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ORIGINAL ARTICLE

Circumportal pancreas: prevalence, subtypes and vascular variations of 55 patients

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Abstract

Purpose To determine the frequency of circumportal pancreas (CP), and accompanying ductal and vascular anatomy variations.

Methods Thin-section multidetector computed tomography of 6813 consecutive patients was retrospectively reviewed. Two radiologists evaluated CP presence with consensus. Concomitant pancreatic ductal and vascular variations were recorded. The course of the pancreatic duct was classified according to the portal vein as anteportal and retroportal, and pancreas fusion level classified according to splenic vein as suprasplenic, infrasplenic and mixed type.

Results A total of 55 (0.8%) CP cases were detected. Six suprasplenic subtype cases were excluded from the classification, because the pancreatic ducts were not clearly distinguishable. Suprasplenic anteportal (45/49, 92%), infrasplenic anteportal (2/49, 4%), suprasplenic retroportal (1/49, 2%), and mixed anteportal subtypes (1/49, 2%) were detected. There were vascular variations in 16 cases (29%). 13/16 (81%) of vascular variations were detected on suprasplenic anteportal subtype. Most of them were replaced right hepatic artery from the superior mesenteric artery (n: 6).

Conclusions CP is a rare but important pancreatic fusion anomaly. Suprasplenic anteportal CP is the most common subtype and other subtypes are very rare. Replaced right hepatic artery from the superior mesenteric artery is the most frequent vascular variation associated with CP. Identifying the CP and defining the pancreatic duct and vascular variations are important to prevent possible complications in patients undergoing pancreatic surgery.

Keywords Circumportal pancreas · Portal annular pancreas · CT · Vascular variations

Introduction

Circumportal pancreas (CP) is a congenital anomaly that completely surrounds the portal vein (PV) and/ or the superior mesenteric vein (SMV) by the uncinate process that extends to the dorsal aspect of the pancreatic body [4] (Fig. 1). CP was first described in 1987 as the hypertrophic uncinate process surrounding superior mesenteric artery and the vein [15]. Two distinct classifications defined for CP according to the relation of fused pancreas parenchyma with splenoportal confluence (suprasplenic, infrasplenic and mixed type), and also according to the extension of the main pancreatic duct with the portal vein (anteportal, retroportal, retroportal with pancreas divisum) [8, 9] (Fig. 2). CP is an asymptomatic pancreatic abnormality, but complications such as pancreatic fistula may occur after pancreatic surgery [2, 4, 5, 14].

CP is not widely recognized by radiologists and surgeons [16]. It is frequently overlooked in cross-sectional imaging and can be detected during surgery [13]. Previous studies have shown CP frequency to be at least 0.2% and at most 2.5% [7, 10]. In a recent publication with 40 cases, it was claimed that CP was more frequent according to the authors' experience [16]. It has also been reported that 52.9% of intraoperatively diagnosed CP cases were missed in preoperative imaging [4]. The purpose of this study was to determine the frequency, subtypes, and accompanying vascular

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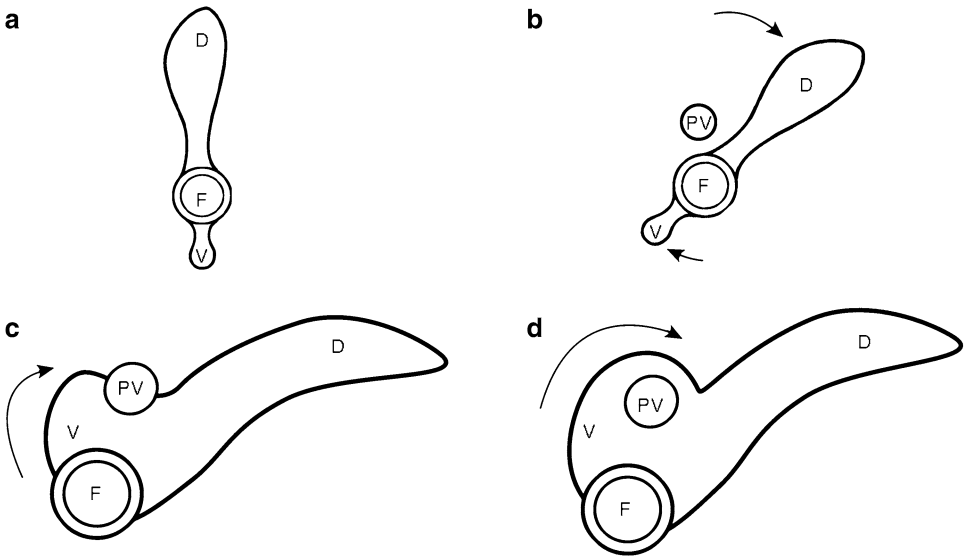

Fig. 1 **a** Normal development of the pancreas. Dorsal (D) and ventral (V) pancreas buds originate from the embryonic foregut (F). **b, c** The growth of the duodenum that results in its rightward loop brings the dorsal and ventral pancreas in close contact. **d** Development of the circumportal pancreas. Ventral bud completely surrounds the portal vein and fuses with the dorsal bud of the pancreas. Adapted from Hikspoors JPJM et al. [6]

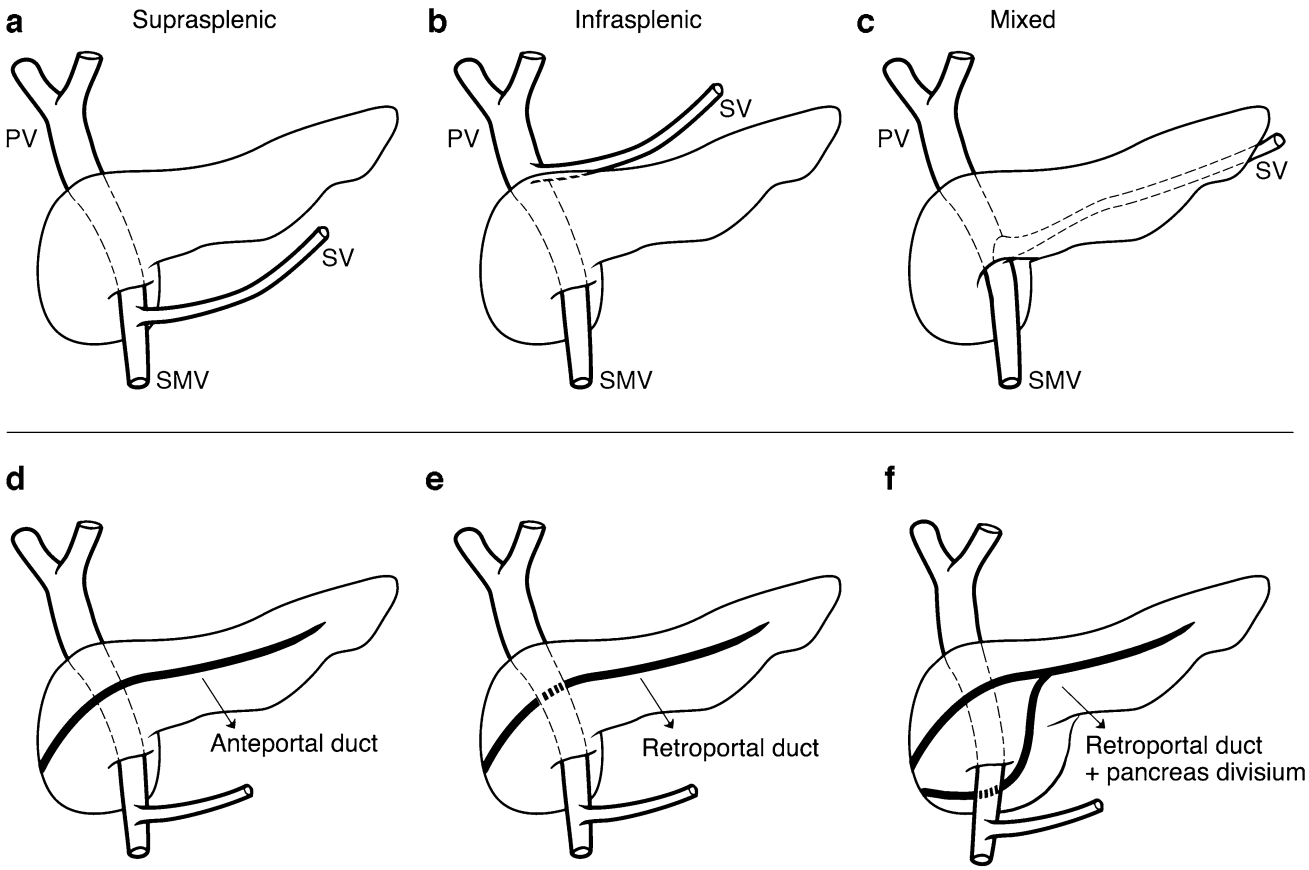

Fig. 2 Illustrative scheme of classification of the circumportal pancreas (CP). **a–c** CP is classified as suprasplenic, infrasplenic and mixed type according to the position of the fused pancreatic diverticula relative to the splenoportal confluence. **d–f** CP also is classified as anteportal, retroportal and retroportal pancreatic duct with pancreas divisum according to the extension of the main pancreatic duct with the portal vein. Adapted from Connelly TM et al. [2]

variations of CP with thin-section multidetector computed tomography (CT).

Materials and methods

This study was approved by the ethics committee of our hospital. Thin-section multidetector CT images of a total of 6813 consecutive patients were retrospectively reviewed between January 2015 and April 2016. Patients with surgery to the head of the pancreas were not included in the study. The most common reasons for CT scans were malignancy (31/55) and abdominal pain (17/55).

Two radiologists with 12 years (EY) and 4 years (AC) of abdominal imaging experience evaluated CP presence with consensus. CP was diagnosed when at least two consecutive sections were seen in which the pancreatic parenchyma surrounded the PV or SMV continuously on axial and oblique axial planes. The diagnosis was confirmed with sagittal and coronal plane images at the workstation. Classification was performed according to the relationship between the pancreatic duct and PV as anteportal and retroportal and between pancreatic fusion site and splenic vein (SV) as suprasplenic, infrasplenic, and mixed. Vascular structures were classified according to origins and presence of intraparenchymal course through the pancreatic head. Figure 3 shows the normal relationship between the pancreatic parenchyma and PV, SV, and SMV.

Results

CP was found in 55 (0.8%) (27 males, 28 females; age range 19–81 years, median age 55 years) of 6813 patients. There was no significant difference between female and male. There were suprasplenic CP in 52 patients, infrasplenic CP in 2 patients, and mixed-type CP in 1 patient. Six patients with suprasplenic fusion were excluded, because the pancreatic ducts were not clearly distinguishable, and 49 cases of CP were classified and divided into subtypes. Forty-five cases (92%) were classified as suprasplenic anteportal (Fig. 4), 1 case (2%) was suprasplenic-retroportal (Fig. 5), 2 cases (4%) were infrasplenic anteportal (Fig. 6), and 1 case (2%) was mixed anteportal subtype (Fig. 7). Sixteen of 55 (29%) cases were accompanied by vascular variations. 13/16 (81%) of vascular variations were seen in suprasplenic anteportal subtype. The demographic and imaging findings of CP subtypes are shown in Table 1.

Discussion

Prevalence

Most patients with CP are incidentally detected and clinically asymptomatic [1]. In a study with a small number of patients (n: 317) and CP cases (n: 8), the CP frequency was

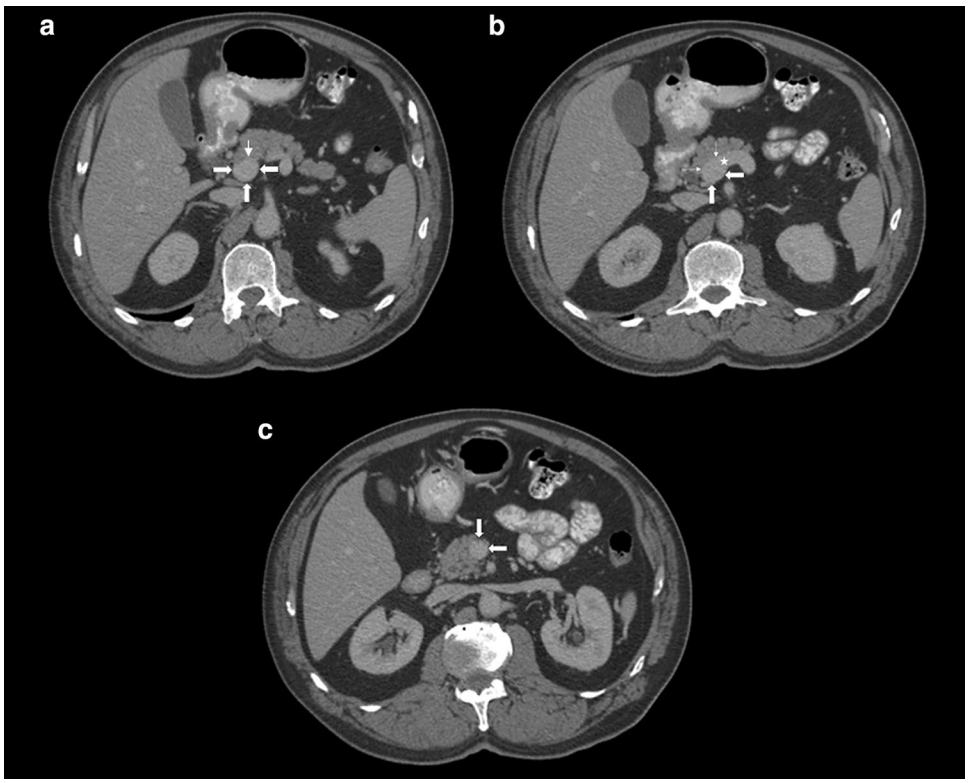

Fig. 3 Topographic relations between pancreatic head and portal vein. **a** Pancreatic parenchyme and the anterior wall of the portal vein are adjacent structures (thin arrow), but the posterior and lateral walls of portal vein (thick arrows) superior to the splenoportal junction are not. **b** Pancreatic parenchyme and the anterior and right lateral walls of the portal vein are adjacent structures (thin arrow), but the posterior and left lateral walls of portal vein (thick arrows) at the level of the splenoportal junction (asterisk) are not. **c** Pancreatic parenchyma and the left anterolateral wall of the portal vein (thin arrow) are not adjacent structures inferior to the splenoportal junction

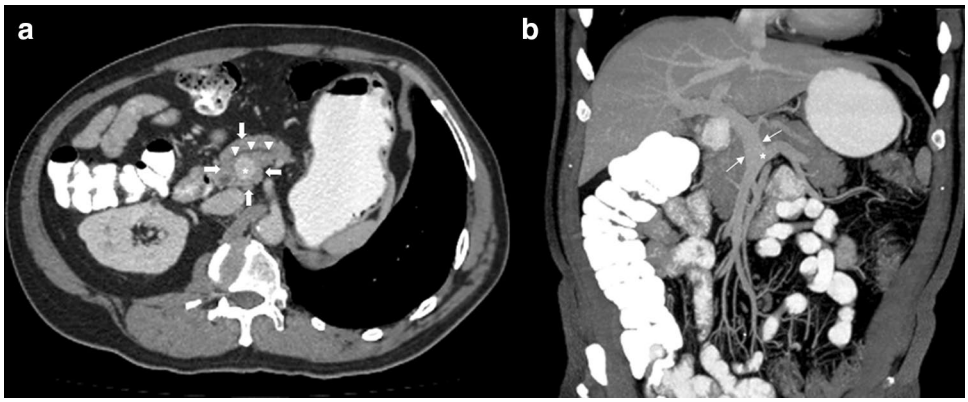

Fig. 4 Suprasplenic anteportal circumportal pancreas (CP) in a 62-year-old male patient

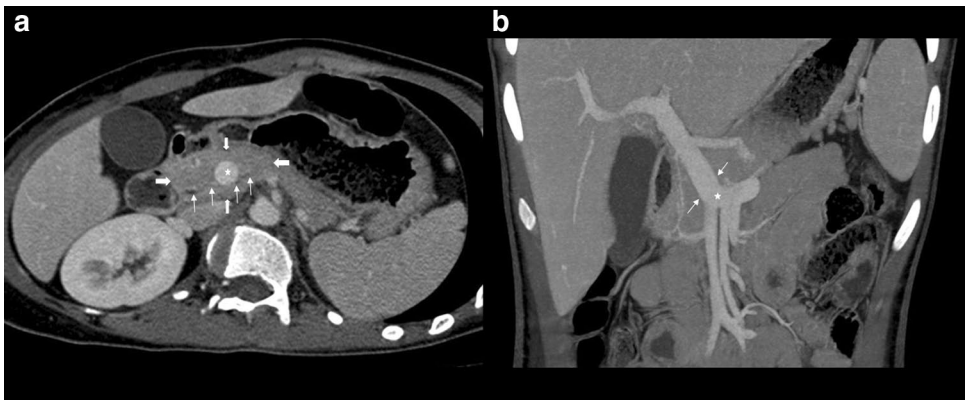

Fig. 5 Suprasplenic retroportal CP in a 19-year-old female patient

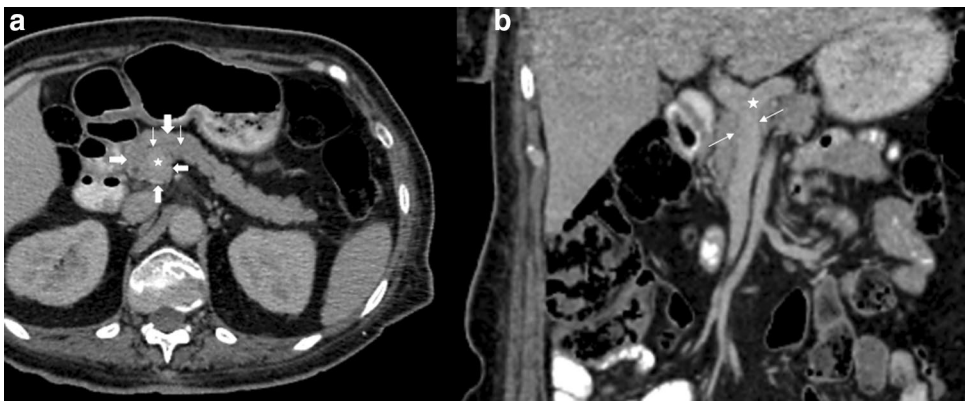

Fig. 6 Infrasplenic anteportal CP in a 59-year-old male patient. **a** Oblique axial post-contrast images demonstrate the portal vein (asterisk) completely surrounded by pancreatic parenchyma (thick arrows). Arrowheads and thin arrows indicate the pancreatic duct. **b** Coronal maximum intensity projection images demonstrate pancreatic fusion level (thin arrows) and splenoportal junction (asterisk)

Table 1 Subtypes of circumportal pancreas

	Patient (n: 49)	Sex	Age (years)	Vascular variations (n: 16)
Suprasplenic anteportal	45 (92%)	23F/22M	19 to 81	RHA originating from SMA, *n:6* (SA crossing the PP, *n:1*) CHA originating from aorta, *n:4* LHA originating from LGA, *n:3* (CHA crossing the PP, *n:1*)
Suprasplenic retroportal	1 (2%)	1F	19	RHA originating from aorta, *n:1*
Infrasplenic anteportal	2 (4%)	1F/1M	59/65	RHA originating from SMA, *n:1*
Mixed anteportal	1(2%)	1M	76	RHA originating from SMA, *n:1*

M male, *F* female, *RHA* right hepatic artery, *SMA* superior mesenteric artery, *SA* splenic artery, *PP* pancreas parenchyma, *CHA* common hepatic artery, *LHA* left hepatic artery, *LGA* left gastric artery

found to be partially high (2.5%) and we think that this value does not show the true CP prevalence [7]. In a recent publication, although not a complete percentage was given, it was claimed that CP is more frequent based on the authors' experience. It was also stated that the rare occurrence may be due to the fact that radiologists and surgeons are not familiar enough with CP [16]. When we evaluated contrast-enhanced multislice CT images of 6813 patients in our study, we found 55 CP (0.8%) patients. As far as we know, our study has the highest number of cases. We think that differences in these findings may be due to retrospective report-image evaluation, differences in surgical workgroups, and may also be due to differences in study populations [1, 13].

In an earlier study, 7 of 8 patients with CP were women [9]; however, it was reported that there was no significant sex difference in a review which examined 21 studies including 59 cases totally [4]. There was also no significant difference between sexes in our study.

Classification of CP

In CP, the main pancreatic duct most often courses anterior to the PV [8]. When the subtypes are classified according to the SV, the most common pancreatic fusion level is suprasplenic location [9]. CP classification has great importance in the planning of pancreatic surgery, the application of surgical technique, and in surgical results. It has been reported that mixed-type CP surgery is the most challenging, especially in cases of pancreaticoduodenectomy [11]. In a study that the extent of the main pancreatic duct and pancreatic fusion level were evaluated together, suprasplenic anteportal (82%), infrasplenic anteportal (10%), suprasplenic retroportal (5%), and infrasplenic retroportal (3%) cases were reported [16]. In our study, 45 of 49 patients were suprasplenic anteportal (92%), one was suprasplenic retroportal (2%), two were infrasplenic anteportal (4%), and one was mixed anteportal (2%) subtypes; infrasplenic retroportal and mixed retroportal subtypes were not detected. The accessory pancreatic duct could be seen coursing posterior to the PV in a small proportion of patients in which the main pancreatic duct coursed anterior to the PV. Each accessory pancreatic channel may not be demonstrated with CT imaging. Magnetic resonance imaging (MRI) is superior to CT for accessory pancreatic duct visualization [16]. There were eight cases with MRI in our study and no accessory channel was detected. However, MRI should be preferred to investigate accessory ducts, especially in patients who require pancreatic surgery.

Diagnosis with CT

CP can also be detected in non-contrasted CT scans. However, retroportal extension of the pancreatic duct, especially in the CP, is better visualized in contrast-enhanced CT [3]. Based on our experience, in non-contrasted studies PV and SMV can be distinguished from pancreas parenchyma in some patients but not in others. Furthermore, a false CP appearance may be seen if the vessel lumen does not completely fill with contrast media, especially in the arterial phase. We think that evaluation of CP in the portal vein phase is more accurate.

Vascular variations

Vascular variations that accompany CP may cause surgical complications [17]. Atypical extension of the celiac artery, common or right hepatic artery, especially in suprasplenic CP cases, may complicate surgery [9]. In a study of 40 cases, it was shown that 10 (31%) of 32 suprasplenic anteportal CP cases had vascular variations and pancreatic parenchyma

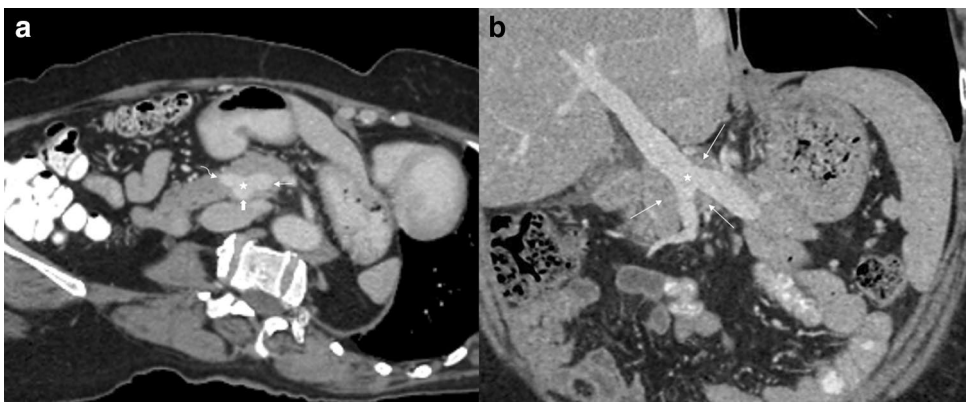

Fig. 7 Mixed anteportal circumportal pancreas in a 76-year-old male patient. **a** Oblique axial post-contrast image demonstrates portal vein (thick arrow), splenic vein (thin arrow) and superior mesenteric vein (curved arrow) are completely surrounded by pancreatic parenchyma at the level of the splenoportal junction (asterisk). **b** Oblique coronal image demonstrates pancreatic parenchyma (thin arrows) completely surrounding the splenoportal junction (asterisk)

transition of common hepatic artery was the most common variation [16]. In our study, vascular variations were shown in 13 (29%) of 45 cases of suprasplenic anteportal CP subtype, and replaced right hepatic artery from the superior mesenteric artery was the most common variation.

Clinical importance

Recognition of CP with imaging can avoid patients from unnecessary surgery [7]. However, if CP is not recognized, it may be misinterpreted as a tumoral mass that surrounds the portal vein or as a mass posterior to the portal vein [12, 13]. It has also been noted that if CP is not fully defined in the presence of neoplasia, the lesion may not be completely removed and may be skipped [2]. For these reasons, CP should be examined more carefully in routine radiologic evaluation.

It has become critically important for surgeons to know about the presence of pancreatic anomalies before surgery by increasing the diversity and frequency of pancreatic surgery methods [16]. However, CP was diagnosed incidentally during surgery in 17 patients (52.9%), which was missed on preoperative MRI and CT scan [4]. CP detection during pancreatic resection changes the surgical procedure significantly and requires pancreaticointestinal reconstruction [9]. If CP is not recognized before or during the operation, the residual pancreatic tissue left posterior to the PV or SMV may cause a pancreatic leak [14]. If the retroportal pancreatic duct is not preserved during distal pancreatectomy, a pancreatic fistula may develop [5].

Limitations

One of the limitations of our study is the retrospective design. Another limitation is the lack of surgical confirmation. CP is a rare asymptomatic fusion anomaly. There was no history of pancreatic surgery in the hospital records of our present cases. However, pancreatic tissue completely surrounding PV, SMV or SV was detected in axial, axial–oblique images in CT, and confirmed in sagittal and coronal planes, thus we believe that imaging findings are sufficient for diagnosis. Another limitation is we could not demonstrate possible accessory pancreatic ductal variations, since there was not enough MRI in our cases.

Conclusion

CP is currently not widely known by radiologists and surgeons. It is a clinically significant pancreatic fusion anomaly with a frequency of 0.8%. Suprasplenic anteportal CP is the most common subtype. The most common vascular variation is the replaced right hepatic artery from the superior mesenteric artery. In patients undergoing pancreatic surgery, prior awareness of the presence of CP, subtypes, and vascular variations is critical to prevent possible complications such as fistulae and vascular injury.

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Author contributions E Yilmaz: project development, data collection, manuscript writing. A Celik: data collection.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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