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Circumportal pancreas: imaging findings in 40 patients

Rafel Tappouni,[1] James Perumpillichira,[1] Michelle Sekala,[1] Keyanoosh Hosseinzadeh,[1] Clancy Clark,[2] John Leyendecker[1]

[1]Department of Radiology, Wake Forest University, Medical Center Blvd., Winston-Salem, NC 27157, USA
[2]Department of Surgery, Wake Forest University, Medical Center Blvd., Winston-Salem, NC 27157, USA

Abstract

Purpose: To analyze the CT and MR imaging features of circumportal pancreas (CP) with emphasis on the relative frequency of variants of parenchymal fusion, ductal anatomy, and vascular anatomy.
Methods: A retrospective review of CT and MR imaging findings of 40 patients with CP was performed. CT and MR images were reviewed by two radiologists in consensus. The course of the pancreatic duct in relation to the portal vein (anteportal vs. retroportal), location of the circumvenous pancreatic parenchyma in relation to the splenic vein (suprasplenic vs. infrasplenic), presence or absence of a visible accessory duct posterior to the portal vein, presence of vascular variants, history of pancreatitis and pancreatic surgery were recorded. Cases were classified into four categories: anteportal suprasplenic, retroportal suprasplenic, anteportal infrasplenic, and retroportal infrasplenic.
Results: One case of suprasplenic fusion was excluded from the classification due to non-visualization of the pancreatic duct. 32/39(82%) of cases were classified as anteportal suprasplenic, 2/39(5%) as retroportal suprasplenic, 4/39(10%) as anteportal infrasplenic, and 1/39(3%) as retroportal infrasplenic. There were 12 vascular variants including nine with an intraparenchymal course (through the pancreatic head) of the common hepatic artery, one with an intraparenchymal course of the right hepatic artery, two replaced right hepatic arteries from the superior mesenteric artery, and one with an intraparenchymal course of the left gastric vein.
Conclusion: Circumportal pancreas is an important pancreatic fusion anomaly with distinctive imaging features. The most common variant of CP is the anteportal suprasplenic subtype, with other subtypes being much less common. Intraparenchymal course of the common hepatic artery is a common variant associated with CP. Recognition of CP is important to avoid potential complications in patients who undergo pancreatic surgery.

Key words: Circumportal—Pancreas—CT—MRI

Congenital anomalies of the pancreas are often detected incidentally in patients undergoing CT or MRI of the abdomen. The increasing number and variety of pancreatic surgical procedures make the preoperative recognition of these anomalies paramount. Well-described pancreatic anomalies include pancreas divisum, annular pancreas, and ectopic pancreatic tissue [1–5]. Circumportal pancreas (CP) is less familiar to radiologists and surgeons, having been first described in 1987 [6]. CP is an anomaly in which the portal vein (PV) and/or superior mesenteric vein (SMV) is/are completely surrounded by an uninterrupted annulus of pancreatic tissue. CP was first described as a case of hypertrophic uncinate process wrapping around the superior mesenteric vessels [6]. Subsequent reports referred to this anomaly as complete pancreatic encasement of the portal vein [7, 8] and portal annular pancreas [9, 10]. More recently, the term circumportal pancreas has been used to avoid confusion with tumor encasement of the portal vein and traditional annular pancreas [11]. A complete annulus of pancreatic tissue typically surrounds the portal vein of swine [12], and until recently, this was thought to be an extremely rare anomaly in humans. However, recent publications reported an incidence of CP ranging from 1.1%–2.5% of patients [13, 14]. It is likely that the apparent extreme rarity of this anomaly is due to its lack of recognition by radiologists and surgeons. When present, CP manifests on CT and MR images as continuity of pancreatic parenchyma between the head/uncinate and the body of

Correspondence to: Rafel Tappouni; *email:* rtappoun@wakehealth.edu

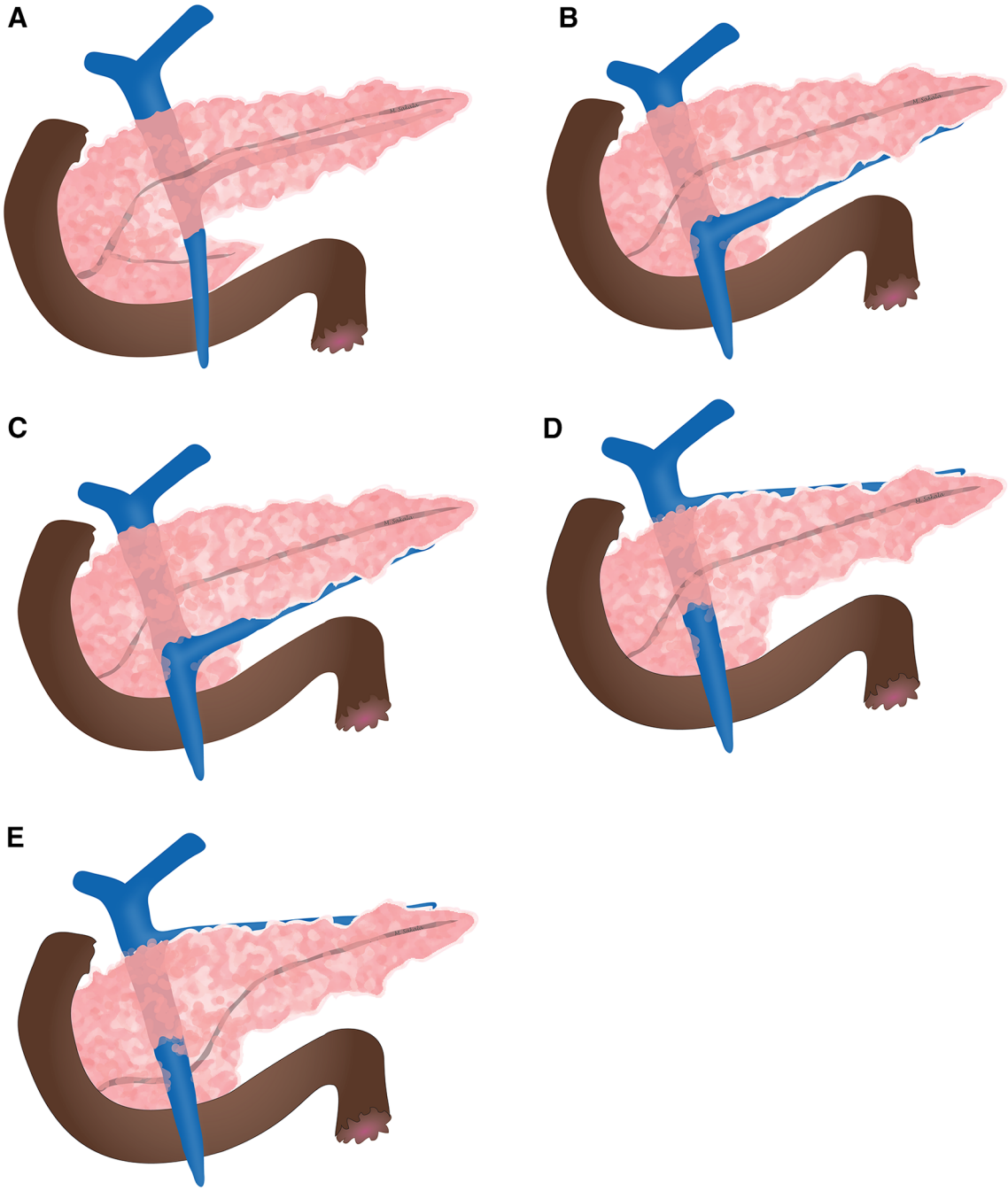
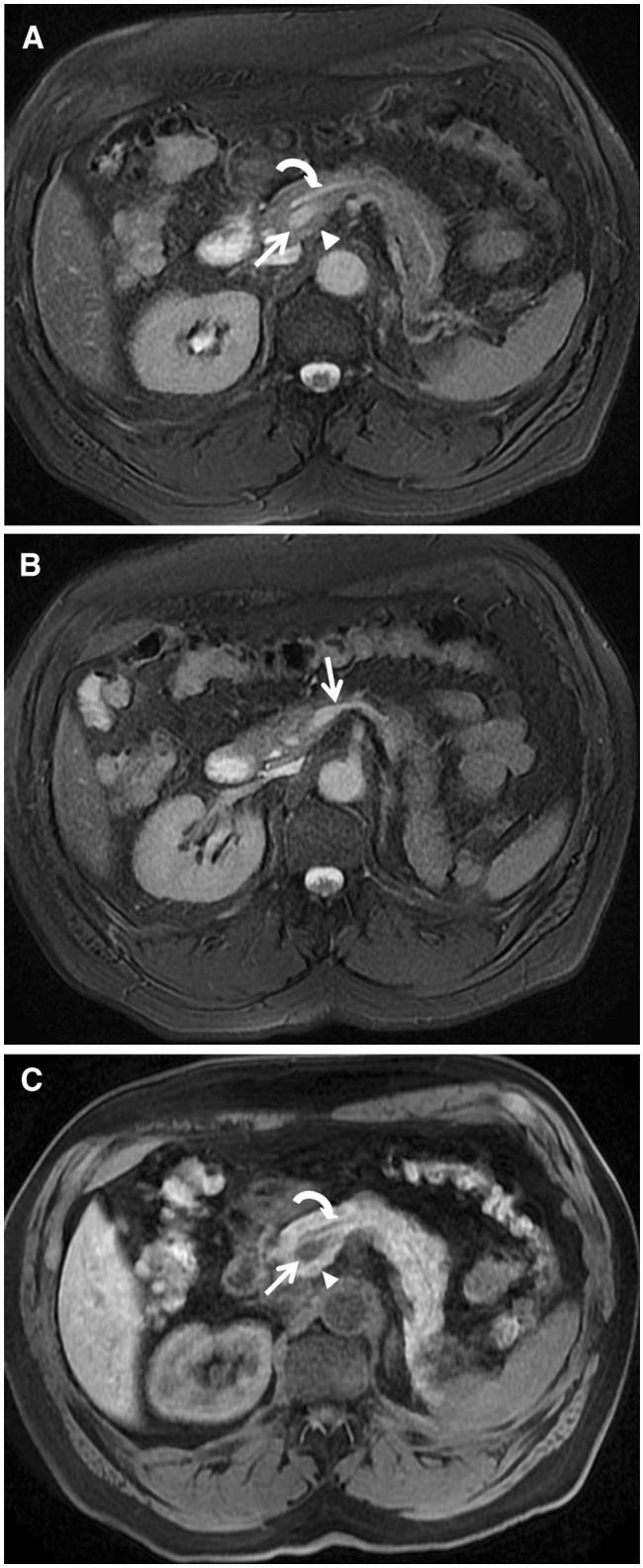


Fig. 1. Drawings illustrate the normal pancreas and the four types of circumportal pancreas based on the course of the pancreatic duct in relation to the portal vein and the location of pancreatic fusion in relation to the splenic vein. **A** Normal pancreas, **B** anteportal suprasplenic, **C** retroportal suprasplenic, **D** anteportal infrasplenic, **E** retroportal infrasplenic.

Table 1. Four subtypes of circumportal pancreas

	Anteportal suprasplenic ($n=32$)	Retroportal suprasplenic ($n=2$)	Anteportal infrasplenic ($n=4$)	Retroportal infrasplenic ($n=1$)
Age range	18–86	59–82	24–79	69
Sex	12 M:20F	1 M:1F	0 M:4F	M
Accessory duct visible behind PV	4	0	0	0
Vascular variants	10	0	2	0
Pancreatitis Hx	2	0	0	1

Note that the accessory duct was not visible in majority of cases and therefore is underrepresented
PV, portal vein; Hx, history

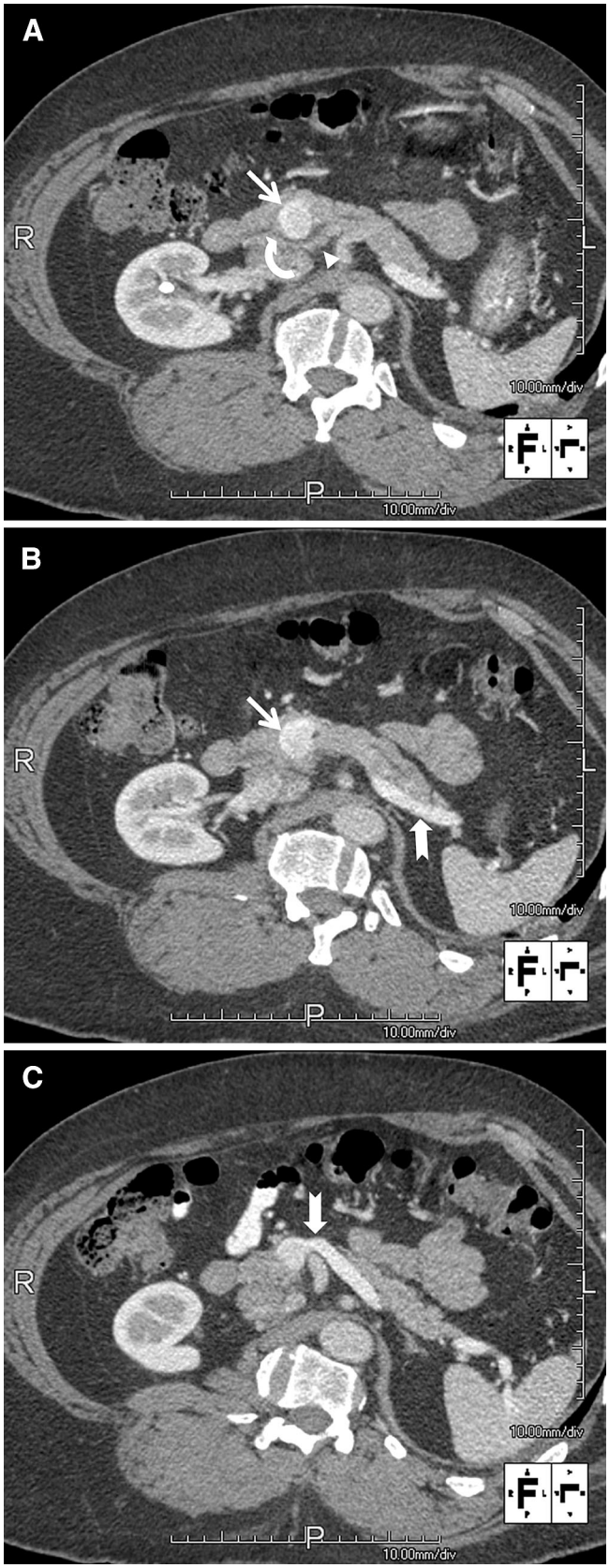


◀ **Fig. 2.** Suprasplenic circumportal pancreas with anteportal duct in an 81-year-old man. **A** Axial fat-suppressed steady-state free precession T2-weighted MR image. The main pancreatic duct (*curved arrow*) courses anterior to the portal vein (*white arrow*). Pancreatic parenchyma (*white arrowhead*) encircles the portal vein. **B** Axial Image obtained caudal to A shows the position of the splenoportal confluence (*white arrow*). **C** Axial fat-suppressed T1-weighted gradient echo MR image. The main pancreatic duct (*curved arrow*) courses anterior to the portal vein (*white arrow*), and pancreatic parenchyma (*white arrowhead*) encircles the portal vein.

the pancreas dorsal to the PV or SMV. CP can be classified according to the course of the main pancreatic duct (anteportal vs. retroportal) and the relationship between the anomalous parenchymal fusion and to the splenic vein (suprasplenic vs. infrasplenic) [9, 10]. Knowledge of the presence and type of CP is important, because if unrecognized, it can be a source of pancreatic leak after pancreatic head resection, particularly when the main pancreatic duct passes dorsal to the portal vein [8, 15, 16]. If CP is present, the surgeon will need to adapt the operation to appropriately manage the aberrant pancreatic tissue and main pancreatic duct during proximal or distal pancreatectomy to avoid pancreatic fistula [6, 8, 13, 15, 16, 18, 19]. It is therefore imperative that radiologists identify and report this anomaly when present. The aim of our study is to describe the relative incidence of CP subtypes and associated vascular anomalies in patients undergoing CT and MRI at our institution over an eight-year period. To our knowledge, this constitutes the largest reported series of this anomaly in the medical literature.

Materials and methods

This HIPAA compliant study was approved by our institutional review board with waiver of the requirement for informed patient consent. We retrospectively reviewed the CT and MR findings of all patients with suspected CP from December 2007 (when we first began to report this finding) through April 2014 at our institution. These cases were identified from the picture archive communication system (PACS) using primordial word search (Primordial Radiology Solutions, Torrance, CA) with additional cases culled from electronic teaching files stored on PACS during this time period, yielding 41 cases. The CT and MR images from these examinations were reviewed by two fellowship-trained abdominal radiologists with 10 years (JP) and 15 years (KH) of



◀ **Fig. 3.** Suprasplenic circumportal pancreas with retroportal duct in a 57-year-old man. Oblique axial post-contrast CT images cranial to caudal (**A**–**C**). **A** Oblique axial post-contrast CT image. The main pancreatic duct (*curved arrow*) courses posterior to the portal vein (*white arrow*) and pancreatic parenchyma (*white arrowhead*) encircle the portal vein. **B** Oblique axial post-contrast CT image shows the location of the splenic vein (*notched arrow*). **C** Oblique axial post-contrast CT image. The splenoportal confluence (*notched arrow*) is inferior to the site of the pancreatic fusion.

abdominal imaging experience. The two radiologists reviewed the CT and MR images, including multiplanar reformats, and reached consensus through discussion during review. A diagnosis of CP was established if an uninterrupted annulus of pancreatic tissue completely surrounded the portal or superior mesenteric vein on at least two consecutive axial images. In one patient, peripancreatic lymphadenopathy created the false appearance of CP. After exclusion of this case, 40 patients comprised the study population (15 males; 25 females; age range 18–86 years). 25 patients were imaged with CT, 14 with CT and MRI, and one with MRI only. Contrast-enhanced CT of the abdomen and pelvis was performed using a 16-detector, 40-detector, or 64-detector row GE Lightspeed CT scanner (GE Healthcare, Milwaukee, WI) with a reconstructed slice thickness of 2.5 mm. Magnetic resonance imaging was performed using a 1.5-T GE Excite scanner (GE Healthcare, Milwaukee, WI) with 8 channel body coil and the following pulse sequences with parallel imaging enabled: coronal single shot fast spin echo (TR = infinite, TE = 80 ms, slice thickness = 8 mm), axial dual echo T1-weighted gradient echo (TR = 175 ms, TE = 2.1, 4.2 ms, slice thickness/gap = 7/1 mm), respiratory-triggered, fat-suppressed T2-weighted fast spin echo (TR = variable, TE = 80–85 ms, slice thickness = 6 mm), axial diffusion-weighted imaging (b values = 0, 500, 1000 s/mm^2, slice thickness/gap = 8/2 mm), and multiphase (precontrast, 25, 60, 90 s, 10 min) dynamic gadolinium-based contrast enhanced, fat-suppressed T1-weighted 3D gradient echo (TR = 3.4 ms, TE = 1.6 ms, partition thickness = 5 mm, overlap = 50%). All CT and MRI examinations were available for review by the readers for each patient, and multiplanar reformats were consulted as necessary. The following observations were recorded in consensus by the two readers: course of the pancreatic duct in relation to the portal vein (anteportal vs. retroportal), location of portal vein encirclement by the pancreatic tissue in relation to the splenic vein (suprasplenic vs. infrasplenic), visualization of an accessory duct posterior to the portal vein, and presence of vascular variants. Vascular variant was defined as a replaced

origin of an artery or intraparenchymal course (through the pancreatic head) of an artery. Following review of the images, the electronic medical record was reviewed for history of pancreatitis. Based on the course of the pancreatic duct in relation to the portal vein and the location of anomalous pancreatic fusion, cases were classified into four categories: anteportal suprasplenic, retroportal suprasplenic, anteportal infrasplenic, and retroportal infrasplenic. Figure 1 demonstrates an illustration of a normal pancreas and the four types of CP.

Results

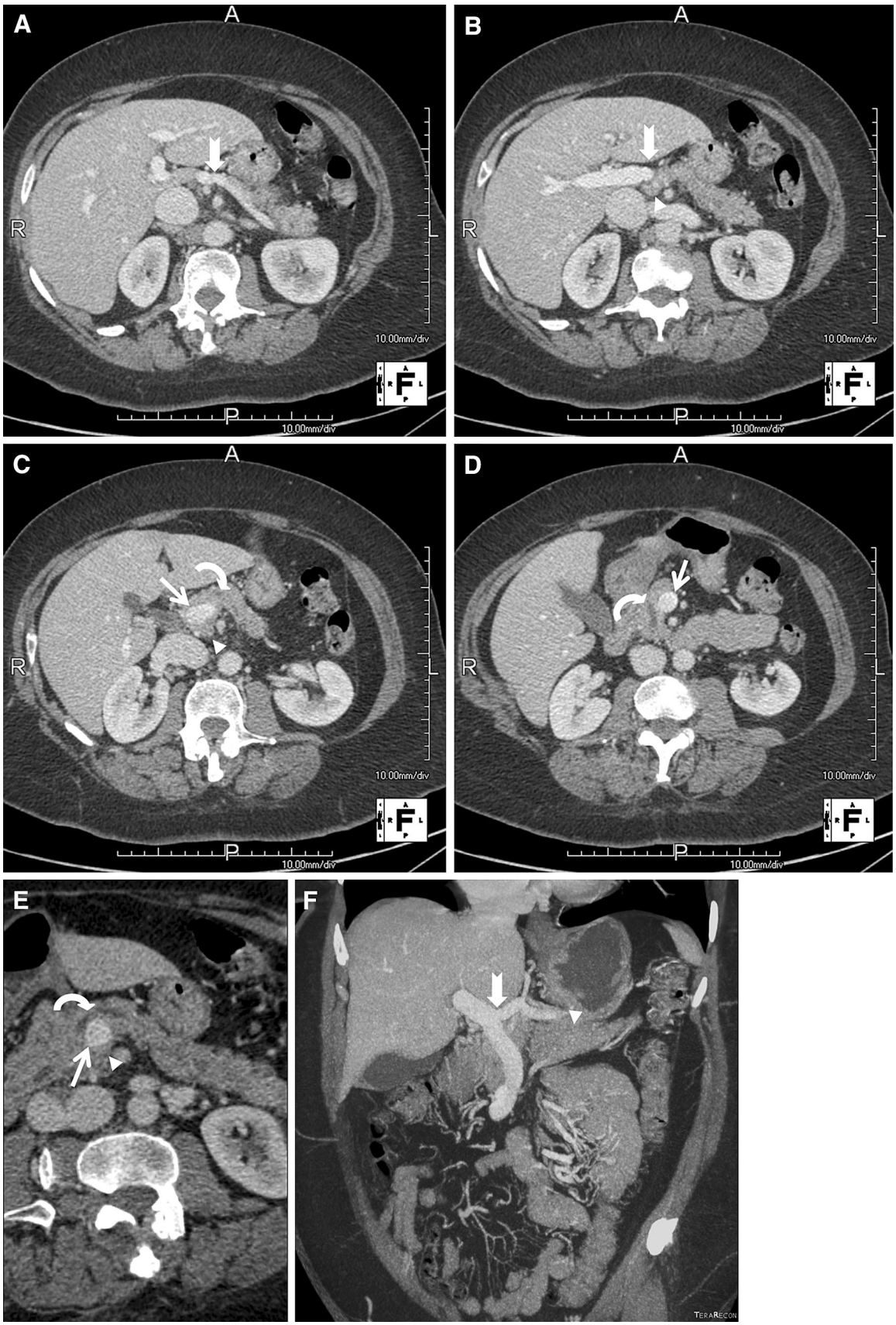
40 cases of circumportal pancreas were identified. Thirty five cases of suprasplenic and five cases of infrasplenic fusion of the pancreas around the portal or superior mesenteric vein were identified. The course of the pancreatic duct was anteportal in 36 and retroportal in three patients. The pancreatic duct was not visualized in one case, in which the fusion was suprasplenic. This case was excluded from classification, yielding a total of 39 cases for classification. 32/39 (82%) of cases were classified as anteportal suprasplenic (Fig. 2). 2/39 (5%) of cases were classified as retroportal suprasplenic (Fig. 3), 4/39 (10%) of cases were classified as anteportal infrasplenic (Fig. 4), and 1/39 (3%) of cases were classified as retroportal infrasplenic (Fig. 5). Table 1 shows the four subtypes of CP and their associated demographics and other imaging and clinical findings.

There were 12 vascular variants involving ten anteportal suprasplenic and two anteportal infrasplenic subtypes (Table 1). There were nine cases with an intraparenchymal course (through the pancreatic head parenchyma) of the common hepatic artery (Fig. 6). Of those, eight were in patients with suprasplenic subtype and one was in a patient with infrasplenic subtype. In all nine cases, the common hepatic artery was a branch of the celiac. There was one case of intraparenchymal course of the right hepatic artery and one case with an intraparenchymal course of the left gastric vein (Fig. 7).

There were two cases with replaced right hepatic artery from the superior mesenteric artery (SMA).In one of these two cases, intraparenchymal course of the common hepatic artery and replaced right hepatic artery from the SMA were both present. An accessory duct was identified behind the PV in 4/14 patients that had both CT and MR examinations. This was seen by CT in 2/4 (Fig. 8) and MR in 3/4. Three patients had a history of pancreatitis.

Discussion

In circumportal pancreas, the head/uncinate process of the pancreas extends to and is fused to the posterior surface of the pancreatic body, resulting in complete encasement of the PV or the SMV by pancreatic tissue. The exact embryogenesis of CP is unclear, but it has been speculated to result from the anomalous fusion of the ventral and dorsal pancreatic primordia [10, 14]. CP was previously thought to be an extremely rare anomaly [10, 11]. However a recent publication showed that the prevalence of CP is higher than previously thought, possibly occurring in as many as 2.5% of individuals [14]. Although our study did not report the prevalence of CP, it is our experience that CP is a more common anomaly than previously thought and that the apparent rarity may be due to lack of recognition by radiologists. CP has been classified according to the position of the pancreatic duct and dorsal fusion of the pancreas relative to the level of the splenic vein [10]. Our study, the largest published to our knowledge, confirms that the combination of an anteportal duct and suprasplenic fusion is by far the most common subtype (82%), and that retroportal main duct is much less common than anteportal main duct. While a mixed subtype has been described in which pancreatic tissue completely surrounds both the portal and the superior mesenteric veins, we did not encounter such a variant in our series, suggesting that it is very rare [9]. In cases where the main pancreatic duct coursed anterior to the portal vein, an accessory duct was visualized posterior to the portal vein in a minority of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◀ **Fig. 4.** Infrasplenic circumportal pancreas with anteportal duct in a 62-year-old woman. Axial post-contrast CT images cranial to caudal (**A**–**D**). The splenoportal confluence (*notched arrow*) is superior to the site of pancreatic fusion. The main pancreatic duct (*curved arrow*) courses anterior to the SMV (*white arrow*) and pancreatic parenchyma (*white arrowhead*) encircles the SMV (*white arrow*). **E** Curved planar reformation CT image. The anteportal course of the main pancreatic duct (*curved arrow*) and pancreatic parenchyma encircling the SMV (*white arrowhead*) are shown. **F** Coronal Maximum Intensity Projection (MIP) CT image demonstrates the infrasplenic location of the pancreatic fusion. The splenoportal confluence (*notched arrow*) is superior to the entirety of the pancreatic parenchyma (*white arrowhead*).

cases. However, failure to visualize such a duct should not be considered proof of its absence. The accessory duct was seen more often with MRI than CT. Therefore, for CP patients undergoing pancreatic surgery, MRI may be the modality of choice to delineate the presence or absence of an accessory duct.

The association of arterial vascular variants with CP has been described in a small number of patients [14]. Of the anteportal suprasplenic subtype, 31% were noted to have vascular variants in our series with the commonest variant being an intraparenchymal course of the common hepatic artery through the pancreatic head. Previous reports in patients without CP show that when the common hepatic artery course is intraparanchymal, it often arises from the SMA [20, 21]. However in our series, all intraparanchymal common hepatic arteries were branches of the celiac artery.

CP can result in multiple technical challenges at the time of proximal and distal pancreatectomy. These include resection of the uncinate, achievement of an adequate surgical margin, closure of the pancreatic stump, and construction of the pancreaticoenterostomy. The neck of the pancreas is typically divided during pancreaticoduodenectomy before the head of the pancreas is dissected off of the uncinate and head of the pancreas. Therefore, recognition of CP may be very late in the procedure at a point of no return. If CP is not recognized preoperatively or intraoperatively, persistent pancreatic leak can result from residual pancreas left posterior to the PV/SMV [8]. Also, if the main pancreatic duct passes posterior to the portal vein, the pancreaticojejunostomy may inappropriately be constructed using the minor duct. Similarly, during distal pancreatectomy, persistent pancreatic fistula may develop if a retroportal main pancreatic duct is not secured [15].

Prior case reports have outlined the technical challenges presented during proximal (pancreaticoduodenectomy) and distal pancreatectomy with incidental findings of a CP [6, 8, 13, 15, 17–19]. Several strategies have been proposed for management of CP [13, 15, 18]. For pancreaticoduodenectomy, two points of transection of the pancreas are required. The first transection plane is at the neck of the pancreas ventral to the portal vein and a second transection is at the fusion point of the retroportal pancreas with the body of pancreas just left of the portal vein [13, 16, 18]. Then, pancreaticojejunostomy or gastrostomy is constructed to the remnant body/tail of pancreas. For subtotal distal pancreatectomy with a transection plane over the portal vein, a retroportal main pancreatic duct will need to be specifically identified and closed [15]. Preoperative main pancreatic duct imaging or intraoperative pancreaticogram [18] can greatly improve application of these strategies.

CP also has significant implications for tumor resectability, as a patient with CP may require PV/SMV reconstruction at time of pancreaticoduodenectomy, and the concomitant intraparenchymal arterial anomalies may complicate resection or deem a patient unresectable.

Despite being the largest series of CP reported to date, our study has several limitations. The cases were identified retrospectively using key word search methodology; therefore, our study does not establish the true prevalence of this anomaly. Furthermore, the cases were not surgically confirmed; however, we believe that the imaging findings of CP on CT or MR are sufficiently characteristic to be diagnostic..

In summary, CP is an important pancreatic fusion anomaly with distinctive CT and MR imaging features. The majority of CP cases are of the anteportal suprasplenic subtype, and the minority of CP cases are retroportal infrasplenic. Recognition and proper classification of CP, and any associated vascular variants is important for surgical planning in patients who undergo pancreatic surgery.

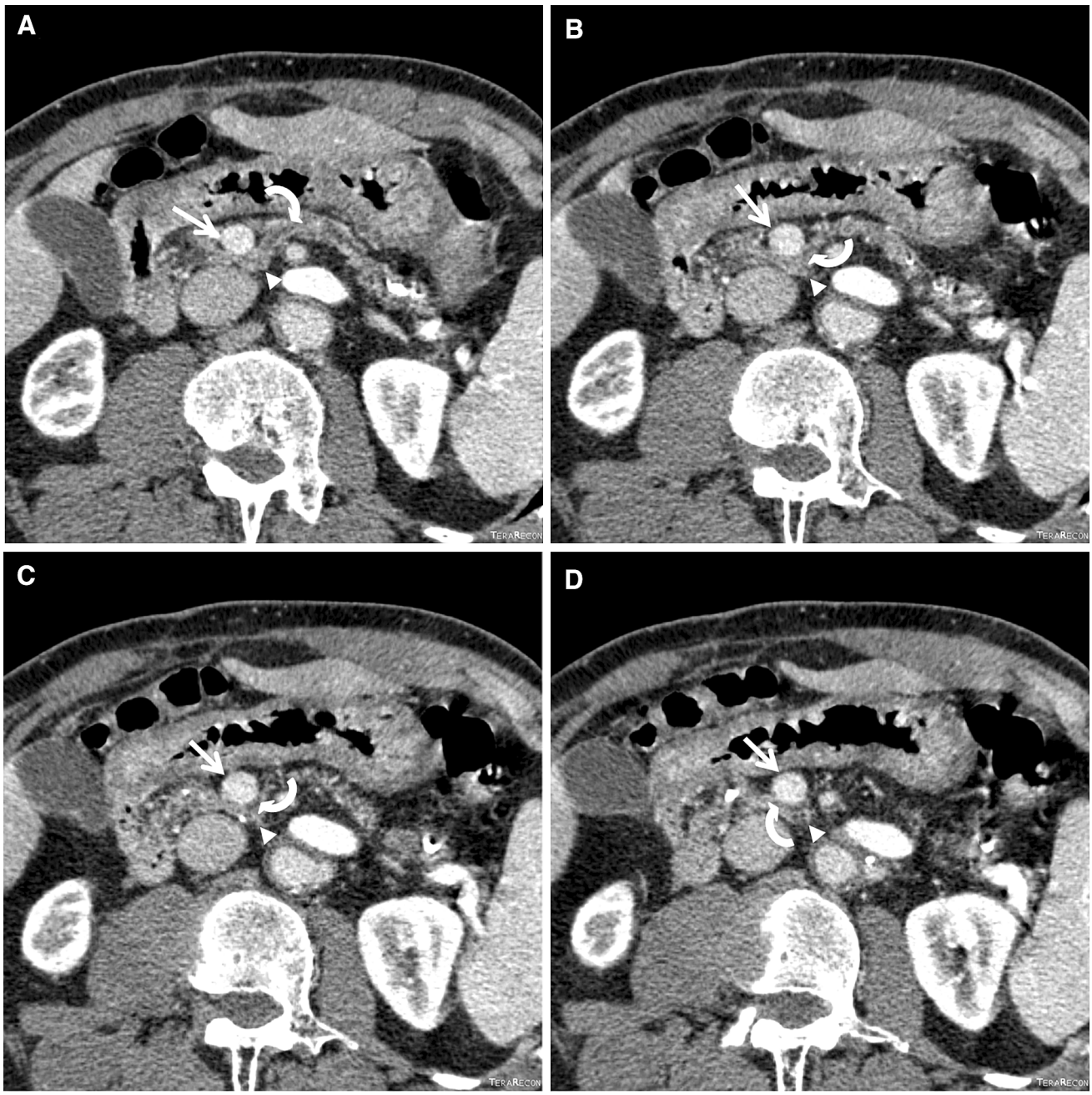

Fig. 5. Infrasplenic circumportal pancreas with retroportal duct in a 69-year-old man. Oblique axial post-contrast CT images cranial to caudal (**A**–**D**). Main pancreatic duct (*curved arrow*) courses posterior to the SMV (*white arrow*) and pancreatic parenchyma (*white arrowhead*) encircle the SMV (*white arrow*). Portions of the pancreatic neck anterior to the portal vein are atrophic due to chronic pancreatitis.

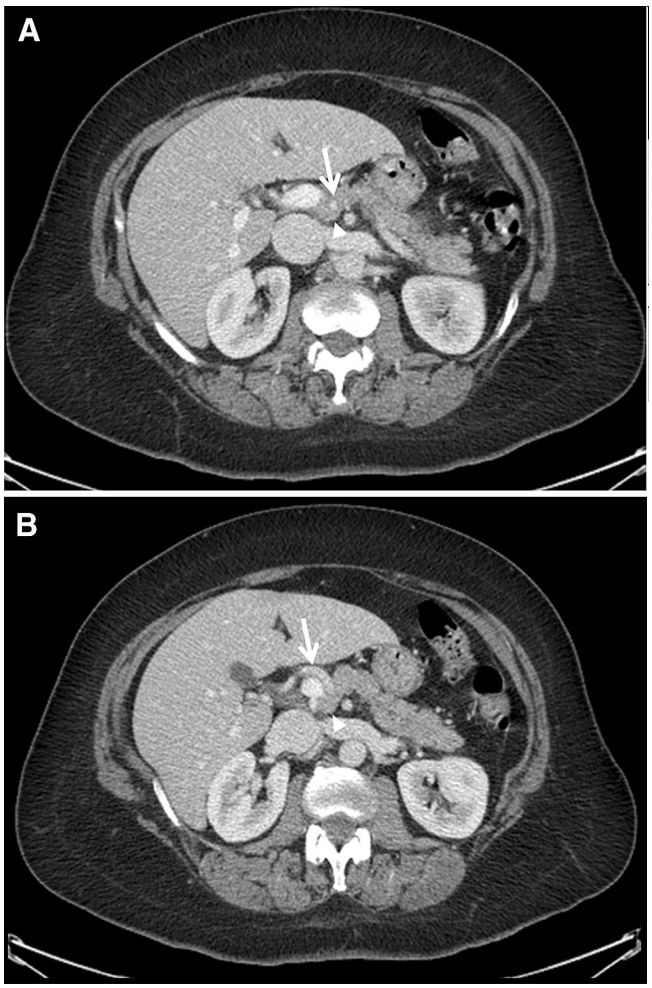

Fig. 6. Intraparenchymal course of the common hepatic artery in a 67-year-old woman with infrasplenic circumportal pancreas and anteportal duct. Post-contrast CT images cranial to caudal (**A**–**B**). The pancreatic parenchyma (*arrowhead*) surrounds the common hepatic artery (*white arrow*).

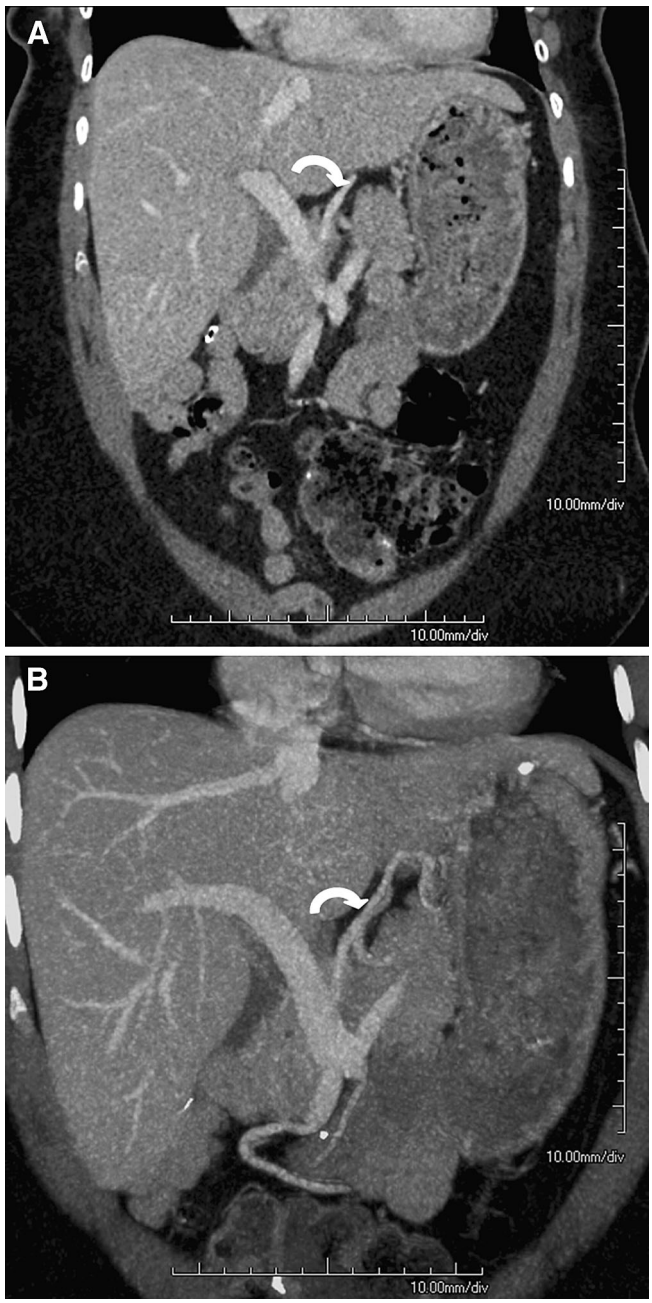

Fig. 7. Intraparenchymal course of left gastric vein in a 61-year-old woman with suprasplenic circumportal pancreas and anteportal duct. **A** Coronal oblique CT image demonstrates the intraparenchymal course of the left gastric vein (*curved arrow*). **B** Coronal oblique Maximum Intensity Projection (MIP) CT image showing the left gastric vein (*curved arrow*) draining into the portal vein.

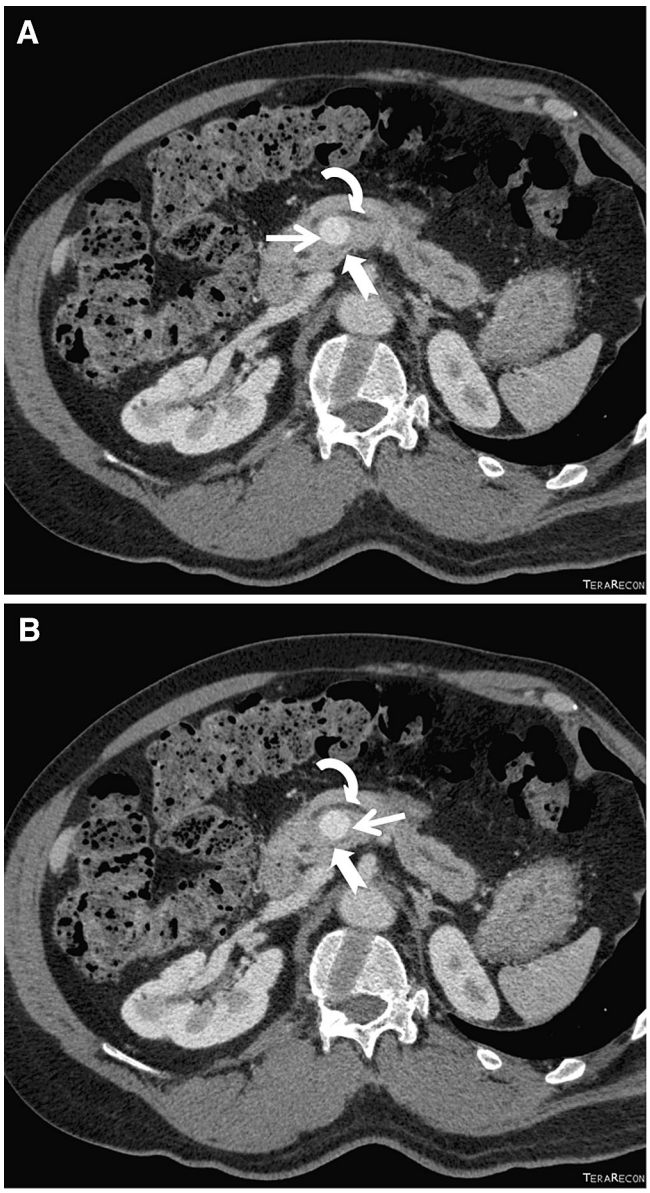

Fig. 8. Accessory duct posterior to portal vein in a 64-year-old man with suprasplenic circumportal pancreas and anteportal duct . Axial oblique post-contrast CT images cranial to caudal (**A**–**B**). Accessory duct (*notched arrow*) courses posterior to the portal vein (*white arrow*). The main pancreatic duct (*curved arrow*) is anterior to the portal vein.

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