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Morphofunctional Features of the Structure of Gastrointestinal Tract Spincters

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Abstract: All sphincters of the gastrointestinal tract were divided into external and internal exercises, and both were divided into muscular and muscular-vascular ones. Musculo-vascular, in turn, were divided into musculo-venous and musculo-arterial. Musculo-vascular sphincters, due to the presence of peculiar venous structures in the submucosa or due to the significant density of arterial capillary networks, provide a better sealing of the lumen of the transition zones in comparison with simply muscle sphincters. The main structural sphincters are: a thickened circular layer of the muscular membrane, its uneven thickness around the circumference, the presence of an angle between adjacent organs, well-developed glands, lymphoid formations, vascular and intermuscular plexus; Morphologically, the sphincter of the alimentary canal is complex - a combination of education.

Keywords: sphincters, sphincter apparatus, vessels, mucous membrane, smooth muscles, transverse hairy muscle, sphincter system, veins, reflux, elastic fibers,Cajal cells.

It is known that the sphincter apparatus in the alimentary canal are functionally active zones that are extremely important in the regulation of the passage of food and chyme. Due to the presence of sphincters, the entire digestive tract is divided into separate cavities (oral cavity, stomach) or parts of one organ (intestine), which are characterized by their characteristic osmotic pressure, intracavitary pressure, microflora, participation in the mechanism of maintaining the constancy of the environment. By the definition of L.L. Kolesnikov (2008), the sphincter is a specially organized muscle tissue (smooth or striated) that allows you to regulate the size and / or duration of communication between the compartments (segments, parts) of a hollow organ. He notes that there are sphincters that are common in our understanding - these are specialized areas of the locking apparatus and sphincter compartments: within them, it is legitimate to distinguish between the pre-sphincter part, the sphincter itself and the post-sphincter part [1].

L.L. Kolesnikova in her works singles out "Sphincterology" - an actual and promising direction in biology and medicine, which substantiates the study of such a complex structure and function of the apparatus as the sphincter. All this raises the problem of studying the sphincters of the digestive system to a new level. This direction is very promising and is of great importance for theoretical and practical medicine.

According to Sachs F.F. (1994), all sphincters of the digestive tract allow the contents to move forward and prevent its reflux (reverse movement). He believes that the triggering mechanism for the development of many non-infectious diseases of the digestive system is a dysfunction of the sphincter apparatus. Therefore, the interest of various scientists in the study of the morphology and pathology of the sphincter apparatus does not diminish. The sphincters of the digestive tube play a leading role in regulating the movement of contents and are in the focus of attention not only of morphologists, physiologists, but also pathologists and clinicians [9], since they represent the sites of localization of inflammatory processes, ulcers and tumors.

The purpose of this work is to study the patterns and features of the organization, the structure and function of the sphincters of the gastrointestinal tract in humans and animals.

According to the definition of morphologists: the sphincter is a thickening of the circular layer of the muscular membrane, pulp, closing the lumen of a tubular organ [2]. According to the histological structure, all sphincters were divided into striated - rhabdosphincters and smooth muscle - leosphincters [3].

Recently, morphologists have been using a different concept - "sphincter apparatus". This term is used in his works by F.F. (1994) and L.L. Kolesnikov (2008), they counted about 35 sphincters within the digestive system. They also divided all sphincters of the digestive system into external and internal. The external sphincter is formed by extraintestinal musculature, which circularly covers the intestine at one length or another and, with its contraction, squeezes its lumen. The internal sphincter is an accumulation of circularly located muscle elements of the own

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muscular membrane of the digestive tube, which provides a regulated transit of food masses, has relative functional autonomy and performs an antireflux function.

F.F. Sachs believes that to a lesser extent, sphincters are built of striated muscle tissue. Most sphincters are composed of smooth muscles and have an involuntary action. Voluntary sphincters are innervated by somatic nerves from the brainstem or sacral spinal cord, while involuntary sphincters are innervated by the intramural nervous system. However, he denies the opinion of Cobine C.A., et all (2010) who proposed to divide all sphincters into anatomical and functional (physiological). F.F. Sachs argues that the functional sphincters, i.e. sphincters without a morphological basis do not exist [2].

L.L. Kolesnikov studied in detail the movement of the muscles in the area of the valves. They note that usually there are no isolated contractions of the muscles of the longitudinal and circular muscles [1]. F.F. Sachs clarifies that often within the digestive tract, longitudinal muscle fibers pass both in transit over the sphincter, and in their greater mass penetrate the circular muscles of the sphincter. Both those and other beams are helically crossed with each other. Therefore, their interaction provides not only contraction, but also sequential opening-narrowing of the lumen.

The most typical sign of a sphincter is the presence of a narrowed area of the lumen of an organ, combined with a thickening of the circular layer of its muscular membrane [10]. The location of the sphincter in relation to the longitudinal axis of the organ is more often oblique than transverse. The presence of an angle between two adjacent organs and a slit-like shape of the lumen is considered as the most important antireflux mechanism [11].

The unevenness of the wall thickness of the sphincters around the circumference was found, mainly due to the circular muscle layer. For example, in the area of the pyloric sphincter, the muscular membrane is significantly thickened along the greater and lesser curvature of the stomach. In the ileocecal sphincter, the fibers of the longitudinal muscle layer, spirally twisting, penetrate between the circular fibers, forming a ligature with diamond-shaped cells. It is believed that the spiral and longitudinal fibers are involved in the expansion of the lumen of the organ. The submucosa in the sphincter area is thickened in comparison with adjacent areas by 15–28% [12].

The coordinated tonic activity of these sphincters ensures the fulfillment of their functional task, which allows them to be grouped into the sphincter apparatus [15, 18].

In the human rectum, the longitudinal layer of the muscular membrane is distributed around the entire circumference and goes down to the upper edge of the internal sphincter of the anal canal. At this point, the rectum is significantly reduced in diameter. The muscle layers, covering it from the outside, sharply approach, and sometimes shift one relative to the other. The adjacent layers exchange muscular-elastic elements [18,13,14].

According to Ilyasov A.S. (2021) and Yukhimets S.N. (2010) with one side they touch the layers of the external sphincter, the other - the outer surface of the internal sphincter of the anal canal. A large number of elastic threads leave the surface of the rollers facing the internal sphincter. Elastic threads pass through the sphincter and come out to its surface, facing the intestinal lumen, where they are fixed on the muscular basis of the anal pillars. Elastic threads coming from the bottom of the ridges pick up the lower edge of the internal sphincter and rise from the bottom up to the same anal columns [17, 18].

It has been established that these threads are thrown over the lower edge of the internal anal sphincter from bottom to top and form into the intersphincter zone [13]. In the area of the anus, the inner layer of the muscular membrane thickens significantly - up to 50-70 mm, forming the internal sphincter of the anal canal. The internal sphincter in the distal direction is approximately 30 mm [16]. According to L.L. Kolesnikov the internal sphincter belongs to the leiomyosphincters of the digestive tract. Its formation occurs due to the compact stacking of thick layers of smooth muscles, passing both obliquely and circularly. Muscle bundles in it look like flat, wide ribbons, separated from each other by thin layers of connective tissue. In some places, especially in the lower part, they are penetrated by layers of longitudinal muscle bundles of the outer layer of the muscular membrane [22].

Around the internal sphincter is the external sphincter of the rectum, consisting of striated muscles, to which most authors attach a leading role in sealing the rectum [22, 14]. The fibers of the external sphincter cover the lower edge of the internal sphincter in such a way that the latter is, as it were, “included in the external” [15,13]. Their muscle elements are not only intertwined with each other, but also attached to the skin, to the tendon center of the perineum, and in men they are connected to the smooth muscles of the membranous part of the urethra. Some authors consider the external sphincter as a single muscle in contact with the pubic-rectal muscle [18].

There are also works showing that three muscle loops of this sphincter pass one into the other, attach not only to the pubic-rectal muscle, but also to the pubic bone, coccyx, organs and tissues of the perineum [19]. The most durable fixation, according to most authors, is created by the levator ani muscle, most of the fibers of which are firmly woven

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into the lower part of the rectum [21]. It was found that the beams m. levator ani are intertwined with the longitudinal bundles of the muscular membrane, then penetrating together with them into the layer between the external and internal sphincter [13,14]. But another opinion is Yamshchikov N.V. et al. (2003) the subcutaneous portion of the muscles in rats does not cover the internal sphincter. It is formed by bundles of muscle fibers that do not have a strictly circular orientation.

According to A.S. Ilyasov (2021), the length of the anal canal of the rectum averages 1625.6 ± 35.3 microns. During postnatal ontogenesis, a greater rate of increase in the length of the anal canal was noted from 11 to 16 days of development, which is associated with the transition from breastfeeding to definitive nutrition. In newborn rat pups, the length of the internal sphincter is 720.7 ± 25.0 μm. The length of the internal sphincter varies unevenly during the process of structural formation. The highest rates of increase in the length of the internal sphincter are detected at 6 and 11 days of age. By the age of 3 months, the rate of increase in the length of the internal sphincter decreases by 2 times in relation to the previous age. This is possibly due to its functional development.

In newborn rat pups, the length of the external sphincter is 324.8 ± 13.3 μm. During ontogenesis in the external sphincter, the rate of increase in its length is greater in comparison with the internal sphincter. The greatest increase in the rate of increase in the length of the external sphincter was noted at 22 days of age by 26.0%, more in comparison with the internal sphincter. This, apparently, is explained by the greater obturator function of the external sphincter.

The internal sphincter of the rectum is thicker in relation to the external sphincter, as a result of which it dampens the waves of peristalsis. In newborn rat pups, the external sphincter is 2.2 times shorter than the internal sphincter. In the process of development, the difference in length between the external and internal sphincters is reduced to 1.6 times at 24 months of age.

In the process of development, the muscular membrane of the sphincters of the anal canal of the rectum is differently formed. During the lactation period, the increase in the thickness of the muscular membrane of the external sphincter is more pronounced in the distal part. By 12 months, the muscular membrane of the external sphincter becomes thicker in the proximal part. The morphological boundary between the canal sections is the place where the fibrous structures of the connective tissue, rearranging in directions, begin to surround the bundles of myocytes. In our opinion, these bundles of myocytes unite the sphincter into a holistic anatomical formation, thereby, possibly, ensuring the synchronization of the work of the internal and external sphincters. In the intersphincter zone, differences in the structure of the epithelium and fibrous structures of the connective tissue were revealed. This is due to the fact that they are on the border between the anal canal and the external environment.

According to the Tomsk morphologist F.F. Sachs (1994), "the sphincter of the digestive system is an accumulation of circularly located muscular elements of the wall of the digestive tube with the presence of dilatator structures located in its transitional region, which performs an antireflux function and has functional autonomy."

The term "valve apparatus" includes sphincters as actuators, as well as receptor devices and a neuro-reflex arc. L.L. Kolesnikov (2008) divides all valve apparatuses into two large groups: areflux valves (with absolute barrier action) and antireflux valves (with relative barrier action). He refers to the first group of the large duodenal papilla and the ileocecal valve. They are located in the area of the T-shaped junction of the parts of the digestive tract and perform the barrier function most reliably. With any, even very significant, increases in intracavitary pressure in healthy people, they do not allow reflux. In the pharyngeal, cardiac, pyloric and duodenojejunal valve apparatuses, the leading functional elements are the reinforced bundles of the circular muscle layer.

Valve apparatuses provide the relative anatomical and functional autonomy of the digestive tract sections and thereby maintain the constancy of the environment in them. [eight].

The sphincter apparatus has its own auxiliary elements - folds of the mucous membrane, submucous veins. The latter, located above the sphincters, form large-capacity venous plexuses, which are a kind of "pillows" when opening and closing the sphincter [18]. But the muscle elements of the sphincters are not equally expressed everywhere. For example, the pyloric or anal sphincters are well pronounced, but the cardiac, bulbo-duodenal sphincters are worse. Above and below each sphincter, for some extent, receptors are concentrated in the mucous membrane of the digestive tract, forming reflexogenic zones. Irritation of the reflexogenic zone below the sphincter causes an increase in its tone, which excludes reflux [5,6].

The structural support of the sphincter device is currently distinguished by both macroscopic and microstructural originality. This must be taken into account when performing a surgical, X-ray or endoscopic examination [7]. In the literature, you can also find the term "sphincter system" [2], which includes muscle, myoepithelial elements and auxiliary sphincter mechanisms.

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The mucous membrane is characterized by a change in the relief and type of epithelium. In the area of the cardiac sphincter, the stratified squamous epithelium becomes a single-layer cylindrical glandular epithelium, forming a border strip. The epithelial junction can form lingual folds, displace in the proximal or distal direction. With age, it shifts from the stomach towards the esophagus. In the area of the pyloric sphincter, the epithelium changes and the formation of villi occurs more gradually. The mucous membrane of the cardiac and pyloric sphincters forms 6-10 folds, the height of which increases with age. Low folds are located between high folds. This form of folds allows the sphincter to tightly close the lumen of the esophageal and pyloric openings [11,12].

In the area of the ileocecal sphincter, the possibility of reflux is prevented by the presence of a mucous-muscular rosette formed due to eversion of the distal part of the ileum into the large intestine. In this case, the circular layer of the muscular membrane of the ileum and colon merges and stretches between the mucous membranes, forming an "intermucosal" muscle layer [9,10]. In the area of the specified sphincter, villi are lost, the height of the border decreases, and the content of goblet cells, the density of crypts, on the contrary, increase by 1.2-1.3 times in comparison with the adjacent extra-sphincter zones. The proper layer of the mucous membrane of the studied sphincters contains intramural glands of a tubular structure. The branching of the end sections of the glands is observed after one month of age, which is associated with a change in the nature of nutrition. The development of glands in the sphincter area provides additional protection of the mucous membrane from increased friction from the content [10,12].

Author M.D. Levin et al. (2010) and S.D. Denisov (2013) describes the relief of the duodenal mucosa during X-ray examination, and notes additional protrusions of the intestinal mucosa, as a result of the contraction of muscle fibers - these are functional sphincters.

According to M.D. Levin et al. (2010) and M.E. Levin et al (2016) the Kapanji sphincter is located in the middle third of the descending part of the duodenum, and in the horizontal part of the intestine, the Oksner sphincter is found, covering the confluence of the common bile duct. The author emphasizes both the variability of the location of the same structures in different experimental subjects and the divergence of research methods, which do not have a single algorithm for their interpretation [24, 25]. The upper esophageal, ileocecal, and other sphincters were classified as muscle-venous sphincters.

The presence of developed vascular plexuses was noted in the sphincter zones. According to F.F. Saks and V.F. Baitinger et al., An additional venous capacity is formed here, which plays the role of "pillows" during their work [2, 28]. The wall thickness of the gastric sphincters over the studied age period from birth to two years increases by 5–6 times, and that of the ileocecal wall by 7 times, mainly due to the thickening of the circular muscle layer.

In the distal part, at the level of the middle of the internal sphincter, the anal columns are connected by folds of the mucous membrane. The latter are called Ball's anal flaps. The muscular layer of the mucous membrane at the level of the anal valves even forms a separate muscle - m. mucosae ani. serves as a ligament [23] that supports the mucosa, and the muscle fibers present here belong to the internal sphincter.

In particular, the veins are located in the columns of the rectum in several layers: the cuts are smaller and predominantly oriented longitudinally. The largest veins (up to 1-2 mm and more) lie directly near the muscular membrane. In addition, they form a vascular ring in the anus. The superior rectal vein is the main pathway for the outflow of venous blood. Its lower branches originate in the venous submucosal plexuses that form the ridges of the columnae rectales directly above the anus [21].

Repeatedly in the literature it is indicated that the venous formations existing here can expand, turning into hemorrhoids. Around these venous plexuses, the Treitz muscle (m. Rectococcygeus) forms a network of connective tissue. In newborns, these enlargements are never observed, but they are constantly found in adults [15,16]. Their appearance is caused by an increase in pressure on the veins from the veins of the portal system. All of these extensions form a ring directly above the anus (anulus rectalis). The veins of the anal part of the rectum in white rats are similar to those in humans. The only difference is that in the former the veins in the area of the hemorrhoidal ring are thin tortuous, while in humans the veins in this area are of a classically distinct shape [17, 18, 19].

Coordinated filling and drainage of the vascular plexus of the anal canal is ensured by the “sphincter” mechanism inherent in the vessels. The muscle tissues of the sphincter apparatus of the rectum have their own sources of development and direction of differentiation. There are no interstitial transformations between them both in embryogenesis and in postnatal development. This indicates the determinism and specificity of the properties of these tissues [19, 22]. Detailed knowledge of the anatomically complex vascular architecture of the small pelvis is mandatory for surgeons of several specializations (surgeon, proctologist, gynecologist, urologist) and for understanding the fundamental mechanisms of both anorectal and urogenital dysfunctions [21]. Both morphological and functional damage to the vascular system of this area can contribute to the development of hemorrhoidal disease [20].

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According to Horiguchi K. (2003), Cajal cells are not just automatic organizers of the sphincters, but also mediators between smooth muscle and neural effector cells. Organizing the peristalsis of the digestive tract as a whole, forming individual networks in the structure in different organs, they form thickening loci, which are topographically connected with the sphincter zones. Moreover, the relative autonomy of Cajal networks in the longitudinal and circular layers of tubular organs has been proven, which allows modulating the isolated slow-wave and fast-wave intestinal contractile activity. features in the distribution, density and ultrastructure of Cajal cells in the anorectal zone in dogs, a thickening of Cajal cells in the circular layer of the sphincter are noted. These cells can be pacemakers, while their limited relationship to nerves suggests that they are not involved in neuromuscular transmission [4]. All this leads to the conclusion that the Cajal cell networks should be considered as an integral part of the "sphincter apparatus" along with all components: muscle tissue, nerve regulatory centers, auxiliary structures (folds and flaps) [4,5].

The studies of A.S. Ilyasov and Turaeva F.S. (2021) showed that lymphoid formations in the rectum of the pre-sphincter region and the transitional zone of the organ are presented in the form of chains and diffuse accumulations of lymphocytes. From 3 months, lymphoid nodules form in the pre-sphincter region. In the transition zone, they are detected later by the 6th month. In the internal sphincter, diffuse lymphocytes are detected. In the intersphincter zone, small accumulations of lymphocytes were noted. In the formation of the local immune system of the rat anal canal, stages can be traced. At the initial stages, diffuse lymphoid tissue is detected. With age, diffuse lymphoid tissue thickens in the form of lymphoid nodules. In the intersphincter zone, differences in the structure of the epithelium, lymphoid formations and fibrous structures of the connective tissue were revealed. This is due to the fact that this zone is located on the border between the anal canal and the external environment.

According to modern literary sources, dysfunctional disorders of the sphincters of the digestive system are isolated as a separate pathology of the biliary tract. Violation and loss of the motor-tonic, evacuation function, dyskinesia of the sphincter apparatus are a predictor of a number of diseases - peptic ulcer and duodenal ulcer, chronic duodenal obstruction, reflux gastritis, inflammation of the intestines, diverticula of the duodenum and intestines. Various endogenous and exogenous risk factors are involved in the occurrence of gastrointestinal dysfunction, which affect different levels of protection of the digestive tract - mucus production, the ability to neutralize the acid of the duodenal contents and inhibit peptic conversion, impairment of blood supply and regeneration of the epithelium of the organ mucosa. [27.28].

Based on the literature data, the following conclusions were made:

1. the main structural features of the studied sphincters are: a thickened circular layer of the muscular membrane, its uneven thickness around the circumference of hollow organs, the presence of an angle between adjacent organs, well-developed glands, lymphoid formations, vascular and intermuscular plexus;
2. the wall thickness of the sphincters increases with age: cardiac - by five, pyloric - by six, ileocecal - by seven times, respectively, mainly due to the circular muscle layer;
3. the most intense morphological changes occur in the early postnatal period.
4. Cajal cells should be considered as a non-atomic part of the sphincter apparatus.
5. Морфологически сфинктере пищеварительная канала это комплексно – комбинирование образование.

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