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# Anaerobic Microflora Impact on Pathomorphogenesis of Swine Dysentery

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**Abstract:** In the presented study actual problems of the anaerobic microflora impact studying are considered. To conduct the experiment among, weaned pig the animals with clinical signs of dysentery were selected. To establish the histological and ultrastructural changes in the large intestine, the material was obtained from the compulsory slaughtered animals. The histological and ultrastructural study of the mucous membrane of the large intestine in animals with swine dysentery revealed catarrhal hemorrhagic inflammation with focal necrosis of the epithelium and edema of the lamina. It was found that microbiocenosis violation occurs in all parts of the colon in the form of lower levels of normal flora and infestation in the lamina propria. New data allow us to establish pathogenic interrelation between Br. hyodysenteriae and anaerobia which should be taken into account when conducting differential diagnostics and improving measures to combat swine dysentery.

**Key words:** Swine dysentery, anaerobic microflora, large intestine, pathological process, intestine, dysentery

## INTRODUCTION

The major problem in the infectious pathology of swine today is acute enteric infections and dysentery takes one of the leading positions, this disease is registered in all regions of Russia. The proportion of dysentery reaches up to 50% in the structure of infectious diseases of pigs (Ivanov, 2005a, b; Kekukh and Gavrikov, 2012). Swine dysentery was described more than 90 years ago but the pathogen was detected only in 1972 in the US and since, then more than 45 years has been intensively studied but there is still no agreement on the etiology of the disease between researchers (Harris *et al*., 1972; Burrough *et al*., 2012; Dimitrova *et al*., 2016).

It has been established that the sources of the pathogen are only pigs: sick animals convalescence animals and recovered ones which for a long time remain carriers of brachyspirae (Harris *et al*., 1972; Pringle *et al*., 2007). In addition, *Brachyspira hyodysenteriae* is constantly isolated from dogs and synanthropic rodents that live in foci of swine dysentery (an infection reservoir). The most likely causative agent of dysentery is *Brachyspira hyodysenteriae* and β-hemolytic strict anaerobic gram-negative intestinal Spirochaeta that belongs to Spirochaetaceae family and was officially recognized in 1998. There were other names: *Treponema hyodysenteriae* (1972) and *Serpulina hyodysenteriae* (1991) (Ochiai *et al*., 1997; Sperling *et al*., 2011; Verlinden *et al*., 2013). Hemolysin is probably the main factor of virulence (Ohya and Sueyoshi, 2010; Rugna *et al*., 2015; Quintana-Hayashi *et al*., 2017). When studying swine dysentery in our country, the following species de pending on the pathogen are still conventionally distinguished: vibriosis dysentery; balantidiasis dysentery; spirochaetic dysentery; anaerobic dysentery; viral dysentery and others. Brachyspira is a permanent colonizer of the intestinal tract of healthy piglets and show their virulence under dysbiotic disorders in the large intestine. The disease is widespread all over the world and leads to significant economic losses. *Br. hyodysenteriae* is the main etiological contagium, but according to a number of researchers (Ivanov, 2005a, b; Rugna *et al*., 2015; Dimitrova *et al*., 2016). *Br. hyodysenteriae* infection is not the only factor for swine dysentery they believe that the main triggering agent is the microbiological imbalance in the gastrointestinal tract, that is the presence of conditionally pathogenic intestinal microflora is

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necessary. Pathomorphogenesis of swine dysentery is not clearly studied, so in this regard it is difficult to developed biologic drug for prevention and treatment, although, work in this direction is underway (Rasback *et al*., 2009; Rubio *et al*., 2012; Verlinden *et al*., 2013; Grahofer *et al*., 2017). That is why further studying of the morphogenetic significance of the causative agent of swine dysentery is the urgent task.

The aim of the research is to study the impact of *Br. hyodysenteriae* and conditionally pathogenic *Cl. perfringens* and *F. necrophorum* anaerobic microflora on pathomorphogenesis of swine colons in dysentery depending on severity of the disease.

## MATERIALS AND METHODS

Establishing the diagnosis was based on epizootology, clinical picture, micrography of the biological material (fecal matter, changed colon mucosa). *Br. hyodysenteriae* was cultivated on Tripticase Soy Blood Agar (TSBA) in anaerobic conditions. For the the isolation of anaerobic gastrointestinal microflora of *Cl. perfringens* and *F. necrophorum* special and differential diagnostic media were used. The numerical composition of colon normoflora was defined by means of bacteriological research. For histological processing large intestine (colon, cecum and rectum) was used.

The samples were fixed in 10% formalin, poured into paraffin blocks there were made histological sections of 4-5 microns thick with a microtome and stained with haematoxylin and eosin. Tissue specimen was studied under light microscope. Ultrastructural studies were conducted according to a generally accepted methodology. Pieces of the large intestine were fixed in a 2.5% solution of glutaraldehyde. The resulting ultra-thin sections were contrasted with lead citrate and examined in a JEM-100S transmission electron microscope.

## RESULTS AND DISCUSSION

In a microscopic study of the samples stained according to Gram method, prepared from the pathological material taken from swine with clinical signs of dysentery (bloody scours), brachyspira had an ascarid-like shape with pointed ends and with 3-4 flexures Fig. 1 when cultured on TSBA (Tripticase Soy Blood Agar) β-hemolysis zones were observed, tinctorial, morphological and pathological properties of isolated pure culture corresponded to *Br. hyodysenteriae* (Fig. 2). The first symptoms of the disease begin with diarrhea. Microscopic examination in the colon revealed that the initial period of development of the dysentery syndrome

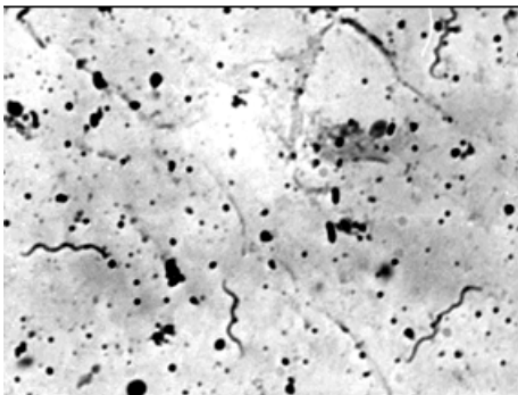

Fig. 1: Brahiespires with serpentine form with 2-5 bends are visible in the figure. Stained with Ziehi's solution. 900-manifold increase

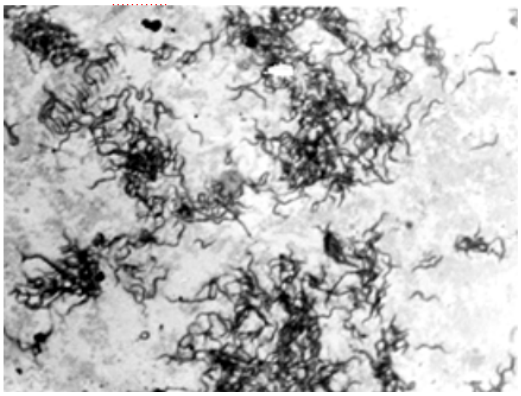

Fig. 2: *Br. hyodysenteriae* culture isolated on selective medium of TSBA. Stained according to Gram's method. 1000-manifold increase

was marked by a slight desquamation of the epithelial cells of the mucosa and cellular infiltration in the stroma. Bacteria were found between the epithelial cells. In the crypt lumen, decaying cells were observed. With the duration of the disease from 5-7 days inflammatory regions on the mucous membrane were more often found between the crypts. Prismatic cells were in a state of destruction and rejected singly or in groups.

Under the swine dysentery duration of 8-9 days, the majority of colonocytes were in the state of destruction their nucleus initially were in a piknotic form and then subjected to necrosis with disintegration into small parts. We revealed the fullness of blood vessels accompanied by hyperpermeability of capillars and edema the surrounding tissues were infiltrated with formed elements. In the lamina propria alterative-dystrophic processes, characterized by dysplasia of the epithelium were observed. In the mucosa of the large intestine during the

ultrastructural study, swelling and vacuolization of the nuclei of epithelial cells, destruction of the mitochondrial crista and blurred contours of the nuclei were found. The boundaries between the cells were indistinguishable. In the lumen of the colon there is an effusion containing cell detritus. Near such changed areas there are areas where the usual structure of the mucous membrane is preserved. Occasionally, excessive mucus was found almost throughout the entire intestine while the epithelial lining was intact. Dystrophic changes were found in survived prismatic cells and were characterized by indistinguishable boundaries of cells and merged into one common mass. Goblet cells were in a state of hypersecretion. Lymphocytes became visible in the extended network of blood capillaries of the mucous membrane, edema in the lamina propria. The flow of water is known to be carried out in a healthy cell by passive osmosis and micropinocytosis its quantity is regulated in response to the appearance of a diffuse gradient, caused by differences in the ion composition of the intercellular fluid and the cytoplasm of the cells. There are also a large number of anionic proteins in the cell that take part in maintaining the balance between water diffusion and ion transporting and their role in this process is obvious. Adenosine triphosphatases are activated by $K^+$ and $Na^+$ ions. The non-uniform stationary distribution of $Na^+$ ions inside and outside the cell is achieved when the flow of $K^+$ ions through the membrane into the cell becomes that is different to the flow of ions from the cell resulting from the passive diffusion. If as a result of the pathological process, the release of $K^+$ ions from the cell arises, $Na^+$ ions enter the cell then as a result of osmotic phenomena, the cell absorbs water which leads to a vacuolar degeneration. Under the conditions of disease natural progression, the integrity of the cell's plasmolemma may occur due to the brachyspira metabolism products impact or an antibody-antigen complex. Passing through the plasmalemma, $Na^+$ ions enter the cytoplasm where the cells are actively involved into the metabolism and the $K^+$ ions on the contrary leave the cell. Intracellular transport of ions is due to the movement of the cytoplasm through the canals of the endoplasmic reticulum while an excessive amount of water leads to cell edema. Ultrastructural changes in the edema of epithelial cells are typical and microvilli as a rule are deformed and spreaded that is accompanied by the destruction of specialized inclusions. In the lack of calcium in the zone of cells differentiation and other cell-cell contacts which provide a strong connection of cells there begin to appear signs of cell divergence, thus, intercellular gaps appear in which vacuoles can form which usually occupy the marginal position at the periphery of the cell. In the cytoplasm,

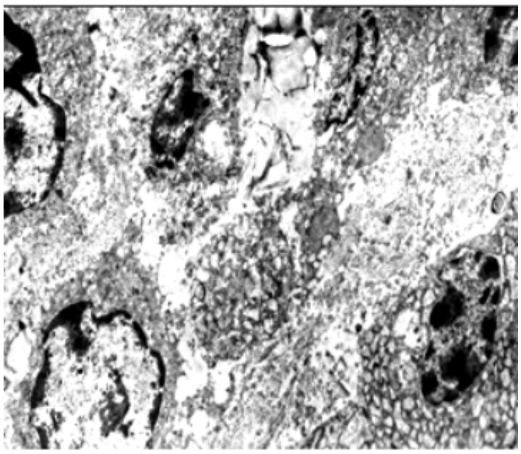

Fig. 3: Colon in swine dysentery. Plasmocytes clusters, some of them are in a state of destruction. The destruction is manifested by the absence of a cell membrane, the release of ultrastructures into the intercellular space. 4000-manifold increase

vacuole organelles are dispersed and look transparent, the underlying connective tissue is exposed. There were areas where the epithelium was transformed into an unstructured granular mass a cluster of histiocytes, lymphoid cells, plasmocytes (Fig. 3) and eosinophils were observed. Under the epithelium of the mucosa, the presence of these cells was more distinct and was accompanied by a strong vascular reaction. Collagen, elastic and reticular fibers form the reticulum in connective tissue.

On the surface of mature granulocytes there were found numerous long digitiform prominences which joined together to form vacuoles. A high concentration of plasma cells in the colon and cecum was observed, some of them were in a state of destruction and presented by the absence of a cell membrane, chromatin melting, vacuolization of endoplasmic reticulum cisterns and the release of ultrastructures into the intercellular space. The necrosis of prismatic cells and dystrophy in the mucous membrane of the colon was constantly revealed. In the submucosal layer, cellular infiltration and edema are observed. Dystrophy of muscular fibers is observed which have the following view: loosening, splitting of the fibers into separate parts, the contours of nuclei are blurred. Reticular fibers often have no lateral branches and are sparse and thickened. Lymphoid hyperplasia with cell destruction was observed. Lymphocytes clusters were visible in the lymphatic vessels. At a microscopic examination it was found: in the submucosal layer of hemorrhage, small-cell infiltration, the phenomenon of edema in some places the connective tissue

transformation, the muscle tissue is atrophied. The boundaries between the colonocytes were blurred which characterized by a high degree of dystrophic process with its transition to the destructive phase. Cell nuclei retained their characteristic shape size and localization in the cytoplasm but the matrix became electronically transparent the condensed chromatin clumps concentrated along the nuclear membrane. The mitochondrial forms and shapes were varied. When the cisterns of the endoplasmic reticulum are expanded a concentric arrangement is observed there was a small number of ribosomes on the membranes, sometimes their vacuolization in some cases their disappearance is observed. The mitochondria had a rounded shape, the matrix was cleared. Mitochondria with destroyed cristae appeared. In many cells the Golgi apparatus had a normal structure, in some of them there was a distention of cisterns presented by single smooth membranes surrounded by large electronically transparent vacuoles. On the apical cytoplasmic membrane of epithelial cells it was possible to observe the regularity of the location of microvilli as well as their destruction. Destructive processes in the cecum proceed in the form of edema of the mucous membrane an increase in epitheliocytes and their nucleus and its chromatin is scattered in clumps. Fibroblasts, plasmocytes and reticular cells were detected. In the colon, hypersecretion of mucus was found which presented in the fact that in the apical part of the goblet cells cytoplasm there were found a multitude of secretory granules filled with of low electron density substance.

The clearing of the core matrix is observed. In the preparations there were found goblet cells, filled with fused secretory granules containing microorganisms, similar changes were observed in cecum and rectum. The inflammatory processes in the large intestine were presented by intensification of the distrophic processes in the epithelial cells, crypts, stroma, forming lamina propria of the mucous membrane, the submucosa and the muscular membrane on the 10-11th day of the disease. In the lamina propria of the mucous membrane, among the sparse, partially piknomorphous lymphoid cells there appeared single plasmablasts and eosinophilic granulocytes are practically disappeared. The nuclei of some endotheliocytes of blood capillaries (Fig. 4) are filled with condensed chromatin. The central core zone is cleared. The nuclear membrane formed invaginations and was loosened. In the cytoplasm of endotheliocytes there presented single mitochondria, some of which contained lysed cristae. Cisterns of the granular endoplasmatic network had the form of electronically transparent vacuoles. There were no micropinocytosis vesicles in the cytoplasm of the endothelial cells. Cellular elements of

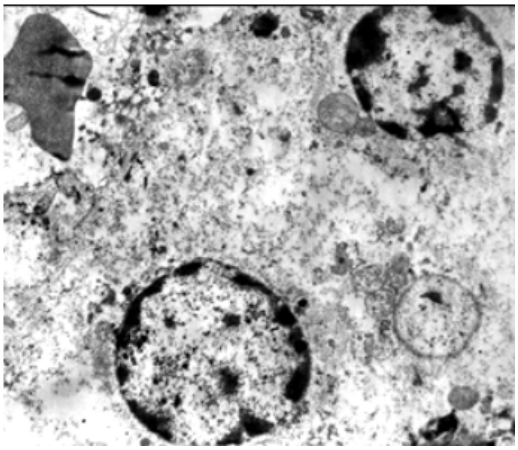

Fig. 4: Cecum swine dysentery. There is destruction of the vessel wall with the release of liquid and erythrocytes. Destruction of lymphoid cells and macrophages. 4000-manifold increase

blood were found in the lumen of the capillaries. Infiltration of the mucosa and submucosal membranes in populations of eosinophils, lymphocytes, macrophages, bazophiles, neutrophils in all the examined animals differed not so, much but still was more evident in the subepithelial zone of the mucous membrane. As far as is known, the intake of endotoxins into the body inhibits phagocytosis, granulocytosis, monocytosis and increase the permeability of capillaries. Microbial lipo-polysaccharides destroy blood leukocytes, cause degranulation of mast cells with the release of vasodilatators. The most important mechanism for protecting the macroorganism from the pathogenic agent is the complex of B-cell and cellular responses that determine the immune response. It is characterized by the appearance of cells in the connective tissue, fibrocytes, fibroblasts, macrophages, mast and plasma cells, being of particular significance as well as lymphocytes, eosinophils, neutrophils performing protective and immunological functions. Immune reactions are determined, first of all by pathogenicity and the amount of antigen.

Immunological reactivity in swine dysentery has been studied insufficiently. In the submucosal layer of the cellular elements fibroblasts with the phenomenon of pyknosis and lysis of the nuclei are distinguishable. In inflammatory processes, the restoration and replacement of damaged tissues begins with the release of fibrinogen molecules from the vessels of and the formation of fibrin which forms a kind of mesh a sceleton for the subsequent cell growth. Rapidly formed fibroblasts are distributed in the focus of repair according to the sceleton. The

division, growth and movement of fibroblasts become possible only after their binding to fibrin or collagen fibers. This connection is provided by a special protein-fibronectin. Multiplication of fibroblasts begins along the periphery of the inflammation zone, ensuring the formation of a fibroblastic barrier. First fibroblasts are immature and do not have the ability to synthesize collagen. Maturation precedes the internal structural and functional restructuring of fibroblasts: hypertrophy of the nucleus and nucleolus, hyperplasia of the endoplasmic reticulum an increase in the content of enzymes, especially of alkaline phosphatase, nonspecific esterase and b-glucuronidase. In these interactions, the synthesis of various fibroblasts is selectively activated and possibly dictated by the necessity for participation in certain metabolic processes. Only after the change the process of collagenogenesis begins. Thus, the morphogenetic function of collagen acts as a regulator of differentiation at the cellular and tissue levels. The function of fibronectin is to limit cell proliferation and migration.

Fibronectin plays an important role in the structural bases of homeostasis responsible for the slowing down the inflammatiry processesof inflammatory processes in the large intestine. Lymphoid hyperplasia in the large intestine was accompanied by an increase in the number of lymphocytes and histiocytes. Epitheliocytes were in a state of destruction. Between the muscle and collagen fibers there were found lumen areas filled with a liquid of different density. In electron microscopic examination, intramural ganglia are the kind of compact formations surrounded from the outside by a basal lamina, around which there are connective tissue cells their branches and bundles of collagen fibers. On the surface of the ganglia and directly among the neurons there are lemmocytes surrounding the groups of unmyelinated axons and containing in the axoplasm mitochondria, synaptic vesicles as well as small granules with an osmiophilic center and surrounded by a membrane. The nuclear envelope with moderately expanded perinuclear space often forms convolutions. At the developed form of dysentery, the shape and structure of the mitochondria was altered an expansion of rounded or ovoid shape was noticed. They have the form of large vacuoles, the cristae are fragmented in them and ruptures of the outer and inner mitochondrial membranes are observed. The granular reticulum in the form of communicating tubules is expanded and located near the structures of the Golgi complex. Sometimes in the same place it is possible to trace the intensified formation of bordered vesicles, originating from its hyprplastic cisterns. The number of primary and secondary lysosomes is increased and their intensive formation coincides with the destruction of various cytoplasmic organelles in time and the formation of myelin-like structures. Dystrophic changes in nerve cells are observed which may accounts for the development of the disease. Microorganisms were found on the surface and in the cytoplasm of prismatic cells. The morphology of bacteria in the study of drugs was characterized by polymorphism from rounded, rod-shaped and convoluted forms. Brachyspirae were found throughout their own layer, along with various desquamated cells. According to the results of our research the isolated anaerobes were refered to: pathogenic *Br. hyodysenteria* to conditionally pathogenic-*Cl. erfringens*, *F. ecrophorum* and normoflora Lactobacillus, Bifidobacterium.

As a result of bacteriological study of animals with dysentery, dysbiotic abnormalities in the large intestine were established. They were determined first of all by the detection of *Br. hyodysenteriae* in all sick animals (3.86±0.91 lg CFU/g). The indicator of dysbiosis was an increase in conditionally pathogenic anaerobes: *Cl. perfringens*-8.64±1.76 lg CFU/g and *F.necrofophorum*-5.61±1.11 lg CFU/g. In healthy animals these values indices corresponded to *F. necrophorum*-3.86±0.85 lg CFU/g and *Cl. perfringens*-5.89±1.28 lg CFU/g.

In sick animals, the number of lactobacilli and bifidobacteria decreased significantly and (3.56±0.85 lg CFU/g and 4.47±1.02 lg CFU/g) in healthy animals these indices were: Lactobacillus-9.16±2.30 lg CFU/g and Bifidobacterium-8.11±1.94 lg CFU/g by 2.05 and 2.28 times more, respectively.

The development of microbiocenosis in the large intestine had its own peculiarities. A marked decrease in the content of lactic flora. In the cecum, 4.63±1.16 lg CFU/g in the colon 3.92±0.95 lg CFU/g in the rectum 2.14±0.46 lg CFU/g in healthy animals these indices were: in the colon-11.86±3.14 lg CFU/g in the cecum-7.74±2.13 lg CFU/g in the rectum-4.73±1.06 lg CFU/g . Indices of lactobacilli in sick animals in the cecum are 5.64±1.26 lg CFU/g in the colon-4.51±1.18 lg CFU/g in the rectum-3.25±0.63 lg CFU/g. The healthy animals had the indices: 8.83±2.41 lg CFU/g, 12.93±3.17 lg CFU/g, 5.72±1.32 lg CFU/g, respectively.

An increase of conditionally pathogenic microflora. In the cecum, the amount of *F. necrophorum* is 5.95±1.24 lg CFU/g, *Cl. perfringens*-8.24±1.77 lg CFU/g; in the colon the content of *F. necrophorum* is 6.65±1.57 lg CFU/g, *Cl.perfringens*-10.94±-2.16 lg CFU/g in the rectum the content of *F. necrophorum* is 4.32±0.52 lg CFU/g, *Cl. perfringens* is 6.75±2.27 lg CFU/g. Healthy animals had the following corresponded indices: in the colon-6.81±1.63 lg CFU/g and 4.38±0.63 in the rectum-4.93±0.92 lg CFU/g and 3.41±1, 15 lg CFU/g and in the cecum-5.93±1.31 lg CFU/g and 3.79±0.76 lg CFU/g of the material studied.

It was found that the dysbiotic disorders of the microflora in the large intestine were presented by an increase in the frequency of isolation of the conditionally pathogenic *Cl. perfringens*, *F. necrofophorum* anaerobes and the detection of *Br. hyodysenteriae* in all sick animals.The presence of a large number of conditionally pathogenic microflora, especially, clostridia is one of the characteristic signs of large intestine dysbacteriosis of large intestine (Ivanov, 2005a; Ohya and Sueyoshi, 2010). In the infectious process of swine dysentery for 5-7 days, the greatest amount of brachyspirae, clostridia, fusobacteria could be isolated in animals with catarrhal colitis with clinically marked by bloody scours, the stool had liquid consistence with a large amount of blood mixed with mucus and fibrin which is consistent with literature data (Ivanov, 2005a; Ohya and Sueyoshi, 2010). The results of pathomorphological studies of the thick intestine in swine dysentery showed that *Br. hyodysenteriae* is present mainly on the surface of the mucosa and deep in the crypts. Moreover, the largest number of them is found in the colon and cecum. Infiltration with cellular elements was combined with a pronounced vascular reaction. The capillaries of the mucosa are expanded their endothelium is distented. Such changes in blood vessels were accompanied by leukocytes emigration, diapedesis of single red blood cells and serous edema of connective tissue. Electron microscopy in the cytoplasm of endothelial cells recorded the destruction of mitochondria, vacuolization and their transformation into multivesicular bodies (Sperling *et al*., 2011; Verlinden *et al*., 2013).

In connection with increased secretion of mucus in goblet cells, deformed nuclei were found. However, even with pronounced changes in the ultrastructural components of the cytoplasm, nuclei are often retained. In the morphological study of the large intestine on 8-9 days of the disease, accompanied by bloody diarrhea, the changes were characterized by hydrophilic degeneration of epithelial cells, desquamation of microvilli and necrosis of epithelial cells, hyperplasia of lymphoid tissue and their nuclei were sclerosed in some nuclei only their contours remained. In addition, hemorrhagic infiltration of the mucous membrane of the large intestine was observed in some areas. Goblet cells are sharply expanded and full of secretion. In the epitheliocytes lining the crypts, destructive processes are observed and there are foci of necrosis. There are certain morphological changes in the muscular structures they also show the distension of the mitochondria, the clearing of the cytoplasm. Among the cellular infiltrate in lamina propria, plasma cells, lymphocytes, eosinophils and mast cells were distinguished. In the epithelial cells, pronounced destructive changes were observed. There were also observed the branching of microvilli, sometimes they formed bundles.

Studying questions of pathogenesis, the researchers Harris *et al*. (1972) and Rasback *et al*. (2009), Xu *et al*. drew their attention to the appearance of microscopic changes in the mucosa of the colon. In their opinion, this is due to the fact that some bacteria, dying, release vasomotor substances which increase the permeability of the mucous membrane. *Br. hyodysenteriae* was also found in the crypts in the cytoplasm of damaged epithelial cells and around the vessels of their own layer of the mucous membrane which proves the pathomorphogenetic significance of the causative agent of swine dysentery. To create optimal conditions for *Br. hyodysenteriae* growth in the large intestine some scientists (Rugna *et al*., 2015; Quintana-Hayashi *et al*., 2017), believe that other microorganisms should also participate. Our results showed that in swine dysentery, the number of *Cl. perfringens* and *F.necrofophorum* sharply increased. Thus, it can be assumed that the causative agent of the swine dysentery show a pronounced tropism to the intestinal epithelium of the large intestine that is more strongly manifested in the colon.

With an increase in the duration of the disease up to 10-11 days there are observed dystrophic changes in the epithelial cells. These changes in epithelial cells are accompanied by edema, vacuolization a disruption of the membranes integrity and a proliferation of fibrous tissue was registered in the submucosa. They also noted the presence of fibrin on the mucous membrane which in places was necrotic and denuded. With electron microscopy, the cells of the epithelium are sparse, show fragmentation and rejection of microvilli, vacuolation of the cytoplasm and nucleus. Brachyespiras were found throughout their own layer, along with various necrotic cells. Similar changes are indicated in the works of some researchers (Pringle *et al*., 2007; Burrough *et al*., 2012).

Concluding the discussion of the results of our own research, we hope that the results obtained will allow us to understand the features of the pathomorphogenesis of swine dysentery better. The role of *Br. hyodysenteriae* as the main etiological agent in swine dysentery was confirmed there were revealed some regularities of the disease development depending on the qualitative and quantitative composition of the anaerobic microflora of the large intestine.

## CONCLUSION

In the large intestine there were observed such phenomena as degenerative changes, cellular infiltration of the mucosa and submucosal layer, decrease in the number of goblet cells and desquamation. The analysis of

the studies results suggests that *Br. hyodysenteriae* can be infested in the lamina propria and in epithelial cells. The acute development of swine dysentery in the large intestine is manifested in the form of a pronounced catarrhal-hemorrhagic or catarrhal inflammation with necrotic patches in the epithelial layer. Bacteriological studies of the large intestine of sick pigs revealed dysbiosis. Severity of dysbiotic disorders was mainly determined by a sharp decrease in the normoflora amount which participates actively in maintaining colonization resistance of the intestine.

The increase in the number of *Cl. perfringens* and *F. necrophorum* allows us to conclude that these microorganisms play a certain role in the development of pathological changes in the large intestine in swine dysentery, the causative agent of which is *Brachyspira hyodysenteriae*.

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