ($p < 0.001$) and relative area of those without germinal centers is slightly decreased (by 0.26 %) in comparison with 5-day old animals.

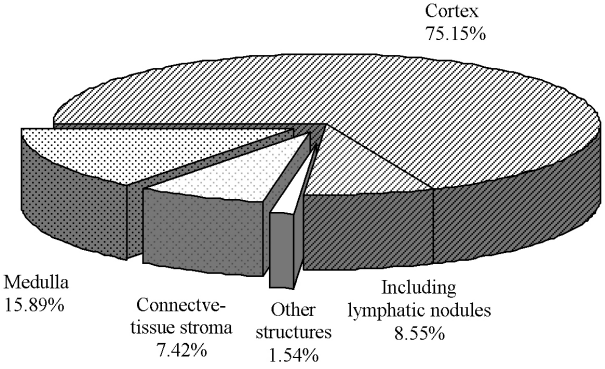


Fig. 3.74 Diagram of relative area of tissue components in gastric lymph nodes of piglets (10-day old)

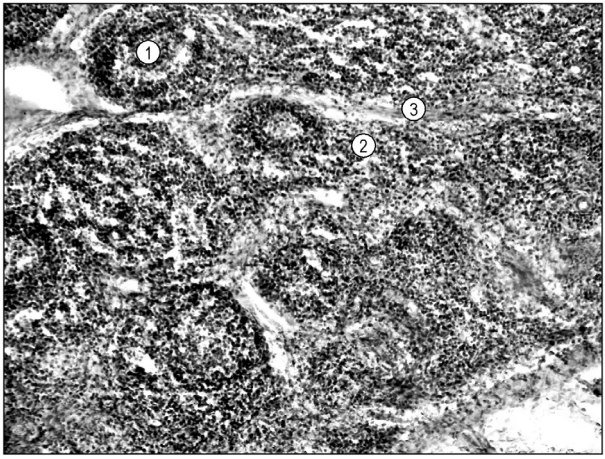


Fig. 3.75 Histological specimen of a piglet's gastric lymph node (10-day old). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — lymphatic nodule with a germinal center; 2 — diffuse lymphoid tissue of the cortex; 3 — trabecule

Similar structure of lymphatic fibers in gastric lymph nodes is also typical for older piglets. Stroma of the diffuse lymphoid tissue in the cortex is formed of a uniform fine-meshed network which becomes denser as it approaches to the medulla (fig. 3.76). In primary lymphatic nodules argentophilic fibers form a middle-meshed network without compaction or rarefaction; and in secondary lymphatic nodules amount of fibers is decreased towards the center where they are noticeably thinned and fragmented.

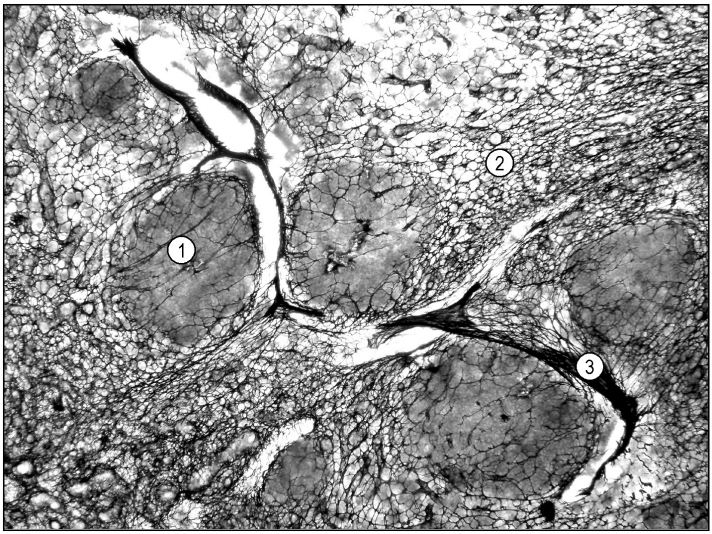


Fig. 3.76 Histological specimen of a piglet's gastric lymph node (10-day old). Silver impregnation, Olympus CX 21, ×100: 1 — reticular framework of a lymphatic nodule with germinal center; 2 — reticular framework of the diffuse lymphoid tissue in the cortex; 3 — trabecule

An analogous trend is typical for 20-day old piglets. So, relative area of the connective-tissue stroma as well as relative area of the gastric lymph node medulla are decreased by 1.65 and 2.61 % respectively (with Cv decreased by 17.34 % and 2.40 %) and reach minimal values among all researched age groups of animals (fig. 3.77). At the same time relative area of the lymphoid tissue is slightly

increased (by 0.48 %) in comparison with 10-day old piglets and this promotes increase of the cortex (by 2.63 %).

In 20-day old piglets relative area of lymphatic nodules in the cortex is increased by 0.52 %; 7.28 ± 0.22 % of them are secondary lymphatic nodules.

Parameters of lymphatic nodules are increased but at the same time the germinal center and the peripheral limbus become more distinct (fig. 3.78).

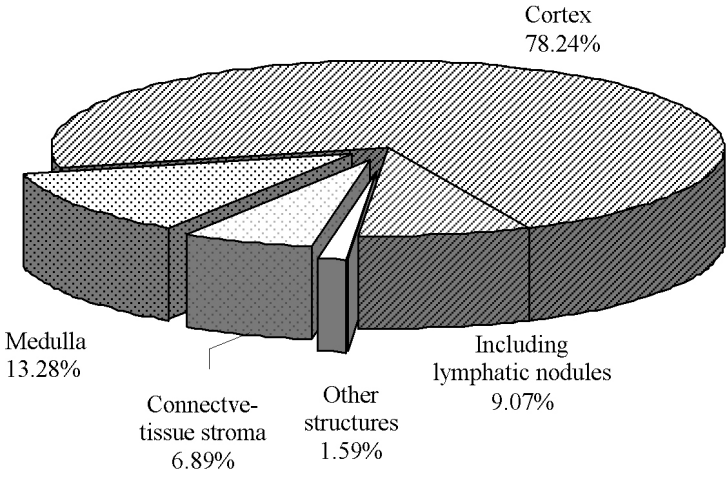


Fig. 3.77 Diagram of relative area of tissue components in gastric lymph nodes of piglets (20-day old)

Architectonics of the reticular stroma of gastric lymph nodes in piglets of this age group has similar peculiarities; but the reticular fibers are thicker and networks formed by these fibers are increased (fig. 3.79).

During 20 days of piglet's life relative area of the connective-tissue stroma is decreased (by 40.39 %). The cortex of a lymph node dominate over its medulla and it is increasing very intensively (by 89.03 %), especially due to lymphatic nodules.

Various areas of piglet's gastric lymph nodes are characterized by unequal development of the reticular stroma and this

process determines their morphofunctional characteristics. Formation of reticular baskets of lymphatic nodules is taking place variously and does not have a clearly determined age-related dynamics as far as neonatal piglets of all researched age groups have also lymphatic nodules with germinal centers (alongside with immature lymphatic nodules). With aging number and parameters of such lymphatic nodules are increased. In lymphatic nodules with germinal centers reticular fibers in the center are rarefied. In gastric lymph nodes of piglets step-by-step formation of lymphatic nodulereticular stroma is taking place. First in lymphatic nodules being formed density of reticular fiber networks is increased; in the process of differentiation these fibers are evenly rarefied up to fragmentation and thinning of fibers in the center of lymphatic nodules.

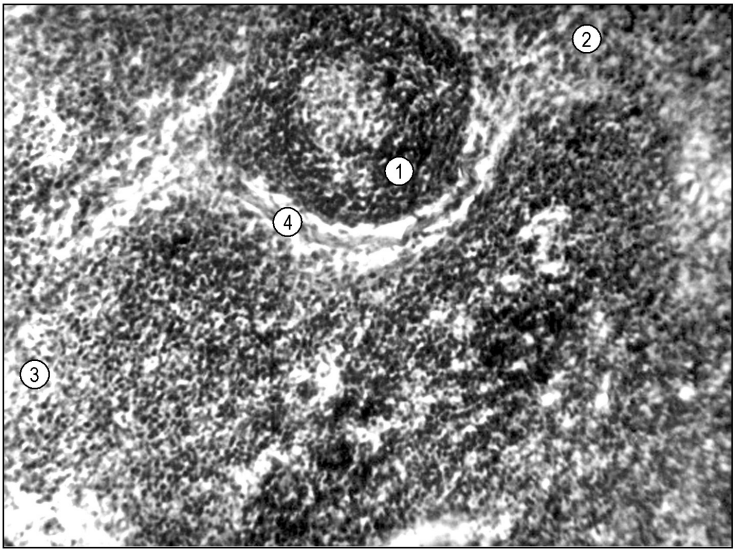


Fig. 3.78 Histological specimen of a piglet's gastric lymph node (20-day old). Hematoxylin and eosin, Olympus CX 21, × 100: 1 — lymphatic nodule with a germinal center; 2 — diffuse lymphoid tissue of the cortex; 3 — medulla; 4 — trabecule

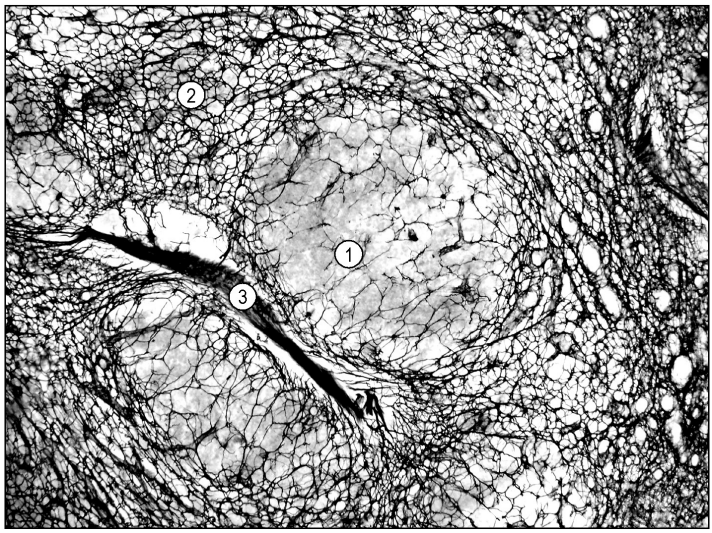


Fig. 3.79 Histotopogram of a piglet's gastric lymph node (20-day old). Caustic silver impregnation according to Foot's method, Olympus CX 21, × 100: 1 — reticular framework of a lymphatic nodule with germinal center; 2 — reticular framework of the diffuse lymphoid tissue in the cortex; 3 — reticular framework of the medulla; 4 — trabecule

Section 4. Generalisation and analysis of the research results

The performed complex researches of morphogenesis of stomach wall tissue components in conjunction with defining peculiarities of immune formations in neonatal piglets give evidence of a general biological pattern of adaptive changes manifested on various levels of structural organization and taking place with unequal intensity.

Our researches show that intensive adaptive changes in the stomach of piglets are taking place on the tissue level as well as on the organ level. So, in case with one-day old piglets with various body weight stomach parameters have insignificant differences, and by the 20th day of life these differences are increased in 1.36–1.68 times, and this bears evidence of the necessity to increase the incoming energy and first of all for destruction of uterine structures and formation of new ones.

Stomach of one-day old animals is characterized by a more expressed roundness, smoothness of transition places between its parts, a much lesser thickness than in older animals. The same regularity was proved by A. Andronesku [23] and Y. M. Margorin [150] who carried out researches of the human stomach.

Permanent structure is typical for folds forming the relief of the gastric mucosa, this structure is almost analogous for all piglets of the neonatal period. In one-day old piglets with body weight corresponding to the breed standard relief of the mucosa in the cardiac part of the stomach is presented as singular slightly tortuous low folds with wide spaces between them; and in the fundus up to 6–8 high longitudinal folds are presented (they are located along the greater

curvature); in the pyloric part the folds are very tortuous and more frequent. Scientific literature sources do not include any information about relief peculiarities of gastric mucosa in neonatal piglets while in case with other mammals this information is quite singular and poor. So, Y. M. Margorin [150] pointed out that in new-born children gastric mucosa is presented as folds, shape and location of these folds is similar to those in adults. At the same time the author pointed out presence of folds only in the cardiac part and the pyloric part which does not correspond to results of our researches. S. D. Samozhapova [104] determined in abomasum of a new-born yak 15–17 longitudinal folds up to 12 mm high; and 20 cross folds up to 1–2 mm high were determined by the author in the pyloric part. In one-day old piglets with body weight corresponding to the breed standard (Group II) in the pyloric part of the stomach thickness of gastric mucosa is maximal with insignificant coefficient of variability; and this fact corresponds to data presented by T. A. Bekov and I. K. Kosim-Khodzhayev [40]. Permanence is also typical for stomach topography in piglets irrespectively of their body weight and age; this fact was pointed out by Bambuliak in his works [283].

Stomach performs a number of functions: secretory function, motoric function, absorption function, excretory function, endocrine function, protective function and this organ also takes part in the synthesis of antianemic factor. All these functions are necessary for supporting homeostasis of the organism [66].

Stomach wall in new-born piglets (as well as in adult animals) consists of four coats; development of each of these coats is characterized by significant variations of morphometric parameters of tissue structures depending on the level of their prenatal growth and development. Despite the fact that up to date there are many works devoted to researching structure and function of the stomach in humans, wild and laboratory animals and birds [102, 87, 132, 284, 117, 286] developmental peculiarities of

stomach wall tissue components in neonatal piglets are still practically undetermined.

When analyzing structure of surface epithelium and pit epithelium of the gastric mucosa in one-day old piglets it has been determined that this epithelium is a single-layer cylindrical (columnar) glandular epithelium and this agrees with the data presented by a number of authors [122, 134, 286, 119, 121]. And according to Y. M. Margorin [150] epithelial lining of the stomach of new-born children is formed by plural-row epithelial cells.

But height of the surface epithelium and height of pit epithelium depend on the part of the stomach, body weight and age of animals. T. A. Bekov and Zh. Zh. Zheyenbayev [38] pointed out that height of mucosa epithelium in the cardiac part of the stomach in new-born children reaches its maximal value by the end of the first year of life. According to the authors it is subjected to the most intensive increase in all parts of the stomach of children during their infancy. According to data presented by T. A. Bekov and I. K. Kosim-Khodzhayev [40] in new-born children the lowest epithelium of the gastric mucosa is determined in the gastric fundus; somewhat higher it is in the cardiac part; and the highest epithelium is typical for the pyloric part of the stomach.

We have determined that in one-day old piglets with body weight corresponding to the breed standard single-layer columnar epithelium appears to be the highest at the border with the glandless part of the lesser curvature as well as in the cardiac part of the stomach. This regularity is confirmed by the fact that epithelium of the gastric mucosa performs the very important protective function — in its apical part mucin (containing neutral glycosaminoglycans) is secreted [124, 287, 288]. In addition to that, L. I. Aruin et al. [139], E. M. Baybekova et al. [123], Ts. G. Masievich [189], Y. N. Uspenskiy [119], Rh. J. Goddard et al. [289], Z. Posalaky et al. [124], M. Pototskiy, Y. Serdiukov [290] consider that the stomach surface

epithelium plays a leading role in the system of stomach protective mucus barrier.

In one-day old piglets the stomach mucosa includes simple tubular glands which open to gastric pits of variable depth in various parts of the organ. According to data presented by L. I. Aruin et al. [139], in the cardiac part of the human stomach the gastric pits are deep and they take almost half of mucosa thickness. Our data show that in one-day old piglets with body weight corresponding to the breed standard the mucosa glandular layer is twofold-threefold larger than the depth of gastric pits. According to a number of authors [87, 139, 146] pits in the fundus of the stomach are deepened to the mucosa to 1/4–1/3 of its thickness while length of glands is several times greater than depth of pits. We have also determined that in one-day old piglets with body weight corresponding to the breed standard depth of gastric pits in the cardiac part of the stomach is almost 1/3 of mucosa thickness, and in the pyloric part this depth is 1/2 of mucosa thickness.

In one-day old piglets with body weight corresponding to the breed standard in the cardiac part of the stomach thickness of all stomach wall coats appears to be dominating. Depth of gastric pits in this part of the stomach is minimal as well as thickness of the mucosa glandular layer. In piglets from Group II number of parietal cells within one cardiac gland is the greatest (in comparison with one-day old piglets from other groups) (15.40 ± 0.40 units) with an insignificant coefficient of variability ($Cv = 5.81\,\%$), and this fact bears evidence of an intensive formation of the gastric mucosa glandular apparatus in piglets yet before birth. There is a significant positive correlational relationship between number of parietal cells and thickness of the mucosa glandular layer ($r = 0.60$).

A. V. Kvasnitskiy [31] pointed out an important peculiarity of the digestive system in piglets — this peculiarity consists in age-related achlorhydria; up to the age of 20–25 days this achlorhydria is

to a significant extent compensated by intestinal digestion. Researchers show that parietal cells of the gastric mucosa are yet unable to provide acid reaction of gastric juice. Works by I.A. Morozov [136] prove that topographic peculiarities of parietal cells depend on the level of their maturity. According to the author the least differentiated ("young") cells are located in the isthmus of glands, while cells with the highest functional activity are located in the body and in the fundus (already with signs of degradation). According to Ts. G. Masevich [189] parietal cells are located singly, but their greater number is presented in the neck and in the fundus they are less numerous. We have determined that topography of parietal cells in gastric mucosa glands of one-day old piglets depends on their prenatal development. In animals from Group II parietal cells are evenly distributed throughout the gland. The maximal number of parietal cells within one fundic gland is also observed in piglets with body weight corresponding to the breed standard (22.40 ± 0.24 units).

Mucosa of the pyloric part of the stomach is the most functionally unfinished [24]. Gastric pits here are deeper and glands are shorter in comparison with other parts of the organ. Composition of pyloric glands includes a narrow well expressed unbranched neck. A greater number of cells in pyloric glands perform mucoid secretion [116, 146]. Y.M. Margorin [150] pointed out that thickness of the gastric mucosa in newborn children is increased from the fundus to the pyloric part where it reaches its maximum. Our researches have shown that in piglets with body weight corresponding to the breed standard gastric pits are the shallowest (providing the greatest thickness of the mucosa glandular layer and other coats of the stomach wall).

In piglets from Group II mucosa pits at the border with the glandless part of the lesser curvature of the stomach are somewhat shallower in comparison with Group I, and the glandular layer is

thicker. Diameter of glands is smaller and number of parietal cells within one gland is the greatest (3.16 ± 0.31 units).

In one-day old piglets with body weight higher than the breed standard the mucosal relief is analogous to that in piglets whose body weight corresponds to the breed standard. But size and tortuosity of mucosa folds are greater and distance between them is shorter and this may be considered to be a criterion of morphofunctional assessment of tissue components in coats of the stomach. According to N. P. Piatnitskiy and N. S. Melanyina [34] the most significant functional insufficiency of the stomach (caused by delayed differentiation of its glandular apparatus structures) is observed in newborns with prenatal underdevelopment contributing to persistent suppression of enzymatic secretion and delayed evacuation of contents. It should be noted that one-day old piglets with body weight lower than the breed standard have the smallest number of folds in their mucosa and in addition tho this height of these folds and their tortuosity is also smaller. It is probable that insufficient development of mucosa folds in piglets with body weight lower than the breed standard gives evidence of a deminished function of the gastric mucosa, and this in its turn results n negative influence on formation of gastric immune structures. This regularity has been confirmed by researches of L. G. Disenbayeva, G. V. Khorunzhyi [33], D. A. Dorofeyev, V. M. Uspenskiy [141], N. P. Piatnitskiy, N. S. Malanyina [34]. The mentioned researches give evidence of a diminished motor function of the stomach in children with low morphofunctional status of the organism.

Surface epithelium and pit epithelium in one-day old piglets from Group I are a bit higher than those in animals from Group II (except for the pyloric part where they are insignificantly lower). We have determined that the highest epithelium in one-day old piglets is presented in the cardiac part and fundus of the stomach in piglets whose body weight is higher than the breed standard. From

our point of view this specularity indicates a high protective function of epithelium. In ne-day old piglets from Group III height of surface epithelium as well as height of pit epithelium are minimal in all parts of the stomach.

In piglets with body weight lower than the breed standard pits in the cardiac part of the stomach are deep peaching 1/2 of the mucosa thickness which agres with the data presented by L. I. Aruin et al. [139] who carried out researches of the human stomach. Pits in the gastric fundus are much shallower (unlike their developed agemates); and in piglets with body weight higher than the breed standard depth of pits in this part of the organ is almost 1/3 of the mucosa thickness.

In prenatally underdeveloped newborn animals organs are characterized by significant immaturity of their tissue components. And due to this fact structure of the gastric mucosa in these piglets (Group III) is almost the same as that in fetuses of the later stage of prenatal development [291]. It is possible that insufficient differentiation and insufficient maturity of the gastric mucosa predetermine decreased activity of enzymes and cause violated processes of nutrient splitting and absorption which in its turn causes reduced viability of animals. An analogous conclusion was made by authors who studied other organs and systems. So, in bone organs of piglets with a low morphofunctional status of their organism greater amount of cartilaginous tissue and osteoblastic bone marrow against the background of decreased red bone marrow and this fact promotes occurrence of immunodeficiencies and anemia [15, 261].

In one-day old piglets from Group I pits of the gastric mucosa in the cardiac part of the stomach are somewhat deeper and the glandular layer is thiner than in Group II. The deepest pits in this part of the gastric mucosa are typical for one-day old piglets whose body weight is lower than the breed standard. These pits are 143.21 % deeper than those in piglets from Group II; and the submucosa,

the muscular coat and the serosa are, on the contrary, thiner; and the surface epithelium is lower. Number of epithelial cells within one cardiac gland is also significantly smaller (by 49.15 %), and these cells are localized predominantly in the isthmus of glands. It is characteristic that correlational relationships between their number and thickness of the mucosa glandular layer appear to be a significant inverse relationship. We have determined that in animals from Group I parietal cells are distributed more evenly throughout the gland and that there is a close positive correlational relationship between number of parietal cells and thickness of the mucosa glandular layer ($r = 0.89$).

In piglets from Group III glands are located at a greater distance from each other. Epithelium is similar to the cuboidal epithelium. Apparently, the barrier function of the stomach in such animals is lower than in their prenatally well-developed agemates; and this insufficiency of the barrier function predetermines not only insufficient secretion of hydrochloric acid by the end of the neonatal period but also a decreased lysozyme formation performed by surface cells of the mucosa. In case with prenatally underdeveloped piglets (Group III) the mucosa glandular layer in the cardiac part of the stomach is the thinest while the subglandular layer is slightly thicker (by 1.42 %; $Cv = 17.54$ %) in comparison with piglets from Group II.

Authors prove that by the moment of birth the process of differentiation of the stomach glandular apparatus which is also typical for the fundus of the organ. In all researched groups of piglets number of parietal cells in the fundus is greater than in other parts of the stomach [71]. On this stage the parietal cells which have already developed are yet unable to provide acid reaction of gastric juice [31]. By the moment of birth and up to the 20th day of piglet's life gastric juice does not include free hydrochloric acid. In the result of that during the neonatal period of life piglets are very

sensitive to technological methods applied and quality of feed; this sensitiveness is predetermined by low gastric acidity in the result of incomplete differentiation of parietal cells [25, 290].

Our researches show that shape of parietal cells in piglets varies from oval to triangular. Spheric nucleus is mainly localized in the center of the cell. The most parietal cells are mononuclear cells but binuclear and even multinuclear samples are not rare. S. D. Samozhapova [104] determined pear-shaped parietal cells lying in croups in abomasum of a yak.

In the gastric fundus mucosa pits are direct and they are the deepest in piglets from Group I (105.64 ± 12.33 microns). Parietal cells are located in separate groups throughout the length of fundic glands. Their number within one fundic gland of the gastric mucosa in one-day old piglets from Group I is 25.84 % smaller than in Group II. Animals from Group III have the smallest number of parietal cells in all parts of the gastric mucosa, which predetermines a longer process of differentiation of heir glandular apparatus.

Pits in the pyloric part of the gastric mucosa in one-day old piglets with body weight exceeding the breed standard are 6.97 % deeper than in animals whose body weight corresponds to the breed standard. The glandular layer of the gastric mucosa is 14.46 % thiner; the subglandular layer is 9.51 % thiner, and the lamina muscularis is 58.01 % thiner. In one-day old piglets with body weight lower than the breed standard depth of gastric pits in the pyloric part of the organ is maximal while the mucosa glandular layer is 0.18 % thiner in comparison with animals whose body weight corresponds to the breed standard. This fact bears evidence of delayed prenatal development of the organ.

Our researches show that there are no parietal cells in composition of pyloric glands. But L. I. Aruin [122] proves that in 20 % of healthy humans these cells are present notonly in the fundus but also in the pyloric part. The author explains this phenomenon by

hereditary factors as far as when researching parietal cells in fetuses it was determined that they appear starting from the 13th week of human prenatal development and are localized in the fundus as well as in the pyloric part; then (by the start of the third trimester) they usually disappear from the pyloric part, but this process does not take place in every fifth fetus. According to our researches in the stomach of one-day old piglets parietal cells are localized only in the cardiac part, fundus and the smaller curvature of the stomach regardless of body weight and age of animals.

In piglets in the area of the lesser curvature of the stomach the glandless part is located. In one-day old piglets it is located from the mucosa fold restricting the diverticulum and up to the pyloric part. With aging the glandless part is increased and it partially takes the area of the diverticulum mucosa. It is characteristic that number of cells in the epithelial stratum (the stratified flat non-squamous epithelium) is increased with aging. A.V. Korobov [292] proves that in piglets bred according to the generally accepted technology at the border with the glandless part of the lesser curvature of the somach ulcers are quite frequent which causes impairment of the digestive function of the organ.

We have determined that the single-layer (simple) columnar epithelium in the lesser curvature of piglet's stomach is localized at the border with the stratified flat non-squamous epithelium. In one-day old piglets from Group I gastric pits at the border with the glandless part of the lesser curvature of the stomach are 29.51 % deeper in comparison with piglets from Group II. Glandular and subglandular layers of the gastric mucosa are thiner. Diameter of glands and number of parietal cells in piglets from Group I are also smaller than in Group II providing a significant coefficient of variability (Cv = 26.57 %).

So, tissue components of gastric coats in one-day old piglets are to a certain extent characterized by incomplete structure which

causes significant transformations during the neonatal period of life. But if environmental factors do not match the required standard this phenomenon appears to be a predetermining factor causing structural and functional impairments of organs.

Morphogenesis of the glandular apparatus in various parts of the stomach is associated with formation of its immune structures including lymphoid formations, lymphatic vessels of stomach walls and regional lymph nodes. Lymphoid formations in stomach walls of piglets are presented as intraepithelial lymphocytes, diffuse lymphoid tissue and lymphatic nodules. Intraepithelial lymphocytes are presented in all parts of the stomach. But their number is prevailing in the fundus mucosa and in the mucosa of the pyloric part which agrees with works by L. I. Aruin and O. L. Shatalova [51]. Diffuse lymphoid tissue in one-day old piglets is mainly presented in the gastric submucosa. Our researches prove that intraepithelial lymphocytes as well as diffuse lymphoid tissue with aging are subjected to lesser variations.

Scientific literature sources provide quite contradictory data concerning availability of lymphoid formations (especially secondarylymphatic nodules) in walls of tubular digestive organs. P. M. Gavrilin, M. O. Leshchova [293] prove that in lymph nodes of jejunum lymphoid formation can be determined already in of 7-month old domestic bull fetuses. But the authors do not provide interpretation of factors determining development of these formations. Other researches [250] prove that lymphoid formation as such are absent in one-day old animals and appear only by the end of the neonatal period of life.

Researches show that a common regularity consists in localization of lymphatic nodules in the gastric submucosa of one-day old piglets. V. M. Koltoniuk and S. I. Boltrukevich [192] prove that the largest lymphatic nodules in the dog's stomach (125.00–525.00 microns) are also presented in the submucosa of the cardiac part

of the organ which is consistent with our data. In their fundus Piglets from Group II have the maximal number of lymphatic nodules with germinal centers (over 5 % of the total number). In the submucosa of the pyloric part of the organ triangular-shaped lymphatic nodules are presented. And according to data presented by N. F. Bambuliak [193] one-day old piglets do not have lymphatic nodules with germinal centers in any part of the stomach.

In the mucosa of the cardiac part of the stomach of one-day old piglets with body weight exceeding the breed standard diffuse lymphoid tissue is prevailing. But there are also some separate pear-shaped lymphatic nodules without germinal centers. In the fundus of piglet's stomach lymphatic nodules are localized in the submucosa and there are some lymphatic nodules with germinal centers among them. Our researches show that in the gastric mucosa of one-day old piglets lymphatic nodules are localized singly or (by way of exception) in groups which is typical for parts of the stomach with well-developed submucosa. Diffuse lymphoid tissue is located not far from lymphatic nodules. It forms the perinodular area.

According to N. F. Bambuliak [193] gastric lymphoid formations in newborn piglets are located in the mucosa and in the submucosa. In the fundus of the stomach the author registered immature lymphatic noduleswhich contradicts results of our researches. M. R. Sapin [54] pointed out that lymphatic nodules with germinal centers appear in the stomach wall of humans yet before birth. The pyloric part of the organ also includes lymphatic nodules which are on the initial stage of their development while diffuse lymphoid tissue appears to be maximally developed. The most lymphatic nodules in the stomach of piglets from Group III are at the initial stage of their development and have the smallest parameters. In our researches we have pointed out availability of lymphatic nodules with germinal centers as well as without germinal centers. But determination of the formation mechanism

of lymphatic nodules with germinal centers in fetuses and one-day old animals requires special researches with application of the respective methods.

Formation of the glandular apparatus of lymphoid formations in gastric coats is related with structural and functional organization of intra-organ lymphatic vessels which is confirmed by our comprehensive researches. Coats of various parts of the stomach of one-day old and newborn piglets include lymphatic capillaries and post-capillaries which merge together and form lymphatic vessels.

In piglet's stomach networks of lymphatic capillaries are localized in all coats of the stomach wall and are closely interrelated y means of multiple anastomoses. Results of our researches are consistent with works by D. A. Zhdanov [211], L. V. Chernshenko and A. A. Sushko [216], M. G. Fedosenko et al. [62]. And according to Y. G. Ostroverkhov [219], the surface layer and the deeper layer of the stomach wall have independent lymph flows.

When researching the gastric mucosa in pigs V. A. Bizhokas [213, 220] determined that capillaries of the largest caliber are located in the cardiac part and in the fundus. According to data presented by this author there are no interglandular sinuses in the stomach wall of fetuses and newborn piglets an this fact is consistent with results of our researches as well as with data provided by other researchers [59]. In addition to that V. N. Balashev [59] pointed out that networks of lymphatic capillaries are absent not only in the gastric mucosa but also in the gastric submucosa of newborn kittens and puppies. D. A. Zhdanov [211] and V. N. Balashev [59] determined that in adult humans more frequent loops of lymphatic capillaries in the mucosa and the submucosa are located on the lesser curvature (in comparison with other parts of the stomach). The authors explain this peculiarity by the fact that the lesser curvature of the human stomach is an area characterized by the most intensive secretion in response to physiological stimuli.

We have determined that the subglandular network of the mucosa lymphatic capillaries anastomoses with the lymphatic flow of the gastric submucosa. The most frequent networks of lymphatic capillaries are located in the cardiac part of the stomach and in the fundus. According to V. N. Balashev [59], wider loops of capillaries in the human gastric submucosa (loops with greater diameter) contain narrower loops (loops with smaller diameter). Lymphatic capillaries of the muscular coat of the stomach are localized in connective-tissue interlayers between bundles of muscle cells. Density of networks is directly related with development of the muscular coat in the respective part of the stomach. V. N. Balashev [59] proves that lymphatic capillaries in the annular muscular layer are located in several planes which lie on top of each other and are connected by anastomoses. In the result of this narrow long loops are formed. The most of these loops are rectangular-shaped.

Our researches prove that capillary loops of the subserosal plexus of piglet's stomach are predominantly oval-shaped. The largest networks of lymphatic capillaries are located in the middle third of stomach walls. Lymphatic vessels formed within the upper third of stomach walls are directed to the lesser curvature and lymphatic vessels formed within the lower third are directed to the greater curvature of the stomach. V. A. Bizhokas and T. B. Bitsiyev [220] made an analogous conclusion. These authors determined the middle third of the anterior and posterior walls of the stomach as the lymph separation area.

Our researches are also consisted with works by V. A. Bizhokas [214], Y. G. Golomako [294], H. Mislin [295] who noted that ranges of length, width and volume of lymphangeons are quite wide (even within the same age-group or the same lymphatic vessel). In one-day old piglets from Group II the longest lymphangeons are presented in the cardiac part of the stomach while in the fundus and in the pyloric part they are shorter. Reduced length of lymphangeons leads to increase of the valve index. The narrowest

lymphangeons are presented in the pyloric part. Lymphangeons of lymphatic vessels in the subserosal plexus of the pyloric part of the stomach usually have cylindrical shaped while in the fundus they are usually oval-shaped. When studying lymphangeons in the intestine of sheep Y. G. Golomako [294], pointed out that in all age groups of animals (irrespectively of the topography of lymphatic vessels) there are ellipsoid, oval and cylindrical lymphangeons.

In the cardiac part of the stomach of piglets from Group III (piglets whose body weight is lower than the breed standard) lymphangeons are the widest. In piglets from Group III lymphangeons are 28.57 % longer in comparison with those in Group II but they are 45.78 % than in Group I. In the fundus and in the pyloric part of the stomach lymphangeons are characterized by decreased length as well as by decreased width. Due to this fact the valve index is increased which may probably indicate their lower depositing ability in prenatally underdeveloped piglets.

So, in newborn piglets with various body weight parameters of the stomach lymphatic system are also unequal. Structural peculiarities of subserosal plexuses of gastric lymphatic vessels are represented in their parameters as well as in shape of their valve segments which may be possibly predetermined by various intensity of nutrient absorption in various parts of the gastric mucosa.

Lymph outflow from stomach walls is performed predominantly to a gastric lymph node and partially to a pancreaticoduodenal lymph node or to a splenic lymph node which is confirmed by the direction of the lymph vessel. Alongside with a significant number of works devoted to structural peculiarities of lymphatic nodules in humans and animals [242, 249, 246, 266] scientific literature sources include only few works determining structure of lymph node tissue components in neonatal piglets [243, 257, 296].

Results of our researches prove that relative area of gastric lymph node structural components is variable depending on

the morphofunctional status of the organism as well as on age of animals. This fact is consistent with data presented by A. V. Oliyar [261], B. V. Kryshtoforova and V. V. Somoliak [297], P. N. Gavrilin [249, 259], L. Y. Koshkunova [212], N. A. Babanin et al. [298], L. P. Vel [299], A. Polikar [300], I. N. Vylkova [301], X. M. Yu, Q. H. Nie [302]. As noted by A. V. Oliyar [261], in newborn prenatally underdeveloped piglets lymph nodes contain lesser amount of diffuse lymphoid tissue as well as smaller number of lymphatic nodules, especially those with germinal centers.

Y. Y. Vyrenkov et al. [203], P. N. Gavrilin et al. [234], Belisle C., G. Sainte-Marie, F. S. Peng [237] define a structure-functional unit in lymph nodes — compartment. According to P. N. Gavrilin et al. [234] functional segments of lymph nodes in mature bearing mammals are organized according to a single principle and are characterized by morphological polarity of lymphoid parenchyma (increase of its volume and differentiation level in the direction towards the orifice of inflow lymphatic vessels) as well as by localization specificity of compartment functional areas (this specificity is predetermined by peculiarities of the intranodular lymphodynamics as well as by the structure of the microcirculatory blood flow in the lymph node).

In one-day old piglets from Group II relative area of lymphoid tissue in a gastric lymph node is maximal and relative area of the connective-tissue stroma is minimal. Our researches have shown that alongside with lymphatic nodules without germinal centers one-day old piglets also have lymphatic nodules with germinal centers which is consistent with data presented by P. M. Gavrilin [259], A. V. Oliyar [261], V. A. Florensov [262]. But some authors [254, 255] hold the opinion that one-day old animals have only lymphatic nodules without germinal centers. T. P. Shubina [303], V. G. Skibitskiy and B. V. Borisevich [256], K. S. Kabak et al. [257] pointed out that there are no well-formed lymphatic

nodules (those with germinal centers as well as those without germinal centers). At the same time works by M. O. Leshchova [260] should be mentioned. The author noted that secondary lymphatic nodules are present already in 7-month old domestic bull fetuses (representatives of mature bearing animals) and this contradicts the well-established opinion telling that lymphatic nodules are formed due to action of the antigen. But Z. S. Khlystova et al. [304, 305] prove that fetuses are developed in sterile conditions but these conditions include antigens and so plasmatic cells in lymphatic nodules appear yet during the prenatal period of ontogenesis. Y. I. Borodin et al. [61] also determined plasmatic cells in lymphatic nodules of human fetuses almost during all observations.

In one-day old piglets from Group I relative area of the connective-tissue stroma in a gastric lymph node is smaller (by 1.59 %) in comparison with piglets from Group II. Capsular trabecules are not numerous, they are thin, unbranched, when they penetrate deep into parenchyma they do not reach hilar ones. And relative area of the cortical substance (45.10 ± 6.93 %) as well as secondary lymphatic nodules (1.43 ± 0.03 %) is larger than n their agemates from other groups.

In one-day old piglets with body weight lower than the breed standard relative area of the lymph node connective-tissue stroma is maximal. At the same time relative area of lymphoid tissue as well as relative area of the cortex are smaller, and relative area of the medulla is larger. Researches performed by a number of authors [259, 261] also indicate decreased relative area of diffuse lymphoid tissue and lymphatic nodulesin piglets whose body weight is lower than the breed standard. L. P. Vel [299] determined that in such animals central and peripheral organs of their immune system are in the state of hypoplasia and aplasia. Dynamics of tissue component relative area is also accompanied by smaller parameters of lymphatic nodules and flatness of their peripheral limbus.

So, in one-day old animals prenatal development of stomach wall tissue components (in various parts and fibers of the stomach) correlate with formation of lymphoid structures, lymphatic vessels and regional lymph nodes. This fact ensures execution of its digestive function as well as protection against penetration of foreign substances. In prenatally underdeveloped animals differentiation of the stomach glandular apparatus as well as differentiation of its immune formations appear to be delayed.

With aging, during the neonatal period of ontogenesis an intensive transformation of prenatal structures of gastric coats takes place. This transformation is accompanied by increase of all parameters as well as by formation of new parameters which ensures viability of the organism in the respective living environment. In case with such bred mature bearing animals as piglets transformation of the mucosa tissue components and immune structures of the stomach appears to be the most intensive. Researches have shown that in 5-day old piglets depth of gastric pits in the mucosa of the cardiac part of the stomach is increased with an insignificant coefficient of variability (in comparison with one-day old piglets from Group II). The cell structure is changed as evidenced by an increased height of surface epithelium and pit epithelium (by 22.46 % and by 18.16 % respectively). Diameter of glands in all parts of the stomach is significantly increased as well as the number of parietal cells (in comparison with the respective values in one-day old piglets from Group II).

Results of our researches showing increase of stomach wall morphometric parameters indicate the beginning of active transformation of uterine structures. When studying gastric mucosa of white rats I. A. Zalizniak [30] noted that parietal cells have the greatest volume on the 5th day of life and so he explained active participation of structures in metabolism of colostrum (milk). But our researches show that in 5-day old piglets depth of pits in the mucosa of gastric fundus is decreased (by 4.20 %) against the background of

the increased glandular layer. Height of the surface epithelium is increased by 20.60 % and height of the pit epithelium is increased by 20.12 %. Thickness of the mucosa glandular layer and thickness of other coats of the pyloric part of the stomach are decreased. Insignificant increase (by 4.90 %) of the mucosa glandular layer occurs at the border with the glandless part of the lesser curvature of the stomach. And the subglandular layer of the gastric mucosa is increased by 35.29 % in comparison with that in one-day old piglets from Group II. Thickness of the submucosa, the muscular coat and the serosa is also increased but not so significantly.

In 5-day old piglets number of intraepithelial lymphocytes is increased. In all parts of the stomach lymphatic nodules with germinal centers can be already determined (over 8 % of the total number). Their parameters are increased and they come into contact with the lamina muscularismucosae. This regularity is especially typical for the cardiac part of the stomach as well as for its fundus. A. A. Moldavskaya [177] pointed out that the decisive criterion of of lymphatic nodule formation in the digestive apparatus consists in changing the nature of feeding for children.

In 5-day old piglets architectonics of lymphatic capillaries, postcapillaries and lymphatic vessels in coats of the stomach wall remains practically unchanged. Density of lymphatic capillary networks and caliber (diameter) of lymphatic vessels are the only parameters subjected to increase in comparison with one-day old animals from Group II. In the cardiac part of the stomach of 5-day old piglets length of lymphangions as well as their width ares somewhat increased which results in a significant increase of their volume. In the fundus length of lymphangeons is increased by 171.87 %, while their width is decreased by 15.38 % in comparison with one-day old piglets whose body weight corresponds to the breed standard. This phenomenon is apparently related with increase of the stomach which in its turn causes increase in lymphization. But the volume

and the valve index are nevertheless much greater than those in one-day old piglets. Analogous structural changes of the lymphatic system take place in the pyloric part of the stomach.

We have pointed out that relative area of lymphoid tissue in a gastric lymph node of 5-day old animals is increased especially due to the cortex. Relative area of lymphatic nodules (without germinal centers as well as with germinal centers) is increased. This fact is consistent with results of researches performed by Oliyar [261], P.M. Gavrilin [259], V.V. Samoliak [306] who explain this phenomenon by an intensive antigenic stimulation of the entire organism. In gastric lymph nodes of 5-day old piglets (unlike one-day old piglets from Group II) amount of lymphoid tissue is increased and the connective-tissue stroma of the lymph node is decreased.

After 5 more days of life (in 10-day old piglets) depth of gastric pits in the cardiac part of the stomach remains practically unchanged (in comparison with 5-day old animals) while the glandular layer is thickened almost by 50 %. Glandular layer of the mucosa in the gastric fundus is increased in 1.35 times (with high confidence — $p < 0.001$) and the subglandular layer as well as the lamina muscularis are increased only in 0.5 times ($p < 0.01$). An analogous trend of tissue component development is also observed in other coats of the stomach (in the fundus as well as in the pyloric part.) But in 10-day old piglets depth of gastric pits in the mucosa of the lesser curvature changes less intensively. Analogously, thickness of the submucosa and the muscular coat of the organ is increased. Diameter of glands is increased and so does the number of parietal cells within one gland of the mucosa in the lesser curvature of the stomach. And thickness of the serosa is, on the contrary, decreased (by 17.23 %).

Immune structures of various parts of piglet's stomach taken in conjunction with their glandular formations are also subjected to structural changes. The greatest number of intraepithelial lymphocytes is presented in the fundus and in the pyloric part of the

stomach; and diffuse lymphoid tissue is dominant in the lamina propria mucosae. In 10-day old piglets lymphatic nodules of the stomach become wider and higher, but variations of parameters are significant (in comparison with 5-day old piglets) and this fact indicates individual developmental peculiarities of the local immunity. At the same time intensity of lymph efflux is increased which is confirmed by changed parameters of lymphangeons against the background of stable architectonics of lymphatic capillaries, post-capillaries and the lymphatic system. In gastric lymph nodes of 10-day old animals relative area of the stroma is decreased and relative area of lymphatic nodules is intensively increased (especially that of secondary lymphatic nodules). In mesenteric lymph nodes of 10-day old piglets A. A. Buyanov et al. [17] noticed clear separation of cortex and medulla as well as presence of exclusively primary lymphatic nodules, and secondary lymphatic nodules were determined only in 20-day old animals. According to data presented by P. A. Shakhov [307] in lymph nodes of 10-day old animals relative area of lymphoid tissue arteries and veins reaches the maximal value; at the same timerelative area of blood vessels in the cortex is increased the most (an intensive growth and development of lymphatic nodules is taking place there.

It should be noted that in 10-day old piglets transformation of stomach perinatal tissue components and its lymphoid structures appears to be the most intensive as indicated also by changes of the coefficient of variability.

By the end of the neonatal period (in 20-day old piglets) height of the surface epithelium and pit epithelium in the cardiac part of the gastric mucosa reaches the maximal value (with insignificant variability) in comparison with all other groups of researched animals. The researches prove that depth of the mucosa glandular layer in the cardiac part of the stomach is maximally developed in 20-day old piglets. Parietal cells of the gastric mucosa are localized

predominantly in the bottom of glands; they have large nuclei with expressed nucleoli and secretory granules in the cytoplasm and this fact indicates their active functioning. In the cardiac part of abomasum of domestic yak A. V. Stepanov and S. D. Samozhapova [286] determined only few parietal cells and in the fundus they determined large parietal cells localized in the area of gland necks.

In 20-day old piglets diameter of glands in the mucosa of the cardiac part of the stomach is increased by 24.89 % in comparison with 10-day old piglets and number of parietal cells in composition of one fundic gland is increased by 22.47 %. Researches show that the strongest structural transformations take place in the fundic mucosa of piglet's stomach while structure and thickness of the muscular coat and the serosa appear to be more stable. In 20-day old piglets depth of gastric pits in the fundic mucosa of the stomach becomes minimal among all other researched animals. And the glandular layer of the gastric mucosa reaches its maximal thickness: its thickness is rliably increased by 47.06 % in comparison with 10-day old piglets ($p < 0.05$). The subglandular layer and the lamina muscularis mucosaealso become somewhat thicker (by 11.83 % and by 21.31 % respectively).

In the pyloric part thickness of the gastric mucosa glandular layer is increased almost twofold and the submucosa becomes insignificantly thiner, on the contrary. According to data presented by T. A. Bekov, Zh. Zh. Zheyenbayev, D. I. Medvedev [39] during the first three years of children's life thickness of the gastric submucosa is decreased more than sixfold in the fundus, in 4.5 times in the pyloric part and in 2.3 times in the cardiac part.

In 20-day old piglets height of surface epithelium and pit epithelium in the pyloric part of the stomach is increased. We have not determined any parietal cells in composition of pyloric glands which is consistent with researches carried out by many authors [30, 164, 136, 178]. On the contrary, L. I. Aruin et al. [139] determined parietal cells in glands of the mucosa in the pyloric part

of the stomach in 20 % of healthy adult humans. According to the author parietal cells appear to be the most active in upper sections of glands while in lower sections their activity is much lower.

V. P. Kabish and L. N. Kadiyevska [291] point out that in piglets up to the age of 4–10 days development of organs takes place according to the scheme of the late fetal period and only after that the postnatal period starts. So, development of digestive system organs in piglets during their neonatal period of life has its own differences which to a certain extent do not match growth of the entire organism. According to data presented by I. V. Petrukhin [308] and A. V. Kvasnitskiy [31] the most intensive development of digestive system organs in piglets takes place during the first 15–20 days of life which coincides with the period of age-related achlorhydria of their gastric juice. Y. M. Lazovskiy [309] noted that differentiation of the stomach wall coats outstrips development of other sections of the digestive tract. During this period of time colostrum (milk) of sows is the only feed for piglets which is not only the source of energy but also a plastic material. But starting from the second decade piglets' energy needs from colostrum are only 82.5 % which requires using additional feed. Furthermore, it is known that development of digestive organs as well as stimulation of digestive apparatus functions may be influenced by means of using feeds containing starting substances [290, 306]. Authors admit that the earlier these substances are introduced the better the starting feeds may influence the growth and development of animals.

Our researches prove that during the neonatal period of ontogenesis piglets' embryonic tissue components of the gastric mucosa are actively transformed which is first of all conditioned by the morphofunctional status of the organism. Researches show that by the age of 20 days the glandular layer of the gastric mucosa is increased in 3–3.5 times. Te most intensive morphogenesis of glands in the mucosa occurs on the 10^{th} – 20^{th} day of life. And before the 5^{th} day

of piglet's life thickness of the glandular layer of the mucosa remains practically unchanged. But authors propose to start extra feeding precisely in this age regardlessof the gastric mucosa status contributing to the occurrence of various types of digestive disorders. And on the contrary, morphological researches prove than when developing the technology of extra feeding for piglets one should take into account not only age of animals but also peculiarities of their prenatal development (including prenatal development of their stomach). So, in case with underdeveloped piglets it is not recommended to introduce extra feeding with forage crops alongside with well-developed piglets due to the fact that differentiation of their gastric mucosa is delayed. It is possible that this approach will to a certain extent complicate organization of feeding and keeping suckling piglets but this approach will significantly increase their safety and it will also have a significant positive influence on growth and development of animals during the postnatal period of ontogenesis which in its turn will positively affect economic efficiency of the sector. Our recommendations are also supported by information that theprevailing reasons of piglets' death during the neonatal period of life are presented as diseases of digestive organs (64–68 %) [157]. According to data presented by V.A. Telepnev [92] in piglets under 15 days of age gastritis occurs in 73.8 % of cases. It is typical that during the neonatal period piglets born with body weight below 1 kg have the smallest disease resistance [290, 306, 310].

In 20-day old piglets over 90.0 % of lymphatic nodules in the cardiac part of the stomach are localized in the glandular layer of the gastric mucosa; and their basis is formed by the reticular stroma which generates plexuses of argentophilic fibers between glands and under their bottom (these plexuses acquire shape of a basket). And in the gastric fundus there are grouped lymphatic nodules which are on various stages of their development (they have a common capsule as well as a less developed individual capsule). And according to

L. I. Aruin and O. L. Shatalova [51], in the gastric mucosa of humans there are only few lymphatic nodules without germinal centers in the pyloric part of the gastric mucosa. According to the authors availability of lymphatic nodules with germinal centers in the biopsic material is a sign of the Helicobacter pylori gastritis.

In 20-day old piglets at the lesser curvature of the stomach lymphatic nodules are localized not only in places of transition to the glandular epithelium of the mucosa but also directly under the stratified flat non-squamous epithelium which bears evidence of high local protection of the organ. This fact is confirmed in works by A. V. Korobov [292] who notes that in the stomach of piglets ulcers are localized predominantly on the lesser curvature.

Lymphatic nodules of the digestive system mucosa in humans were researched by M. R. Sapin [54], K. M. Batuyev [311, 312], L. V. Chernyshenko et al. [216], who prove that these nodules are like "security posts" and are ready to perform immune protection of the organism at any time in case of an antigenic impact. Lymphoid cells in the mucosa of the digestive tract form a local protection against foreign antigens and ensure immune balance of the organism in general [50, 54, 57, 201].

In the structure of lymphatic nodules in piglet's stomach we have determined definite regularities of their localization (fig. 4.1). In the gastric submucosa of one-day old piglets there are accumulations of the diffuse lymphoid tissue and lymphatic nodules without expressed connective-tissue capsules. That is the first stage of lymphatic nodule development. In one-day old piglets from Group II about 2 % of lymphatic nodules have germinal centers. In 5-day old piglets there are lymphatic nodules (about 20 %), elevating the lamina muscularis mucosae. Alongside with analogous lymphatic nodules 10-day old piglets also have lymphatic nodules which penetrate through the lamina muscularis to the lamina propria of the mucosa. In 20-day old piglets already 90 % of lymphatic nodules are localized in the lamina propria

of the mucosa. M. R. Sapin, L. Y. Etingen [49] define 4 stages of lymphatic node development in the mucosa and determine availability of germinal centers yet before birth. But a number of authors arrive to a different opinion. So, according to R. P. Masliako et al. [250] development of lymphatic nodules of the mucosa is finished only during the 2nd week after birth. According to the author formation of lymphatic node capsule and migration of lymphocytes occurs after birth. Using a modification of T. Gelman's method N. K. Pototskiy et al. [196] determined lymphatic nodules in the piglet's stomach only by the age of month; the maximal concentration of these nodules was determined by the authors in the cardiac part while in the fundus and in the pyloric part they can be determined only in single cases. According to the authors, in case with piglets lymphatic nodules of the stomach are located inside the mucosa or in the submucosa and they do not have germinal centers. A. Andronesku [23] points out that lymphatic nodules are absent in the stomach wall (excluding the pyloric part where there are few of them and they are interrelated with the lamina muscularis mucosae). The greatest number of works is devoted to studying intestine lymphoid structures [174, 176, 178, 197, 255, 270], but these work do not provide any unified definition of the structural and functional status of lymphatic nodules.

Rapid increase of length and width of lymphangeons occurs in the cardiac part and the pyloric part of the stomach in 20-day old piglets and this in its turn promotes a significant increase of their volume.

In lymph nodes of 20-day old piglets relative area of the connective-tissue stroma as well as relative area of the medulla are decreased (by 1.65 % and by 2.61 % respectively) reaching minimal dimensions among all researched groups of animals. Relative area of the cortex dominates over relative area of the medulla which is a characteristic of visceral lymph nodes [246, 307]. In 20-day old piglets relative area of lymphatic nodules is intensively increased which is consistent with works of other authors [259, 261].

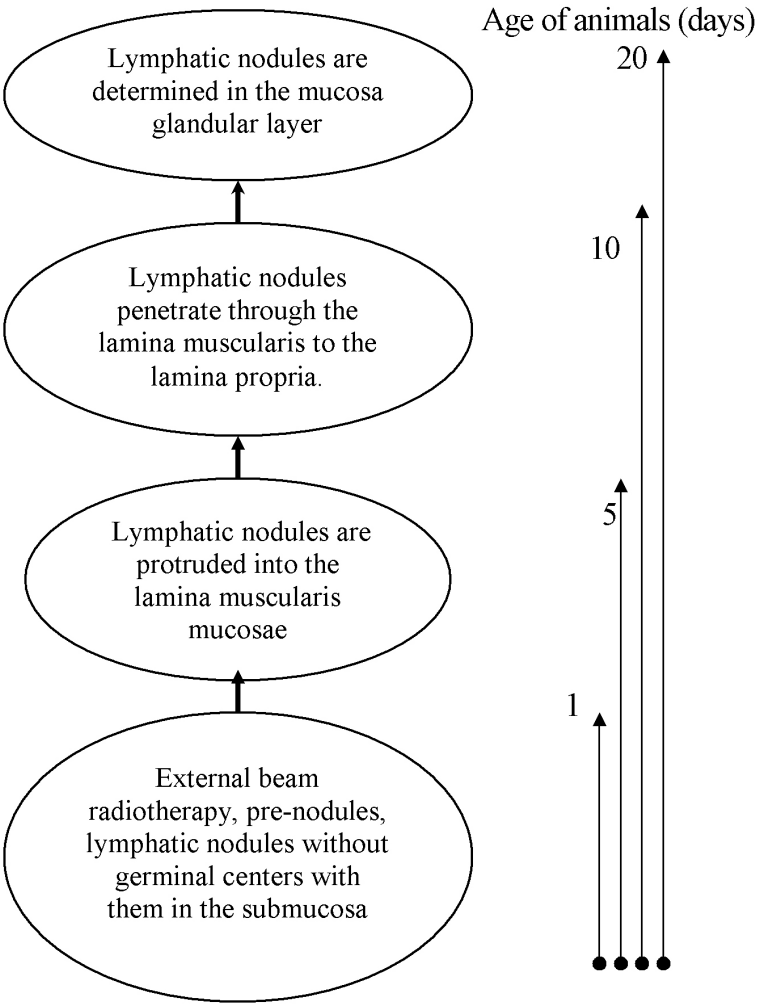


Fig. 4.1 Morphogenesis of stomach wall lymphoid structures in piglets (scheme)

So, in the result of analyzing performed researches a general biological regularity has been determined; this regularity indicates that the greatest structural transformations occur in the gastric mucosa of piglets while the muscular coat and the serosa appear to be more stable. In one-day old piglets from Group III parietal cells are localized

predominantly in the isthmus of glands of the mucosa in small number while in Groups I and II they are located more evenly throughout the length of gastric glands. In 20-day old piglets parietal cells are localized predominantly in the bottom of glands; they have large nuclei with expressed nucleoli and secretory granules in the cytoplasm and this fact indicates their active functioning. During the neonatal period of ontogenesis (by the 20th day of piglet's life) the glandular layer of the gastric mucosa is increased in 3–3.5 times. Lymphatic nodules are presented in all parts of the stomach and are on various levels of their development. Their greatest number is presented in the mucosa of the cardiac part of the stomach as well as in the fundus of the organ. Availability of germinal centers in gastric lymphatic nodules already in one-day old piglets indicates a certain functional functional immunocompetence. In animals with low body weight they are absent. In one-day old piglets lymphatic nodules are localized in the gastric submucosa while in 20-day old piglets almost 90.0 % of lymphatic nodules are localized in the glandular layer of the gastric mucosa.

Morphometric indexes of intra-organ lymphatic vessels are directly proportional to the body weight of animals. Among one-day old piglets lymphangeons of intra-organ lymphatic vessels are the longest in newborn piglets from Group I. In the process of lymphatic vessel morphogenesis growth of lymphangeons (elongation as well as widening) is intensified. Lymph outflow from walls of the stomach is performed predominantly to a gastric lymph node in which in case with one-day old piglets parenchymatous components are prevailing with insignificant amount of stromal structures. With aging increase of the lymph node cortex is taking place against the background of reduction of the medulla and connective-tissue stroma of the organ. This indicates high relevance of researching tissue components and immune structures of the stomach in piglets in conjunction with dynamics of their adaptive processes to conditions of extrauterine life.

Conclusions

1. In this thesis work morphological researches have determined morphogenic peculiarities of tissue components and immune structures of the stomach in piglets with various body weight when born and in addition to that changes of the organ during the neonatal period have been determined. A method for determining structural and functional status of the stomach in piglets has been proposed.

2. In one-day old piglets with body weight corresponding to the breed standard high and frequent folds form relief of the gastric mucosa containing surface epithelium with height of 20.58 ± 0.46–26.64 ± 0.49 microns, pit epithelium — 15.80 ± 0.38–20.37 ± 0.21 microns high, as well as glandular layer — from 135.98 ± 36.11 microns to 228.54 ± 15.62 microns high. Number of parietal cells (22.04 ± 0.24 units), thickness of the glandular layer (228.54 ± 15.62 microns) are maximal in the fundic mucosa of the stomach, and depth of gastric pits (116.74 ± 16.44 microns), thickness of the muscular coat (901.25 ± 85.31 microns) and thickness of the serosa (73.66 ± 14.50 microns) are maximal in the pyloric part of the stomach.

3. Height of surface epithelium and pit epithelium, structural and morphometric peculiarities of mucosa glands as well as interrelations between coats and their tissue components in various parts of the stomach are directly proportional to body weight of one-day old piglets.

4. With aging height of epithelium and thickness of the gastric mucosa glandular layer are increased and so does the number of parietal cells within cardiac and fundic glands. And these processes take place against the background of asynchronous dynamics of correlative relationships between tissue components.

5. The most intensive changes morphometric parameters and structure of mucosa tissue components take place in 10-day old

piglets in the fundus and in the pyloric part of the stomach (with insignificant changes in thickness of the muscular coat and the serosa).

6. During 20 days of piglet's life all structural components of the stomach wall are increased asynchronously: in the cardiac part maximal increase of the height of surface epithelium and pit epithelium occurs (in 1.22–1.99 times); increase of the glandular layer (in 3.66 times) and increased number of parietal cells (in 1.13–2.26 times) are typical for the fundus; and the pyloric part is characterized by an increased thickness of the lamina muscularis mucosae (in 1.79 times).

7. Lymphoid structures of stomach coats are formed by intraepithelial lymphocytes, diffuse lymphoid tissue and lymphoid nodules on various stages of their development. In one-day old piglets these structures are located in the submucosa while in 20-day old piglets they are located in the mucosa glandular layer.

8. The middle third of side walls of the stomach is the zone of lymphatic division: capillary networks form lymphatic vessels directed in opposite directions to the lesser curvature as well as to the greater curvature and falling into gastric, splenic and pancreaticoduodenal lymph nodes. With increasing body weight and age of animals parameters of lymphangeons in intra-organ vessels are also increased causing decrease of the valve index.

9. In gastric lymph nodes of one-day old piglets there are lymphoid nodules located among diffuse lymphoid tissue of the cortex; these nodules are on various stages of their formation, and with aging of animals their area is increased (with decreased area of the medulla and the connective-tissue stroma).

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