Pancreatic Duct Diversity

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Objectives: The formation of the pancreatic duct system is the result of the fusion of 2 embryonic buds, the ventral and dorsal primordia. Frequently, this fusion process is localized in the pancreatic head; variations, however, may account for the structural diversity of the duct system. Pancreatic duct anomalies and diversity of body and tail are thought to be casuistic.

Methods: Ninety-nine consecutive adult autopsies with reference to macroscopic anomalies in the distal part of the gland were evaluated. Pancreatograms were performed after large duodenal papilla cannulation. Ducts parallel to gland axis with a diameter of at least one third of the main pancreatic duct at the junction point and aberrant duct with different shapes and/or abnormal third-degree ductuli architecture were noted.

Results: Our study revealed a 9.9% frequency of main pancreatic duct diversity in the pancreatic corpus and tail. Eleven atypical ducts were visible, 9 cranially and 2 caudally from the main pancreatic duct.

Conclusions: The pancreatic duct system in the body and the tail presents abnormal configuration not described in the past.

Key Words: pancreatic ducts, cadavers, anomaly

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Pancreatic duct anatomy was first described by Wirsung in 1642 and later completed by Santorini in 1724.[1] The complex embryogenesis of the head of the pancreatic gland accounts for several developmental malformations, such as pancreas divisum, ansa pancreatica, and anular pancreas.[2–4] Pancreatology and pancreatic surgery developed on the basis of anatomical and physiological progress at the beginning of the 20th century. Although Anacker[2] wrote more than 30 years ago that "without knowledge of normal anatomy, there can be no knowledge of pathological changes," his idea is still up-to-date. Although our knowledge of pancreatic head anatomy is elaborated, anatomical data characterizing the pancreatic duct system within the body and tail of the gland remain woefully limited. Furthermore, there is ongoing discussion how frequent duct anomalies really are and what their role in pancreatic disease is. Particularly, the question whether and how frequently incomplete pancreatic bud fusion causes pancreatitis remains to be elucidated.[5–7] Therefore, in the present study, we analyzed the frequency of adult pancreatic duct system diversity within body and tail, that is, within the dorsal primordium of the gland.

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MATERIALS AND METHODS

The study protocol was approved by the local ethics committee of the Medical University of Gdansk (KNEBN/191/2004). One hundred consecutive pancreatic specimens obtained during autopsies of adult patients were analyzed. The most frequent cause of death was cardiovascular disease. Patients without previous pancreatic disease were enrolled into the study. Ninety-nine specimens (from 61 male and 38 female patients) were evaluated; one was technically insufficient. The mean patient age was 66.9 ± 12.1 years (range, 31–97 years).

Autopsies were performed as a standardized procedure. After inspection of the abdominal cavity, the pancreas with duodenum, superior mesenteric vessels, and portal vein were removed en bloc to avoid injury to the gland. The duodenum was then longitudinally opened, and the major duodenal papilla was identified and cannulated with an 18-gauge catheter. After injection of 2 to 3.5 mL of barium sulfate (depending on pancreatic size) into the pancreatic duct system, plain radiograms were obtained. Pancreatic ducts visible on pancreatogram were identified and classified by blinded experts according to the classification system described by Bang et al.[8] The pancreatic duct size as well as all aberrant, additional, or bifurcated ducts visible on the pancreatograms were described and measured.

Ducts were classified as abnormal when:

1. an aberrant duct parallel to gland axis was present with a diameter of at least one third of the main pancreatic duct at the junction point or when
2. an aberrant duct with a different shape and/or abnormal third-degree ductuli architecture was present.

Statistical Analysis

The standard descriptive statistics reported are means and SDs. Statistical evaluation was performed by running the STATISTICA 7 version 1 (StatSoft, Inc, Tulsa, Okla) packages on personal computers for Windows XP. A value of $P < 0.05$ was considered to be statistically significant.

RESULTS

Analysis of 99 consecutive autopsies revealed 9 patients (9.9%) with 11 atypical ducts within the dorsal primordium. Nine aberrant ducts were cranial to the main pancreatic duct and 2 caudal. The anomalous ducts were usually located far from the isthmus of the gland, the mean distance being 50.7 mm (from 4 to 115 mm; SD, 28.0 mm). The mean size of the main duct at the anomalous region was 2.22 mm (from 1.2 to 3.0 mm; SD, 0.43). The mean aberrant duct size was 0.94 mm (from 0.44 to 1.8 mm; SD, 0.35). The mean angle between the main pancreatic duct and the anomalous one was 49.2 degrees (from 16 to 90 degrees; SD, 25.8 degrees) (Figs. 1–3).

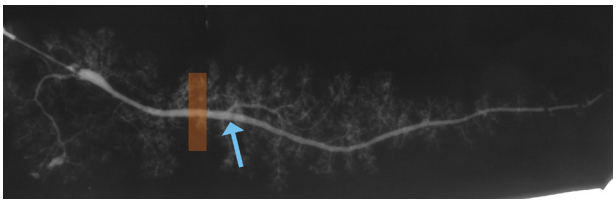

FIGURE 1. Pancreatogram revealing an aberrant duct cephalic to the main pancreatic duct and parallel to the gland axis. The orange box indicates the isthmus location, and the blue arrow indicates the location of the aberrant duct.

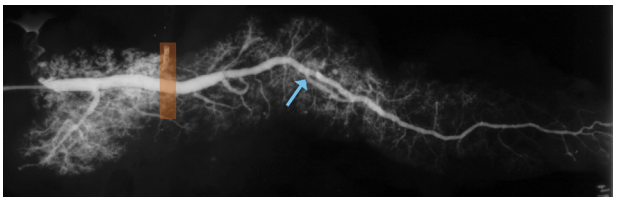

FIGURE 3. Pancreatogram showing an aberrant duct caudal to the main pancreatic duct and parallel to the gland axis. The orange box indicates the isthmus location, and the blue arrow indicates the location of the aberrant duct.

An abnormal pancreatic duct parallel to the gland axis with a diameter of at least one third of the main pancreatic duct was present in 7 cases (6.93%). Two pairs of abnormal ducts with extraordinary shape and third-degree ductuli architecture were observed in 2 cases. A schematic representation of 2 kinds of aberrant pancreatic ducts within body and tail of the pancreas is shown in Figure 4. The incidence of pancreatic duct diversity within the dorsal primordium did not correlate with the configuration of ducts at the bud junction (Table 1).

DISCUSSION

The ventral and dorsal pancreatic primordia join together during the seventh week of embryogenesis and form the pancreatic duct system.[9,10] The junction site as well as the relation between both ducts and pancreatic size varies between individuals.[11–13] The pancreatic head is usually formed from both primordia, whereas the isthmus, body, and tail are formed from the dorsal primordium only. Embryonic developmental anomalies of the primordia result in diversion of the duct.[10,14]

Nagai[15] suggests, "Nevertheless, the configurational anatomy of the pancreas has rarely been discussed in modern literature. Almost all surgeons and anatomists seem to take it for granted that there is nothing new or relevant in the shape of the pancreas besides those features known for centuries.….unknown or scarcely known features of pancreatic configuration do exist, and knowledge of these should help surgeons to perform pancreatic surgery safely and efficiently." Pancreatic anomalies are generally divided into migration anomalies (annular, ectopic), fusion anomalies (pancreas divisum), and duplication anomalies (number variations, form variations).[8] Bang et al[8] reported anatomical anomalies in 8.8% of endoscopic retrograde cholangiopancreatography (ERCP) patients, fusion anomalies in 3.3%, and duplication anomalies in 5.5%. Endoscopic and autopsy data confirm aberrant pancreatic tissue in the duodenum or stomach wall in about 3% of cases.[13] Anacker[2] and Baddeley et al[13] reported an incidence of 10% for pancreatic duct bifurcation within the tail of the gland. Large anatomical series revealed occasional large second-degree ducts called *ramus corporis superior* or *inferior* draining a section of pancreatic parenchyma.[2]

Pancreatic isthmus anomalous ducts detected in this study seem to be a potential important feature in pancreatic surgery. Isthmus of the pancreas seems to be a safe location of pancreatic transsection concerning its distance to potential anomalous ducts. Moreover, pancreatic remnant anastomosis after pancreatic head resection and/or hemostatic stitches situated on the section line may cause obstruction of anomalous ducts and further local pancreatitis. On the other hand, duct-to-mucosa reconstruction after unrecognized anomalous duct transection might result in pancreatic juice leakage and fistula formation.

Studies in pediatric pathology suggest the possibility of anomalies within the dorsal pancreatic primordium.[16] Pancreatic duct diversity within the head of the gland or duplications observed in childhood may result in cyst formation and increased risk of pancreatitis.[6,7] Several authors confirmed the correlation between the location of the larger duodenal papilla and the configuration of the main and accessory pancreatic ducts.[17] Some anomalies correlate with an increased incidence of pancreatitis.[18–21] Incomplete fusion of the ducts causes pancreas divisum, present in 5% to 14% of the population.[14] Pancreas divisum is considered to be one of the possible normal anatomical variations by some authors.[5,22,23] A large series revealed a link between acute and chronic pancreatitis with different types of pancreas divisum.[6,24] The incidence of pancreatitis in pancreas divisum varies from 2.3% to 27.8%.[6] There are numerous evidences of pancreatic anomalies accompanying diseases.[6,8,18,20] On the other hand, the incidence of outflow obstruction within pancreas divisum and normal configuration is thought to be almost equal in some series.[10,21]

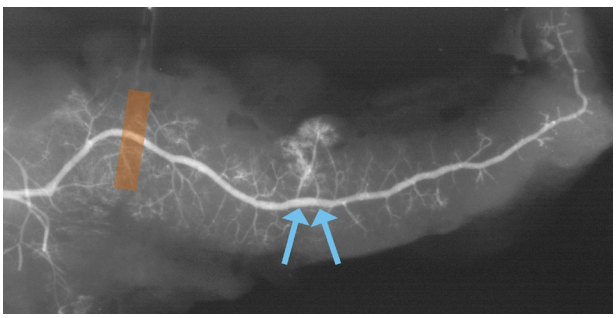

FIGURE 2. Pancreatogram showing aberrant ducts with an extraordinary third-degree ductuli architecture. The orange box indicates the isthmus location, and the blue arrows indicate the location of the aberrant ducts.

FIGURE 4. Schematic representation of 2 kinds of aberrant pancreatic ducts within the body and tail of the pancreas. Gray lines represent main pancreatic duct, dark blue lines represent aberrant ducts parallel to gland axis with a diameter of at least one third of the main pancreatic duct at the junction point, and blue lines represent aberrant ducts with different shapes and/or abnormal third-degree ductuli architecture.

TABLE 1. Abnormal Pancreatic Duct System and Duct Characteristics

Specimen No.	Sex	Pancreatic Duct Configuration Within the Head	Direction of Anomalous Duct	Size of Main Duct/Anomalous Duct, mm	Ratio	Distance From Isthmus, mm	Angle to Main Duct, degrees
45506	Female	A2	Up	2.20/0.80	2.8	8	19
45513	Male	C4	Up	3.0/1.20	2.5	7	40
45562	Male	A6	Up	2.0/0.90	2.2	37	27
45647	Male	A2	Up	2.50/0.77	3.2	52	71
			Up	2.50/0.77	3.2	58	90
45654	Male	A2	Down	1.20/1.0	1.2	115	70
45669	Female	C3	Up	2.50/1.80	1.3	70	18
45685	Female	A1	Up	2.10/1.10	1.9	53	52
45813	Female	C3	Down	2.20/1.06	2.1	49	16
45820	Female	A1	Up	2.20/0.50	4.4	47	55
			Up	2.0/0.44	4.5	62	83
Mean				2.22/0.94	2.66	50.7	49.2
SD				0.43/0.35	1.04	28.0	25.8

Authors' hypothesis was that aberrant duct within the body and tail of the pancreas might be as prone to pathology as other anomalies. Taking into consideration fusion and duplication anomalies accompanying increased frequency of pathology (ie, pancreas divisum), "per analogiam" authors speculate the importance of the presented findings. The anatomical configuration of the pancreatic head is relatively well documented because of the popularity of ERCP interventions since the 1970s. The anatomical studies consider the pancreatic duct branches of body and tail as regular and symmetric, although anatomical studies addressing this question are rare.

Our findings reveal 2 major groups of abnormal branches. The first type of aberrant duct is the large single duct, draining part of the gland with typical third-degree duct architecture joined to the main pancreatic duct within the body, and the second type is the small duct with different shapes and abnormal third-degree ductuli architecture. Our findings are not directly correlated with clinical features. Other anomalies such as congenital pancreatic cysts or gastrointestinal duplication cysts are rare findings within the epigastrium.[10] Almost 10% of patients with pancreatitis, pseudocysts, or pancreatic internal fistula have no detectable pathological promoting factor (anatomical variation) in their history or medical documentation.[25]

Barium contrast pancreatograms on cadaveric patients produce high-quality images and have been successfully used for populational studies for decades.[4,11] In contrast, ERCP or magnetic resonance cholangiopancreatography (MRCP) exhibits several drawbacks, limiting their application in precise anatomical studies. Low-contrast pressure and aqueous solutions rarely reveal second-degree pancreatic ducts on ERCP in cases of small duct diameter. Furthermore, ERCP is usually performed in 1 position only without further reconstruction being possible.[23] Magnetic resonance cholangiopancreatography on the other hand, being a noninvasive procedure, allows to reconstruct the pancreatic ducts in several planes.[23,26,27] Pancreas divisum, for example, might be difficult to recognize during normal ERCP studies but can be easily diagnosed by MRCP.[5,22,23] Megibow et al[24] reported a high success rate of pancreas divisum diagnosis and assessment of ductal anatomy with the use of secretin stimulation during MRCP. This technique allows to visualize accessory pancreatic ducts without the necessity of endoscopic cannulation of the minor duodenal papilla.[24,28] Magnetic resonance cholangiopancreatography is also an alternative for patients with failure in ERCP.[22] There are no epidemiological or demographic studies using ERCP or MRCP to assess ductal anatomy. Because data in this area are missing, most physicians would expect that the pancreatic duct system in the body and tail of the gland is homogeneous. However, our data demonstrate that this is not the case.

The dorsal duct diversity may be responsible for idiopathic or spontaneous forms of pancreatitis and pancreatic cyst formation, with no previous pancreatitis history. Idiopathic pancreatitis accounts for about 10% of acute pancreatitis cases.[25] The diversion of the dorsal pancreatic primordium itself, however, does not inevitably cause pancreatic disease. The awareness of diversion possibility may result in a new anatomical and clinical insight into pancreatic pathology.

In conclusion, the anomalous main pancreatic duct was not described in the past. We found an anomalous dorsal pancreatic primordium development in approximately 9% of cases. This might highlight a new perspective in pancreatic pathology thinking. Our study may be the background for further anatomical and embryological studies.

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