0002-9270/87/8204-0315
THE AMERICAN JOURNAL OF GASTROENTEROLOGY

Vol. 82, No. 4, 1987
Printed in U.S.A.

Pancreas Divisum: Incidence, Detection, and Clinical Significance

Farooq P. Agha, M.D., FACG and Kenneth D. Williams, M.D.
Department of Radiology, University of Michigan Medical Center, Ann Arbor, Michigan

Pancreas divisum is a congenital anomaly in which the ventral and dorsal pancreas drain separately into the duodenum. It is the most common congenital variant of pancreatic ductal fusion and drainage anomalies. With widespread use of endoscopic retrograde cholangiopancreatography, pancreas divisum is being detected with increasing frequency. Ten cases of pancreas divisum detected among 500 endoscopic retrograde cholangiopancreatography examinations performed between 1979 and 1985 at our institution were critically analyzed. Patients with symptomatic pancreas divisum (group 1) were typically young (mean age 29 yr), usually female, and had no history of significant alcohol abuse. Those with incidental detection of pancreas divisum (group 2) were older (mean age 62 yr), usually male with hepatobiliary disease, and had a history of significant alcohol ingestion. The radiological feature of pancreas divisum is characterized by a short (1–6 cm) and thin (2 mm diameter) pancreatic duct (duct of Wirsung) that branches off into regular arborization and drains only the posterior part of the head of the pancreas. This appearance is quite typical; however, this may be simulated by other conditions such as previous pancreatic trauma, partial pancreatectomy, or pancreatitis with irreversible damage to the duct, pseudocyst, and pancreatic carcinoma. The differentiation between true and false pancreas divisum is important because of its clinical implications.

INTRODUCTION

The pancreas develops early in embryonic life from a single dorsal and two ventral endodermal buds along the distal foregut. The two ventral buds are closely associated with the developing hepatic diverticulum. One of the ventral buds, usually the left, typically undergoes atrophy, with the remaining bud rotating posteriorly behind the distal foregut to lie caudal to the dorsal anlage. The dorsal anlage forms the superior portion of the pancreatic head, as well as the body and tail, and is initially drained via the duct of Santorini through the minor papilla. The ventral anlage becomes the inferior portion of the head of the pancreas and drains through the duct of Wirsung at the ampulla of Vater. Usually the ductal systems fuse, and the body and tail drain through the duct of Wirsung. The duct of Santorini regresses to a diminutive size, playing a minor accessory role in drainage, or it may even regress entirely (1). In a small percentage of individuals the ductal systems fail to fuse, resulting in a congenital anomaly—pancreas divisum (Fig. 1).

Several autopsy studies have reported frequencies of pancreas divisum ranging from 4 to 14% (2–10). Its existence is being recognized more frequently with increased clinical use of endoscopic retrograde cholangiopancreatography (ERCP) (11–13). Various reports place the prevalence of pancreas divisum, as diagnosed by ERCP, in the range of 1.3–6.7% (6, 9–23). Familiarity and recognition of pancreas divisum is important for several reasons. First, the uninitiated may mistake the radiographic appearance of pancreas divisum for ductal obstruction due to pathologic processes such as pancreatitis, pseudocyst, or carcinoma; second, pancreas divisum has been increasingly recognized as an important cause of obscure abdominal pain and idiopathic pancreatitis (13–29).

The main objectives of this paper are to *1*) report our experience with 10 patients among 500 ERCP examinations, six of these with symptomatic pancreas divisum and four with asymptomatic incidental pancreas divisum, and *2*) discuss diagnostic features of pancreas divisum and to present conditions that may simulate pancreas divisum.

MATERIALS AND METHODS

Between July 1979 and December 1985, 500 ERCP examinations performed at the University of Michigan hospitals were reviewed retrospectively, specifically to identify cases with pancreas divisum. ERCPs were performed in 212 patients for evaluation of known or suspected pancreas divisum and in 288 patients for hepatobiliary ductal evaluation. Ten patients were found to have pancreas divisum. The medical records, radiographic studies (ERCP, ultrasound, and computed tomography), and surgical pathological data of these 10

Received July 18, 1986; revised Nov. 24, 1986; accepted Nov. 28, 1896.

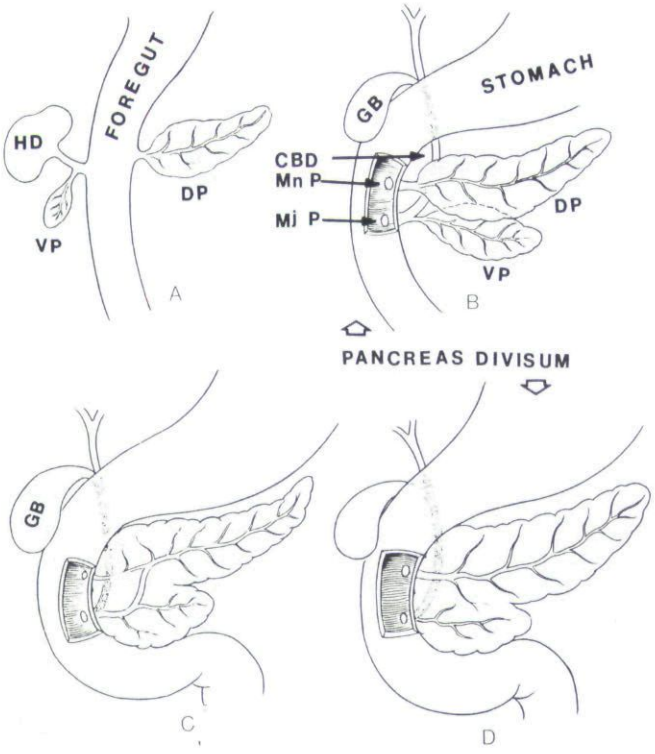

FIG. 1. Embryological development of the pancreas (modified from Reference 1). *A*, a 4-wk-old 5-mm embryonic stage: dorsal pancreatic anlage (*DP*) arises from the posterior portion of the distal foregut. Ventral pancreas anlage (*VP*) arises from the anterior portion of the distal foregut in close proximity to the hepatic diverticulum (*HD*). *B*, a 5–6-wk-old 10-mm embryonic stage: ventral pancreatic anlage (*VP*) migrates behind the distal foregut (future duodenum) and lies immediately caudal to the dorsal pancreatic anlage (*DP*). Common bile duct (*CBD*) and duct of the ventral pancreas maintain close proximity and drain into the duodenum via the major papilla (MjP, ampulla of Vater). Dorsal pancreatic duct drains into the duodenum via the minor papilla ((*MnP*). Persistence of this stage characterizes the anomaly of pancreas divisum (*GB*, gallbladder). *C*, a 7–8-wk-old 13-mm embryonic stage: The duct of the dorsal and ventral pancreatic anlagen (ducts of Santorini and Wirsung, respectively) and the ventral pancreatic duct becomes the main draining pathway. The duct of the dorsal pancreas undergoes atrophy or assumes a minor accessory role of drainage via the minor papilla. This arrangement characterizes a normally developed pancreas. *D*, a variation of pancreas divisum: the ventral pancreatic anlage undergoes marked atrophy with only a small ductal remnant.

patients were studied. Pancreas divisum was diagnosed on ERCP when the duct of Wirsung was short, tapered, with rapid arborization into tiny side branches, and had no communication with the duct draining the body and tail of the pancreas (Figs. 2 and 3). It was assumed in such instances that the remainder of the pancreatic ductal system drained separately through the duct of Santorini. Cannulation of the accessory papilla was attempted in five patients who subsequently underwent operation, at which time a transduodenal pancreatogram confirmed the duct of Santorini as the main draining duct.

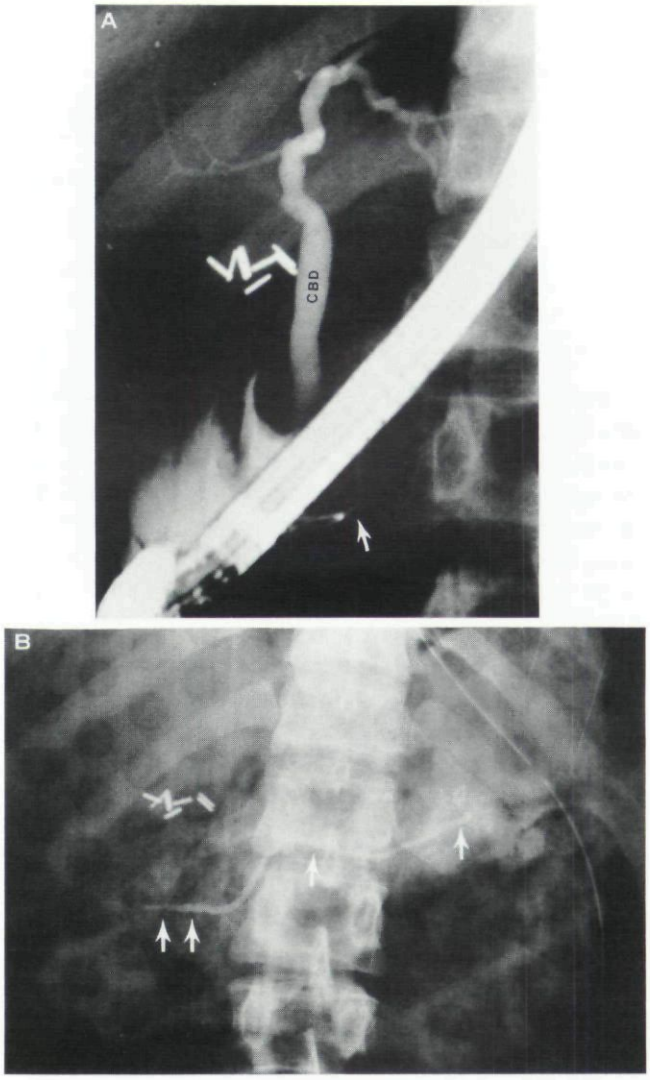

FIG. 2. Pancreas divisum. *A*, an ERCP shows filling of the duct of Wirsung (*arrow*) and the common bile duct (*CBD*) through a common cannulation at the major papilla. *B*, the duct of Santorini (*arrows*) opacified with contrast through the minor papilla intraoperatively before sphincteroplasty.

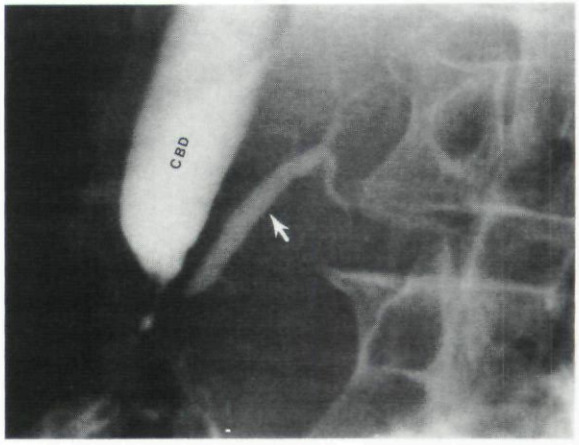

FIG. 3. Pancreas divisum. ERCP shows a short duct of Wirsung (*arrow*) and a dilated common bile duct (*CBD*) with a stricture of the distal end due to previous choledocholithiasis.

RESULTS

Of the 500 ERCPs performed, 410 patients had successful cannulation of both common bile duct and pancreatic duct. The success rate of cannulation increased proportionately with experience compared with earlier years experience during this study period. Thus 82% success rate of cannulation of both ducts represented an overall success rate of this study period. Of the remaining 90 patients only one duct was cannulated (pancreatic duct in 40 and common bile duct in 50 patients). Thus 10 patients with pancreas divisum among 450 successfully cannulated main pancreatic ducts constituted an incidence of 2.2% among our referred patient population. Six patients among 212 with known or suspected pancreas disease constituted an incidence of 2.8%, and four patients with incidental detection of the pancreas divisum among 288 patients with known or suspected hepatobiliary disease constituted an incidence of 1.4%. Thus it appears that the incidence of pancreas divisum was twice as high among patients with suspected pancreatic disease compared with those with no known or suspected pancreatic disease. Although the number of cases is small in our study group and overall incidence of pancreas divisum is less than previously reported series (15, 17, 20, 21), it is simply a reflection of the patient population referred to our institution.

These 10 patients (six women, four men; ranging in age from 26 to 66 yr) with pancreas divisum were divided into two groups depending on the indications for ERCPs. It was quite apparent that detection of pancreas divisum in each group had different clinical significance.

Group I

This group consisted of six patients with clinical diagnosis of recurrent pancreatitis. There were five women and one man (mean age 29 yr) with history of chronic recurrent abdominal pain and concurrent elevation of serum amylase (more than 400 Somogyi units) during episodes of pain. The average duration of symptoms was 2.5–3 yr. No patient had hyperamylasemia due to nonpancreatic causes of macroamylasemia. Only one patient had history of excessive alcohol intake; the others had no history of alcoholism, cholecystolithiasis, or choledocholithiasis. The one patient with history of alcoholism was a 29-yr-old man with 3-yr history of alcoholism and low-grade recurrent abdominal pain. The ERCP showed normal appearance of the ventral pancreas in all six patients. The cannulation of accessory pancreatic duct of five patients by transduodenal approach showed dilated duct of Santorini and ectasia of its side branches consistent with chronic pancreatitis. Two patients also had pseudocysts. Five patients underwent sphincteroplasty of the accessory papilla with improvement of symptoms in four. The two patients with pseudocysts, in addition, underwent cystogastrostomy and cystojejunostomy for drainage of the pseudocysts. Transduodenal pancreatograms obtained during operation revealed dilated accessory pancreatic duct and side branches. One patient not included in the treatment plan was a 28-yr-old woman with advanced systemic lupus erythematosus with severe renal involvement who died of uremia. Thus pancreas divisum was confirmed in five patients surgically and at autopsy in one patient. The surgical treatment relieved abdominal pain of chronic pancreatitis and eliminated recurrent attacks of acute pancreatitis in four of the five patients confirmed with follow-up clinic visits of 16, 20, 24, and 26 months, respectively. One patient with no history of alcoholism continued to have recurrent abdominal pain at 1-yr follow up. The patient with history of alcoholism responded well to the sphincteroplasty therapy.

Group 2

This group consisted of four patients (three men, one woman) with a mean age of 62 yr. All four patients had hepatobiliary disease and history of alcoholism. There was no clinical or biochemical evidence of pancreatitis. The ERCP showed characteristic appearance of pancreas divisum as demonstrated by opacification of the ventral pancreas ductal system in the head of the pancreas with no communication to the accessory duct. It was assumed that the body and tail of the pancreas were drained by the accessory duct, and it was felt that cannulation of the minor papilla to outline the dorsal pancreas was neither necessary nor indicated. In this group of patients the pancreas divisum was an incidental finding of no clinical significance.

DISCUSSION

Autopsy studies have reported that pancreas divisum is the most common congenital anomaly of the human pancreas with an incidence ranging from 4 to 14% (1–8). With the widespread use of ERCP several investigators have reported an incidence of 1.3–6.7% (overall 3.7%) of pancreas divisum detected at ERCP (15, 17, 20, 21). In this study we have found a 2.2% incidence of pancreas divisum among 450 successfully cannulated pancreatic ducts. The incidence was slightly higher among patients with known or suspected pancreatic disease than in those patients with no known or suspected pancreatic disease (2.8 *versus* 1.4%). Since the number of patients with pancreas divisum is small in our study group, it is difficult to draw any conclusions of statistical significance.

Pancreas divisum was initially considered a clinically insignificant congenital ductal anomaly and was often

a confusing finding at pancreatography (17). Recently, an association between pancreas divisum and pancreatitis has been reported by several investigators (15, 18, 19, 22, 25–29). Others have considered this to be an incidental finding (16, 17, 30). The controversy regarding clinical relevance of pancreas divisum and perhaps its etiological linkage to pancreatitis in some patients with chronic recurrent abdominal pain is still unresolved and perhaps requires a meticulously randomized study with long-term follow-up (3, 13, 15, 18–20, 23, 24, 31–39). A recent report based on endoscopic retrograde manometry of the duct of Wirsung and the duct of Santorini of patients with normal pancreatic ductal anatomy and patients with pancreas divisum concluded that patients presenting with pancreas divisum and suffering from relapsing upper abdominal pain accompanied by elevation of the pancreatic enzymes but without morphological evidence of pancreatic destruction had significantly higher pressure readings after cannulation of the accessory papilla than those obtained in the duct drained through the papilla of Vater (39). This study concluded that patients with pancreas divisum may develop chronic stasis of pancreatic fluid, and additional factors such as alcoholism causing increased viscosity of the pancreatic saliver may increase the risk of pancreatitis in patients with pancreas divisum (39).

Pancreas divisum has also been recognized in children with idiopathic pancreatitis (40). Additionally, pancreas divisum has been reported in coexistence with annular pancreas (41) and hereditary pancreatitis (42).

The reason for the association of recurrent pancreatitis with pancreas divisum is unknown. It has been suggested that the duct of Santorini and the accessory papilla are too small in some patients to transmit the volume of pancreatic juice. Thus a relative stenosis may be present at the accessory papilla in some patients, causing "retention pancreatitis" (15).

In the anomaly of pancreas divisum the persistent unfused ventral pancreas is a complete drainage system. The main duct and its branches are small with characteristic arborization. Since this is a small volume system, there is an increased likelihood of significant acinarization with minimal injection of contrast medium during ERCP. Therefore, it is important to recognize pancreas divisum lest injection of excess contrast medium result in marked acinarization and a bizarre appearance simulating a pseudocyst. Furthermore, increased acinarization is known to cause unnecessary pain and chemical pancreatitis (43).

Radiologically true pancreas divisum must be differentiated from false pancreas divisum (44). The pancreas divisum appearance may be simulated by acquired lesions such as previous partial surgical resection of the pancreas (Fig. 4), previous traumatic pancreatic transection (Fig. 5), obstruction of the duct of Wirsung resulting from irreversible damage by recurrent pancreatitis, pseudocyst, or calculi obstructing the duct (Fig. 6), and, most importantly, carcinoma of the pancreas (Fig. 7). History of previous trauma or pancreas resection is very helpful for proper interpretation. In patients with chronic recurrent pancreatitis and pseudocyst formation, correlation with ultrasound and computed tomography usually resolves the confusing appearance seen at ERCP. The most important differentiation is from a pancreatic carcinoma (45–47) (Fig. 7). Careful study and analysis of the duct terminus, as well as correlation with other imaging modalities, can usually resolve this problem. Differentiation between true and false pancreas divisum is important for appropriate selection of therapy.

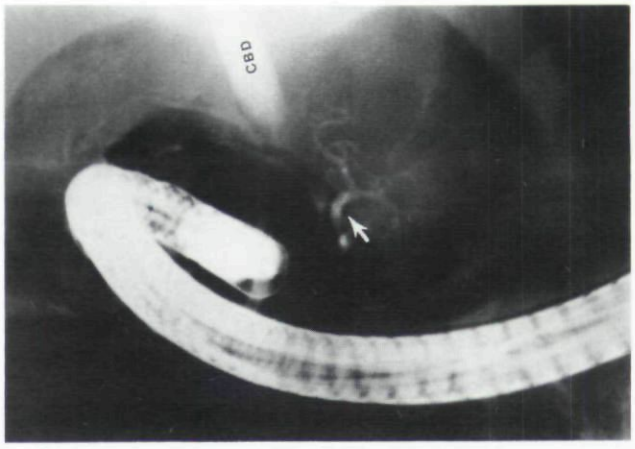

FIG. 4. Pancreas resection simulating pancreas divisum. ERCP shows a radiographic appearance indistinguishable from pancreas divisum. This 35-yr-old man underwent pancreas resection at age 6 for an unknown cause (*arrow*, duct of Wirsung; *CBD*, common bile duct). The dorsal duct was not cannulated in this patient.

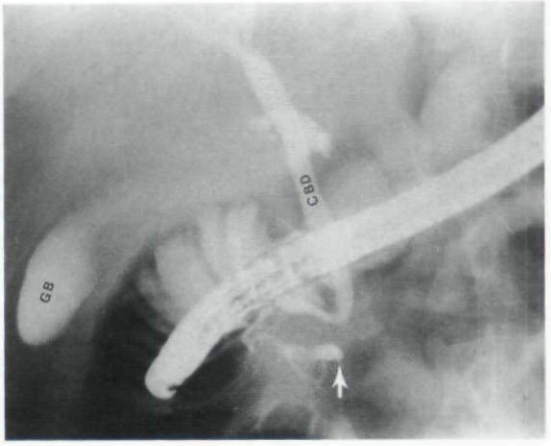

FIG. 5. Traumatic pancreatic transection simulating pancreas divisum. ERCP shows a short duct of Wirsung with an abrupt "cut off" (*arrow*). This 25-yr-old man had traumatic pancreatic transection 2 yr earlier. (*CBD*, common bile duct; *GB*, gallbladder). A normal caliber pancreatic duct with abrupt "cutoff" and clinical history of upper abdominal trauma are diagnostic.

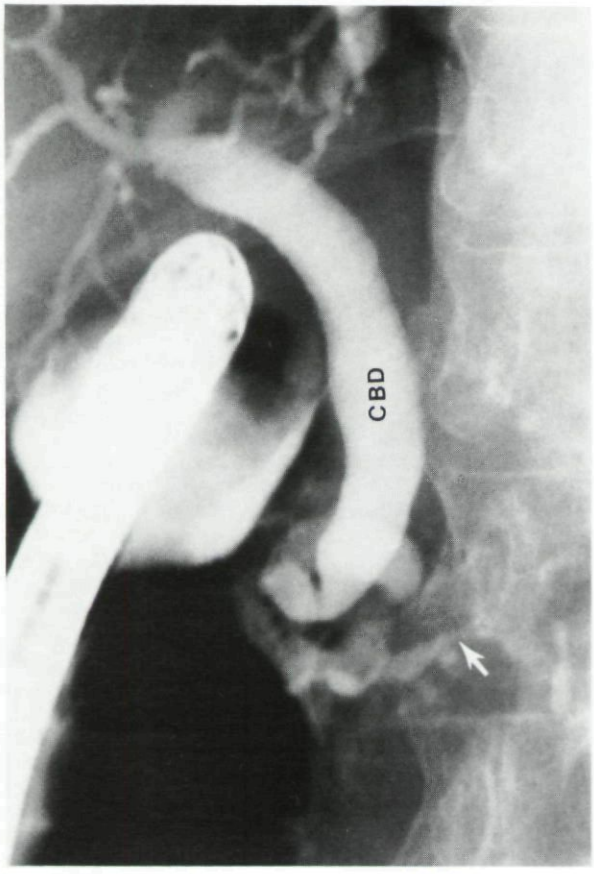

FIG. 6. Recurrent obstructing pancreatitis. ERCP shows marked ectasia of the pancreatic duct and its side branches in the region of the head. The main duct of Wirsung shows tapered appearance (*arrow*) and is obstructed. The side branches are ectatic (*arrowheads*). The common bile duct (*CBD*) is slightly dilated with normal intrahepatic ducts.

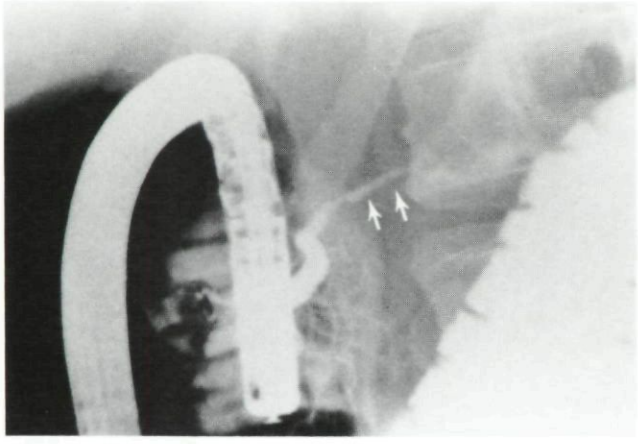

FIG. 7. Carcinoma of pancreas simulating pancreas divisum. ERCP in a patient with pancreatic carcinoma shows a tapered irregular terminus of the duct of Wirsung with complete obstruction (*arrows*). The prominent appearance of the distal main pancreatic duct is a feature suggesting that it is a normal-sized duct rather than duct of pancreas divisum.

Although the number of patients in our study is small, it shows, however, distinctive clinical differences in two groups of patients with pancreas divisum. For this information to be statistically significant, further studies with a larger number of patients are necessary.

ACKNOWLEDGMENTS

The authors thank Peter Hedlesky and Senta Stiefel for secretarial assistance, Dennis Lee of the Department of Biomedical Illustrations for the drawing shown in Figure 1, and members of the Department of Internal Medicine, Division of Gastroenterology, who performed endoscopic cannulations during ERCP examinations and provided patient care.

Reprint requests: Farooq P. Agha, M.D., Department of Diagnostic Radiology, Evanston Hospital, 2650 Ridge Ave., Evanston, IL 60201.

REFERENCES

1. Freeny PC, Lawson TL. Embryology of the pancreatic and biliary ducts. In: Freeny PC, Lawson TL, eds. Radiology of the pancreas. New York: Springer-Verlag, 1982:98–100.
2. Baldwin WM. The pancreatic ducts in man together with a study of the microscopic structure of the minor duodenal papilla. Anat Rec 1911;5:197–228.
3. Kleitsch WP. Anatomy of the pancreas, a study with special reference to the duct system. Arch Surg 1955;71:795–803.
4. Birnstingl M. A study of pancreatography. Br J Surg 1959;47:128–39.
5. Millbourne E. Calibre and appearance of the pancreatic ducts and relevant clinical problems. A roentgenographic and anatomic study. Acta Chir Scand 1959/60;118:286–303.
6. Berman LG, Prior JT, Abramow SM, et al. A study of the pancreatic duct system in man by the use of vinyl acetate casts of postmortem preparations. Surg Gynecol Obstet 1960;110:391–403.
7. Dawson W, Langman J. An anatomical-radiological study in the pancreatic duct pattern in man. Anat Rec 1961;139:59–68.
8. Smanio T. Proposed nomenclature and classification of the human pancreatic ducts and duodenal papillae. Study based on 200 postmortems. Int Surg 1969;52:125–34.
9. Ott H, Rosch W. Pancreas divisum—Ursache einer Pankretitis? Med Welt 1983;34:2–4.
10. Thompson MH, Williamson RCN, Salmon PR. The clinical relevance of isolated ventral pancreas. Br J Surg 1981;68:101–4.
11. Seifer E. Endoscopic retrograde cholangiopancreatography, evaluation based on experience with 805 examinations. Am J Gastroenterol 1977;68:542–9.
12. Varley PF, Rohrmann CA, Silvis SE, et al. The normal endoscopic pancreatogram. Radiology 1976;118:295–300.
13. Richter JM, Shapiro RH, Mulley AG, et al. Association of pancreas divisum and pancreatitis, and its treatment by sphincteroplasty of the accessory ampulla. Gastroenterology 1981; 81:1104–10.
14. Belber JP, Bill K. Fusion anomalies of the pancreatic ductal system. Differentiation from pathologic states. Radiology 1977;123:637–42.
15. Gregg JA. Pancreas divisum: its association with pancreatitis. Am J Surg 1977;134:539–43.
16. Mitchell CJ, Lintott DJ, Ruddell WSJ, et al. Clinical relevance of an unfused pancreatic duct system. Gut 1979;20:1066–71.
17. Rosch W, Koch H, Schaffner O, et al. The clinical significance of pancreas divisum. Gastrointest Endoscop 1976;22:206–7.
18. Tulassay Z, Papp J. New clinical aspects of pancreas divisum. Gastrointest Endoscop 1980;26:143–6.
19. Cotton PB. Congenital anomaly of pancreas divisum as cause of obstructive pain and pancreatitis. Gut 1980;21:105–14.
20. Kruse A. Pancreas divisum. A significantly high incidence in chronic pancreatitis? Scan J Gastroenterol 1977;12(suppl 45):52.

21. Phillip J, Koch H, Classen M. Variations and anomalies of the papilla of Vater, the pancreas and the biliary duct system. Endoscopy 1974;6:70–1.
22. Sahel J, Cros RC, Bourry J, et al. Clinicopathological conditions associated with pancreas divisum. Digestion 1982;23:1–8.
23. Britt LG, Samuels AD, Johnson JW, Jr. Pancreas divisum: is it a surgical disease? Ann Surg 1983;197:654–62.
24. Cooperman M, Ferrara JJ, Fromkas JJ. Surgical management of pancreas divisum. Am J Surg 1982;143:107–11.
25. Gold RP, Berman H, Fakhry J, et al. Pancreas divisum with pancreatitis and pseudocyst. AJR 1984;143:1343–4.
26. Chevillotte G, Sahel J, Pietri H, et al. Recurrent acute pancreatitis associated with pancreas divisum: clinical study of 12 cases. Gastroenterol Clin Biol 1984;8:352–8.
27. Warshaw AL, Richter JM, Shapiro RH. The cause and treatment of pancreatitis associated with pancreas divisum. Ann Surg 1983;198:443–52.
28. Buhler H, Seefeld U, Deyhle P, et al. Clinical significance of pancreas divisum. Schweiz Med Wochenschr 1983;113:320–4.
29. Heiss FW, Shea JA. Association of pancreatitis and variant ductal anatomy: dominant drainage of the duct of Santorini. Am J Gastroenterol 1978;70:158–62.
30. Delhaye M, Engelholm L, Cremer M. Pancreas divisum: Congenital anatomic variant or anomaly? Gastroenterology 1985; 89:951–8.
31. Madura JA, Fiore AC, O'Connor KW, et al. Pancreas divisum. Am Surg 1985;51:353–7.
32. Warshaw AL, Cambria RP. False pancreas divisum: acquired pancreatic duct obstruction simulating the congenital anomaly. Ann Surg 1984;200:595–9.
33. Jacocks MA, ReMine SG, Carmichael DH. Difficulties in the diagnosis and treatment of pancreas divisum. Arch Surg 1984;119:1088–91.
34. Gregg J, Solomon J, Clark G. Pancreas divisum and its association with choledochal sphincter stenosis. Diagnosis by endoscopic retrograde cholangiopancreatography and endoscopic biliary manometry. Am J Surg 1984;147:367–71.
35. Gregg JA, Monaco AP, McDermott WV. Pancreas divisum: results of surgical intervention. Am J Surg 1983;145:488–92.
36. Keith RG, Shapero TF, Saibil FG. Treatment of pancreatitis associated with pancreas divisum by dorsal duct sphinterotomy alone. Can J Surg 1982;25:622–6.
37. Blair AJ III, Russel CG, Cotton PB. Resection for pancreatitis with pancreas divisum. Ann Surg 1984;200:590–4.
38. Cobb BW, Meyer KK, Cotton PB. Recurrent pseudocysts and pancreatitis after trauma: A complication of pancreas divisum. Surgery 1985;97:626–9.
39. Staritz M, Hutteroth T, Meyer Zum Büschenfelde KH. Pancreas divisum and pancreatitis. Gastroenterology 1986;91:525–6.
40. Yedlin ST, Dubois RS, Philippart AI. Pancreas divisum: A cause of pancreatitis in childhood. J Pediatr Surg 1984;19:793–4.
41. Lehman GA, O'Connor KW. Coexistence of annular pancreas and pancreas divisum—ERCP diagnosis. Gastrointest Endoscop. 1985;31:25–8.
42. Beggs I, Salmon PR. A case of hereditary pancreatitis and pancreas divisum. Eur J Radiol 1984;4:71–3.
43. Van der Jagt EJ. Pancreas divisum—radiological and clinical implications of a congenital anomaly. Diagn Imaging Clin Med 1984;53:193–7.
44. Washaw AL, Simeone J, Shapiro RH, et al. Objective evaluation of ampullary stenosis with ultrasonography and pancreatic stimulation. Am J Surg 1985;149:65–72.
45. Nakajima M, Yamaguchi K, Akasaka Y. Endoscopic retrograde cholangiopancreatography (ERCP) in the diagnosis of pancreatic cancer. In: Kawai K, ed. Early diagnosis of pancreatic cancer. Tokyo: Igaku-Shoin, Ltd, 1980:140–63.
46. Bilbao MK, Katon RM. Neoplasms of the pancreas. In: Stewart ET, Vennes JA, Creenen JE, eds. Atlas of endoscopic retrograde cholangiopancreatography. St. Louis: CV Mosby Co, 1977:181–235.
47. Ariyama J. The pancreas. In: Radiology in disorder of the liver, biliary tract and pancreas. Tokyo: Igaku-Shoin, Ltd, 1981:118–62.