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SOME PATTERNS OF CHANGES IN THE LYMPHOCIRCULATORY SYSTEM OF THE INTESTINE AFTER GASTRIC RESECTION

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Annotation: The present study investigates morphological and histochemical changes in the lymphocirculatory system of the small intestine following various types of gastric resection in dogs. A total of 122 dogs were examined, including 104 that underwent gastric resection using different methods (Billroth I, Kupriyanov-Zakharov, Hofmeister-Finsterer, and Polna-Reichel) and 18 in the control group. Structural transformations of lymphatic capillaries and vessels were analyzed over different postoperative periods ranging from 3 days to 1 year. Significant alterations were observed in the mucosal lymphatic network, including capillary dilation, new anastomoses, and wall protrusions. Pathohistological examinations revealed edema, infiltration by lymphocytes and plasma cells, deformation of villi and crypts, and epithelial atrophy. These changes were most prominent in the early postoperative period, with partial recovery and adaptation over time. The findings highlight compensatory remodeling of intestinal lymphatic vessels aimed at restoring microcirculation and lymphatic drainage under conditions of venous stasis and interstitial edema caused by surgical trauma.

Keywords: gastric resection, small intestine, lymphatic system, morphology, histochemistry, villi, anastomosis.

Despite the significant number of studies devoted to the investigation of the lymphatic system of the gastrointestinal tract under various pathological conditions, certain questions remain unresolved. This is especially true regarding changes in the lymphatic network of the small intestine after different types of gastrectomy procedures [2,3,5]. Gastrectomy, regardless of the method used, is accompanied not only by the removal of a significant portion of the organ but also by damage to nerves and blood vessels. This undoubtedly affects the morphological condition of the lymphatic network, not only of the stomach itself but also of other abdominal organs. Therefore, the issues related to lymphatic system pathology associated with damage to the digestive tract—particularly due to gastrectomy—remain highly relevant [1,4].

Objective of the Study: To investigate the morphological and functional changes in the intestinal wall and its lymphatic network after various types of gastrectomy.

Materials and Methods: The study was conducted on 122 mongrel dogs. Of these, 104 animals underwent gastrectomy using the following techniques: Billroth I, Kupriyanov-Zakharov, Hofmeister–Finsterer, and Polya–Reichel. The remaining 18 animals served as the control group. To study the structural changes in the lymphatic vessels of the small intestine, animals were euthanized at 3, 7, 15 days; 1, 1.5, 2, 3, and 6 months; and 1 year after gastrectomy. At the end of each experimental period, animals were euthanized via overdose of narcotic agents (hexenal or

thiopental sodium). Intra-organ lymphatic vessels were examined using an isolated segment of the small intestine, 12–15 cm in length, taken 35–40 cm from the duodenojejunal flexure. These vessels were filled with Gerota's mass via interstitial injection. Then, clarified specimens were prepared and studied under an MBS-2 binocular microscope.

In the examination of 492 specimens obtained from 82 dogs, attention was paid to the external structure, orientation of the lymphatic vessels and their loops, the presence of anastomoses, and the density of the vascular pattern. The diameters of lymphatic loops, capillaries, and vessels, as well as the protrusions and lateral bulges on their walls, were measured — a total of 37,520 measurements were performed.

To study the pathohistological and histochemical structures of the small intestine walls, samples were taken from 2 dogs in each group at 3, 7, 15, and 30 days after gastrectomy (a total of 32 animals). Histological and histochemical examinations of the intestinal wall were conducted. For microscopic examination, tissue samples were taken from the initial section of the small intestine. The samples were fixed in a 10% solution of neutral formalin, passed through a series of alcohols, and embedded in paraffin. The resulting 6–8 μm thick sections were stained with hematoxylin-eosin and by Van Gieson's method, and PAS (Periodic Acid–Schiff) reaction was applied.

Quantitative indicators were statistically analyzed using the "ES-1020" computer system. Significance was accepted at levels of $P < 0.05$, $P < 0.01$, and $P < 0.001$.

Research results and discussion: It was found that, at various intervals after gastrectomy, the restructuring of the lymphatic network is characterized by an increase in the density of the network across all layers of the intestinal wall. The most significant changes occurred in the lymphatic network of the mucous membrane. These capillaries were dilated and convoluted. In some areas, they were swollen and formed anastomoses at different levels. The loops varied in shape, with the following average dimensions: length — 61.0 ± 3.0 μm ($P < 0.001$), width — 39.0 ± 1.0 μm ($P < 0.001$).

In the muscular layer, a distinct capillary network was present. The capillary diameter was 29.0 ± 4.0 μm ($P < 0.001$). The loops they formed had an oval-elongated shape, with a length of 12.0 ± 3.0 μm ($P < 0.001$) and a width of 6.0 ± 2.0 μm ($P < 0.001$); their orientation matched the alignment of muscle fibers. Compared to the loops of the muscular layer in control animals, an increase in size was observed, which was associated with an increased diameter of the capillaries themselves.

Lymphatic capillaries and vessels forming networks and plexuses in the serous membrane had varying contours and were dilated. The capillaries reached a diameter of 3.0 ± 3.0 μm ($P < 0.001$) and formed small oval-shaped loops with the following dimensions: length — 98.0 ± 3.0 μm ($P < 0.001$), width — 61.0 ± 2.0 μm ($P < 0.001$). Wide lacunae of various shapes were frequently observed. The lymphatic vessels were dilated, with a diameter of 41.0 ± 1.0 μm ($P < 0.001$), and the distance between valves in their lumen decreased to 247.0 ± 3.0 μm ($P < 0.001$).

At later time points, further remodeling of the lymphatic capillaries and vessels of all layers of the small intestine was observed (see Fig. 1, 0).

In the mucosal layer, the caliber of lymphatic capillaries and vessels decreased, but the network became denser. Outgrowths on their walls were more frequently detected, and the loops had a polygonal shape with the following dimensions: length — 111.0 ± 2.0 μm ($P < 0.001$), width — 49.0 ± 2.0 μm ($P < 0.001$).

In the submucosal layer, lymphatic capillaries formed a dense network with smooth walls and no outgrowths. Capillary lacunae were reduced and had irregular or oval shapes. The loops formed by these capillaries were more commonly oval and had dimensions approaching those observed in the control group of animals.

The efferent lymphatic vessels anastomosed with one another, forming plexuses that were located in the same plane as the capillary network. The anastomoses between the efferent vessels were well developed, with a diameter of 38.0 ± 2.0 μm ($P < 0.001$).

In the muscular layer, lymphatic capillaries formed a single-layered network. The loops of the capillaries and the collecting vessels were oriented toward the mesenteric edge of the intestinal wall. The lacunae formed by these vessels had a triangular shape. The contours of the efferent vessels, now reduced in diameter, were smooth, and the distances between valves in their lumens were elongated.

In the serous membrane, lymphatic capillaries formed small oval-shaped loops, whose internal dimensions were increased. The lacunae had an irregular star-shaped form. The efferent lymphatic vessels of the 1st, 2nd, and 3rd order, compared to earlier postoperative periods, were reduced in diameter. The anastomoses between these vessels were fairly large (4.0 ± 2.0 μm, $P < 0.001$), and some of them even exceeded the diameter of the main vessels.

One to six months after gastrectomy, due to the proliferation of vessels through the formation of numerous anastomoses and lateral finger-like and other protrusions, an extensive network of lymphatic capillaries and vessels is formed. Under these conditions, the vessels of the mucosal and submucosal layers — and less frequently, those of the serous and subserous layers — noticeably lose their orderly arrangement and directional orientation. A clearer orientation is retained by the larger second- and third-order vessels, which help determine the direction of lymphatic outflow.

In the early stages following gastrectomy performed using the Billroth I method and its modifications, pathomorphological changes of the small intestinal wall are observed in the form of mucosal edema, deformation of villi and crypts (see Fig. 2, a, b).

Hypertrophy of individual mucosal villi is accompanied by a reduction in their overall number per unit area. The surface epithelium of the villi contains numerous goblet cells, and the crypts are shortened and dilated.

In the stroma of the villi and crypts, diffuse infiltration is observed, predominantly lymphocytic in nature. The apical part of the cytoplasm in the columnar cells of many crypts and some villi shows a strongly positive PAS reaction. In the hypertrophied villi, high activity of alkaline phosphatase is noted in the apical parts of the cells and in the brush border zone.

During this period, microstructural changes in the intestinal mucosa after gastrectomy using the Billroth II method and its Hofmeister–Finsterer modifications are manifested by pronounced edema and infiltration of the villous stroma by lymphocytes. A large number of lymphocytes are found among the epithelial cells. Villi deformation, lymphocytic infiltration, and destruction of some crypts are observed (see Fig. 2, b). The submucosal layer is markedly sclerotic. Due to compression of the lymphatic vessels, phenomena of lymphostasis occur, and the lacteals of the villi are also dilated. The lamina propria of the crypts and villi is infiltrated by lymphoid and plasma cells. Between the crypts, small areas of fibrous tissue can be seen, which may replace isolated groups of crypts. In these areas, villi are either absent or appear severely shortened.

In the muscular layer, dystrophic changes are observed, with small foci of round-cell infiltration and dilated blood vessels.

At later stages after the operation (using the Billroth I method and its modifications), signs of mucosal inflammation persist (edema, some hemodynamic disorders, as well as epithelial destruction). However, during this time, an increase in the size of villi and crypts is noted, the number of goblet cells decreases, the height of the columnar cells increases, and the brush border becomes thickened and distinctly outlined, especially in the surface epithelium. The submucosal layer is slightly edematous and shows focal infiltration by plasma cells. The ganglion cells of the nerve plexuses located in the submucosa and muscular layer are edematous, and their cytoplasm appears vacuolated.

After gastrectomy using the Hofmeister–Finsterer method, and especially the Polya–Reichel method, atrophy of the small intestinal mucosa is observed. The villi become noticeably shortened, and their tips become almost flat. Some villus tips appear deformed with club-shaped swellings. Certain villi are fused together, mainly in the apical region. Between the fused villi,

peculiar pockets form that contain mucus in which neutral glycosaminoglycans are detected. The number of goblet cells in the epithelium increases significantly, and they become larger. Focal hyperemia of the vessels persists, while cellular infiltration decreases.

Conclusion: Thus, the morphological remodeling of the lymphatic vessels in the intestinal wall is compensatory in nature and is aimed at maintaining hemostasis and microcirculation, as well as facilitating the transport of increased lymph production under conditions of venous stasis and interstitial edema of the intestinal wall — a condition that develops following acute trauma to the main vascular and neural structures of the stomach.

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