



Bifid Pancreatic Tail: an Anatomical Case Series and their Classification

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Abstract

Anomalies and variants of development of the pancreas are relatively frequent. Bifid pancreatic tail is a rare anatomic variation with only a few cases reported in the literature. The present case series were encountered during dissection of 50 anatomical specimens of the pancreas, spleen, and duodenum. We observed four unusual cases (8%) of bifid pancreatic tail. One case was of a vertically oriented bifid pancreas tail (2%), in another case, the tails here horizontally oriented (2%) and in two cases the bifid tails were horizontally oriented but unequal (4%). The bifid tails had an arterial supply that penetrated the glands between the tails and two out of four were also supplied by the superior horizontal pancreatic artery of Popova. The ductal system usually bifurcated at the level of the tails, but a case of trifurcation was also encountered. The current cases should be taken into account in hepato-pancreato-biliary surgery to avoid misdiagnosis and to comprehensively assess the patient preoperatively.

Keywords

bifid pancreatic tail, dissection, bifid pancreatic ducts

INTRODUCTION

Pancreas is an organ of the endocrine and gastrointestinal systems that lies deep within the abdominal cavity making it one of the most complicated organs to manage due to its location and anatomy.¹ These particularities result in difficulties diagnosing and treating pancreatic diseases. Moreover, the incidence and prevalence of pancreatic diseases tends to rise while the mortality and morbidity remains high.² Based on GLOBOCAN 2018 estimates, pancreatic cancer ranked the 11th most common cancer in the world, causing 4.5% of all cancer deaths.³ Bearing this in mind, the variations of development should be given special attention since they often present a diagnostic challenge.

Anomalies and variants of development of the pancreas are relatively frequent. In general, there are three groups of pancreatic anomalies: migration anomalies (ectopic pan-

creas and annular pancreas), fusion anomalies (pancreas divisum) and anomalies that affect the number and form, or only the configuration of the main pancreatic duct (bifid ducts).⁴ Variations of forms, position, direction and vascularization of the pancreas are another group, which is usually not included within these three categories.¹

One of the abnormalities of development is the bifid pancreatic tail, also known as fishtail pancreas due to its appearance. It most likely reflects a failure of the regression of one of the lobes from which the pancreas originally derives.⁴ Bifid pancreatic tail is an extremely rare developmental variation and there have been only incidental cases described in the literature.⁵ The present study describes several anatomical cases of bifid pancreatic tail taking into account its surface, vascular and ductal particularities.

CASE REPORT

The cases were encountered during dissection of 50 anatomical specimens of the pancreas, spleen, and duodenum at the Department of Human Anatomy according to the ethical standards of the institution. During dissection, four unusual cases (8%) of bifid pancreatic tail were encountered. One case was of a vertically oriented bifid pancreatic tail (2%), in another case, the tails were horizontally oriented (2%), and in two cases, the bifid tails were horizontally oriented but unequal in their size (4%).

Case 1

The first case of bifid (horizontally oriented) pancreatic tail and superior horizontal pancreatic artery of Popova was encountered in a male cadaver (64 years) (**Fig. 1A**). The pancreas measured 14 cm in length and 3.5*2.0 cm in height at the level of the head and body, respectively. Each tail of the pancreas measured 1.9 cm in length and one was oriented anteriorly and the other posteriorly (**Fig. 1B**). The splenic artery divided into two branches (inferior and superior). The inferior terminal branch gave off an artery to the tail of the pancreas that entered the parenchyma between the two tails. Another artery branched off at the level of the body of the pancreas and had a horizontal trajectory along the superior surface of the gland but before entering deep into the gland received a branch from the splenic artery forming an arcade at this level and then penetrated the parenchyma of the tail. The main pancreatic duct at its beginning measured 0.5 cm and the accessory pancreatic duct 0.2 cm. At the level of the tail, the duct divided into three branches: one drained the posterior tail, the other – the anterior tail, and the third – the intermediate pancreatic tissue between the tails (**Fig. 1C**).

Case 2

The second case of fishtail pancreas with unequal tails was encountered in a male cadaver (64 years) (**Fig. 2A**). The pancreas measured 18 cm in length and 5.0*0.4 cm at the level of the head, 3.2*0.6 cm at the level of the body. One tail of the pancreas measured 3.0*0.5 cm and the other 1.7*0.4 cm. The splenic artery divided into two terminal branches (superior and inferior). At the level of the tail the splenic artery gave off two branches to the pancreas that entered the parenchyma between the two tails (**Fig. 2B**). The main pancreatic duct at its beginning measured 0.4 cm and the accessory pancreatic duct - 0.1 cm. At the level of the tail, the duct divided into two branches: a more prominent for the posterior (larger) tail, the other for the anterior (smaller) tail (**Fig. 2C**).

Case 3

The third case of fishtail pancreas with unequal tails was in a female cadaver (72 years) (**Fig. 3A**). The pancreas measured 17.5 cm in length and 4.5*1.2 cm at the level of the

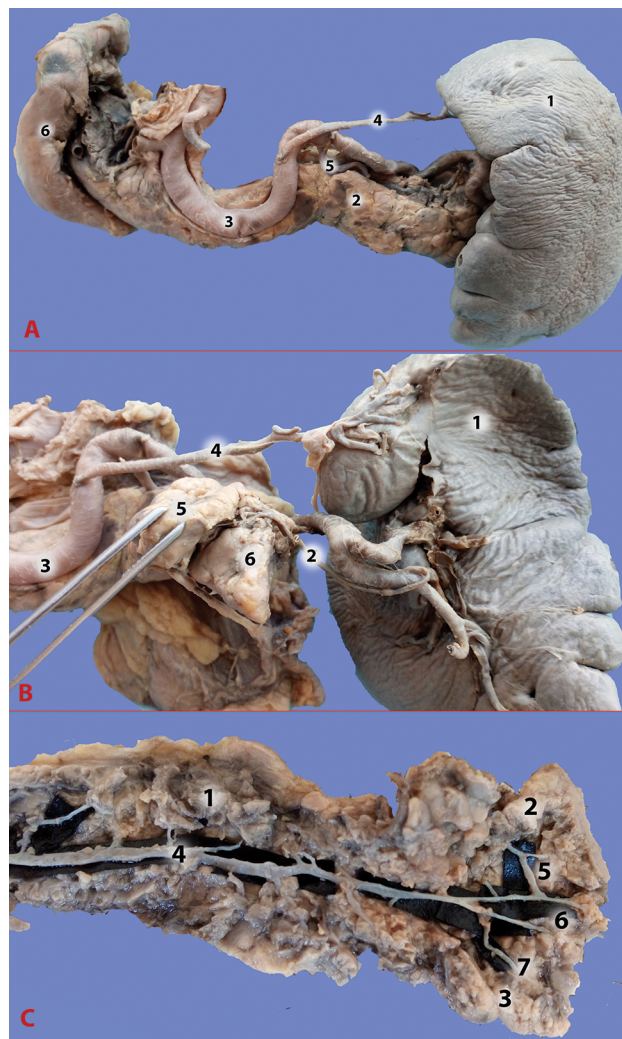


Figure 1. Case 1. **A.** Bifid (horizontally oriented) pancreatic tail and superior horizontal pancreatic artery of Popova. 1 - spleen, 2 - pancreas, 3 - splenic artery, 4 - superior polar artery, 5 - superior horizontal pancreatic artery of Popova, 6 - duodenum; **B.** Bifid pancreatic tail and its arterial supply. 1 - spleen, 2 - artery to the tail of the pancreas, 3 - splenic artery, 4 - superior polar artery, 5 - ventral tail, 6 - dorsal tail; **C.** The ductal system of the bifid pancreas. 1 - pancreas, 2 - dorsal tail, 3 - ventral tail, 5 - dorsal pancreatic tail duct, 6 - intermediate pancreatic tail duct, 7 - ventral pancreatic tail duct.

head, 3.2*0.6 at the level of the body. The pancreas had a more developed posterior tail that measured 3*0.5 cm and a less developed anterior tail that measured 1.7*0.4 cm. The splenic artery branched into two terminal vessels: the inferior and superior branch. The inferior terminal branch of the splenic artery gave off a large artery to the tail of the pancreas that entered the parenchyma between the tails. Another arterial vessel originated from the splenic artery before its division into terminal branches. The superior horizontal pancreatic artery of Popova ran along the superior border of the pancreas and penetrated the parenchyma between the tails of the pancreas. (**Fig. 3B**). The main pancreatic duct at its beginning measured 0.4 cm and the accessory pancreatic

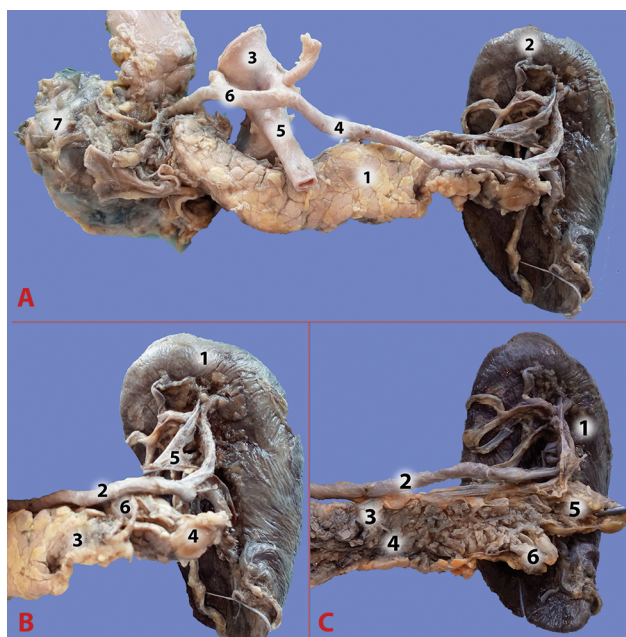


Figure 2. A. Case 2. Fishtail pancreas with unequal tails. 1 - pancreas, 2 - spleen, 3 - aorta, 4 - splenic artery, 5 - superior mesenteric artery, 6 - common hepatic artery, 7 - duodenum; B. Fishtail pancreas with unequal tails and its arterial supply. 1 - spleen, 2 - splenic artery, 3 - ventral pancreatic tail, 4 - dorsal pancreatic tail, 5 - splenic vein, 6 - two arterial branches to the tail of the pancreas; C. The ductal system of the fishtail pancreas. 1 - spleen, 2 - splenic artery, 3 - pancreas, 4 - main pancreatic duct, 5 - dorsal tail of the pancreas, 6 - ventral tail of the pancreas.

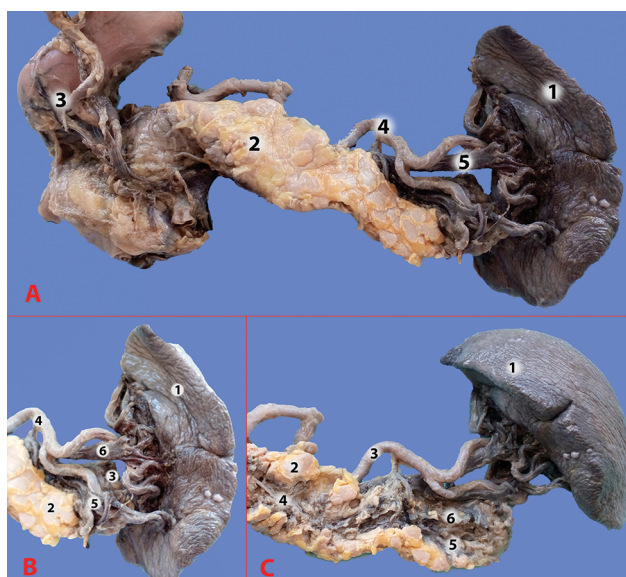


Figure 3. Case 3. A. Fishtail pancreas with unequal tails. 1 - spleen, 2 - pancreas, 3 - duodenum, 4 - splenic artery, 5 - splenic vein; B. Fishtail pancreas with unequal tails and its arterial supply. 1 - spleen, 2 - ventral pancreas tail, 3 - dorsal pancreas tail, 4 - splenic artery, 5 - artery to the tail of the pancreas, 6 - splenic vein; C. Fishtail pancreas and its ductal system. 1 - spleen, 2 - pancreas, 3 - splenic artery, 4 - main pancreatic duct, 5 - ventral pancreatic duct, 6 - dorsal pancreatic duct.

duct 0.2 cm. At the level of the tail, the duct divided into two branches: one for each tail (Fig. 3C).

Case 4

The fourth case of bifid (vertically oriented) pancreatic tail was in a male cadaver (69 years) (Fig. 4A). The pancreas measured 16.5 cm in length and 5.0*1.5 cm at the level of the head, 3.4*0.8 cm at the level of the body. The pancreas had vertically oriented tails. The superior tail measured 2.0*1.0

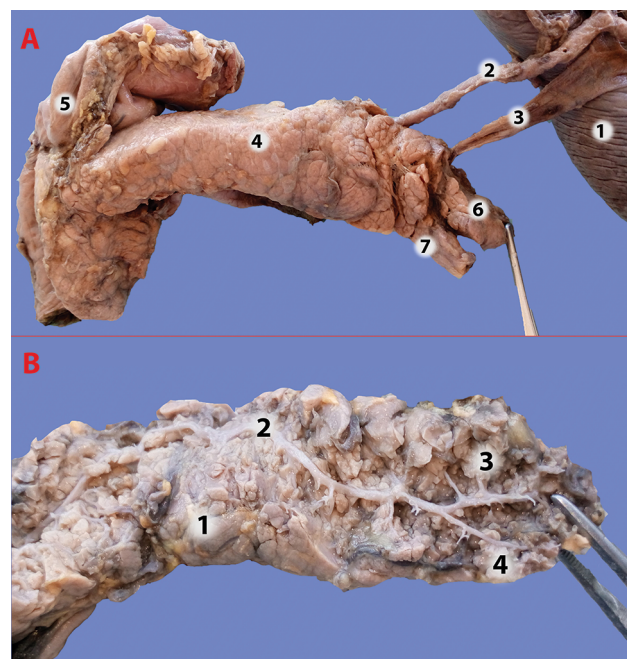


Figure 4. Case 4. A. Bifid (vertically oriented) pancreatic tail. 1 - spleen, 2 - splenic artery, 3 - splenic vein, 4 - pancreas, 5 - duodenum, 6 - superior pancreatic tail, 7 - inferior pancreatic tail; B. Fishtail pancreas and its ductal system. 1 - pancreas, 2 - main pancreatic duct, 3 - superior pancreatic tail duct, 4 - inferior pancreatic tail duct.

cm and the inferior tail measured 0.8*1.2 cm. The main pancreatic duct at its beginning measured 0.5 cm and the accessory pancreatic duct 0.2 cm. At the level of the tail, the duct divided into two branches: one for each tail (Fig. 4B).

DISCUSSIONS

The embryology of the pancreas is complicated and has not been studied thoroughly, especially its ductal anatomy and variations. Pancreatic cell differentiation is orchestrated by coordinated interactions between diverse genes such as FoxA2, Pdx1, Ptf1a, Sox9, Nkx6.1, Neurog3, Nfatc1, Ins, Arx, Gcg and others.⁶ Embryologic development of the pancreas begins approximately 4 weeks after fertilization with

two budlike outgrowths of the foregut. These two buds are named according to their orientation: ventral and dorsal. Although the cell types comprising the dorsal and ventral pancreas are indistinguishable, current evidence suggests that they are specified from early posterior foregut endoderm as two entirely distinct organs. Moreover, their molecular pathway development is different. For instance, retinoic acid is essential for dorsal pancreas specification, while it appears to be dispensable in the early ventral foregut. On the contrary, BMP signalling is critical for ventral pancreas specification, while there seems to be no role for BMP in the dorsal foregut development. FGF signalling represses pancreatic fate in the ventral foregut whereas low levels of FGF2 from notochord are hypothesized to have a positive effect on specification of the dorsal pancreas.^{7,8} The dorsal bud grows more rapidly, whereas the ventral bud rotates with the stomach and duodenum. Approximately seven weeks after gestation, the two parts unite thus forming the pancreas. The dorsal pancreatic bud forms the neck, body, and tail of the developed pancreas, and the ventral pancreatic bud forms the head and uncinate process. Therefore, the ducts of the ventral and dorsal buds fuse, forming the main pancreatic duct (the duct of Wirsung). Part of the dorsal duct undergoes hypoplasia or aplasia. When it persists, it is called accessory pancreatic duct or the duct of Santorini.^{4,9} Deviations of these processes result in a number of abnormalities: migration anomalies (ectopic pancreas and annular pancreas), fusion anomalies (pancreas divisum) and anomalies that affect the number and form, or only the configuration of the main pancreatic duct (bifid ducts), variations of forms, position, and direction of the gland.^{1,4}

Bifid pancreatic tail is a rare anatomic variation and there are only a few case reports in the literature. Its

exact incidence is not known as there haven't been any large anatomical or clinical studies. It is presumed that bifid pancreatic tail represents failure of regression of one of the pancreatic buds during organogenesis. Therefore, this results in abnormal branching pattern of the main pancreatic duct with formation of two tails.^{4,5,10} The orientation of the tails can be different: anterior (ventral) and posterior (dorsal), or inferior (caudal) and superior (rostral). The other point that should be noted that the tails can be unequal, one being more prominent than the other. The true incidence of this anomaly is not known. To our knowledge, this is the first attempt to assess how frequently it is encountered in a cadaver series. Therefore, the true bifid pancreas tail was encountered in 4% of cases (2% horizontally oriented tails and 2% vertically oriented tails) and another 4% of cases with unequal bifid pancreas tail. The unequal tails are probably a result of incomplete regression when one of the tails persists and the other undergoes partial atrophy. The classification is presented in Fig. 5.

The anomaly can be identified on magnetic resonance cholangiopancreatography as complete or incomplete bifurcation of the pancreatic duct in the body/tail of the pancreas and during multidetector computer tomography or magnetic resonance imaging as bifurcated tail of the pancreas (fishtail pancreas), bifurcated pancreatic duct in the body/tail of the pancreas.¹¹

The ductal system of the pancreas is a complex and understudied subject, although some of its anomalies can lead to acute pancreatitis, chronic pancreatitis and chronic abdominal pain syndrome and therefore have a direct clinical impact.¹² In a report describing 650 patients with duplication variants of the pancreatic ductal system investigated with endoscopic retrograde cholangiopancreatography, only

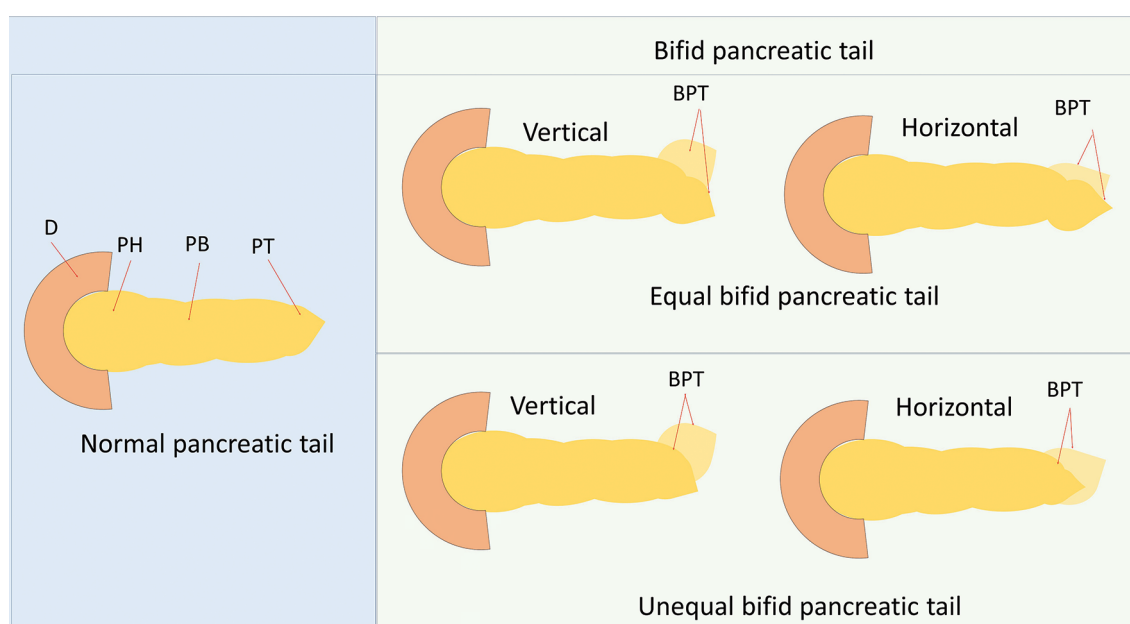


Figure 5. Classification of the bifid pancreatic tail. D: duodenum, PH: pancreatic head, PB: pancreatic body, PT: pancreatic tail, BPT: bifid pancreatic tail.

six (0.92%) patients had pancreatic bifurcation.¹³ Nevertheless, duplication of the ductal system can exist without bifid tail of the gland. Moreover, in case of a bifid pancreatic tail, the main pancreatic duct can divide either into two branches for each tail (depending on the orientation of the tails anterior and posterior or superior and inferior) or into three branches (depending on the orientation of the tails ventral and posterior or superior and inferior, with the third branch for the intermediate pancreatic tissue between the tails).

Arteries that supply the tail of the pancreas can be frequently encountered during dissection. One artery to the tail of the pancreas can be encountered in 27.27-30% of cases, two arteries in 38-45.46%, three arteries in 6-9.09% of cases, and no arteries in 18.8-26% cases.¹⁴ In our cases, the artery or arteries typically would divide the tails, entering between them in three of the four cases. The only case when there was no artery for the tail of the pancreas was the vertically oriented bifid tail. Interestingly, in two out of four cases, the pancreas was supplied by the superior horizontal pancreatic artery of Popova. The artery of Popova is not a commonly accepted term, but the vessel itself was described in 1910, as an artery that starts directly from the splenic artery and runs along the superior border of the body and tail of the pancreas.^{1,15} The most comprehensive study of its incidence was conducted by Mosca and coworkers and demonstrated that it could be identified in 25.9% of cases on 1015 angiographies.¹⁵ Another research demonstrated that during dissection, the superior horizontal artery of Popova was encountered in 5% of the cases and in 4.54% of the corrosion cast group.¹⁴ The arterial supply plays an important role not only as source of nutrients but also in its organogenesis by regulating pancreas branching, differentiation and growth in the embryonic period.^{16,17} Therefore, the organs morphology is linked to its vascular supply and its variations.

There are several reports of bifid pancreatic tail associated with acute pancreatitis of either one of the tails or both.^{18,20} One case of bifid pancreas tail was associated with enteric duplication cyst of the pancreas and relapsing pancreatitis in a 1-year old girl.²¹ There are only a few cases when the patients with bifid pancreatic tail required surgery.^{22,23} In one of the cases the patient had undergone pancreaticoduodenectomy and intraoperatively, it was discovered that the patient had two ducts one of which was ligated and sutured.²² In the second case following pylorus preserving pancreaticoduodenectomy, a second duct was identified which required double duct to mucosa pancreaticojejunostomy.²³ Knowledge of the anatomical variations of the pancreas is essential for invasive and mini-invasive procedures on the pancreas, its ducts and biliary system.²⁴ Careful preoperative evaluation of the abdominal anatomy is important in surgical practice.²⁵

The limitations of the present study are the relatively small number of cases which is to some degree accounted for by the fact that the material is based on cadaver dissection and the anomaly is extremely rare.

CONCLUSIONS

Developmental anomalies of the pancreas are relatively common but understudied. We therefore provide an anatomical case series of bifid pancreatic tail. During dissection, four unusual cases (8%) of bifid pancreatic tail were encountered. One case was of a vertically oriented bifid pancreatic tail (2%), in another case the tails here horizontally oriented (2%) and in two cases the bifid tails were horizontally oriented but unequal (4%). The bifid tails would usually have an arterial supply that penetrated the glands between the tails. Interestingly, in two out of four cases, the pancreas was supplied by the superior horizontal pancreatic artery of Popova. The ductal system usually bifurcated, but we also encountered a case of trifurcation. The current data should be taken into account in hepato-pancreato-biliary surgery to avoid misdiagnosis and to comprehensively assess the patient preoperatively.

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Бифидный хвост поджелудочной железы: серия анатомических случаев и их классификация

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Резюме

Аномалии и вариации в развитии поджелудочной железы довольно распространены. Раздвоенный хвост поджелудочной железы – это редкая анатомическая вариация, и в медицинской литературе описаны лишь несколько случаев. Текущая группа случаев была установлена путем вскрытия 50 анатомических образцов поджелудочной железы, селезенки и двенадцатиперстной кишки. Мы наблюдали четыре необычных случая (8%) раздвоенного хвоста поджелудочной железы. Один случай был на вертикально ориентированном раздвоенном хвосте поджелудочной железы (2%), в другом случае хвосты были ориентированы горизонтально (2%) и в двух случаях раздвоенные хвосты были ориентированы горизонтально, но неравномерно (4%). Двустворчатые хвосты имели артериальное кровоснабжение, которое проникало через железы между хвостами, а два из четырёх также снабжались верхней горизонтальной панкреатической артерией Поповой. Система каналов обычно раздваивается на уровне хвостов, но обнаружен и случай тройного деления. Данные случаи следует рассматривать в хирургии гепатокреатина и жёлчных путей, чтобы избежать ошибочного диагноза и подробно оценить состояние пациента до операции.

Ключевые слова

раздвоение хвоста поджелудочной железы, расслоение, раздвоение протоков поджелудочной железы