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Common and Uncommon Benign Pancreatic Lesions Mimicking Malignancy: Imaging Update and Review

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There is a broad range of inflammatory, pseudotumoral, and benign lesions that may masquerade as pancreatic malignancies, often representing a challenge to the radiologist. Unawareness of these entities can lead to inadequate differential diagnoses or misdiagnosis, with important prognostic and therapeutic consequences. The purpose of this article is to revisit a spectrum of lesions, varying from common to exceedingly rare nonmalignant, that may mimic malignant pancreatic neoplasms on imaging, identifying relevant features that may contribute to reaching the correct diagnosis. Representative cases include focal fatty replacement, intrapancreatic accessory spleen, pancreatic lobulation, lipoma, autoimmune pancreatitis, focal pancreatitis, eosinophilic pancreatitis, groove pancreatitis, hemangioma, intrapancreatic aneurysm, tuberculosis, and Castleman's disease.
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Introduction

The advances and large widespread use of multimodality imaging of pancreas in the past years have improved the detection of pancreatic diseases, some of which are being increasingly discovered incidentally.[1-3] Currently, the roles of imaging include identifying and characterizing the lesion, ultimately helping to establish the most appropriate management. Despite these advances, however, there is a range of inflammatory, pseudotumoral, and benign lesions that may mimic a pancreatic malignancy, and they often represent a challenge for the radiologist. Unawareness of these entities can lead to inadequate differential diagnoses or misdiagnosis with important implications, as nonneoplastic lesions have different approaches and prognoses than the malignant ones.[4]

On the contrary, pseudotumoral lesions may present specific imaging features that may help to suggest a correct diagnosis. This is particularly relevant because CA19-9, the only clinically available Food and Drug Administration-approved blood biomarker for pancreatic ductal adenocarcinoma,[5] has a median sensitivity of only 81% and specificity of 90% when using a 37 kU/L cutoff value, whereas increasing the cutoff value to 100 kU/L improves specificity to 98% but reduces sensitivity to 68%.[6] Moreover, CA19-9 has a high rate of false-positive results induced by obstructive jaundice, and a major limitation is that it may be markedly elevated in patients with other malignancies such as colorectal, liver, breast, and lung cancers, as well as nonmalignant diseases such as pancreatitis, cirrhosis, and lung disorders.[7] In this sense, because CA 19-9 serum levels alone cannot distinguish between benign or malignant pancreatic lesions, the American Society of Clinical Oncology states that the diagnostic performance of CA 19-9 alone is inadequate for a reliable diagnosis of pancreatic cancer,[7,8] which highlights, in such a context, the pivotal role of imaging studies.

The purpose of this article, therefore, is to revisit the most frequent benign lesions that may mimic malignant pancreatic neoplasms on imaging, identifying associated clinical and imaging features that are helpful in reaching the correct diagnosis.

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http://dx.doi.org/10.1053/j.sult.2017.10.002
0887-2171/

Mimickers of Primary Pancreatic Tumors

Fatty Replacement of the Pancreas

Fatty replacement of the pancreas is a benign process that has been associated with a myriad of diseases, such as obesity, diabetes mellitus, chronic pancreatitis, hereditary pancreatitis, obstruction of the pancreatic duct by calculus or tumor, and cystic fibrosis.[9-11] The natural marbling of pancreatic tissue with fat, typically seen in individuals who are middle aged or older, may occur in a heterogeneous pattern.[12] In such rare cases, the focal fatty replacement or sparing, however, may mimic masses, producing possible pseudotumors in regions of relatively less involvement, typically between the ventral (uncinate process) and dorsal pancreas.[12]

Ancillary findings that may help in the differentiation between focal fatty replacement and true tumors include the absence of mass effect, nondeformity of the configuration of the pancreatic contours, and absence of associated ductal or vascular displacement in the affected area[13,14] (Figs. 1 and 2). On US, focal fatty infiltration is hyperechoic in comparison to the rest of the normal pancreas; in contradistinction, focal fatty sparing is hypoechoic (Fig. 2) in comparison to the surrounding fatty pancreas.[13,14] If the lesion contains sufficient macroscopic fat to possess negative attenuation on CT, unenhanced CT can be useful (Fig. 2); contrast-enhanced CT, otherwise, is usually not helpful in such cases, as the attenuation of the lesion increases consequent to the presence of normal parenchyma interspersed between foci of fatty infiltration, preventing the detection of fat.[13,14] Chemical shift T1-W MR imaging in combination with fat-suppression techniques are considered the preferred modality to characterize these lesions,[10,14] specially when the degree of focal fatty replacement is not so high, making it difficult to differentiate it from true pancreatic neoplasm on CT.[10] Macroscopic fatty replacement exhibits high signal with T1- and T2-weighted (W) sequences, with signal loss in the fat-suppressed sequences.[14] Microscopic fat, commonly present in fatty infiltration, is reliably detected with use of chemical shift MR imaging, the affected areas showing some degree of loss of signal intensity on the opposed-phase T1-W sequence relative to the in-phase T1-W sequence (Fig. 1).[10,12,14]

Intrapancreatic Accessory Spleen

Accessory spleens are a congenital anomaly (consequent to a failure of fusion of the splenic anlage in the dorsal mesogastrium) found in approximately 10% of the population, with 1 out of 6 cases occurring in the pancreatic tail.[15-17] Despite this, intrapancreatic accessory spleens (IPAS) are rarely recognized radiologically.[18] IPAS are benign and usually asymptomatic lesions (except in the context of diseases like recurrent immune thrombocytopenic purpura[19]), and remain stable over years of follow-up imaging.[17] They are currently more readily detected due to improved cross-sectional techniques, better spatial resolution, and dynamic contrast imaging. However, they are

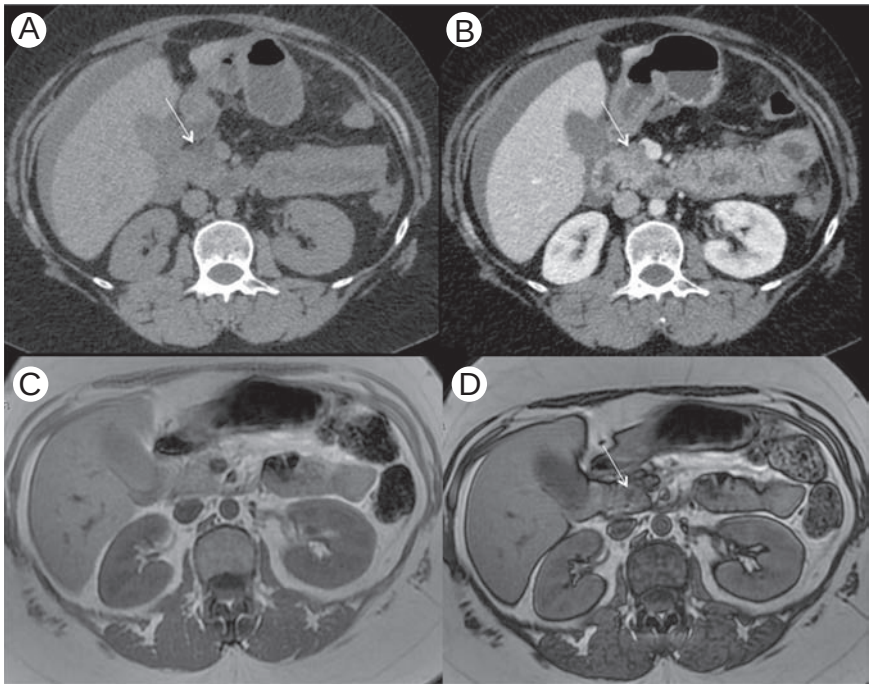

Figure 1 Focal fatty replacement in the periportal portion of the head of the pancreas in a 42-year-old woman with a history of breast cancer who presented for follow-up after chemotherapy. Axial unenhanced CT (A) scan shows an ovoid, low-attenuation lesion (arrow) that does not deform the contours of the pancreatic head. Axial contrast-enhanced CT scan in the portal phase (B) shows heterogeneous enhancement (arrow) of this area, simulating a true mass. Axial T1-W gradient-echo in-phase sequence (C) shows no focal lesion in head of pancreas, whereas the opposed-phase sequence (D) exhibits a focal signal drop in the pseudolesion (arrow), proving its fat content.

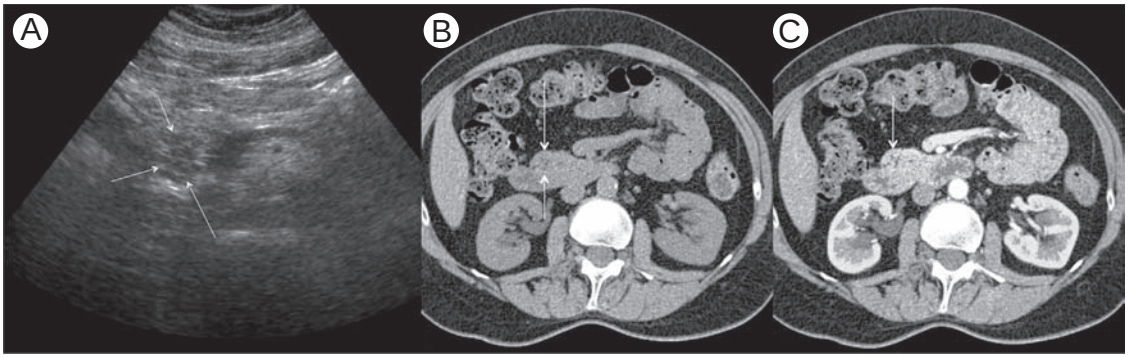

Figure 2 Focal fatty replacement in the head of the pancreas in a 55-year-old asymptomatic man. Ultrasound image (A) shows a 2.0-cm heterogeneous, mostly hypoechoic, solid nodule in the head of the pancreas (arrows). Subsequent axial unenhanced (B) and contrast-enhanced arterial phase (C) CT images demonstrate multiple tiny foci of fatty replacement in the head of the pancreas with surrounding normal parenchyma (arrows).

also increasingly mistaken for other pancreatic lesions,[17] particularly for asymptomatic small neuroendocrine tumor (NET),[18] but also for well-differentiated adenocarcinoma, solid pseudopapillary tumor, or metastatic tumor to the pancreas.[20]

IPAS can, in most cases, be confidently diagnosed non-invasively on high-quality thin-slice multiphasic contrast-enhanced CT or MRI (Fig. 3). Typical location, similar attenuation or signal of the lesion to the spleen on unenhanced CT or MRI, and contrast-enhanced CT or MRI at different phases are helpful to establish diagnosis of IPAS.[17,18] In particular, the characteristic arciform pattern of arterial enhancement (a feature shared both by IPAS and the spleen itself), resulting from perfusion differences between the red and white pulps, is an important criterion for differentiating IPAS from hypervascular neoplasms such as NETs and metastases.[14] In patients with imaging findings characteristic for intra-pancreatic accessory spleen, follow-up imaging at 6 and 12 months, for a 1-year duration, is helpful in confirming interval lesion stability consistent with this benign diagnosis, avoiding the small but not negligible risks of biopsy-related complications such as hematoma, pancreatitis and trauma to adjacent tissues.[21] Diffusion-weighted MR imaging (both by qualitative and quantitative analyses of signal intensity in terms of similarity between the pancreatic lesion and splenic parenchyma) has been demonstrated a useful tool, in conjunction with conventional sequences, in differentiating IPAS from

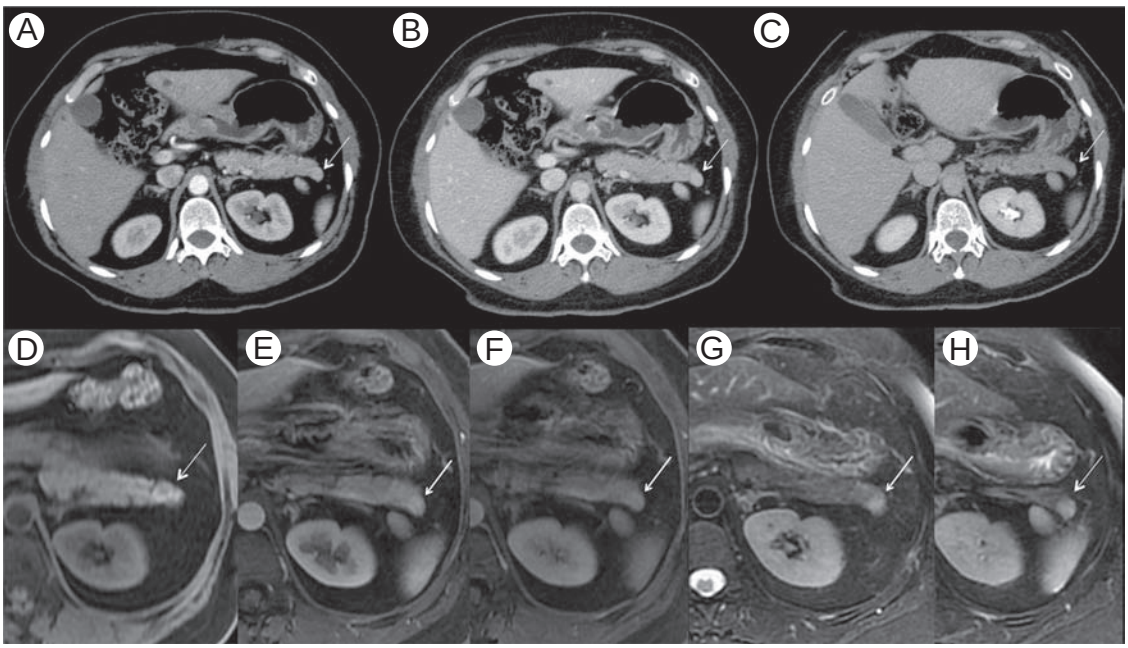

Figure 3 Intrapancreatic accessory spleen in a 40-year-old man with an incidental pancreatic mass. Arterial (A), portal (B), and delayed (C) CT images demonstrate a 1.5-cm pancreatic tail mass (arrows) that shows enhancement a little more pronounced than that of the normal pancreatic parenchyma, matching the density of the spleen on all phases. Unenhanced, arterial and portal phases of dynamic contrast-enhanced MRI (D-F) show the accessory spleen undergoing a pattern of enhancement that is similar to that of the spleen (arrows). Similarly, on axial fat-saturated T2-W images (G and H) the intrapancreatic accessory spleen (arrows) has a relative hyperintense signal similar to that of the spleen.

small (<3 cm) solid pancreatic tumors.[22] Finally, Tc-99m scintigraphy, superparamagnetic iron oxide (SPIO)-enhanced MRI and Levovist-enhanced US can be used to confirm the diagnosis when IPAS is suspected.[23]

Pancreatic Lobulation

The normal pancreas has a lobulated appearance and sometimes a prominent focal exophytic lobulation (generally an extension of the parenchyma more than 1 cm beyond the pancreatic contours) may mimic a pancreatic lesion (Fig. 4).[24,25] This occurs more commonly in the pancreatic head and neck, and, depending on the relationship with the anterior superior pancreaticoduodenal artery, Ross et al.[25] classified these lobulations in anterior (type I), posterior (type II) and horizontal (type III). Pancreatic lobulations can be distinguished from other mass lesions on imaging based on the fact that their features and enhancement patterns strictly follow those of the rest of the pancreatic parenchyma.[25]

Pancreatic Lipoma

Pancreatic lipomas (Fig. 5) are rare tumors, found in only 0.083% of cases in a large series of 6000 CT scans.[26] Lipomas tend to be homogenous and well-circumscribed pancreatic tumors. The most important feature for the diagnosis is the detection of fatty tissue on CT and MR scans, when the differential diagnosis then includes other rare fatty pancreatic tumors (focal fatty infiltration, teratoma, liposarcoma).[27] Grossly, a pancreatic lipoma is a mass made up of mature adipose cells encapsulated in a collagen layer that facilitates enucleation and helps differentiate it from lipomatosis.[28,29] Most lesions are located in the head of the pancreas, rather than in the body or tail,[29] the size ranging from 0.1 to about 5.0 cm (tending to be stable over time).[30] Resolution of the lipoma has also been described. Most patients are asymptomatic.[30]

Pancreatic lipomas are nonenhancing masses with an homogeneous negative attenuation (values ranging from −30 to 120 HU), rarely infiltrating into surrounding structures.[29,31] On MRI, the signal intensity is similar to that of fat found elsewhere in the body, i.e., hyperintense on both T1 and T2-W sequences; fat-suppressed T1-W images demonstrate homogeneous suppression of signal intensity within the tumour, confirming the macroscopic fatty content; although not common, pancreatic or biliary obstruction may be seen as a consequence of extrinsic compression of ductal structures.[26,27,29] Some lipomas have prominent fibrous septa and nodularity, with a more complex appearance that may raise concern for a well-differentiated liposarcomas at imaging.[32]

Autoimmune Pancreatitis

Autoimmune pancreatitis (AIP) is a rare type of pancreatitis in which an immune-mediated mechanism is thought to trigger a process of marked infiltration of lymphocytes and plasma cells in pancreatic tissue.[26,27] First described in 1961,[28] it can be classified radiologically into two types: diffuse, the most common (up to 70% of cases) or focal (approximately 30% of cases),[33-35] the latter characterized by focal swelling of the

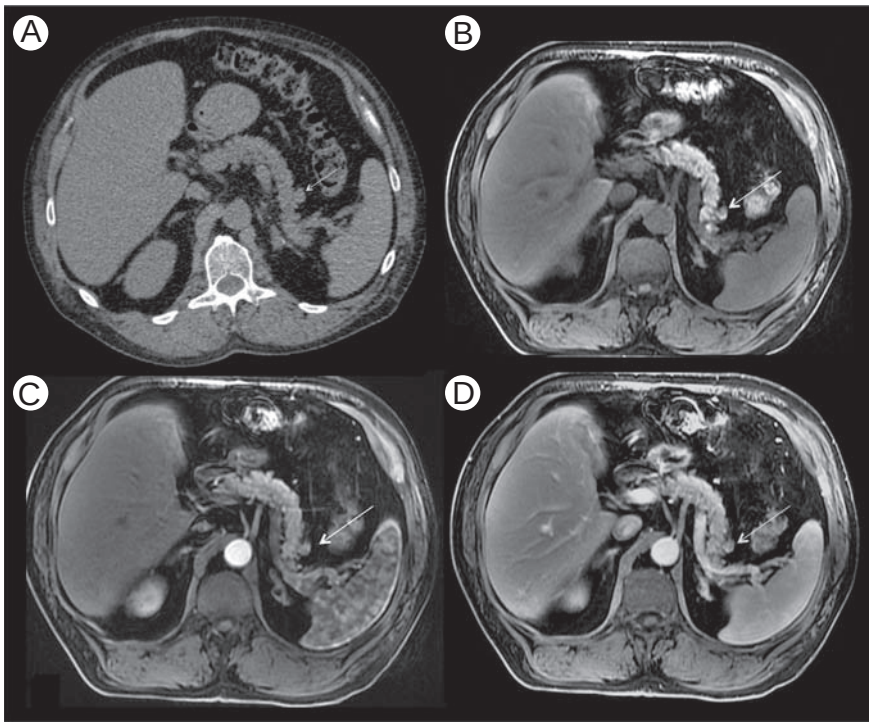

Figure 4 Prominent pancreatic lobulation mimicking metastasis in a 64-year-old woman with previous renal cell carcinoma. Unenhanced CT (A) shows a well-defined exophytic focal mass (arrow) that is isodense relative to the surrounding pancreas and isointense on axial fat-suppressed unenhanced (B), postcontrast arterial (C), and portal (D) T1-W phases (arrows). These findings are consistent with pancreatic lobulation.

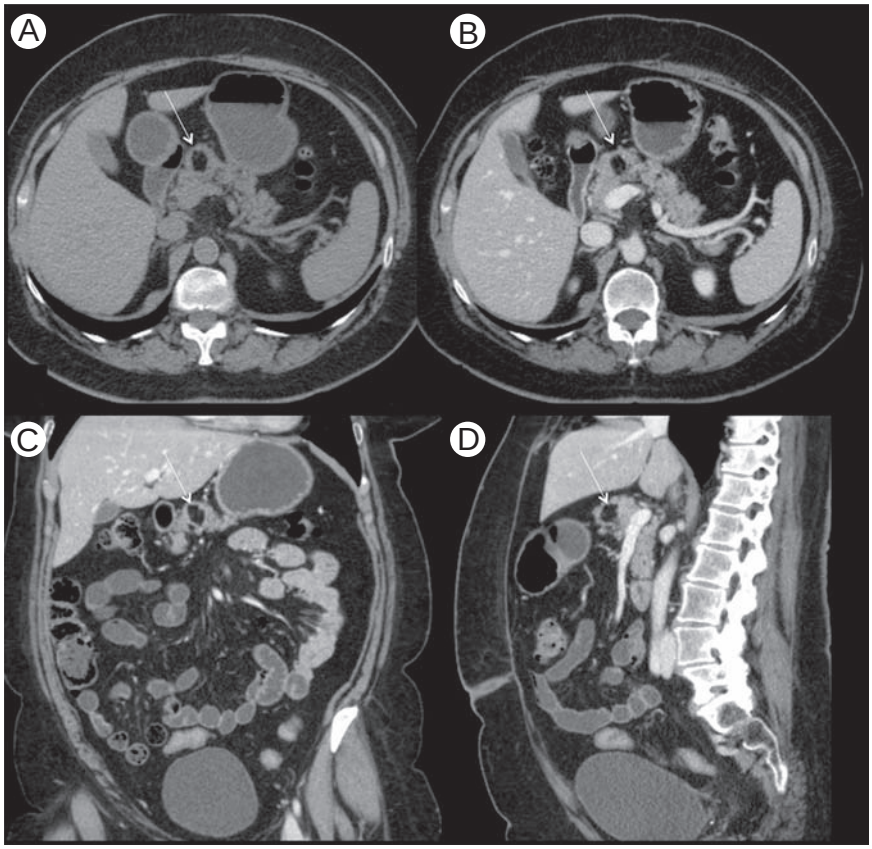

Figure 5 Incidental intrapancreatic small circumscribed lipoma in the head of the pancreas in a 50-year-old woman, stable for 3 years. Axial unenhanced (A) and axial (B), coronal (C), and sagittal (D) contrast-enhanced CT images shows fat attenuation of the lesion (arrows), without enhancement.

pancreas and localized narrowing of the main pancreatic duct.[27] Diagnostic features of AIP include an elevated serum IgG4 level, focal or diffuse pancreatic enlargement on imaging, and dense lymphoplasmacytic infiltrates positive for IgG4 on histologic study.[36] The disease can be associated with extrapancreatic manifestations, including sclerosing cholangitis and retroperitoneal fibrosis, and tends to respond dramatically to corticosteroid treatment.[36,37]

Particularly when a focal pancreatic enlargement is observed on imaging in the context of AIP (Fig. 6), differentiation from pancreatic cancer is very difficult[37,38]; in this context, it has been described that about 3%-5% of patients undergoing pancreatic resection for presumed pancreatic cancer in fact have AIP.[39]

On imaging studies, the diffuse form typically appears as a diffuse parenchymal enlargement, with effacement of the normal lobulations of the pancreatic contours. Such swelling tends to be hypoechoic on US, and CT shows a diffusely decreased pancreatic enhancement during the early phase and delayed enhancement in the late phase of contrast enhancement.[33,34,36] Similarly, on MRI the pancreatic parenchyma exhibits a diffusely hypointense signal on T1-W images, with slightly hyperintense signal on T2-W images, and a heterogeneously diminished enhancement during the early phase and delayed enhancement during the late phase of contrast enhancement.[33,34,36] In up to 40% of patients, a capsule-like rim, consisting of a hypodense halo with soft-tissue attenuation (also T1- and T2-W hypointense on MRI), may be seen involving the enlarged pancreas, thought to represent inflammatory cell infiltration.[36] The focal form usually follows the MRI signal intensity/CT density and contrast-enhancement patterns observed in the diffuse form (Fig. 6).[36] Occasionally, diffuse or localized narrowing of the main pancreatic duct may be also noted.[36]

Focal Pancreatitis

Pancreatitis can manifest itself as a focal inflammatory mass (pseudotumoral pancreatitis) (Figs. 7 and 8), often in the pancreatic head, thereby mimicking adenocarcinoma, a situation in which the differentiation between the 2 entities is difficult clinically, radiologically, and even histologically.[12,14] First, clinical features such as abdominal pain, obstructive jaundice and weight loss may be seen in both situations; moreover, imaging studies may be confusing as inflammation can coexist with adenocarcinoma and this neoplasm may also arise in long-standing chronic pancreatitis (2% of cases after 10 years and 6% after 20 years).[14,40,41] It has been described that focal pancreatitis accounts for 5%-10% of pancreatectomies for presumed malignancy.[14,42]

On imaging, both adenocarcinoma and focal pancreatitis are usually hypoechoic at US, hypoattenuating at CT, and have the same signal intensity at T1- and T2-W MR imaging.[14,43] Moreover, both entities may present with other associated

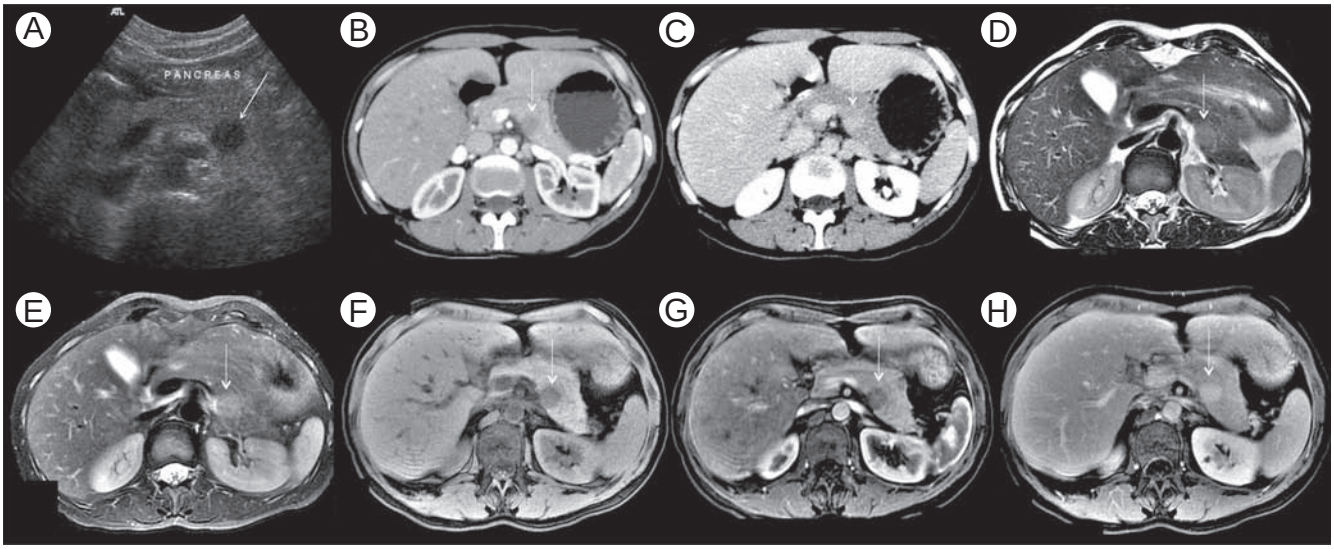

Figure 6 Focal autoimmune pancreatitis in a 41-year-old asymptomatic woman, resolved after corticosteroids therapy. Ultrasonography (A) shows a solid hypoechoic nodule in the tail of the pancreas (arrows). Contrast-enhanced arterial phase CT scan (B) shows a hypovascular nodule in the pancreatic tail with persistent delayed enhancement (C) (arrows). T2-W images without (D) and with (E) fat-saturation show an hyperintense signal of the nodule (arrows). Non-enhanced (F), arterial (G), and delayed (H) T1-W 3D GRE images show the hypovascular nature of the nodule with persistent delayed enhancement (arrows).

findings such as the double duct sign, ductal strictures, infiltration of adjacent fat, arterial encasement, and peripancreatic venous obstruction.[14,43] In contradistinction, calcification is rarely present in pancreatic cancer, and at MR cholangiopancreatography, the "duct penetrating sign" may contribute to differentiation: a tumor mass does not contain pancreatic ductal structures, whereas focal pancreatitis may display numerous dilated side branches traversing the mass.[44] An abrupt interruption of a smoothly dilated pancreatic duct with upstream pancreatic gland atrophy, on the other side, is a

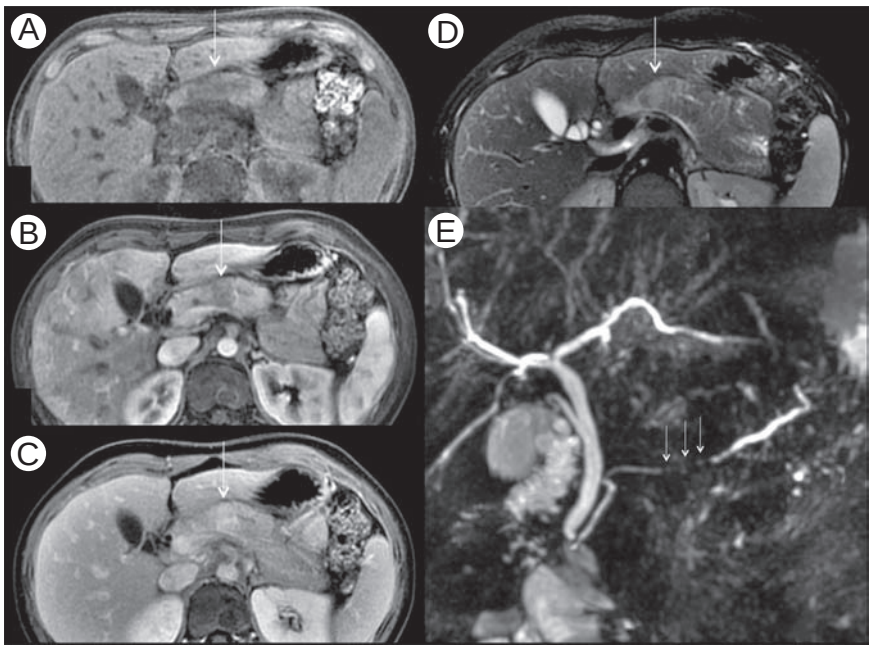

Figure 7 Pseudotumoral acute pancreatitis confirmed by endoscopic ultrasound-guided fine-needle aspiration biopsy in a 19-year-old woman with abdominal pain, elevated serum levels of amylase, lipase, and CA19-9 = 102 (normal <37 U/ml). Axial T1-W 3D GRE images in the unenhanced (A), arterial (B) and portal venous phases (C) show a relatively well-demarcated, hypointense lesion (arrow) in the body of pancreas, with progressive homogeneous enhancement. The lesion has hyperintense signal relative to the pancreas on T2-W fat-suppressed image (D), which also demonstrates slight and diffuse enlargement of the pancreas (arrows). MRCP image (E) shows focally narrowed and irregular main pancreatic duct (arrows) in the affected segment of the pancreas, with mild upstream dilation.

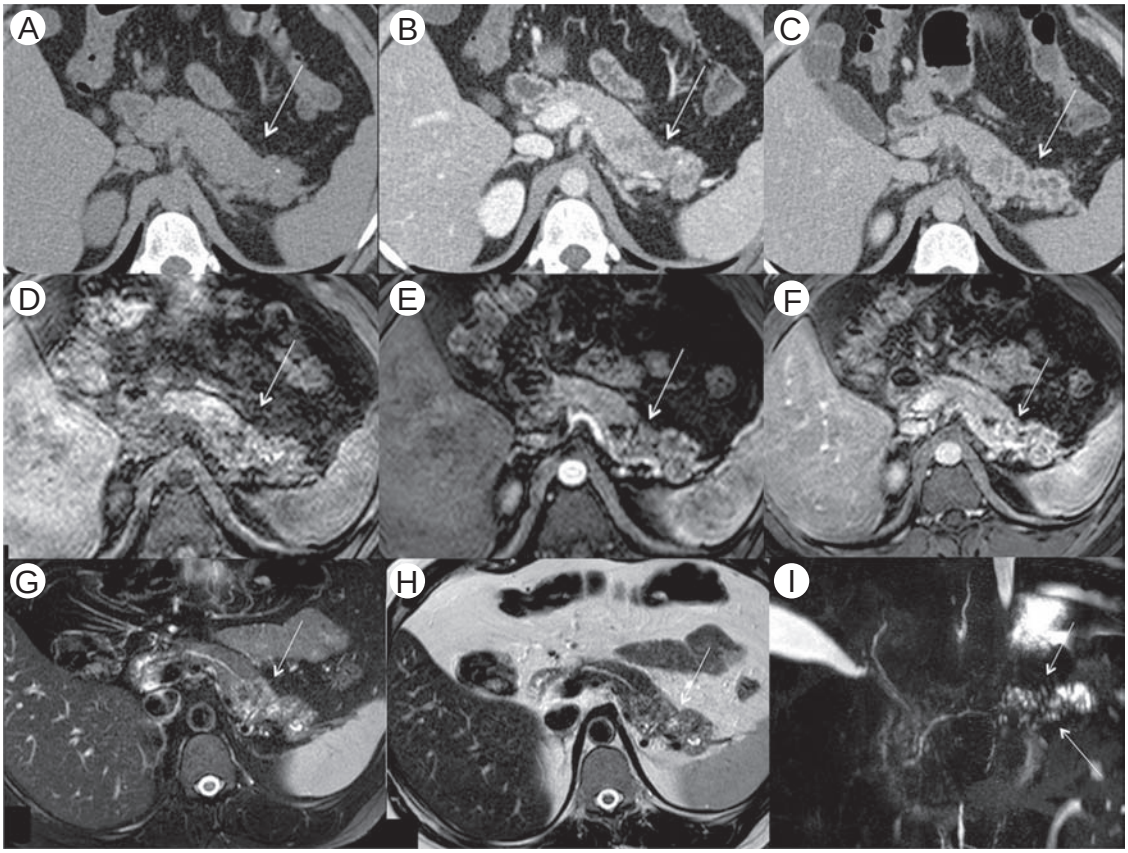

Figure 8 Focal chronic pancreatitis in a 33-year-old man with history of chronic alcoholism who was submitted to distal pancreatectomy. Unenhanced (A), portal (B), and delayed (C) phases of CT scan show an heterogeneous area in the tail of the pancreas (arrows) with cysts (suggestive of ductal dilatation) and punctate calcifications. Unenhanced (D), arterial (E), and portal (F) axial T1-W 3D GRE images confirm these findings (arrows). T2-W images with (G) and without (H) fat-suppression better detail the cysts, suggestive of ductal dilatation in the pancreatic tail (arrows). Thick-slab coronal MR cholangiopancreatography image (I) shows multiple small cysts around the main pancreatic duct (arrows), suggestive of dilatation of secondary ducts, mimicking intraductal papillary mucinous neoplasm.

feature that favors a diagnosis of adenocarcinoma. Modest atrophy and nonabrupt gradual narrowing of the biliary or pancreatic duct is more common in focal pancreatitis.[43] The role of diffusion-weighted MRI in differentiating between mass-forming chronic pancreatitis and pancreatic adenocarcinoma still remains a controversy, with some studies claiming its usefulness,[45] and others not.[46,47]

Eosinophilic Pancreatitis

Eosinophilic pancreatitis (EP) (Fig. 9) is a particularly rare form of chronic pancreatitis characterized by localized or diffuse eosinophilic infiltration of the pancreas and elevated serum IgE levels.[48] Differentiation with pancreatic tumor is not feasible based on imaging studies only, whose features are still poorly reported, but not significantly different from those of focal pancreatitis. EP is usually not diagnosed until the patient undergoes percutaneous biopsy or pancreatic resection.[49,50]

Groove Pancreatitis

Groove pancreatitis (Figs. 10 and 11) is an uncommon and distinct manifestation of focal chronic pancreatitis that involves the groove between the head of the pancreas, the duodenum, and the common bile duct. Its etiology remains unknown and the clinical manifestations are not specific.[51-54] Two forms have been described: the segmental form (Fig. 10), which involves the pancreatic head (usually with mass like enlargement of this part) and courses with scar tissue in the pancreaticoduodenal groove; and the pure form (Fig. 11), which affects the groove (often with a "sheetlike" curvilinear crescentic shape) but spares the pancreatic head.[14,51-54] The duodenum is always involved by a chronic inflammatory process, with scar tissue in the wall leading to fibrosis and various levels of stenosis. Hyperplasia of Brunner's glands is also a major finding that is seen in almost all cases. Cystic lesions, either true cysts or pseudocysts, are frequently encountered in the groove or the duodenal wall.[51]

Contrast-enhanced CT and MRI typically shows focal segmental pancreatitis in the groove region, cysts in the duodenal wall, and inflammatory duodenal wall thickening.[51-54] The areas of inflammatory changes are hypointense in comparison to the pancreatic parenchyma on T1-W images, iso- to slightly hyperintense on T2-W images, and reveals delayed enhancement on T1-W dynamic images.[51-56] The imaging characteristics of the segmental form of groove

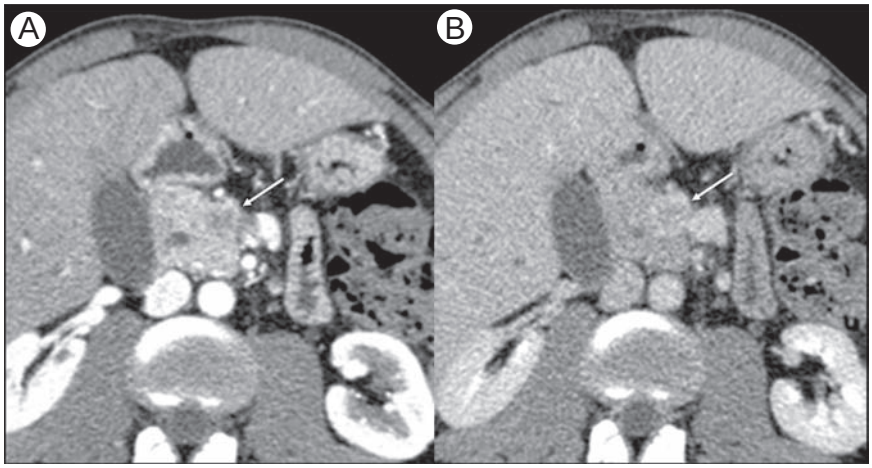

Figure 9 Eosinophilic pancreatitis in a 36-year-old man with a previous diagnosis of eosinophilic pneumonia, presenting with abdominal pain and jaundice; the patient was referred to an abdominal CT scan after an US revealed dilatation of the biliary tree. Arterial (A) and portal (B) phases of contrast-enhanced CT demonstrate a small hypovascular nodule with progressive enhancement in the head of the pancreas (arrows). CA 19-9 was slightly raised (40,4 U/ml; normal <37 U/ml). Endoscopic US-guided fine-needle aspiration confirmed eosinophilic pancreatitis.

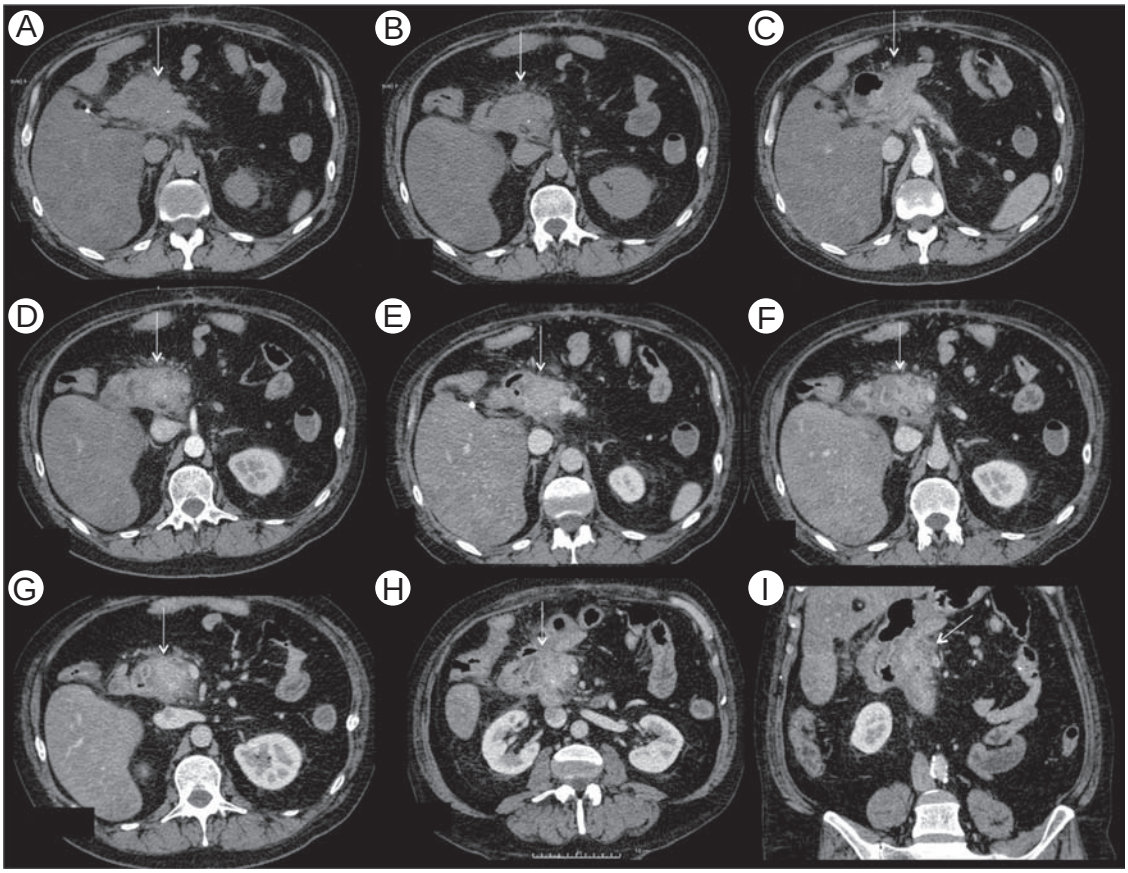

Figure 10 Segmental form of groove pancreatitis in a 44-year-old woman with history of cholecystectomy, presenting with jaundice and abdominal pain. Axial unenhanced (A and B), contrast-enhanced arterial (C and D) and venous (E and F) CT images exhibit enlargement of the pancreatic head with heterogeneous enhancement, small calcifications, and hypoattenuating tissue in pancreaticoduodenal groove (arrows). Thickening and enhancement of duodenal wall also are evident, causing duodenal stenosis. Oblique (G and H) and coronal (I) reformatted CT images in the venous phase better delineate these findings (arrows).

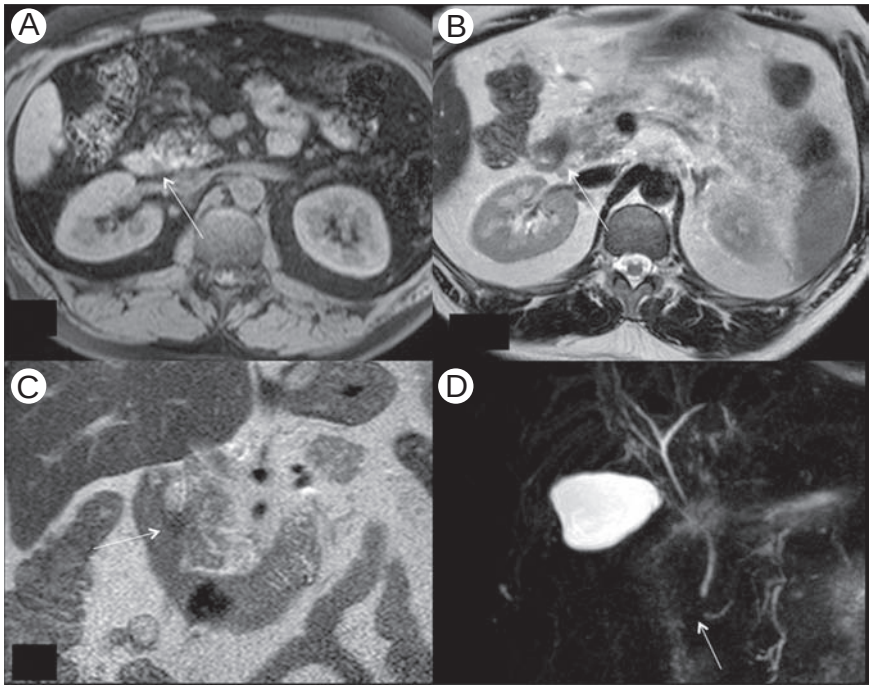

Figure 11 Pure form of groove pancreatitis in a 53-year-old man with recurrent abdominal pain and elevated serum levels of liver enzymes. Fat-suppressed T1-W (A) and T2-W (B and C) images show a hypointense sheet like mass in the pancreaticoduodenal space (arrows). Pancreatic parenchyma is spared. MR cholangiopancreatography image (D) shows widening of the distance between the duodenal lumen and distal ducts (arrow) caused by inflammatory tissue in the pancreaticoduodenal groove.

pancreatitis and those of pancreatic adenocarcinoma may significantly overlap. The presence of vascular invasion is considered the most useful feature in distinguishing pancreatic carcinoma from groove pancreatitis.[55,56] MR cholangiopancreatography may reveal smooth tapering of the distal intrapancreatic portion of the bile duct in case of groove pancreatitis; conversely, an abrupt irregular duct stricture is typical of pancreatic carcinomas.[55]

CT and MR imaging differentiation between groove pancreatitis and pancreatic adenocarcinoma, however, remains a challenge.[57,58] Endoscopic ultrasound seems to have no additional role in patients with a visible mass on CT suspected for malignancy and should not be performed routinely in such cases, but it is useful to confirm the presence of a tumor in patients without a visible mass on CT.[59] Ultrasound-guided percutaneous fine-needle aspiration of solid pancreatic neoplasms, however, has been demonstrated to be a sensitive, accurate, and safe method for the invasive diagnosis in such cases, with sensitivity, specificity, and accuracy values of 98.7%, 100%, and 98.7%, respectively, and complication rates around 0.8%.[60]

Pancreatic Hemangioma

Vascular tumors (hemangioma, lymphangioma, hemolymphangioma, hemangioendothelioma, hemangiopericytoma, hemangioblastoma, and angiosarcoma) represent only 0.1% of all pancreatic tumors.[61,62] Pancreatic hemangiomas (Fig. 12) are extremely rare, with only about 20 cases reported in the literature since 1960.[62,63] Hemangiomas are composed of blood vessels lined by endothelial cells; they are rarely suspected clinically due to the nonspecificity of their symptoms. Moreover, the inability of cross-sectional imaging techniques to differentiate them from other pancreatic lesions (malignancy, more specifically) leads, in many instances, to surgical resection (Fig. 12).[61]

Hemangiomas of the pancreas are reported to be typically well-circumscribed lesions with homogeneous low attenuation on unenhanced CT and a hypervascular pattern of enhancement on contrast-enhanced CT.[63] Similar to cavernous hemangiomas in other locations, they are isointense on T1-W and hyperintense on T2-W images.[63] However, other reports demonstrate that because of the presence of areas of neovascularization with arteriovenous shunting, the blood flow through these cavernous vascular components may be slow, resulting in diminished contrast enhancement on arterial phase CT.[61,64,65] Therefore, poor arterial phase enhancement on contrast-enhanced CT should not rule out a pancreatic hemangioma, and the signal intensity features observed on MRI should be a valuable corroborative finding to support this diagnosis.[61,64,65] When the tumor has a hypervascular component, main differential diagnoses include lymphangioma, hemangioendothelioma, hemangiopericytoma, and angiosarcoma, neuroendocrine tumors and metastases.[66]

Intrapancreatic Aneurysm

Intrapancreatic aneurysms and pseudoaneurysms may simulate a solid, hypervascular mass like a neuroendocrine tumor, or, when associated with thrombosis or hemorrhage, even a

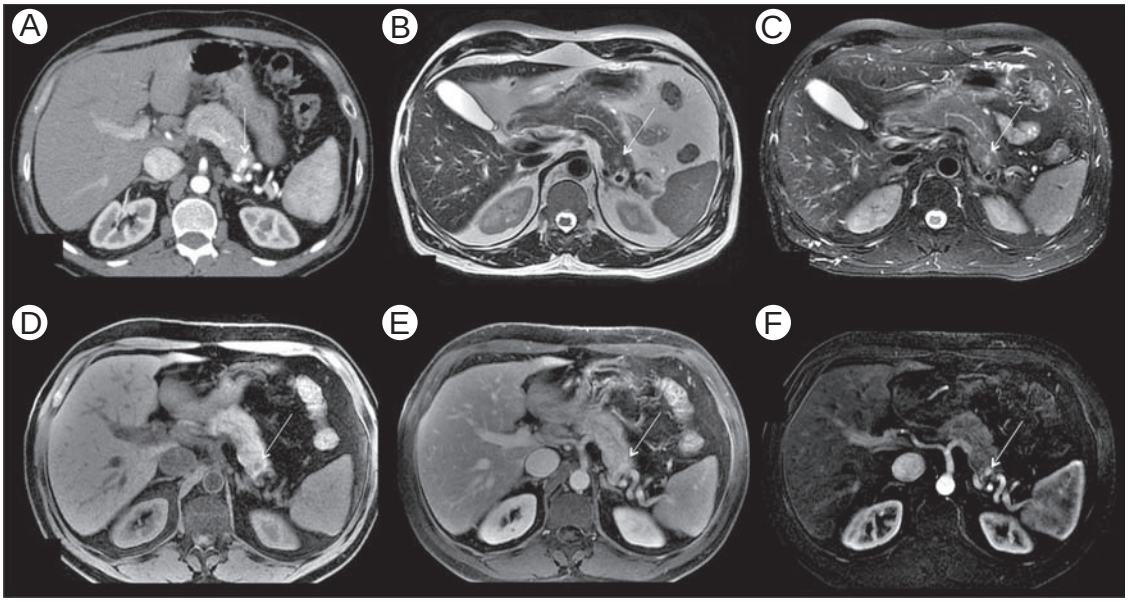

Figure 12 Hemangioma of pancreas in an asymptomatic 56-year-old man with history of non-Hodgkin lymphoma, previously treated with chemotherapy. The patient underwent distal pancreatectomy with a presumed diagnosis of a neuroendocrine tumor. Contrast-enhanced arterial phase CT image (A) demonstrates a small hypervascular nodule in the pancreatic tail (arrow), which is slightly hyperintense on T2-W images without (B) and with (C) fat suppression (arrows). The nodule is hypointense on unenhanced T1-W 3D GRE image (D), with a hypervascular pattern of enhancement (E and F) (arrows).

pancreatic carcinoma.[67-71] Aneurysms of the visceral branches of the abdominal aorta are rare and potentially life threatening, with a prevalence ranging from 0.1%-2%.[72] The increased widespread of cross-sectional imaging techniques has led to a growing identification of asymptomatic visceral artery aneurysms.[72] Additionally, increase in the number of percutaneous and endoscopic procedures involving the biliary tree and placement of intravascular chemoembolization catheters have resulted in a greater incidence of pseudoaneurysmal degeneration of the visceral vessels.[72] The exceptional

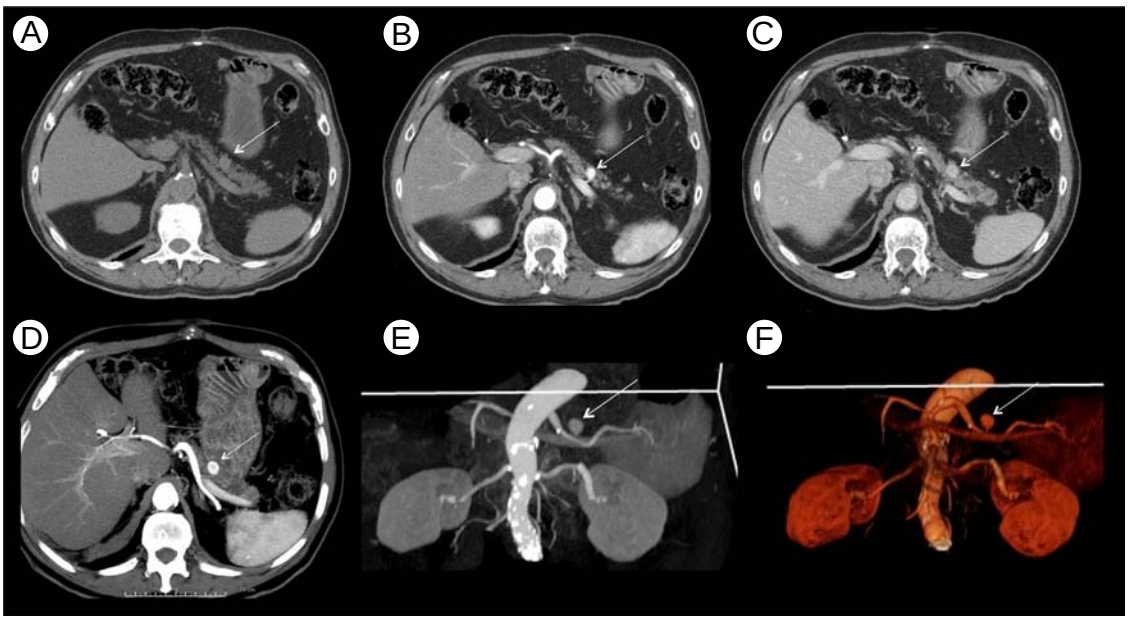

Figure 13 Intrapancreatic true arterial aneurysm mimicking hypervascular pancreatic tumor in an 81-year-old man. Unenhanced (A), arterial (B), and portal (C) CT axial images reveal a 1.8-cm aneurysm arising from an arterial branch of the mid portion of the splenic artery (arrows). The aneurysm appears well defined and homogeneous, with a central thrombus on axial maximum intensity projection (MIP) reformation (D) (arrow). 3D angiographic MIP (E) and 3D volume rendering (F) images help to better demonstrate the vascular origin of the lesion (arrows). (Color version of figure is available online.)

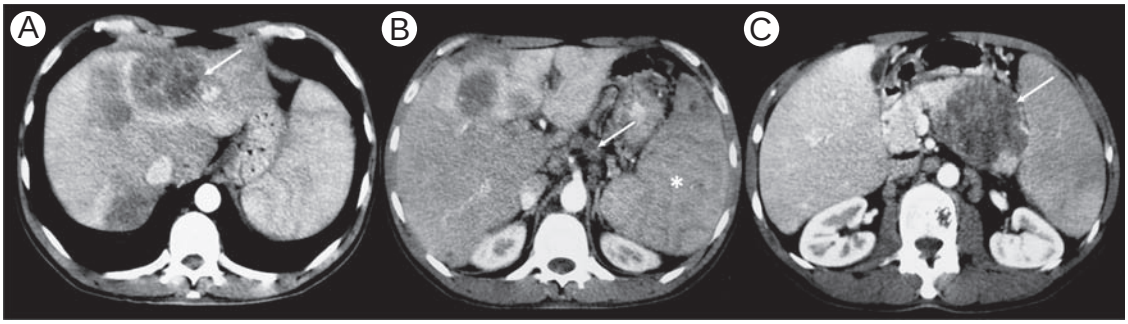

Figure 14 Disseminated abdominal tuberculosis with pancreatic involvement in a 41-year-old man. Chest radiographs were normal. Arterial phase images of contrast-enhanced CT (A-C) reveal multiple, confluent, hypovascular hepatic masses with rim enhancement (arrow in A), necrotic retroperitoneal lymphadenopathy (arrow in B), splenomegaly (asterisk in B), and an irregular hypovascular mass involving the body and tail of the pancreas (arrow in C). Laboratory and histopathological analyses after percutaneous and surgical biopsies confirmed the diagnosis (Case courtesy of Dr. Antônio José da Rocha, Division of Radiology, Santa Casa de São Paulo, São Paulo, Brazil).

resolution of 3D renderings from multidetector CT datasets (Fig. 13), however, contributes to the correct characterization of visceral artery aneurysms and pseudoaneurysms, distinguishing them from tortuous vessels or small, hypervascular neuroendocrine tumors of the pancreas.[73]

Pancreatic Tuberculosis

Pancreatic tuberculosis (TB) (Fig. 14) is extremely rare, even in regions with high prevalence of TB (about 376 cases reported until 2016[74]), and in most cases mimicks pancreatic adenocarcinoma.[75] Although the ileocecal region is most commonly affected in abdominal TB, solid organs such as kidneys, spleen, and liver still get involved much more commonly than the pancreas.[75] Patients with HIV infection have a greater incidence of atypical and extrapulmonary TB, as the disease is more likely to be disseminated[74]; moreover, with the epidemics of HIV/AIDS and increasing emigration from developing countries, there has been a resurgence of tuberculosis as an opportunistic infection in both developing and developed countries.[74,75]

Patients with pancreatic TB may present with nonspecific findings such as epigastric pain, fever, anorexia, weight loss, jaundice, and a pancreatic mass indistinguishable from a pancreatic neoplasm.[76] Moreover, pancreatic TB may also cause remarkable elevation the CA 19-9 levels, making such a distinction even more challenging.[77] Three forms of pancreatic involvement have been described: (1) as part of miliary

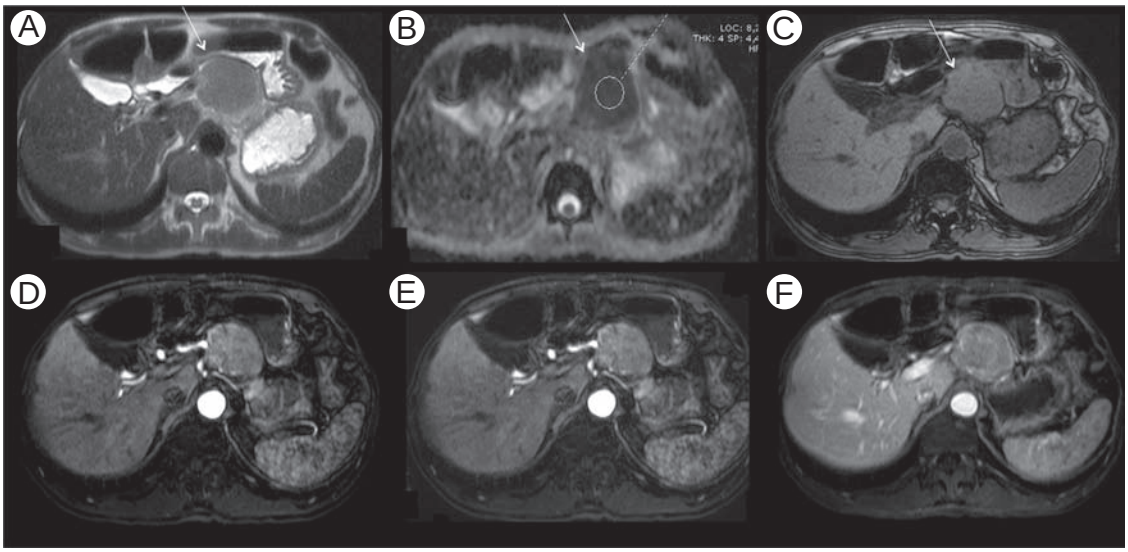

Figure 15 Castleman disease of the pancreas (hyaline vascular subtype) in a 64-year-old man with a 6-months history of asthenia. T2-W (A) image shows a 5.5 × 4.5 cm isolated smoothly marginated mass arising from the pancreatic body (arrow) with a signal intensity similar to that of the normal pancreatic parenchyma. Apparent diffusion coefficient (ADC) map image (B) shows restriction to water diffusion (arrow). T1-W unenhanced (C) and dynamic contrast-enhanced images in the arterial (D and E) and portal (F) phases reveal heterogeneous hypervascular enhancement of the mass (arrows) (Case courtesy of Dr. Franz Robert Apodaca-Torrez, Division of Gastrointestinal Surgery, Federal University of São Paulo, São Paulo, Brazi).

tuberculosis, (2) spread to the pancreas from retroperitoneal lymph nodes, and (3) localized pancreatic tuberculosis, secondary to primary tubercular infection of the intestinal tract.[75]

Pancreatic tuberculosis may manifest as an abscess, mass (Fig. 14), or a cystic lesion in the pancreas.[75] Given the lack of characteristic imaging features, the diagnosis of pancreatic TB requires histological, cytological, and bacteriological confirmation; endoscopic US-guided fine-needle aspiration is the diagnostic modality of choice for pancreatic TB.[76] Most cases respond well to standard anti-TB regimens for 6-12 months.[76]

Castleman's Disease of the Pancreas

Castleman's disease (CD) was first reported by Castleman et al. in the United States in 1956 as a lymphoproliferative disease of unknown etiology associated with localized or multicentric lymph node hyperplasia.[78] CD can be classified clinically into unicentric (localized) or multicentric disease; most of the lesions are located in the thorax (until 70%), but extrathoracic involvement (neck, axilla, mesentery, and retroperitoneum) has also been reported.[79] CD of pancreas (Fig. 15) is extremely rare, with only about 25 cases reported in the literature to date.[80] When CD is localized in the pancreas or retroperitoneum it has no distinctive clinical or radiological features and it may be confused with malignant tumors.[81,82]

On US, CD is characterized by a well-defined, homogeneous, hypoechoic mass, sometimes with calcifications.[80] On contrast-enhanced CT, lesions less than 5 cm in diameter usually demonstrate early and markedly homogeneous enhancement, whereas bigger lesions tend to show heterogeneous enhancement, reflecting the presence of fibrosis or necrotic components.[80] MR imaging findings consist of a smoothly marginated mass T1-W hypointense and T2-W isointense, with peripheral arterial rim enhancement following contrast material administration.[83] As the imaging findings are nonspecific, a histopathological examination is essential for the diagnosis of pancreatic CD.

Conclusion

A range of common, uncommon, and very rare lesions of the pancreas may masquerade as malignancy, making it extremely challenging to establish an accurate diagnosis based on a single imaging modality, often requiring a multimodality imaging approach. Although in many cases a definitive diagnosis can be reached only by means of histopathology, some of them can be confidently diagnosed by imaging studies or have their differential substantially narrowed through proper knowledge of the relevant clinical information and key radiologic features. Imaging remains, however, essential for lesion detection and characterization, ultimately contributing for the most appropriate clinical management and treatment planning.

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