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Morphological study of the pancreatic duct system in chinchilla (*Chinchilla laniger* Molina)

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Summary

The aim of the investigation was analysis of the morphology of the pancreatic duct system in chinchilla. Investigation was carried out on twenty adult individuals of either sex. Macromorphological studies of pancreatic duct system were performed using colored latex. The histological studies were performed paraffin slides with H&E staining method. Photography documentations were prepared using a Nikon Digital Sight SD-L1 System. The pancreas in this species is formed of three irregular flattened parts or lobes. The main accessory duct was not observed. The accessory pancreatic duct was the only duct to drain pancreatic secretion into the duodenum on the minor duodenal papilla. The histological structure of these ducts does not differ from the general scheme. The investigation demonstrated significant anatomical variability of the pancreatic duct system in chinchilla which is not always accurately described in literature.

Keywords: pancreas, ductal system, chinchilla

The pancreas is an important organ that allows digestion of proteins, fat, and carbohydrates and, moreover, regulates the sugar level in the blood. The exocrine part of the pancreas forms 80% of its mass. The microscopic view is similar in most mammals. It consists of a well-developed system of pancreatic ducts.

Glandular epithelial cells form secretory acini containing flat or low cuboidal centroacinar cells lining the vesicles on their inner side. The centroacinar cells form the intra-acinar component of the intercalated duct lined by a simple cuboidal epithelium. The intercalated ducts connect into larger intralobular and interlobular ducts lined with simple cylindrical epithelium of increasing height. Interlobular ducts join together to form the pancreatic duct. The pancreatic duct is lined by a tall columnar epithelium containing a number of mucin-secretory goblet cells. A compact layer of connective tissue surrounds all pancreatic ducts. The thickness of this layer is reduced as the diameter of the ducts decreases. The intercellular tight junctions (occluding junctions) between the centroacinar cells, secretory cells, and epithelial cells of all types of pancreatic ducts are very important in preventing leaks from the duct system.

Enzymes produced in pancreatic acinar cells are released into a solution rich in carbohydrates, which flows into the pancreatic duct system and joins the duodenum through the major duodenal papilla or the minor duodenal papilla (in a different configuration). Integration of the pancreatic duct system is essential to prevent penetration of exocrine enzymes into the pancreatic parenchyma, where they may be activated, causing tissue damage which can lead to pancreatitis.

Investigation of the topography of the distal part of the pancreatic ducts has distinguished three basic structure types (13). In the first type, the common bile duct and the pancreatic duct join with each other (as in deer, goat, sheep, and rat). In the second type, both ducts run separately but merge together in Vater's papilla (as in human, dog, cat, and horse). In the third type, the pancreatic duct and the common bile duct enter the duodenum separately. This type has been observed in prairie dog, pig, rabbit, and guinea pig (1, 6, 8, 23). The anatomy of the pancreas is relatively better known in most laboratory animals than in other animals. The chinchilla often is used as an animal model for studies related to the dysfunction of the otitis media (14), pregnancy (16), the digestive system, and pneumonia

(27). There is however a lack of detailed data on the morphology of the pancreatic ducts due to the atypical development of these structures in this species. The aim of our investigation was analysis of the morphology and topography of the pancreatic duct system in chinchilla. Our study points to the presence of the third type of pancreatic duct system in this species; there is only the accessory pancreatic duct, which opens onto the minor duodenal papilla.

Material and methods

Our investigation was conducted on twenty adult chinchilla individuals (*Chinchilla laniger* Molina), of both sexes (9 ♀, 11 ♂). The animals were collected from a chinchilla breeding professional reproductive farm (E-012 Skoki 69A) and were killed for fur by qualified personnel according to the Polish law. As soon as possible after slaughter, the abdominal cavity was opened, and a cannula was inserted into the distal part of the accessory pancreatic duct. The pancreatic ducts were filled with pigmented (Pigment-Mix, INCHEM, Poland) acrylic latex (LBS 3060 Synthos Dwory, Poland) and material was fixed for 12 h in 10% acidified formalin solution. Histological investigations were performed after fixating tissues in 4% buffered formalin, dehydrated through ascending grades of alcohol, cleared in xylene, and embedded in paraffin (Paraplast plus), cut with a microtome (Microm 325, Zeiss) for 5 µm slides, stained according to the routine hematoxylin and eosin (H&E) method. Photographic documentations were performed using a Nikon Digital Sight SD-L1 System (Japan).

Our results were interpreted in line with the veterinary anatomical and histological nomenclature guidelines (21, 22). The study was approved in accordance with the Polish Act of 15 January 2015 on the "Protection of Animals Used for Scientific or Educational Purposes" (studies of tissues obtained postmortem do not require the approval of the Ethics Committee).

Results and discussion

The chinchilla pancreas extends to the right from the hilus of the spleen to the pylorus, where it then bends at a right angle as the head of the pancreas (the duodenal part) runs along the duodenal loop towards the bend of the caudal duodenum (Fig. 1, 2). A thin connective tissue capsule macroscopically observed within the mesentery surrounds the pancreas. The chinchilla pancreas has a lobular structure with a dispersed arrangement (though to different degrees) forming a flattened leaf-shaped organ. The small amount of the connective tissue among the lobules increases in the presence of excretory ducts, blood vessels, nerve fibers, and neurocytes of the autonomic nervous system.

The chinchilla pancreas is formed of three irregular lobes covered by folds of mesentery and adipose tissue, which makes it difficult to recognize them in the fresh material. By analyzing their position relative to the abdominal organs, a duodenal part (the head of the pancreas), a gastric part (the body of the pancreas), and a splenic part (the cauda of the pancreas) were

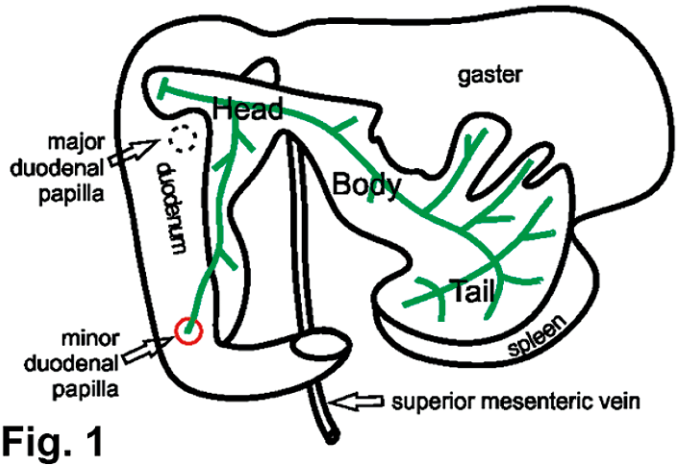

Fig. 1. Scheme of pancreatic duct system (PDS) – author's drawing

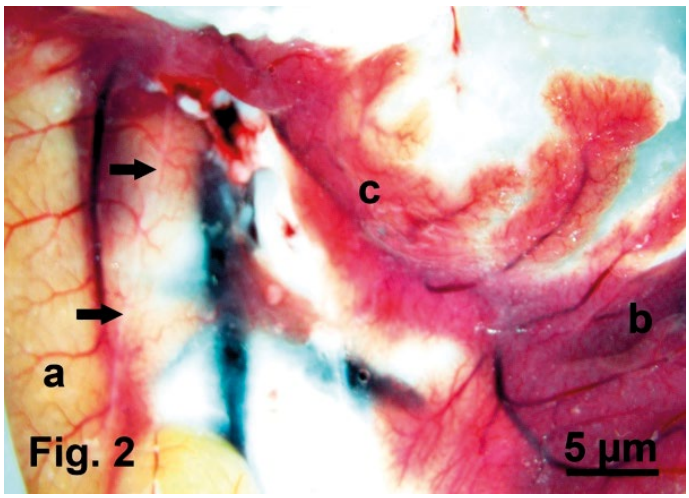

Fig. 2. Gross anatomy of pancreatic ducts system – PDS
Explanations: a – duodenum; b – spleen; c – pancreas; arrows – accessory pancreatic duct

distinguished. There are no clear borders between the individual lobes, although the position of the cranial mesenteric vein indicates the proximal part of the pancreatic body. The pancreatic head is located between the descending and ascending branches of the caudal duodenal loop. The head passes into the body at right angles and runs further to the left on the posteroinferior wall of the gaster and then, expanding, surrounds the spleen. This part of the pancreas was usually the smallest and the most differentiated part of this organ. The pancreatic duct was visible through the parenchyma of the duodenal part (Fig. 2, 3).

By filling the hepatic and pancreatic ducts with a suitable colored latex, detailed study reveals the lack of a major pancreatic duct, which should open on the major duodenal papilla (Fig. 4). The pancreatic duct in the chinchilla opens at the minor duodenal papilla, and so is considered an additional pancreatic duct.

The numerous tributaries that drain all parts of the pancreas form the accessory pancreatic duct, which runs towards the mesenteric edge of the caudal part of the duodenal loop and opens on the minor duodenal

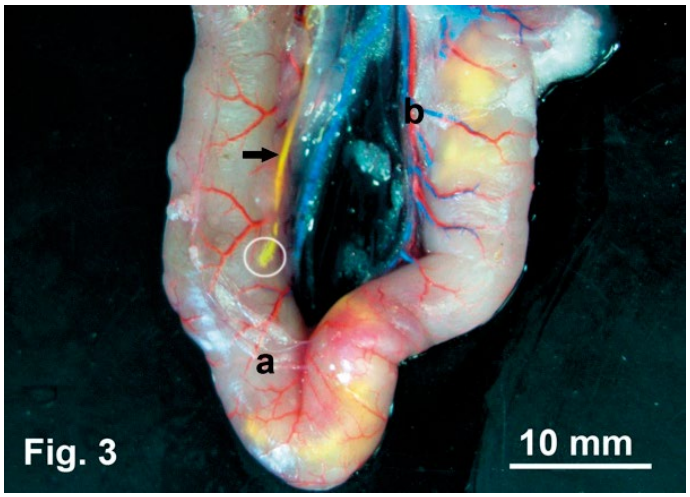

Fig. 3. Topography of the accessory pancreatic duct
Explanations: a – duodenum; b – branch of the pancreaticoduodenal artery and vein; arrow – accessory pancreatic duct, circle – minor duodenal papilla

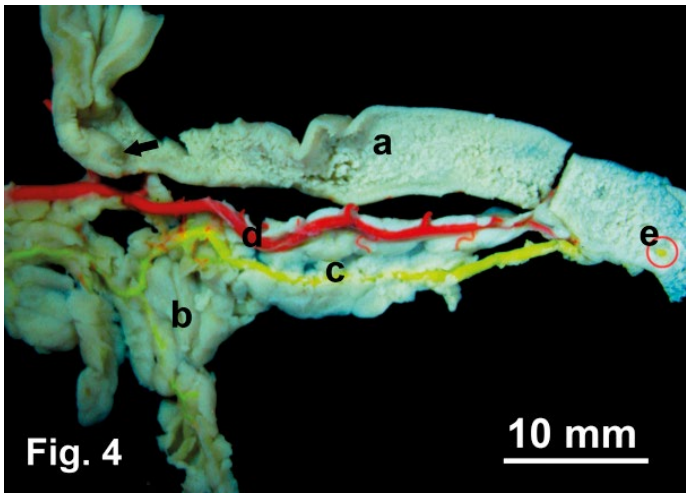

Fig. 4. Course of the accessory pancreatic duct
Explanations: a – duodenum; b – pancreas; c – accessory pancreatic duct; d – branch of the pancreaticoduodenal artery; e – minor duodenal papilla; arrow – major duodenal papilla

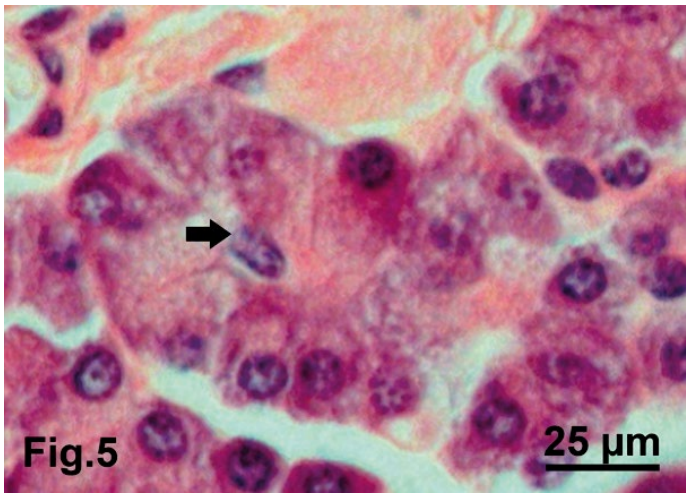

Fig. 5. Pancreatic acinus
Explanation: centroacinar cell – arrow

Fig. 6. The wall of intralobular duct
Explanations: a – lumen of the intralobular duct; b – ganglionic neurocytes; c – simple columnar epithelium

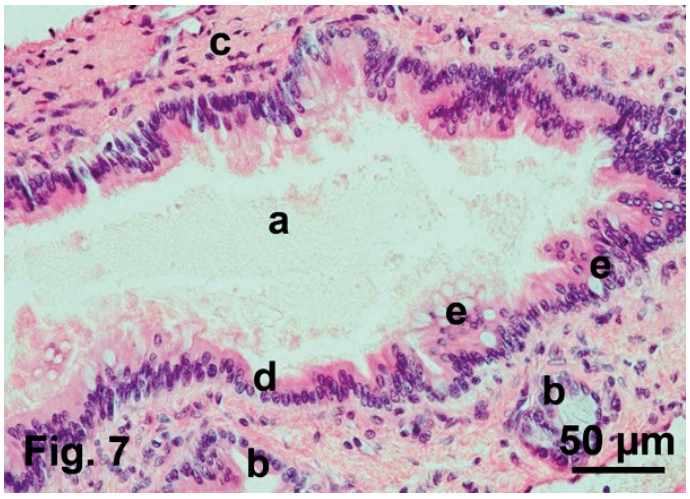

Fig. 7. Distal part of the accessory pancreatic duct
Explanations: a – lumen of the accessory pancreatic duct; b – subepithelial mucosal glands; c – submucosa; d – simple columnar epithelium; e – goblet cells

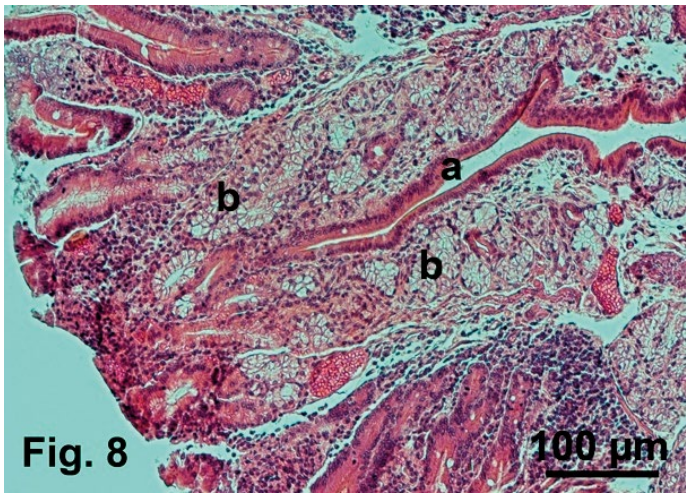

Fig. 8. Cross-section through the minor duodenal papilla
Explanations: a – lumen of the accessory pancreatic duct; b – mucosal glands

papilla at about 40-60 mm from the major duodenal papilla (Fig. 4). Thus, the pancreatic accessory duct and the bile ducts are completely separated in this species.

Centroacinar cells, which establish the first part of the duct system, were observed upon section of many pancreatic acini. These are the first parts of the smallest pancreatic ducts (intercalated ducts), built into the acini (Fig. 5). In their further course, the intercalated ducts join, enlarging their diameter and forming intralobular and interlobular ducts made of simple cuboidal or low simple columnar epithelium (Fig. 6). Next, the interlobar ducts form the accessory pancreatic duct running to the minor duodenal papilla in this species (Fig. 7, 8). The ducts with the largest diameter are lined with tightly arranged simple columnar epithelium with numerous goblet cells and subepithelial mucous glands (Fig. 7). At the point were the accessory pancreatic duct passes through the wall of the duodenum, the mucous membrane forms high folds covered with a columnar epithelium with goblet cells (Fig. 7). A thick layer of connective tissue surrounds the accessory pancreatic duct and the interlobular ducts (Fig. 8). Moreover, histological analysis revealed single neurons in the wall of the examined pancreatic ducts (Fig. 6). There was no sexual differentiation in the examined pancreatic ducts system.

While the histology of the exocrine part of the pancreas of mammals has proven interesting to researchers, the morphology of the ducts that lead out of the pancreas has not been sufficiently examined. Knowledge of the entire secretory system is of particular importance in pathology, as certain types of pancreatic cancer originate from the epithelium of pancreatic ducts (3, 33). Only the accessory pancreatic duct is present in the chinchilla, which is similar to the situation in the rabbit (2, 8, 26, 34), guinea pig (18), prairie dog (6), pig, and ox (36). Until recently, little was known about the mechanisms that control the development of the hepatopancreatic system. It is now known that several transcription factors and signaling molecules are involved in the formation of the hepatic and pancreatic duct system (34). In dogs, there are often two pancreatic ducts: the pancreatic duct itself and the accessory pancreatic duct, which was found in 24% of studied cases (17, 25). In cats, both pancreatic duct and accessory pancreatic duct were found in 20% of cases (20, 36). The pancreatic duct disappears during embryonic development. An accessory pancreatic duct communicates with both pancreatic lobes (32).

The anatomical structure of the chinchilla pancreas is comparable to what has been described for the rabbit (7), in which the same division into three lobes has been observed. The human pancreas is a compact organ that is protected from severe trauma by being located close to the back wall of the abdominal cavity. The pancreas of monkeys is similar to that of humans (28). The pancreas shows significant anatomical variability among laboratory animals, including rodents. Most often two types are represented. The first, the diffuse or mesenteric type, is characteristic of rabbits and some rodents (4). The second more compact type is found in monkeys, humans, dogs, and hamsters (29). The mouse and rat pancreas are of intermediate type, as its head (the duodenal part) is dispersed, while the tail (the spleen part) is relatively compact (24). This intermediate type has also been observed in the chinchilla. Macromorphological observations of the pancreas in chinchilla coincide with observations of Yi et al. (37). The pancreas of animals such as rat, mice, guinea pig, cat, and dog show clear divisions between the right, central, and left lobes (2, 4, 13).

Previous investigations have looked at the anatomy of pancreatic ducts and the location of their outlet in relation to duodenal papillae. In the rat, several pancreatic ducts open to the common bile duct at various points, but before entering the duodenum at the duodenal papilla (7, 10). The minor duodenal papilla is absent in rats, so the distal segment of the common bile duct contains a mixture of liver and pancreatic secretions (33). In mouse, the pancreatic duct enters the common bile duct before entering the duodenum at the duodenal papilla. McMinn and Kugler (15) looked at the mucosa of the pancreatic ducts in mouse, hamster, rat, guinea pig, cat, dog, rhesus monkey, and human. Glands of the mucous membrane of the pancreatic ducts and goblet cells were found in most of these species. Goblet cells were not found in the pancreatic ducts of cat, dog, or human. These authors stated that investigated ducts show strong succinate dehydrogenase activity in all species, which suggests that, like the salivary glands, the final biliary and pancreatic ducts are not passive in function but, are actively involved in transport mechanisms.

In the mouse, as in the rat, the common bile duct opens into the duodenum at the major duodenal papilla. Moreover, many smaller accessory pancreatic ducts release their contents directly into the duodenum, through one or more minor duodenal papillae. This multiplication of the minor duodenal papillae is common in mouse (30, 31). Thus, in these species, the anatomy of the pancreatic ducts is slightly different.

Morphological studies of the pancreas have mainly focused on the pancreatic vesicles and islands, with less attention being paid to the discharge duct epithelium. However, Yoshizawa (38), Madden and Sarras (12), and Motta et al. (19) have described the pancreatic duct epithelium of several mammalian species. McMinn and Kugler (15) and Kendrey and Roe (11) performed a histochemical investigation of pancreatic duct epithelial cells in mammalian species (the mouse, hamster, rat, guinea pig, cat, dog, and rhesus monkey). The pancreatic duct epithelia revealed specialized cells, different in different species (35).

In summary, the term "main pancreatic duct" as used in our investigation refers to the duct that opens on the major duodenal papillae, while "accessory pancreatic

duct" refers to the duct that opens on the minor pancreatic papillae, which is not always accurately indicated in the literature.

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