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Original Research Article

Formation of a Hepato-Pancreas Ampulla in some Lizards

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ABSTRACT:
Principles of formation of the hepato-pancreas ampulla of the duodenum in some lizards are proposed. The morphometric indicators of the ratio of the cavity of the common bile duct and the pancreatic duct are presented. Morphological details in the structure of the hepato-pancreatic ampulla are not entirely understandable at the moment. The data available in the available literature are not always correct, more often contradictory. Most of the studies have been performed on laboratory animals. Therefore, the study of its structure, the formation of the internal relief in reptiles in connection with the peculiarities of their nutrition allows us to solve some problems of theoretical and applied histology. These studies will further help to solve the problems of modeling some biological processes.

Keywords: *Formation, Hepato-Pancreas Ampulla, Duodenum, Reptiles, Lizards, Ducts, Cavities, Liver, Pancreas*

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INTRODUCTION

Unlike many other organ systems, the specificity of the digestive system is such that we have to talk about its direct contact with elements of the external environment, for example, with food. Therefore, it seems quite natural that researchers tried to find an explanation for the morphological diversity of the organs of the digestive system primarily in the characteristics of nutrition. Such a connection was found by anatomists of the late 19th - early 20th centuries and is presented in many large summaries on comparative anatomy and morphology. They come down, ultimately, to the statement of typical features in the structure of the digestive system of carnivores and omnivores, on the one hand, and herbivores, on the other (Naumov, 1982).

The object of our study, the hepato-pancreatic ampulla, is located in the upper part of the small intestine. The section of the small intestine is the longest: it starts from the pylorus of the stomach and extends to the cecum. It forms many arcuate loops with convex, free and concave curvature, to which the mesentery is attached.

The hepato-pancreatic ampulla occupies a central place in the duodenocholedochopancreatic zone of the alimentary canal. It opens the common bile and pancreatic ducts, which contain the main digestive enzymes, without which digestion in the small intestine is unthinkable. The function of the hepato-pancreatic ampoule is not only to collect bile and pancreatic juice, it is a "physiological mixer" (Dexkanov, 1990) of these juices, promotes portioned release depending

on the amount of chyme entering the duodenum from the stomach. In addition, in the area of the hepato-pancreatic ampulla, the main sphincters are localized: the own sphincter of the common bile duct, the own sphincter of the pancreatic duct, the mouth sphincter of Westphal, together they form the sphincter of Oddi, which work in conjunction and strictly coordinated depending on digestion (Gorshkova & Kurcin, 1967; Klimov, 1969) and from the periodic activity of the alimentary tube.

The results obtained are of great theoretical importance for substantiating the role and significance of the gallbladder for the body. An equally urgent issue is the study of the issue of the relationship between the muscular membranes of the hepato-pancreas ampoule with that of the duodenum, on which there are different, often opposite points of view. In the available literature, studies of this kind were carried out on representatives of mammals (Allanazarova, 2010; Allanazarova & Adelova, 2016; Dexkanov & Axmedov, 2002), on some birds (chickens) (Allanazarova & Shakirova, 2005); on laboratory mammals (Sadullaeva, 2006); on fish and amphibians (Allanazarova, 2018). Most of them are the work of the author and his students.

In numerous reptiles widely spread over land, in contrast to amphibians, there is a large differentiation of the digestive tract, which makes it possible to make fuller use of the animal prey that has come across. The intestine is clearly subdivided into the longer small intestine and the relatively short colon. On the border of the small and large intestine is an underdeveloped cecum, which is absent in amphibians. A large reptile liver has a gallbladder. The pancreas in the form of a long, dense body lies in the loop of the duodenum. The ducts of the liver and pancreas open into the initial section of the small intestine - the duodenum (Kuznecov, Chernov & Katonov, 1989; Naumov & Kartashov, 1979).

It should be noted that in the majority of works devoted to the study of the internal relief of the hepato-pancreatic ampulla, stereoscopic studies of the opened ampoule were used (Edemskiy & Svitcev, 1986), in which the integrity and architectonics of a complex ensemble of valves were violated. In order to study the structural components of the wall, the relief of the mucous membrane and the microarchitectonics of the valves of the ampoule, we carried out serial sections of the material along its entire length, while a piece of the wall was always planted in the block with the mouth of the ampoule down.

MATERIALS AND METHODS

The material for the study was the organo-complex of the duodenum of the agama and the yellow-bellied, including the end sections of the common bile and pancreatic ducts. When performing the work, we used classical methods of research in histology. The material was fixed in 12% neutral formalin. The filling of the material into paraffin was carried out according to the generally accepted method. Sections were stained with hematoxylin-eosin using the Van Gieson and Mallory technique (Eliseev, 1967). A consistent study of the sections made it possible for us to trace the mechanism of the formation of the ampoule and trace the microrelief of the mucous membrane along its entire length. The diameter of the ducts, the thickness of the membranes and layers of the ampulla of the large duodenal papilla and its components were measured using an eyepiece ruler inserted into the eyepiece of a light microscope. Studied by the method of sequential (serial) histotopographic sections, every 10 sections, 4 sections were mounted on a glass slide. The whole block was cut.

Sequential study of serial sections made it possible to study in detail the process of formation of the hepato-pancreas ampulla of the reptile duodenum. In the same way, the internal relief of the ampoule, the structure and microarchitectonics of its flaps and folds were studied.

RESULTS

The food for reptiles, as well as the methods of obtaining food, are very diverse. Real lizards (Lacertilia) feed on beetles, arachnids and molluscs. Molluscs form the basis of the diet of the yellow slider. Herbivorous reptiles are less common.

The duodenal wall of the agama (Agama lehmanni) consists of the mucous membrane, submucosa, muscular and serous

membranes. The epithelial cover of the mucous membrane is represented by a single-layer columnar epithelium. The thickness of the epithelial cover ranges from 16.4 to 32.8 microns, on average 24.6 ± 1.7 microns. The mucous membrane of the duodenum of the agama has long, slender villi, in which the apex and base have the same width. The crypts are relatively shallow, with a narrow base and a wide aperture. The epithelium is single-layered, cylindrical, edged, and has a relatively small number of goblet cells. The proper lamina of the mucous membrane smoothly passes into the submucosa, which is formed by the fibrous structures of the connective tissue. The thickness of the submucosa is 65.6 to 98.4 microns, on average 82 ± 3.5 microns. The submucosa is rich in cellular elements and contains a small amount of mucous-protein glands. The muscular membrane of the duodenum consists of two layers: the inner layer of circularly located smooth muscle fibers and the outer layer of longitudinally directed fibers of smooth muscle tissue. The inner muscle layer is relatively thick compared to the outer layer. The thickness of the muscular membrane averages 237.8 ± 11.5 microns, while the total thickness of the duodenal wall averages 344.4 ± 13.2 microns. The serous membrane is relatively thin and consists of loose connective tissue that contains a large number of blood vessels.

Table 1: Morphometric indicators of digestive ducts and duodenum of agama (microns)

	Total wall thickness	Muscular membrane	Submucosa	Epithelial cover	Inner diameter
Duodenum	270.6 - 393.6 344.4 ± 13.2	180.4 - 287.0 237.8 ± 11.5	65.6 - 98.4 82.0 ± 3.5	16.4 - 32.8 24.6 ± 1.7	-
Common bile duct	278.8 - 352.6 319.8 ± 7.9	188.6 - 246.0 221 ± 6.1	57.4 - 90.2 73.8 ± 3.5	16.4 - 32.8 24.6 ± 1.7	954.1 - 629.3 751.1 ± 20.1
Pancreas duct	360.8 - 426.4 393.6 ± 7.0	262.4 - 295.2 278.8 ± 3.5	73.8 - 114.8 90.2 ± 4.4	16.4 - 32.8 24.6 ± 1.8	466.9 - 609.0 548.1 ± 8.8
Hepato-pancreatic ampoule	-	114.8 - 196.8 155.8 ± 8.8	32.8 - 65.6 49.2 ± 3.5	16.4 - 32.8 24.6 ± 1.7	832.3 - 609.0 730.8 ± 13.8
Interductal septum	-	196.8 - 246.0 221.4 ± 5.3	-	-	-

The pancreatic duct and common bile duct are located along the duodenal wall. First, they walk a certain distance apart from each other. Then their fusion is observed, and a common hepatic-pancreas duct is formed, which appears in the intestinal lumen and has, on one side, a common wall with the wall of the duodenum. The wall of the pancreatic duct consists of the mucous membrane, submucosa, muscular and serous membranes. At the confluence of the pancreatic duct with the common bile duct, the diameter of the lumen of the pancreatic duct averages 548.1 ± 8.8 microns. The mucous membrane of the pancreatic duct is covered by a single-layer columnar epithelium. Its thickness is 24.6 ± 1.8 microns. The mucous membrane forms small folds; they are shorter and wider than in the duodenal mucosa. The thickness of the submucosa of the pancreatic duct ranges from 73.8 to 114.8 microns. The muscular membrane of the pancreatic duct is represented by two layers: an internal circular and an external longitudinal. Myocyte bundles of the longitudinal layer are located obliquely with respect to the circular layer. The thickness of the muscular membrane of the pancreatic duct is greater than the thickness of the muscular membrane of the duodenum and is on average 278.8 ± 3.5 microns. The thickness of the wall of the pancreatic duct also prevails over the thickness of the duodenal wall and is 393.6 ± 7 microns.

The common bile duct is located between the lumen of the duodenum and the pancreatic duct. Its diameter is larger than the diameter of the pancreatic duct. The mucous membrane of the common bile duct forms folds, which are larger in height and width than the folds of the mucous membrane of the pancreatic duct. In some areas of the mucous membrane of the common bile duct, the width of the folds is greater than that of the folds of the duodenal mucosa. The single-layer columnar epithelium of the mucous membrane in thickness ranges

from 16.4 to 32.8 microns, on average 24.6 ± 1.7 microns. In most parts of the common bile duct, the submucosa and the muscular membrane are thinner than in the pancreatic duct. The muscular membrane of the common bile duct is formed by the circular muscle layer. In the sections of the duct wall adjacent to the duodenum, it is seen how the bundles of duodenal myocytes and the common bile duct are connected.

As mentioned above, the common bile duct is located in relation to the duodenum longitudinally and directly adjacent to it. The pancreatic duct is located laterally and behind in relation to the common bile duct. Gradually, as it approaches the ampulla, the pancreatic duct begins to shift anteriorly and is located laterally from the common bile duct. Near the hepato-pancreas ampulla of the duodenum, the pancreatic duct bends from the outside to the inside. In these areas, it runs transversely and obliquely in relation to the common bile duct. On transverse sections, one wall of the pancreatic duct is much thicker, which indicates its oblique location. At this stage, bundles of circular myocytes of the common bile and pancreatic ducts begin to connect. The pancreatic duct begins to penetrate into the wall of the common bile duct at an acute angle and as it deepens, its lumen narrows at the beginning and then expands. In the mucous membrane of the pancreatic duct at the confluence with the common bile duct there are large folds. Apparently they function as valves. In the wall of the former united (hepato-pancreatic) duct, bundles of circular myocytes of both ducts are connected. The lumen of the formed hepatic-pancreas duct is elongated, oval in shape with a valve-like structure in the middle of the duct. The mucous membrane of this duct from the side of the pancreatic duct forms folding. Then there is a gradual departure of the pancreatic duct from the formed combined duct, and between them an interductal septum is formed from circular muscle fibers. Its thickness ranges from 196.8 to 246 microns, which on average is 221.4 ± 5.3 microns (Table 1).

The ampulla of the large duodenal papilla is formed from the combined hepato-pancreas duct. In the formation of this ampoule, the wall of the common bile duct from the side of the duodenum takes most of it. The form of the formed hepato-pancreas ampulla is round, with a diameter of 730.8 ± 13.8 microns. Its wall is thick, with a well-developed muscular membrane. The thickness of the muscular membrane is 155.8 ± 8.8 microns. The bundles of circular myocytes in the sections of the ampulla wall adjacent to the duodenal wall are connected to the bundles of myocytes of the circular layer of the duodenum. The mucous membrane has "villous" low, branched outgrowths. The submucosa, having a height in the range from 32.8 to 65.6 microns, on average 49.2 ± 3.5 microns, forms folds large in thickness. The single-layer columnar epithelium of the ampulla mucosa has the same thickness as in the ducts. In the thickness of the ampulla wall, in the muscle and submucosa, there are many blood vessels. In the lumen of the duodenum, the ampulla opens with the mouth in the form of a slit-like space, which, as it opens, expands and opens, looking like a slingshot. At first, this gap, both from the side of the duodenum and from the side of the ampulla, is limited by large folds of the mucous membranes, but then the mouth of the ampoule increases. The “shoots of the slingshot”, gradually shortening, disappear. As it decreases, the wall of the hepato-pancreas ampulla is delimited by the wall of the duodenum and the ampulla gradually decreases (Fig. 1).

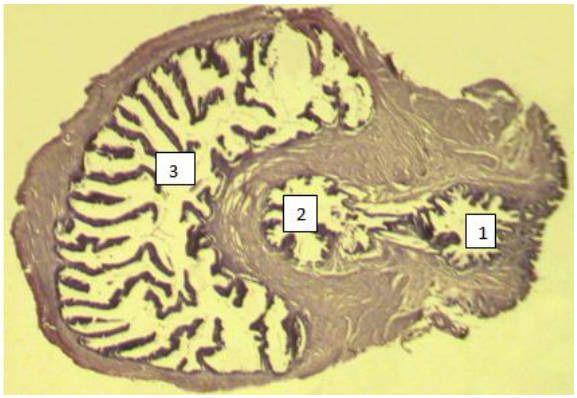

Figure 1: Micrograph of the initial stage of the fusion of the common bile (1) and pancreatic (2) ducts into the common one before penetration into the wall of the duodenum (3) of the agama

The duodenal lumen has a two-chambered appearance at the confluence of the common hepatic-pancreas duct. The hepatic-pancreas duct, going parallel to the intestine, is located in the thickness of the intestinal wall. The duct wall, having a thickness ranging from 410 to 492 microns, on average 442.8 ± 8.8 microns, consists of the mucous membrane, submucosa, muscular and serous membranes. The mucous membrane of the duct is formed by a single-layer columnar epithelium, has goblet cells. The cells of the single-layer columnar epithelium are tightly adjacent to each other. The nuclei of epithelial cells, which have a rounded oval shape, are located in the basal part of the cell. The height of the epithelium ranges from 24.6 to 41 microns, on average 32.8 ± 1.7 microns. In the lamina propria of the mucous membrane of the duct, glands lie. The glands located closer to the submucosa have a larger lumen. The mucous membrane of the duct forms wide folds. Branched villi are visible on the cross section of the duct. The submucosa of the duct is formed by the fibrous structures of the connective tissue. The thickness of the submucosa of the duct is from 114.8 to 164 microns. In the submucosal base of the duct, there are branched muco-protein glands with a predominance of mucous end sections. They open into the lumen of the duct. The muscular membrane of the duct consists of two layers of smooth muscle tissue: inner - circular and outer longitudinal. The inner layer of the muscular membrane is thicker than the outer one. Between the layers of the muscular membrane there are layers of connective tissue, in which the blood vessels of the muscular membrane are located. The bundles of myocytes of the longitudinal layer in relation to the circular layer lie transversely and obliquely. The thickness of the muscular membrane of the duct ranges from 229.6 to 303.4 microns and averages 270 ± 7.9 microns.

The duodenal wall of the yellow-bellied (Ophisaurus apodus), like the bile-pancreatic duct, consists of four membranes: mucous membrane, submucosa, muscular and serous membranes. The epithelial cover of the mucous membrane of the duodenum, as well as in the duct, is represented by a single-layer columnar epithelium, has a small number of goblet cells. The nuclei of epithelial cells are spindle-shaped, and lie closer to their base. The height of the epithelial cover in the mucous membrane of the duodenum does not differ from the height of the epithelium in the duct and averages 32.8 microns. The mucous membrane of the duodenum forms crypts and villi. Most of the villi at the apex and in the middle are wider than at the base. The crypts are not deep, with a wide aperture, which gives the shape of a bowl. The submucosa of the duodenum is loose, formed by fibrous structures of connective tissue, and contains many blood vessels. The thickness of the submucosa varies on average from 65.6 ± 3.5 microns on the lateral side of the duct to 57.4 ± 3.5 microns on the opposite side of it. In the duodenum, the thickness of the submucosa is less than in the duct, and is 139.4 ± 5.3 microns. The muscular membrane of the duodenum consists, as in the duct, of two layers: the inner - circular and outer - the longitudinal layers. Between these two layers of the muscular membrane, the connective tissue layer is well developed. The outer longitudinal layer has a wavy appearance and forms a fold. The bundles of myocytes of the longitudinal

layer have a smaller thickness than the bundles of myocytes of the circular layer and are located in relation to it transversely or obliquely. The thickness of the muscular membrane is not the same throughout the duodenal wall. So the thickness of the muscular membrane on the side of the duct varies on average from 287 ± 5.3 microns to 311.6 ± 5.3 microns, and on the opposite side of it averages 303.4 ± 3.5 microns.

The duodenum has the smallest wall thickness on the opposite side of the duct, which subsequently forms the ampulla. The thickness of the septum separating the duct from the duodenum varies from 184.5 to 246 microns. Compared to the wall of the duodenum and the duct itself, the septum between them has a smaller thickness. The monolayer columnar epithelium covers the septum from both the duodenum and the duct. Its thickness from the side of the duodenum is slightly greater than from the side of the duct. The submucosa on both surfaces of the septum is formed by fibrous structures of connective tissue. It varies from 20.5 to 36.9 microns, on average 28.7 ± 1.7 microns. From the side of the duodenum, it ranges from 41 to 65.5 microns. The muscular membrane of the septum between the duct and the duodenum is formed by the muscular lamina of the duodenal mucosa. In it, the bundles of myocytes lying in the lateral parts of the septum are located transversely or obliquely. The bundles of myocytes in the middle part of the septum have a circular direction. The thickness of the muscular membrane of the septum is on average 53.3 ± 2.6. On the outside, the intestinal wall is covered with a serous membrane, consisting of connective tissue (Table 2).

Table 2: Morphometric indicators of digestive duodenal ducts and duodenum yellow-bellied (microns)

		Total wall thickness	Muscular membrane	Submucosa	Epithelial cover	Inner diameter
Duodenum	Lateral left side	360.8 - 451.0 401.8 ± 9.7	287.0 - 336.2 311.6 ± 5.3	41.0 - 82.0 65.6 ± 4.4	24.6 - 41.0 32.0 ± 1.7	-
	Lateral right side	336.2 - 426.4 385.4 ± 9.7	262.4 - 311.6 287.0 ± 5.3	49.2 - 82.0 65.6 ± 3.5	24.6 - 41.0 32.0 ± 1.7	-
	Side opposite to the duct	360.8 - 418.2 393.4 ± 5.3	287.0 - 319.8 303.4 ± 3.5	41.0 - 73.8 57.4 ± 3.5	24.6 - 41.0 31.8 ± 1.7	-
Common hepato-pancreas duct		410.0 - 492.0 442.8 ± 8.8	229.6 - 303.4 270.6 ± 7.9	114.8 - 164.0 139.4 ± 5.3	24.6 - 41.0 31.8 ± 1.7	-
Hepato-pancreatic ampoule		94.3 - 135.3 114.8 ± 4.4	53.3 - 82.0 69.7 ± 3.0	24.6 - 36.9 30.3 ± 1.3	12.3 - 20.5 16.4 ± 0.8	1116.5 - 1238.3 1177.4 ± 7.5
The septum between the hepato-pancreas duct and the duodenum		184.5 - 246.0 215.3 ± 6.6	45.1 - 110.7 73.8 ± 7.1	-	-	-

Gradually, the septum between the duodenum and the duct bends towards the duodenal lumen. The intestinal lumen begins to flatten. The middle part of the septum becomes thinner. The septum itself is gradually extended into the lumen of the duodenum. The sides of the septum form the walls of the ampoule. Even in an unopened state, the hepato-pancreas ampoule has an irregular rounded shape. Its diameter averages 1177.4 ± 7.5 microns. The ampoule wall thickness ranges from 94.3 to 135.3 microns. The muscular membrane of the wall consists of circular bundles of myocytes formed by the muscle fibers of the septum between the duct and the duodenum. The thickness of the muscular membrane of the ampoule varies from 53.3 to 82 microns, which averages 69.7 ± 3 microns.

Inside the hepato-pancreas ampulla, the mucous membrane forms folds that are smaller in height and width than folds in the duct and villi in the duodenum (Fig. 2). The mucous membrane of the greater papilla is covered by a single-layer columnar epithelium. Its thickness is slightly less than in the intestine and in the

duct and is equal to 16.4 ± 0.8 microns. The submucosa is 30.3 ± 1.3 microns. In the open state, the ampulla of the large duodenal papilla has the shape of a flask with a narrow neck. The lumen of the ampulla narrows towards the mouth. The lateral parts of the septum in the open state of the greater papilla perform the functions of the valves of the valve apparatus, preventing the penetration of the contents of the duodenum into the ampulla of the greater papilla.

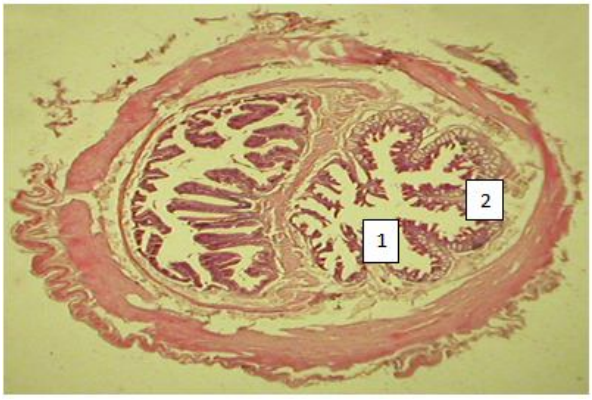

Figure 2: A micrograph of the cavity of the ampulla of the yellow pus, which is divided into many chambers (1), the mucous membrane forms folds, branched outgrowths (2).

CONCLUSION

Thus, the shape and volume of the hepato-pancreatic ampulla depend on the level of confluence of the common bile duct and the pancreatic duct. So in the agama it has an oval cavity with a slit-like mouth, and in the yellow-bellied it is flask-shaped with an elongated mouth in the form of a neck. The internal structure, the volume of the hepato-pancreas ampulla of the duodenum in the animals studied by us have their own characteristics, which are influenced by the feeding habits of these animals, despite the fact that they belong to the same order of lizards. In the yellow-bellied**,** the cavity of the ampoule is divided into many chambers, the mucous membrane forms folds, branched outgrowths. A large number of glands lie in the lamina propria of the ampulla mucosa. In our opinion, these structural features of the ampulla of the greater papilla are associated with the fact that the yellow-bellied is both an insectivorous and carnivorous animal. As mentioned above, it feeds on various insects, mollusks occupy a significant place in its diet, and it often eats small vertebrates - lizards, small snakes, rodents, eggs and chicks of birds nesting on the ground. Agama, like the yellow-bellied, belonging to the same order of reptiles - lizards, differs from it in the type of food, being an insectivorous animal. All kinds of insects, spiders and wood lice serve as its main food. But it is not strictly an insectivorous animal, as it sometimes eats juicy parts of plants, in particular, flowers of plants. The internal structure of the ampulla of the greater duodenal papilla of the agama differs somewhat from that of the yellow-bellied**,** while having more similarities than differences in comparison with the ampoules of other animals studied by us. The ampulla of the agama also has folds, outgrowths dividing it into lobes, but they are less pronounced than in the ampulla of the yellow-bellied. Its ampulla also differs in that all its ducts have the same size of the integumentary epithelium. The wall of the ampulla of both lizards has a well-developed muscle layer.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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