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SPECIAL SECTION: PANCREATITIS

Differentiation of focal autoimmune pancreatitis from pancreatic ductal adenocarcinoma

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Abstract
Autoimmune pancreatitis (AIP) is an inflammatory process of the pancreas that occurs most commonly in elderly males and clinically can mimic pancreatic adenocarcinoma and present with jaundice, weight loss, and abdominal pain. Mass-forming lesions in the pancreas are seen in the focal form of AIP and both clinical and imaging findings can overlap those of pancreatic cancer. The accurate distinction of AIP from pancreatic cancer is of utmost importance as it means avoiding unnecessary surgery in AIP cases or inaccurate steroid treatment in patients with pancreatic cancer. Imaging concomitantly with serological examinations (IgG4 and Ca 19-9) plays an important role in the distinction between these entities. Characteristic extra-pancreatic manifestations as well as favorable good response to treatment with steroids are characteristic of AIP. This paper will review current diagnostic parameters useful in differentiating between focal AIP and pancreatic adenocarcinoma.

Keywords Pancreatic adenocarcinoma · Pancreatitis · Autoimmune pancreatitis · Chronic pancreatitis · Computed tomography · Magnetic resonance imaging

Introduction

Autoimmune pancreatitis (AIP) is a rare type of chronic pancreatitis that is more commonly seen in males than females and accounts for 2–10% of all chronic pancreatitis [1, 2]. The etiology and pathogenesis of AIP remains unclear [3] but a multifactorial process related to autoimmunity, genetic susceptibility, and exposure to environmental factors is favored [4]. AIP is classified as Type 1 and Type 2 with Type 1 being more common than Type 2. Type 1 is an IgG4-related systemic disease that can have extra-pancreatic involvement. Type 2 histologically demonstrates idiopathic duct-centric pancreatitis with the hallmark granulocytic epithelial lesions (GEL) [5]. Type 2 only involves the pancreas [6].

When diffuse involvement is present, autoimmune pancreatitis characteristically appears on cross-sectional imaging as "sausage-like" enlargement of the pancreas. However, AIP can also present as a focal mass-forming pancreatitis, which comprises about 28-41% of cases of autoimmune pancreatitis [7, 8]. It can be difficult to distinguish focal mass-forming AIP from pancreatic adenocarcinoma as imaging as well as clinical characteristics often overlap. However, this differentiation is critical as the management and prognosis vary drastically. AIP is a benign fibroinflammatory disease that responds favorably to corticosteroid therapy (Fig. 1), while pancreatic adenocarcinoma requires surgical resection for a chance for cure. In addition, the overall survival rate for pancreatic adenocarcinoma is 28% after 1 year and 7%

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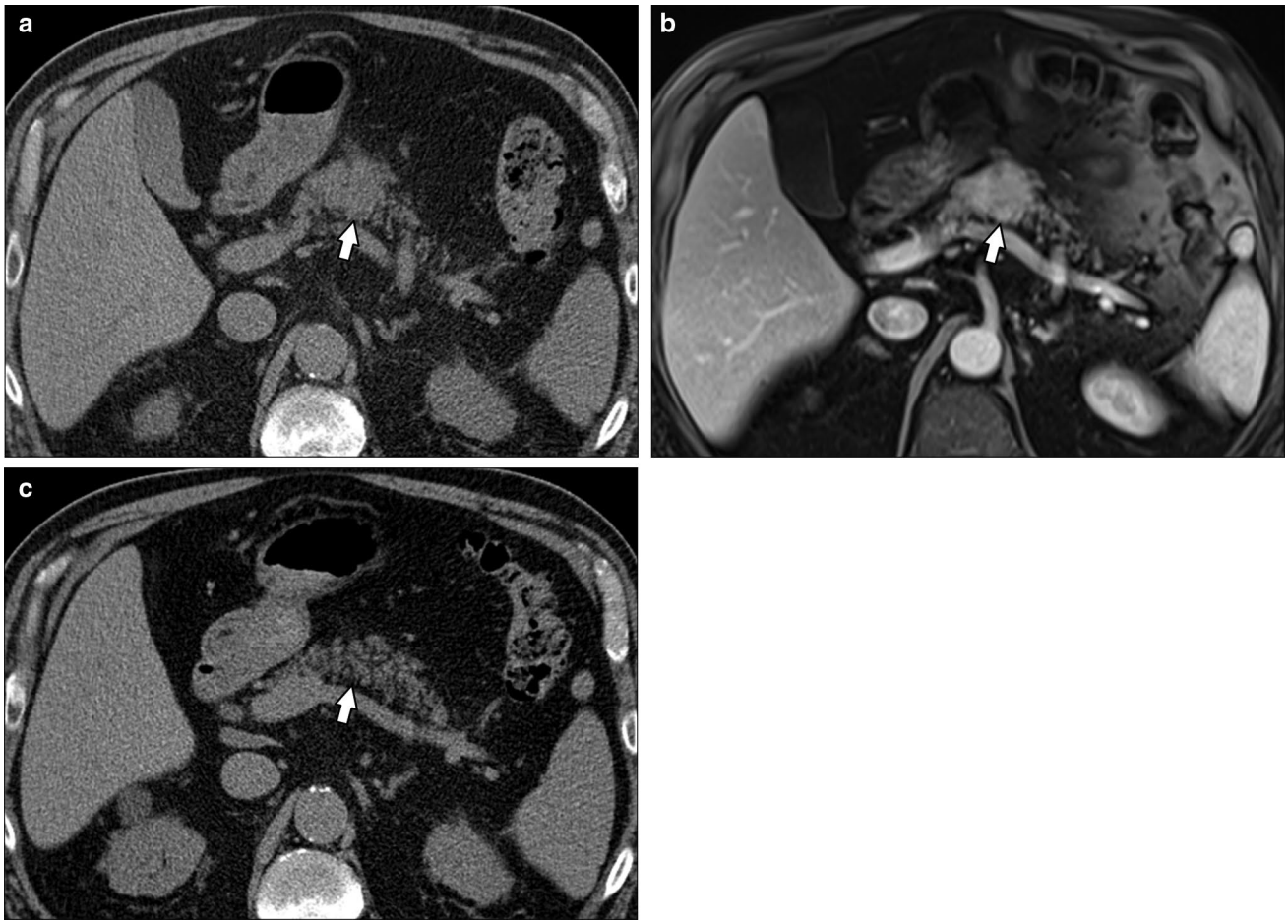

Fig. 1 A 72-year-old male with pancreatic mass incidentally found on chest CT and normal serum IgG4. **a** Axial unenhanced CT image shows mass-like lesion in the pancreatic body (arrow) prompting further evaluation with MRI. **b** Axial T1 FS portal venous phase MR image shows an enhancing lesion (arrow), corresponding to finding on chest CT. **c** Axial unenhanced CT image 8 months after steroid treatment for presumed AIP based on biopsy shows resolution of the mass-like lesion (arrow) in the pancreas consistent with autoimmune pancreatitis

after 5 years [9] and surgery can have a 5% mortality and 40–50% morbidity [10].

This paper will review diagnostic parameters that assist in the differentiation between mass-forming AIP and pancreatic adenocarcinoma.

Diagnostic approach

Several diagnostic criteria have been proposed for AIP in an attempt to unify the diagnostic criteria for AIP incorporating clinicopathological and radiological characteristics. These include the original Japanese Pancreas Society guidelines, the Mayo Clinic HISORt (Histology, Imaging, Serology, Other Organ involvement, Response to therapy) criteria and the most recently proposed in 2011 criteria from The International Consensus Diagnostic Criteria (ICDC). The ICDC proposed two forms of AIP on the basis of their histopathological profiles, which are referred to as type I, associated with a histological pattern of lymphoplasmacytic sclerosing pancreatitis (LPSP), and type II, characterized by idiopathic duct-centric pancreatitis (IDCP) [3]. Type 1 is considered a prototype of immunoglobulin 4 (IgG4)-related disease, with high serum levels of IgG4 (> 140 mg/dl), IgG4-positive plasma cell infiltration, and sclerosis, while type 2 is related to granulocytic epithelial lesion [3, 6, 11]. Both types can take on various morphologies in the pancreas, which include diffuse, focal/mass-forming, or multifocal disease. While AIP is still rare, the diffuse type is being diagnosed with increasing frequency due to increasing awareness of its pathology [12]. As focal AIP can mimic pancreatic cancer, the distinction can be difficult, however, certain clinical and imaging features can help distinguish the entities and will be discussed.

Clinical

AIP's clinical presentation can closely mimic cancer. Both entities commonly present with painless obstructive jaundice, reported in up to 70% of patients with AIP [13, 14]. Some studies have suggested that the course of the jaundice associated with cancer may have a steady progression in comparison to the jaundice of AIP that fluctuates or improves spontaneously [15]. While abdominal pain and weight loss are more common in pancreatic cancer [16–18], these symptoms can also be seen in patients with AIP. Weight loss is seen in up to one-third of the patients with AIP [2, 19].

Serology

Serum IgG4 levels is a useful diagnostic parameter that can be elevated in cases of AIP. Prior studies have shown that using a cut-off value of 135 mg/dL for serum IgG4 can yield a sensitivity of 65% and a specificity of 98% for diagnosing AIP [20]. However, 7–10% of pancreatic cancer patients exhibit elevated serum IgG4 levels and a significant minority of type I AIP patients may have equivocal serum IgG4 levels [21, 22]. In addition, because of the low prevalence of AIP compared to pancreatic cancer, the positive predictive value of IgG4 for diagnosing AIP is not high, estimated to be near 80% [23], which may limit its utility. Serum CA 19-9 level is the most useful marker for pancreatic cancer with a sensitivity and specificity of 79% and 82%, respectively [24], and is more often elevated in pancreatic cancer than in AIP patients [25]. However, elevated levels of CA19-9 are also seen in other non-malignant conditions, including AIP [26–29] which can be confounding. CA19-9 also lacks sensitivity for smaller diameter (≤ 2 cm) pancreatic cancers that present the greatest diagnostic challenge in distinguishing cancer from focal AIP [30]. Therefore, elevated CA19-9 cannot be used alone to confidently choose the diagnosis of pancreatic cancer in favor of focal AIP. Recent studies have also investigated the utility of serum IgG4 levels in conjunction with CA19-9 levels to distinguish type I AIP from pancreatic cancer [17, 20], which present it as a promising tool for distinguishing the two entities. However, the ideal cut-off parameters and diagnostic performance reported are variable and require further validation with larger studies. A multitude of other serologic markers have been investigated for their potential utility, including levels of total IgG, gamma-globulin, glycosylation profile of IgG [31–34] carcinoembryonic antigen, and autoantibodies, such as ANA, RF, anti-carbo anhydrase II, and antilactoferrin [35]. Currently, these parameters lack sufficient validation to be of clinical utility.

Histology

Histologically, the presence of fibrosis and lymphoplasmacytic infiltration of the pancreas is considered diagnostic of AIP. In the setting of characteristic imaging findings and elevated IgG4, biopsy is not necessary to confirm the diagnosis of diffuse form of AIP although a response to steroid therapy should be validated. The histologic evaluation of AIP requires an adequate sample size and the preservation of the pancreatic tissue architecture. EUS-guided Tru-Cut core biopsy (TCB) is a suggested way of obtaining samples as it allows for adequate sample sizes and preservation of tissue architecture. This technique has been shown to confirm IgG4-positive plasma cell infiltration in up to 94% of patients with AIP [21]. Although EUS-FNA is relatively accurate for the cytologic diagnosis of pancreatic cancer [36–38], EUS-FNA is less accurate for AIP as it lacks any specific cytologic findings. In addition, due to the smaller caliber of the needle, the resulting tissue architecture is often compromised and the sample size inadequate [39, 40]. Histologic findings that confirm AIP may be either periductal lymphoplasmacytic infiltrate with obliterative phlebitis and storiform fibrosis or lymphoplasmacytic infiltrate with storiform fibrosis and 10 or greater IgG4 cells/HPF.

Extra-pancreatic lesions

AIP demonstrates a variety of extra-pancreatic manifestations with 92% of cases showing simultaneous pancreatic and extra-pancreatic lesions [41]. The presence of extra-pancreatic involvement can assist in distinguishing focal AIP from pancreatic cancer. Type 1 AIP is typically associated with extra-pancreatic findings, whereas type 2 is not, although type 2 AIP is associated with inflammatory bowel disease, especially ulcerative colitis [42]. The most commonly affected extra-pancreatic sites in AIP are the biliary tree (68-88% of patients) [43], kidneys (35% of patients), retroperitoneum (10–20% of patients) [44, 45], and salivary/lacrimal glands (12–16% of patients) [43]. Biliary tract involvement, also known as an IgG4 sclerosing type cholangitis, typically involves the distal common duct resulting in stricturing of the distal duct but can also present with multifocal intra- and extra-hepatic strictures similar in appearance to primary sclerosing cholangitis. Gallbladder involvement may also be present manifesting as wall thickening. Renal involvement presents as focal lesions secondary to tubulointerstitial nephritis [44]. Retroperitoneal fibrosis, salivary/lacrimal gland involvement, lymph node involvement, and interstitial pneumonitis have also been associated with AIP. The extra-pancreatic involvement in AIP does not have the typical appearance of metastatic disease from pancreatic cancer, and when present, these findings can aid in distinguishing focal AIP from pancreatic cancer.

Symptoms related to these extra-pancreatic lesions also often improve with steroid treatment and can be useful for the evaluation of treatment response. These lesions may also have implications regarding AIP relapse, with Naitoh et al. reporting that diffuse pancreatic ductal changes and sclerosing sialadenitis at clinical onset were independent predictors of relapse [46].

Imaging: pancreatic findings

Computed tomography (CT)

CT is a commonly used imaging modality when evaluating for pancreatic pathology. The classic imaging appearance of AIP with diffuse pancreatic involvement includes diffuse sausage-like pancreatic enlargement and a symmetric rim of low attenuation surrounding the pancreas (Fig. 2) that is considered to be characteristic of AIP [47].

The diagnosis of focal AIP can be more challenging based on imaging and difficult to distinguish from pancreatic cancer. Focal AIP is associated with focal mass-like enlargement of a portion of the pancreas, usually the head and/or uncinate process, and, similar to pancreatic adenocarcinoma, appears hypoattenuating in the early arterial phase of enhancement [48]. A study by Takahashi et al. showed focal AIP to demonstrate increased enhancement compared to pancreatic cancer on the portal venous phase of imaging (12). In distinction to pancreatic cancer, some imaging findings have been noted to be more associated with focal AIP. These include delayed homogeneous enhancement on dynamic CT (Fig. 3) [7, 10, 16, 18, 47, 49–51], a hypoattenuating capsule-like rim [7, 16, 18, 47, 51, 52], absence of atrophic changes in the body and tail of the pancreas [7, 16], absence of significant upstream main pancreatic duct (MPD) dilatation (> 5 mm) [51–53], the presence of the "duct-penetrating" sign (mass penetrated by an unobstructed pancreatic duct), and enhanced duct sign (wall enhancement of MPD in the lesion) on multiphase contrast-enhanced CT [47].

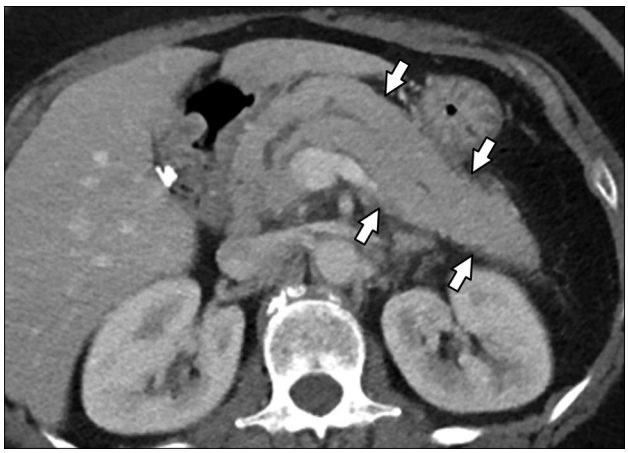

Fig. 2 A 56-year-old female with elevated lipase and normal serum IgG4. Axial contrast-enhanced CT image shows a diffusely enlarged ("sausage shape"), homogeneously enhancing pancreas (arrows). A subtle low attenuation rim is seen around the periphery of the pancreas. The patient was treated with corticosteroids based on clinical judgment and characteristic imaging findings with resolution of the patient's imaging findings consistent with autoimmune pancreatitis

Pancreatic cancer most commonly occurs in the pancreatic head (60–70%) [54]. On CT, adenocarcinoma typically appears as a hypodense mass that may result in pancreatic ductal dilatation and biliary dilatation (double duct sign) [10, 52, 53], abrupt termination of the involved duct, upstream pancreatic atrophy [53], and peripancreatic lymphadenopathy [51]. Vascular involvement (Fig. 4) manifesting as caliber change, irregularity to the vessel walls, and tumoral encasement of more than 180° of vessel circumference, as well as peritumoral fat infiltration is also important for the diagnosis of pancreatic cancer and determining appropriate therapy [55].

Follow-up imaging is important to distinguish AIP from other diseases as a lack of response following 2–4-week course of steroid therapy suggests an alternative diagnosis including adenocarcinoma [56].

Magnetic resonance imaging (MRI)

MRI of AIP shows similar morphologic findings as CT including focal (or diffuse or multifocal, depending on the pattern) enlargement of the pancreas. The involved area is hypointense on T1-weighted images, and slightly hyperintense on T2-weighted images (Fig. 5). Some authors have described a "speckled" enhancement pattern in the pancreatic phase of imaging as more characteristic of focal AIP than pancreatic cancer [57]. The "duct-penetrating" sign [7, 58–60], best appreciated using secretin-enhanced MRCP [61], is more characteristic of focal AIP than pancreatic cancer. This is believed to be a result of the inflammatory nature of AIP being more apt to narrow the main pancreatic duct as opposed to pancreatic cancer obstructing the duct [44]. The degree of dilatation involving the MPD (Fig. 6) is less in focal AIP and are usually limited to < 4 mm as opposed to pancreatic cancers, which usually cause ≥ 4 mm dilatation [7, 18, 49, 58, 62]. Irregular narrowing of the MPD is typical of AIP [44] and may be better visualized on endoscopic retrograde cholangiopancreatography (ERCP), due to the inferior resolution of MRCP when compared to ERCP [63]. In addition, focal AIP more frequently shows a longer length of narrowing of MPD (3 cm or more in length) [62] in the involved segment of the pancreas [18, 49], as well as the "icicle sign" (smooth tapered narrowing of the upstream pancreatic duct) (Fig. 6) [53, 60]. At MRCP, multiple strictures of the MPD may be a useful sign of focal AIP, with a reported prevalence of 61.5% of these multifocal strictures

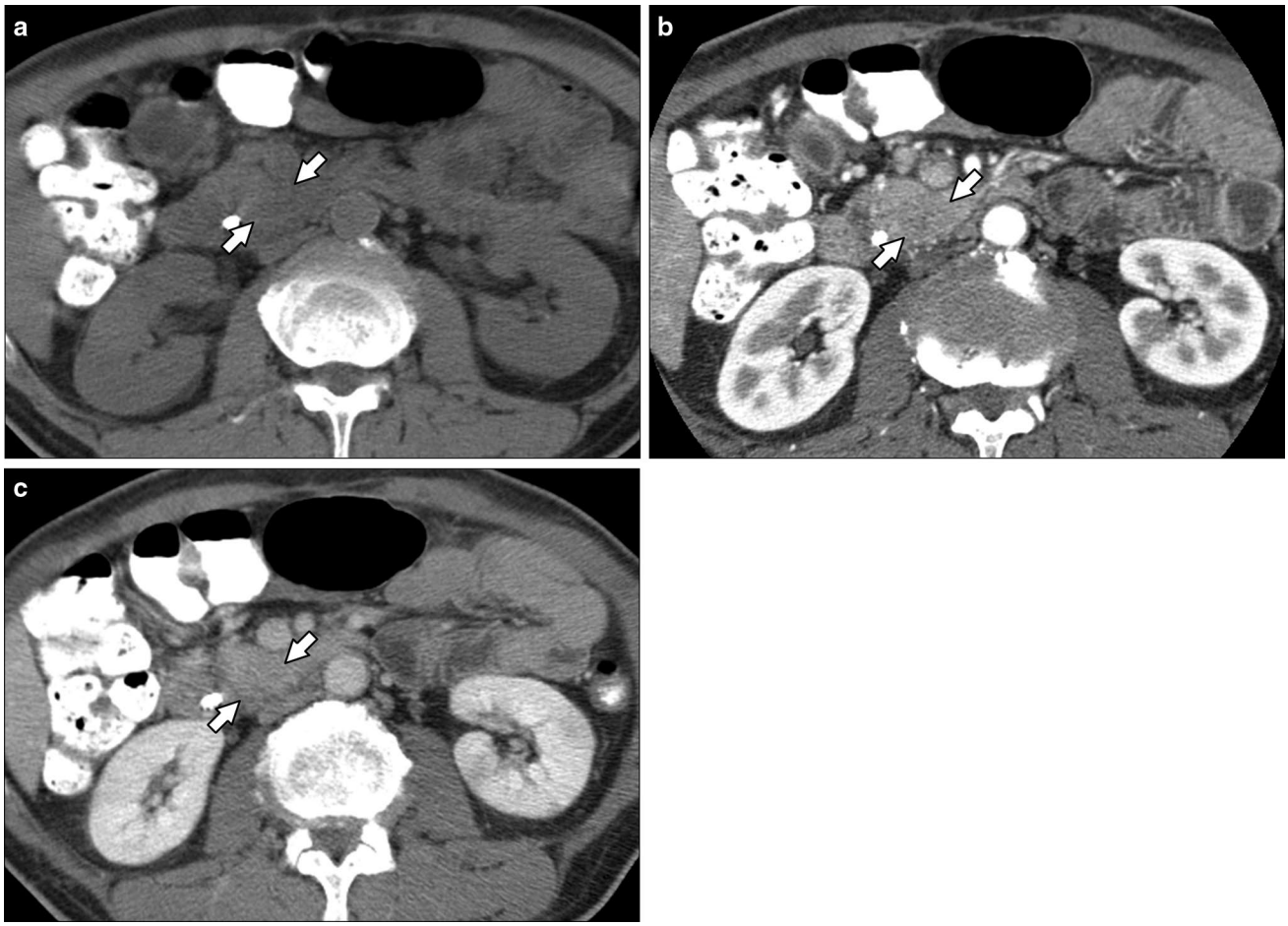

Fig. 3 A 64-year-old male with elevated liver test function and status post biliary stent placement. **a** Axial unenhanced CT image shows focal enlargement of the pancreatic head (arrows). **b** Axial arterial phase contrast-enhanced CT and **c** delayed phase shows progressive enhancement of the lesion in the pancreatic head (arrows). Pathology yielded lymphoplasmacytic sclerosing pancreatitis

along the whole extension of the MPD even if the parenchymal changes were segmental [64]. Additional MR findings seen more frequently with AIP include delayed homogeneous enhancement of the lesion (Figs. 5 and 6) [7, 59] and a hypointense capsule-like rim [7, 59–61].

As on CT, pancreatic cancer on MR is more likely than AIP to show a mass with associated peripancreatic infiltration and vascular encasement, upstream pancreatic atrophy, and peripancreatic lymphadenopathy [58].

Diffusion-weighted MRI (DWI) has been increasingly utilized in abdominal imaging to assess for pathology. On DWI, both AIP and pancreatic cancer show high signal intensity areas at high *b* values [15] AIP presents as high signal intensity areas with a diffuse, solitary, and multiple pattern, whereas pancreatic cancer typically has a solitary high signal intensity areas. The apparent diffusion coefficient (ADC) was significantly lower in AIP than pancreatic cancers or normal pancreas [7, 15, 58, 59]. Different ADC optimal cut-off values have been reported in the literature to try to distinguish focal AIP from pancreatic cancer, ranging from 0.88 to 1.26×10^{-3} mm^2/s [7, 15, 58, 59].

Ultrasonography (US)

Conventional US may be the first imaging modality performed in the presence of abdominal symptoms especially right upper quadrant pain. The distinction of pancreatic cancer from focal AIP on ultrasonography is exceedingly difficult as they both present as hypoechoic masses.

Positron emission tomography- computed tomography (PET-CT)

Due to the concern for pancreatic cancer based on clinical and/or imaging findings, patients who are ultimately diagnosed with AIP may undergo fluorodeoxyglucose positron emission tomography (FDG-PET) after initial cross-sectional imaging (Fig. 7). Studies have shown that AIP

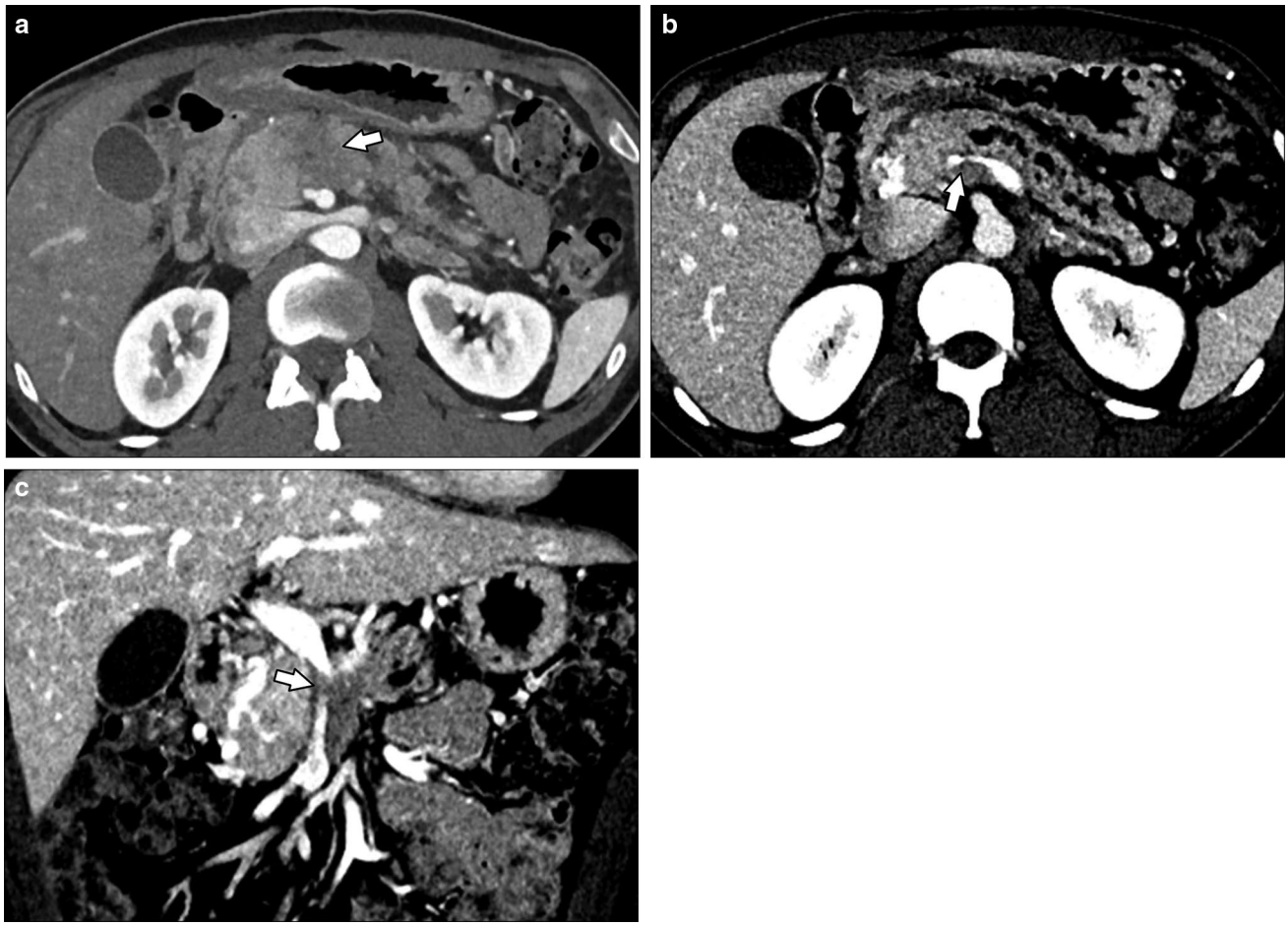

Fig. 4 A 43-year-old male with pancreatic mass. **a** Axial contrast-enhanced arterial phase CT image shows a hypoenhancing pancreatic neck mass (arrow) abutting the anterior aspect of the superior mesenteric artery. **b** Axial contrast-enhanced venous phase CT image shows narrowing of the splenic vein at the level of portal confluence (arrow) and dilatation of the pancreatic duct. **c** Coronal contrast-enhanced CT image shows the mass encasing the superior mesenteric vein (arrow). This lesion was biopsy-proven pancreatic adenocarcinoma

presents with lower FDG activity when compared to pancreatic cancer, with both early and delayed maximum standardized uptake value (SUVmax) being higher in pancreatic cancers [65]. Lee et al. observed that 53% of AIP had diffuse uptake of FDG compared to 3% in pancreatic cancer [66]. In the pancreatic cancer cases, the high uptake was because of obstructive pancreatitis, which could be distinguished by other CT characteristics. In another study, heterogeneous FDG uptake was mostly found in AIP cases while pancreatic cases show homogeneous uptake [67]. PET/CT has also been used to assess response to steroid therapy with decreased uptake in the pancreas and extra-pancreatic locations following therapy [66].

Novel imaging techniques

MR elastography has been recently evaluated to facilitate differentiation between AIP and pancreatic cancer with a recent study showing pancreatic stiffness was significantly lower in AIP (2.67 kPa) when compared to pancreatic cancer (3.78 kPa). However, the clinical relevance of MRE to distinguish focal AIP from pancreatic adenocarcinoma and stage AIP has yet to be determined.

The role of contrast-enhanced ultrasound (CEUS) to distinguish focal AIP from pancreatic cancer (27–29) is also an emerging technology. A recent study demonstrated hyper- to iso-enhancement in the arterial phase, homogeneous contrast distribution, and absent irregular internal vessels observed more frequently in focal AIP than in pancreatic cancer [68]. These authors concluded that CEUS may be a valuable non-invasive tool in the differential diagnosis of focal AIP and pancreatic adenocarcinoma [68]. However, further investigation is warranted to determine the role CEUS may play in distinguishing the two entities.

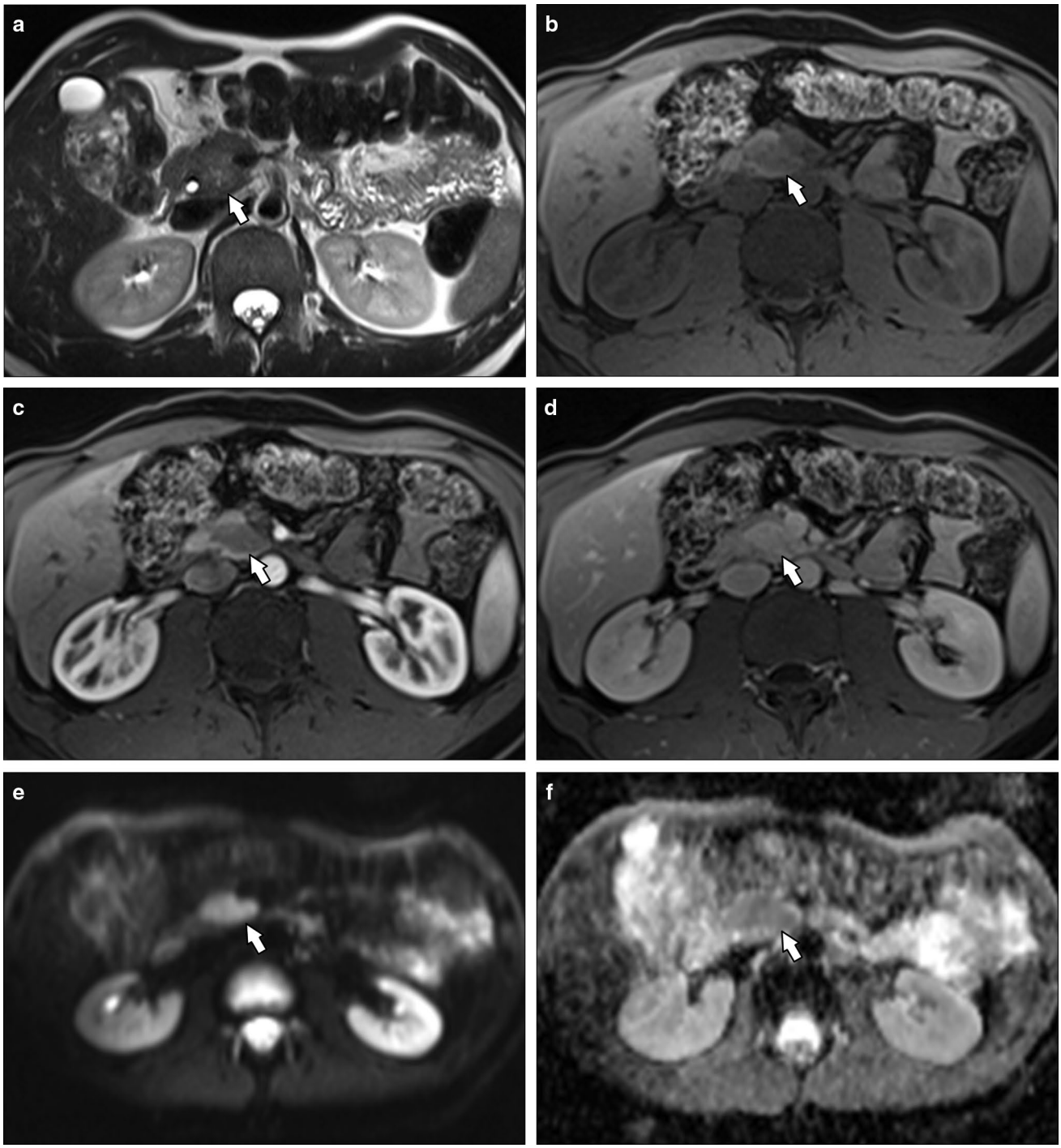

Fig. 5 A 29-year-old male with history of recurrent pancreatitis, elevated lipase, and normal serum IgG4. **a** Axial T2-weighted MR image shows a mildly hyperintense lesion in the uncinate process of the pancreas (arrow). **b** Axial unenhanced T1 FS MR image shows the lesion to be hypointense (arrow). **c** Axial T1 FS contrast-enhanced MR arterial phase image shows hypoenhancing lesion (arrow) and **d** delayed phase image shows progressive enhancement (arrow). **e** Diffusion-weighted axial MR image (b500 s/mm^2) shows increased signal and **f** low signal on ADC map from restricted diffusion (arrow). After a trial of corticosteroid treatment, based on clinical judgment, the patient's symptoms and imaging findings resolved which suggested autoimmune pancreatitis

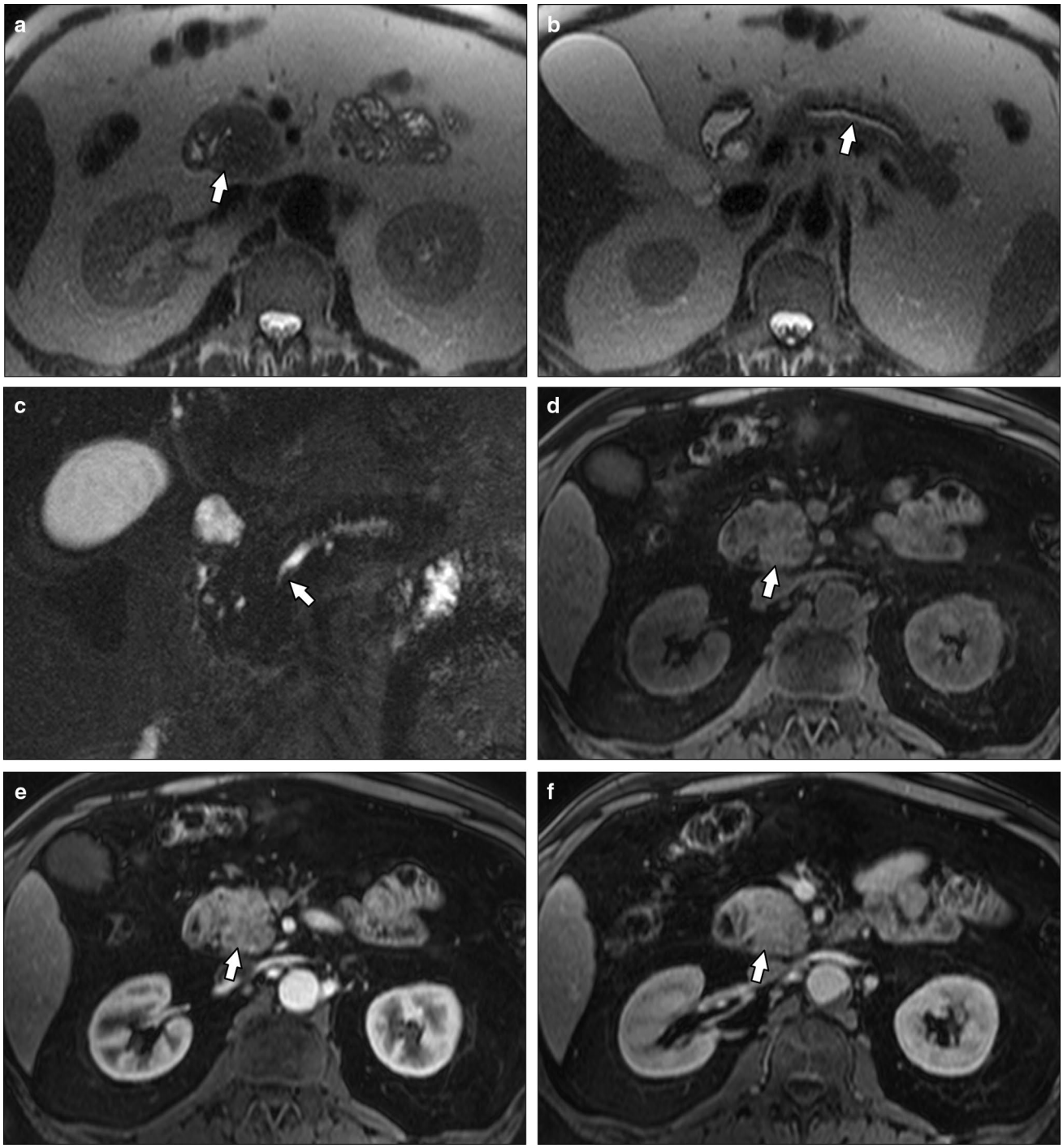

Fig. 6 A 62-year-old man with obstructive jaundice, post placement of an indwelling biliary stent, elevated CA19-9 and IgG4. **a** Axial T2-weighted MR image shows heterogeneous lesion in the pancreatic head (arrow). **b** Axial T2-weighted MR image shows mild pancreatic duct dilatation (arrow) the degree to which is at a lesser extent than typical for a pancreatic adenocarcinoma. **c** MRCP images show smooth tapered narrowing of the upstream pancreatic duct mimicking an icicle or ice pick ("icicle sign"). **d** Axial unenhanced T1 FS MR image shows a heterogeneous lesion in the pancreatic head. **e** Axial arterial phase T1 FS contrast-enhanced MR images shows heterogeneous enhancement of the lesion (arrow) and **f** delayed phase shows progressive homogeneous enhancement (arrow). Patient underwent a Whipple procedure because of suspicion of malignancy but pathology yielded lymphoplasmacytic sclerosing (autoimmune) pancreatitis

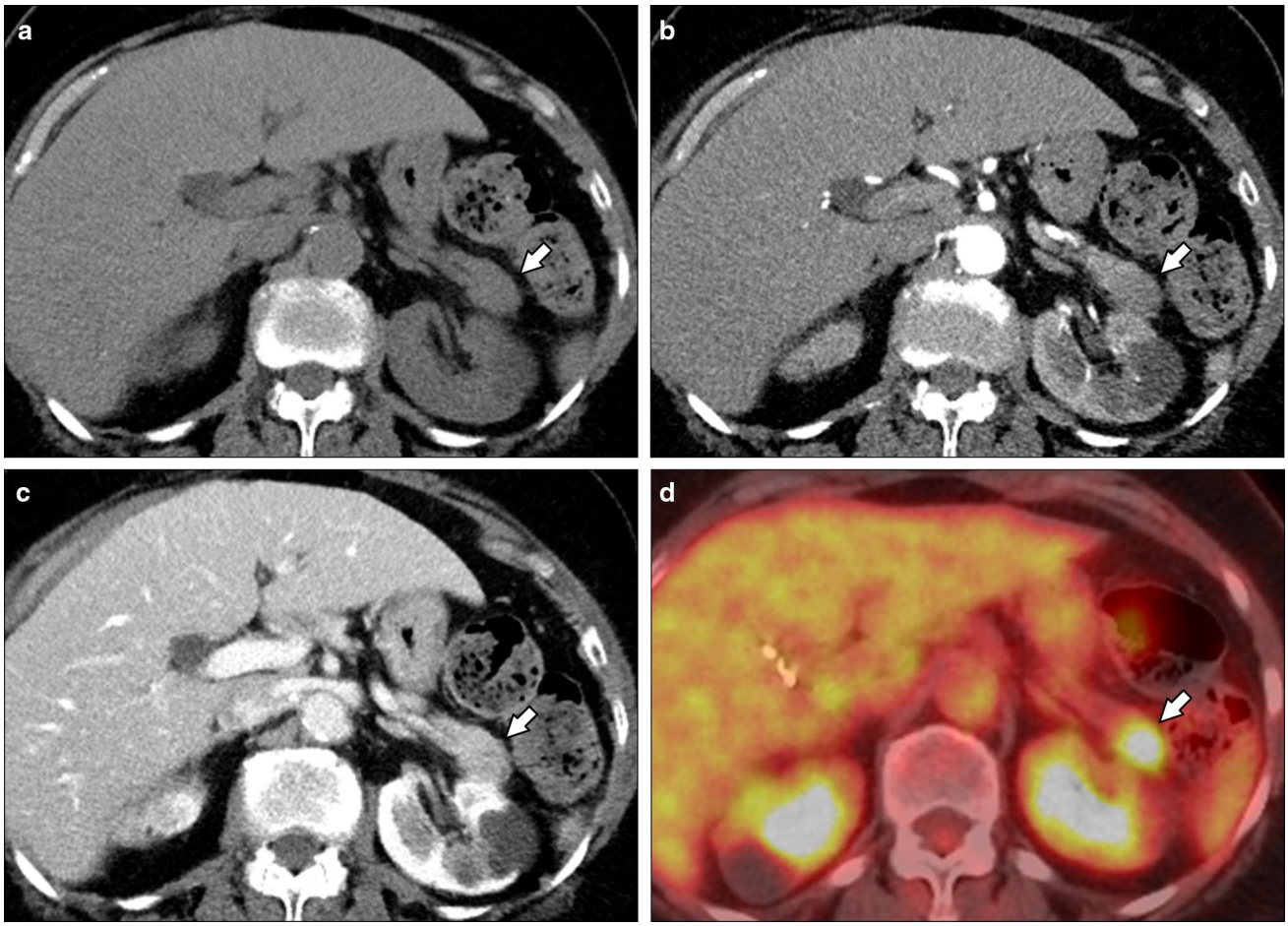

Fig. 7 A 79-year-old female with a history of breast and lung cancer with normal serum IgG4 and elevated CA19-9. **a** Axial unenhanced CT image shows focal enlargement of the pancreatic tail (arrow). **b** Axial contrast-enhanced arterial and **c** venous phase CT image shows progressive enhancement of the pancreatic tail lesion on the venous phase (arrow). **d** Axial PET/CT images show hypermetabolic activity in the pancreatic tail lesion. Pathology after surgical resection yielded autoimmune pancreatitis as biopsy was not definitive

Imaging: extra-pancreatic findings

Radiologic recognition of the extra-pancreatic manifestations of AIP is paramount as they can be critical to the diagnosis of AIP when pancreatic features are atypical and the distinction from pancreatic cancer is difficult [44]. Extra-pancreatic findings of AIP differ from the typical location and appearance of metastatic pancreatic cancer and can help in the distinction between the two entities. Pancreatic metastases occur primarily to the liver (Fig. 8), lungs [54], peritoneum and omentum, and lymph nodes [69], whereas extra-pancreatic involvement of AIP most commonly involves the biliary tree, kidneys, retroperitoneum, and salivary/lacrimal glands.

Biliary involvement of AIP is most commonly characterized by a long segment stricture with pre-stenotic dilatation of the distal common bile duct (Fig. 9) [44]. Multifocal strictures or thickening of the intra- or extra-hepatic bile duct (10–35% of patients), resembling primary sclerosing cholangitis, can also be present. Gallbladder involvement appears as diffuse mural thickening [44], and decreased signal intensity on T2-weighted images as well as delayed contrast enhancement [45].

Renal involvement, primarily occurring in the renal cortex, appears on MRI as iso- or hypointense lesions on T1- and hypointense lesions on T2-weighted images with gradual enhancement on contrast-enhanced images [44, 45, 70] and restricted diffusion (Fig. 10) [45]. On CT, renal lesions appear hypoattenuating on early-phase contrast-enhanced imaging, with gradual enhancement on delayed phases [70]. Gallium-67 scintigraphy shows increased uptake in the involved renal lesions [41].

In the retroperitoneum, findings suggestive of retroperitoneal fibrosis include a characteristic fibrotic mass around the aorta or inferior vena cava (Fig. 11). Entrapment of the ureters resulting in hydronephrosis can occur [44, 45]. Sonographically, retroperitoneal fibrosis appears as a retroperitoneal hypoechoic soft-tissue lesion. MR shows a low or

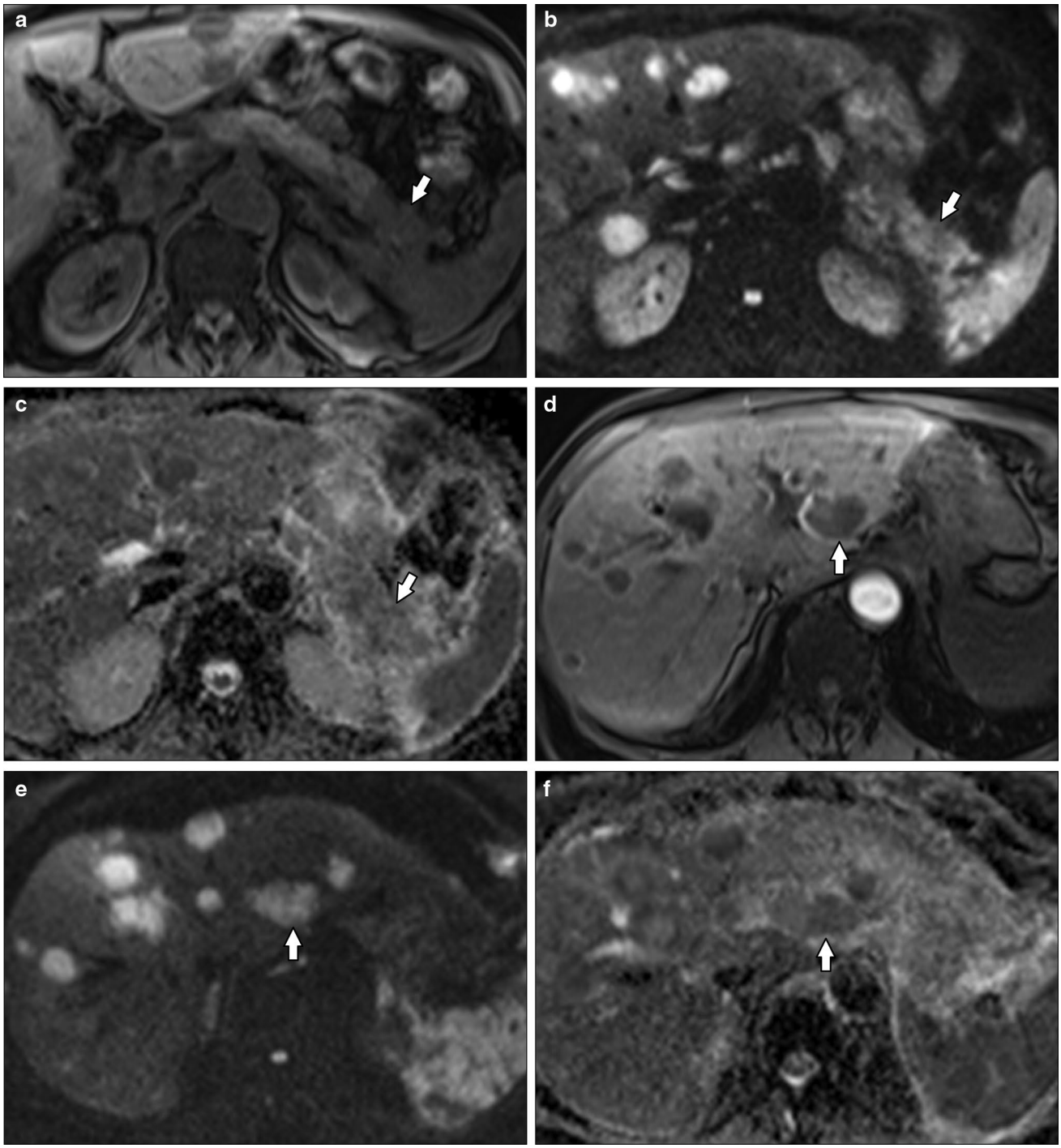

Fig. 8 A 69-year-old female with a history of follicular lymphoma and elevated liver function tests. **a** Axial T1 FS MR image shows a hypointense mass in the pancreatic tail (arrow). **b** Diffusion-weighted MR image (b800 s/mm^2) and **c** ADC map show restricted diffusion of the mass (arrow). **d** Axial T1 FS arterial phase MR image shows multiple hepatic masses with peripheral enhancement and central hypoenhancement (arrow) characteristic of metastases (arrow on a representative metastasis). **e** Diffusion-weighted axial MR image (b800 s/mm^2) and **f** ADC map show restricted diffusion of the hepatic lesions (arrow on a representative metastasis). Biopsy confirmed the diagnosis of hepatic metastases from pancreatic ductal adenocarcinoma

intermediate signal intensity lesion on T1-weighted images, variable signal intensity on T2-weighted images, and variable contrast enhancement [70].

Salivary and lacrimal glands involvement are seen as an enlargement of the glands and may lead to Mikulicz disease or Kuttner tumor. In Mikulicz disease, bilateral swelling of

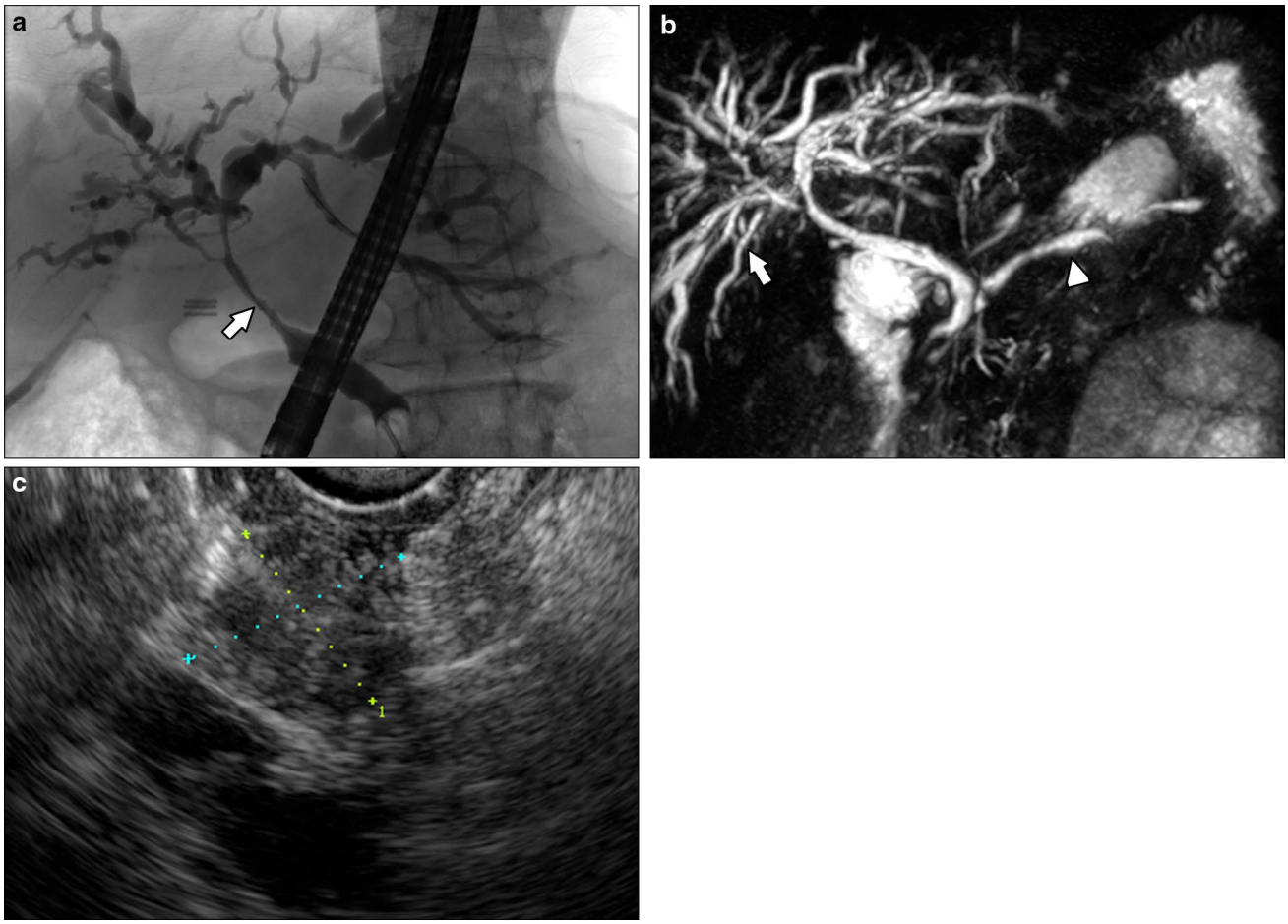

Fig. 9 A 78-year-old male with history of jaundice, normal serum IgG4 and Ca19-9. **a** ERCP image shows a beaded appearance to the intrahepatic biliary tree with multifocal areas of strictures and intrahepatic biliary dilatation. Stricture of the common bile duct is also present (arrow). **b** MRCP image status post ERCP with balloon dilatation of the common bile duct shows persistent intrahepatic biliary dilatation with multifocal strictures (arrow) and resolution of the common bile duct stricture. Mild prominence of pancreatic duct (arrowhead) is also present. **c** EUS image shows a pancreatic head mass (calipers). Biopsy of the pancreatic head mass confirmed the diagnosis of autoimmune pancreatitis with histiocytic and plasma cell infiltrate

the involved glands with MR show homogeneous T1 and T2 hypointense lesions that show enhancement on contrast-enhanced sequences. Kuttner disease is a chronic sclerosing sialadenitis that results in a non-neoplastic lesion that on MR is isointense on T1-weighted images, hypointense on T2-weighted images, and enhances homogeneously [45].

IgG4-related prostatitis has been reported to have a prevalence of 10% with the prostate appearing diffusely enlarged with low attenuation and surrounding inflammatory stranding [48]. At DWI, the prostate showed swelling with high signal intensities, mimicking prostatitis and prostate cancer [41].

On PET scans, both pancreatic cancer and AIP show extra-pancreatic FDG uptake; however, increased uptake in the kidney and salivary gland has been shown to be seen only in AIP cases [66]. Unlike pancreatic cancer, AIP more often has increased FDG activity of the extra-pancreatic portion of the bile duct, higher SUV max for the prostate gland, and slower liver clearance of FDG activity, with FDG retention index values of 1.8% for AIP and 6.7% for pancreatic cancer [65]. A simultaneous finding of diffuse pancreatic FDG uptake and increased inverted "V"-shaped FDG uptake in the prostate was observed only in AIP cases according to Zhang et al. [65].

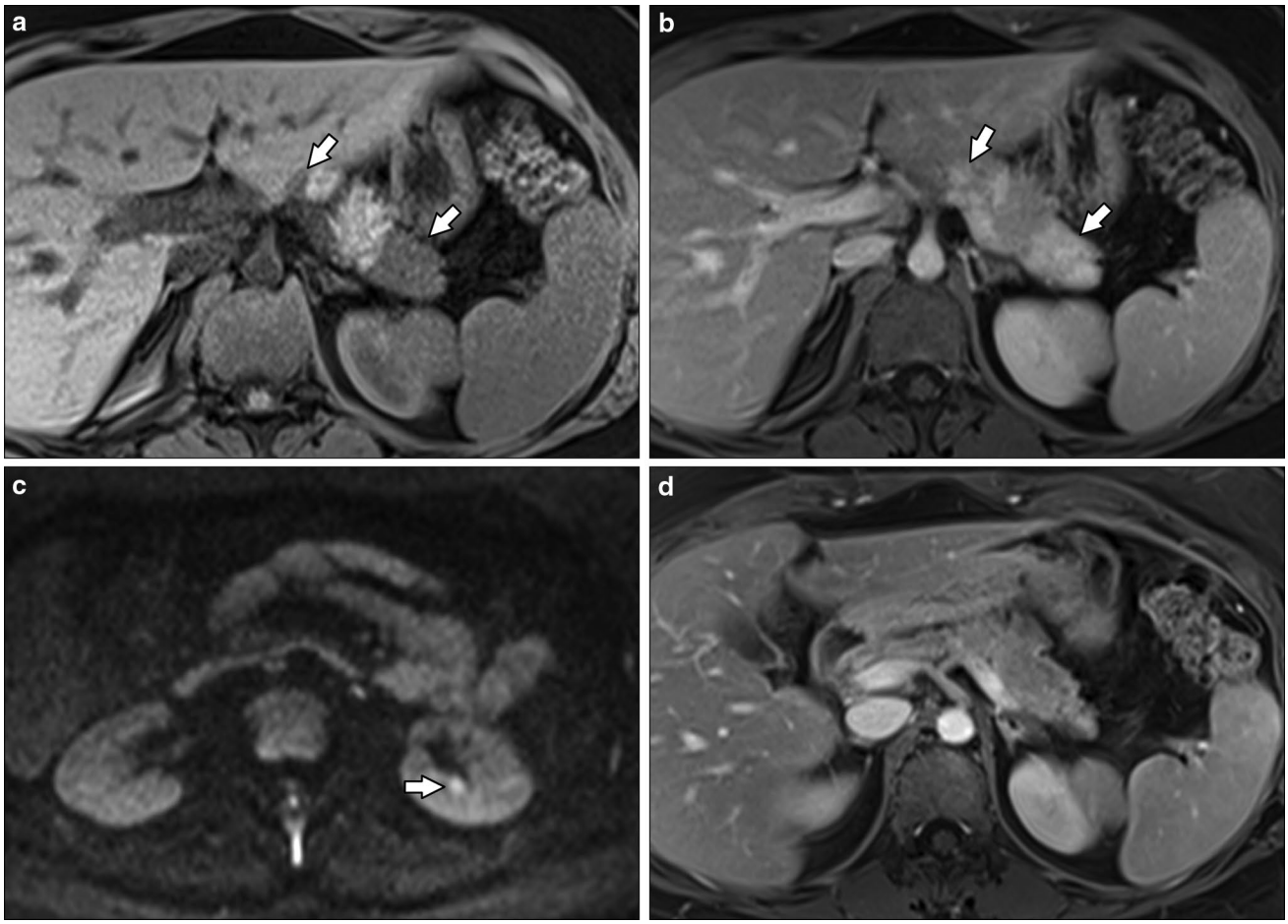

Fig. 10 A 30-year-old female with a pancreatic mass seen during a prenatal ultrasound and normal serum IgG4. **a** Axial T1-weighted FS image shows T1 hypointense lesions in the pancreatic body and tail. **b** Axial T1-weighted FS delayed contrast-enhanced image shows that lesions are hyperenhancing relative to the pancreas. **c** Diffusion-weighted MR images (b800 s/mm^2) show subtle focal lesions within the renal medulla with increased signal intensity (arrows). The patient was treated for suspected autoimmune pancreatitis with corticosteroids, based on clinical judgment. Post steroid treatment (six months later) axial T1-weighted FS delayed contrast-enhanced image shows resolution of the lesions of the pancreatic body and tail representing response to treatment. The renal lesions also resolved (not shown)

Conclusion

Differentiating focal AIP from pancreatic ductal adenocarcinoma poses a diagnostic challenge as there is clinical and radiological overlap. It is essential for the radiologist to be knowledgeable of the imaging features that are suggestive of focal AIP over pancreatic ductal carcinoma as the treatment between and prognosis of the two entities varies greatly. Features that are suggestive of focal AIP over pancreatic ductal adenocarcinoma include delayed homogeneous enhancement, hypointense/hypodense capsule-like rim, absence of pancreatic atrophic changes, "duct penetrating" sign, irregular narrowing of the MPD and extrapancreatic manifestations (most commonly the biliary tract and renal involvement), and excellent response to steroid treatment. Findings favoring pancreatic adenocarcinoma, though not specific, include "double duct" sign, abrupt duct cut-off, pancreatic atrophy, vascular encasement, and the presence of metastases to common sites, most typically the liver. Though imaging and clinical parameters can be suggestive of one particular entity, in many cases biopsy is still needed for diagnosis.

Fig. 11 A 62-year-old male with a history of common bile duct stent placement. **a** Axial contrast-enhanced CT and **b** T1 FS contrast-enhanced MR images show circumferential soft tissue surrounding the aorta (arrow) compatible with retroperitoneal fibrosis associated with autoimmune pancreatitis. **c** Axial contrast-enhanced CT image shows a diffusely enlarged, homogeneously enhancing pancreas with hypodense rim (arrows). After a trial of corticosteroid treatment, based on clinical judgment, the patient's imaging findings resolved which suggested autoimmune pancreatitis

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