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CYSTIC AND SOLID PANCREATIC LESIONS

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Introduction

Clinical features including age and gender are important when seeking to differentiate pancreatic tumors, and imaging features can be informative in terms of both detection and characterization of lesions. For example, most solid pancreatic tumors are either malignant or potentially so, and surgical resection should thus be initially considered as a curative treatment. On the other hand, cystic pancreatic lesions may be either benign or exhibit malignant potential. Therefore, accurate diagnosis of pancreatic lesions is critical in terms of management planning. However, the detailed characterization and differentiation of such lesions reamins challenging because of overlap in morphological features [1, 2].

Cystic Pancreatic Lesions

Recent improvements in imaging quality have increased the diagnostic rate of cystic pancreatic tumors. Solid pancreatic tumors may either degenerate or undergo a change in appearance to become cystic. Although most pancreatic cystic tumors are benign, solid tumors that have undergone cystic degeneration are usually malignant; this is particularly true of pancreatic ductal adenocarcinoma (PDAC). In the time since the importance of cystic lesions has become better understood, cystic forms of solid tumors have been better defined [3]. Rarely, large cystic degenerations containing necrotic and hemorrhagic debris have been described in solid-pseudopapillary tumors (SPTs) and PDAC [4].

Pseudocysts

The most common cystic lesions of the pancreas are pseudocysts. These are unilocular or multilocular fluid-filled lesions with sharp margins, encapsulated by fibrous tissue. Pseudocysts usually develop after episodes of acute pancreatitis or trauma caused by inflammation, necrosis, or hemorrhage. Such pancreatic or peripancreatic conglomerations are typically visible after administration of contrast material, but do not exhibit enhancement if they are uncomplicated. Thicker and/or calcium-containing walls may be evident in older cysts. Pancreatic pseudocysts usually present as round or oval hypodense lesions on unenhanced CT images. Hemorrhage within a lesion presents as a region of increased attenuation. The pseudocyst wall becomes enhanced, but the fluid within does not, on contrast-administered CT (fig.1).

A pseudocyst exhibits homogeneous hyperintensity on T2-weighted magnetic resonance (MR) imaging. Unless a hyperintense hemorrhage is present, pseudocysts present as hypointense lesions on unenhanced T1-weighted MR imaging. The fibrous capsule of a pseudocyst may exhibit contrast enhancement in contrast-enhanced T1-weighted sequences [5].

True Epithelial Cysts

A true pancreatic epithelial cyst presents as a small fluid-filled structure with an obscure wall, no internal septae, and demonstrating a lack of contrast enhancement on CT imaging. Such cysts do not communicate with the pancreatic duct. True pancreatic epithelial cysts are strongly associated with von Hippel-Lindau disease, in which multiple unilocular cysts are distributed in the normal pancreatic parenchyma. Such unilocular lesions appear hyperintense on T2-weighted imaging, hypointense on T1-weighted imaging, and exhibit no enhancement [5] (fig.2).

Serous Cystadenoma

Serous cystadenomas are considered to be benign cystic neoplasms; only sporadic instances of malignant degeneration have been noted. Although the classical appearance is that of a serous microcystic adenoma, a less common presentation is an oligocystic (macrocystic) adenoma. Of all pancreatic neoplasms, 2% are serous microcystic adenomas, occurring most often in elderly patients (mean age, 65 years). These adenomas are more common in females (70% of all patients), and tend to occur in the pancreatic head [6].

Although most serous cystic tumors are isolated, an association with von Hippel-Lindau disease has been documented [6]. On pathological examination, a

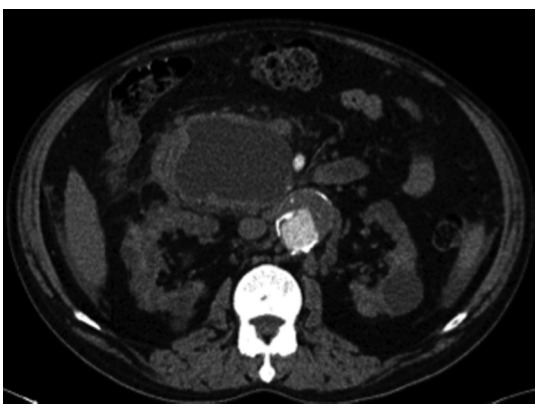

Fig. 1. Pancreatic pseudocyst. Axial contrast enhanced CT image of abdomen shows a thick walled lowdensity nonenhancing cystic lesion in the midline.

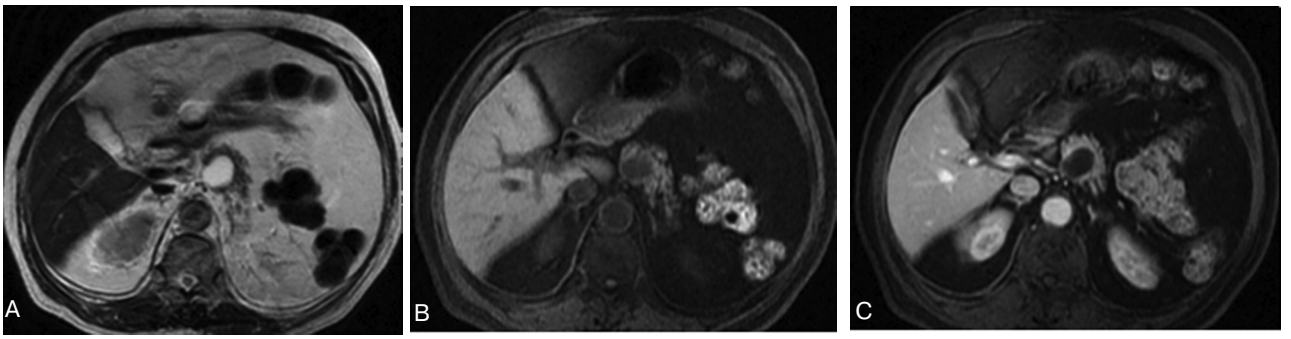

Fig. 2. MRI of pancreatic pseudocyst. **A**. Axial T2-weighted MR image shows unilocular hyperintense cystic lesion located between pancreas and aorta. **B**. Axial T1-weighted MR image presents the hypointense lesion. **C**. On axial contrast-enhanced T1-weighted MR image the lesion shows no gadolinium uptake

serous microcystic adenoma is a large (mean diameter 6 cm) mass consisting predominantly of multiple (>6) small (<2 cm in diameter) cysts separated by thin septae. Such well-circumscribed tumors are often lobulated and contain a central, stellate calcified scar. The presence of ≥6 small cysts within a mass is suggestive of the presence of a serous cystic rather than a mucinous cystic neoplasm [6, 7]. Such tumors are typically not associated with pancreatic duct dilatation or atrophy of the pancreatic tail. The tumors usually present as lobular hypodense lesions on unenhanced CT imaging. After contrast administration, the fibrous part of the lesion exhibits enhancement [8].

If calcification exists, the center of the lesion commonly appears to be hyperintense and shows a characteristic stellate arrangement. Of all lesions, 20% may exhibit a typical spongelike or irregular honeycomb structure. Generally, the number of fibrous septa present, and the extent of enhancement of such septa, identify a serous microcystic adenoma. Thus, the presence of fewer fibrous septa may cause the level of tumor attenuation to be equal to that of the surrounding fluid after contrast administration [5].

Although lesions with large numbers of microcysts may be solid-like in appearance, and exhibit increased contrast enhancement on CT images, MR imaging is generally diagnostic in the sense that a cluster of small fluid-containing cysts is evident. MR imaging reveals the well-delineated contours of such tumors, thin septations, and cystic components. Serous cystic tumors are usually markedly hyperintense on T2W MR imaging, although central areas of low signal intensity may occasionally be seen; these are attributable to the presence of fibrous scars or calcification [9]. On T1W MR images, such tumors exhibit low signal intensity, except when a hemorrhage is present [9]. The tumors are hypervascular, possessing a rich subepithelial capillary network (fig. 3).

Mucinous Cystadenoma

Mucinous cystadenoma is rare, comprising 2,5% of exocrine tumors of the pancreas. Such tumors range from benign slow-growing cystic adenomas (67% of all tumors) to aggressive and invasive mucinous cystadenocarcinomas (33%). Such cystic lesions often have thickened walls lined with mucin-producing columnar epithelium [5].

Most (> 95%) mucinous cystadenomas occur in females and typically involve the body and tail of the pancreas. The tumors are often clinically silent and therefore attain diameters greater than 10 cm before becoming palpable. On CT, mucinous cystadenomas are well-defined smooth lesions that are hypodense when compared to the surrounding pancreatic parenchyma. The cystic contents have the density of fluid. Administration of contrast material enhances the cyst wall and accentuates septations and mural nodules. The presence of mural nodules, or septal thickening and calcification, strongly suggests that a malignant lesion is present. Distal to the tumor, the pancreas may exhibit changes characteristic of chronic pancreatitis, including atrophy, duct dilatation, coarse

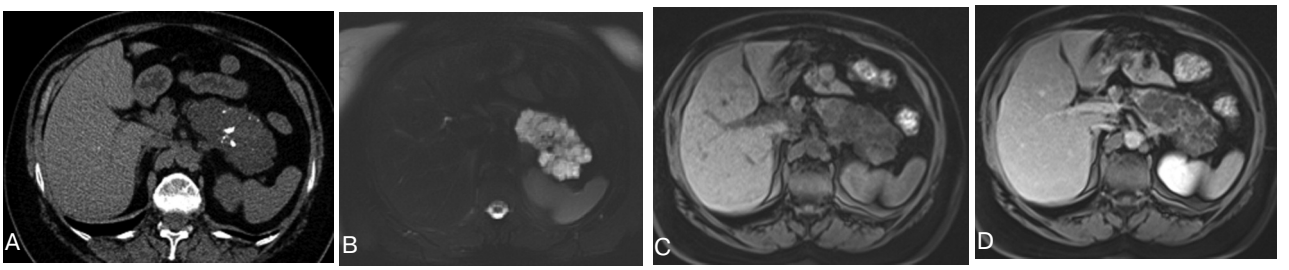

Fig. 3. Serous cystadenoma. **A**. CT scan shows a heterogeneous hypodense lesion with lobulated outlines and central calcifications in the body and tail of the pancreas. The lesion has the appearance of a solid mass with numerous small cysts. **B**. T2-weighted MR image shows the internal morphologic features of the lesion, with high-signal-intensity microcysts being clearly distinguished from the dark central calcifications. **C**. T1-weighted MR image shows the heterogeneously hypointense lesion with multiple septations and lobulated contour. **D**. Gadolinium-enhanced T1-weighted MR image shows the lesion has low signal intensity with rim enhancement and enhancing fine internal septations.

calcification, and areas of decreased enhancement. However, such changes are not specific for mucinous neoplasms. It is essential to search for evidence of local invasion of surrounding organs [5].

Mucinous cystic tumors range in nature from tumors with malignant potential to frankly malignant cystadenocarcinomas (i.e., mucinous cystadenomas, mucinous borderline tumors, and mucinous cystadenocarcinomas). A mucinous macrocystic adenoma is benign in nature, is more common in women (90% of all patients), and usually presents in the fifth decade of life (the mean patient age is 45 years). Approximately 85% of such neoplasms arise in the tail or body of the pancreas. Typically, these solitary, large (mean diameter 6–10 cm) hypovascular tumors are multilocular in nature; <6 individual cysts measuring >2 cm in diameter are present [7]. The tumors contain mucin and usually have thick walls, internal septations, solid papillary excretions, and (occasionally) peripheral calcifications [10, 6].

MR imaging reveals the unilocular or multilocular nature of such a mass; scans obtained after IV administration of gadolinium may reveal enhancement of both the septations and the peripheral wall [7]. On MR images, the contents of the cystic masses vary in terms of signal intensity; such variability is associated with the protein content of the fluid, increasing as protein levels rise [7] (fig. 4).

Intraductal Papillary Mucinous Neoplasms (IPMNs)

An IPMN is a mucin-producing tumor of the pancreas; the tumor is clinically and histopathologically distinct from mucinous cystadenoma. Such tumors are most frequently noted in males (mean age, 60 years) and are characterized by mucinous transformation of the pancreatic ductal epithelium. IPMNs can be classified on the basis of whether the disease involves the main pancreatic duct, isolated side branches, or both. Tumor location is very important in terms of prognosis. Main duct IPMNs are likely to exhibit malignant transformation (70% of all cases), whereas only ~15–20% of side-branch lesions have malignant foci [5].

On CT, a side-branch IPMN typically presents as a hypodense nonenhancing pleomorphic lesion. The tumor is classically located in the uncinate process and is closely associated with a nondilated main pancreatic duct. Multiplanar reformatted images reveal that the lesion and the duct communicate; this connection may not be readily evident on axial images. Main pancreatic duct lesions can be classified in terms of associated diffuse or segmental duct dilatation. Internal enhancing elements may be noted on contrast-enhanced CT. MRCP has shown significant utility as a noninvasive technique affording a multiplanar perspective of the pancreatic ductal system . A main pancreatic duct IPMN causes dilatation of the entire duct in the absence of a discrete intraductal obstructive lesion. Side-branch lesions are pleomorphic in appearance, are hyperintense on T2-weighted sequences, and hypointense on unenhanced scans [5] (fig. 5).

IPMN was described relatively recently, but the incidence thereof is increasing, probably because of an increase in the use of imaging modalities such as CT and MRP [11-13]. Such distinct mucin-producing tumors are thought to originate in the main pancreatic duct or side-branches thereof. When a tumor arises from a side-branch, it is most commonly located in the uncinate process. The tumors have either a papillary hyperplastic, an atypical, or a malignant epithelium that can cause local and vascular invasion and distant metastasis [11, 12]. The tumors present at a mean patient age of 65 years and are slightly more common in males (60% of all patients) [14]. On MR imaging, such a tumor typically presents as a uni- or multi-locular cystic lesion in association with a dilated main pancreatic duct (because mucin secretion is marked) [11,12]. Such tumors can be solitary, multiple, or diffuse and sessile. Communication between the main pancreatic duct and the cystic lesion may be evident, especially when MRP is used for imaging [11].

The most specific predictors of a malignant IPMN tumor are the presence of a solid mass, main pancreatic duct dilatation >10 mm, diffuse or multifocal involvement, and attenuated or calcified intraluminal contents [12].

Solid and Papillary Epithelial Neoplasms

A solid and papillary epithelial neoplasm is a rare tumor that usually develops in the tail of the pancreas. The tumor occurs exclusively in young females (mean age, 35 years), primarily those of African and Asian descent. A solid and papillary epithelial neoplasm is usually a benign or a low-grade malignant tumor exhibiting a

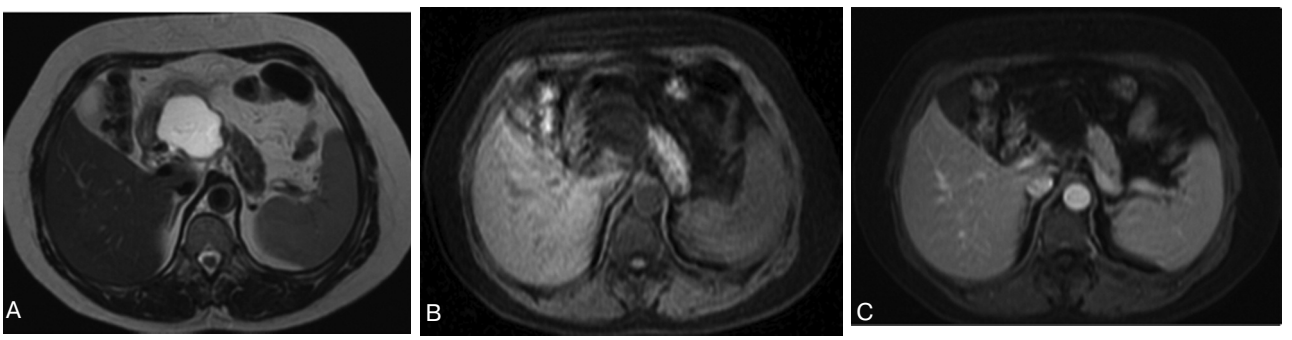

Fig. 4: MRI of mucinous cystadenoma. **A**. Axial T2-weighted MR image shows wellcircumscribed hyperintense lesion in the head of pancreas. **B** and **C**. The lesion has low signal intensity on unenhanced T1-weighted MR image (B) and does not contain enhancing solid components (C)

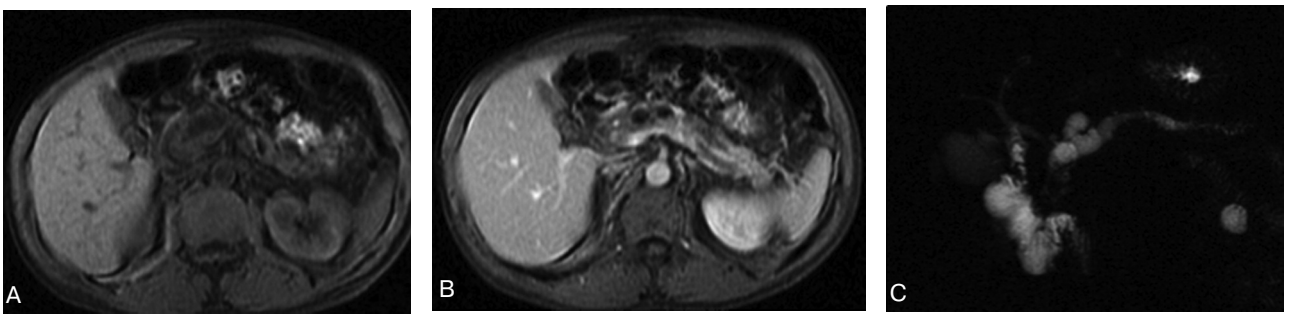

Fig. 5. MRI of mixed type intraductal papillary mucinous neoplasm at the junction of the head and body of the pancreas. **A**. T2-weighted MR image shows dilatation of the main pancreatic duct and of a side branch. **B**. T1-weighted gadolinium enhanced image **C**. MR pancreatography image.

slow growth pattern; is generally asymptomatic; and may be diagnosed incidentally. As the lesion progresses, a mass effect on surrounding structures may be evident, but these structures are not invaded [5].

On CT, a solid and papillary epithelial neoplasm presents as a large encapsulated mass with cystic and solid components. The cystic components are attributable to tumor degeneration. The solid tissue elements are peripherally located, and central regions of hemorrhage and cystic degeneration, with internal branching papillae, may be noted. Both the solid components and the capsule become enhanced after contrast administration [5].

A solid pseudopapillary tumor (also termed a solid and papillary epithelial neoplasm, a papillary cystic tumor, or a solid-cystic tumor) is a benign or low-grade malignancy constituting 1–2% of all pancreatic tumors. The tumors usually present in young females (mean age 30 years) and do not exhibit any racial or geographical bias. 46 Each solitary, large (mean diameter 10 cm) well-demarcated mass has a capsule and both solid and cystic areas. Internal hemorrhage, characterized by high T1 and low T2 signal intensity, is a classic MR feature of such tumors, as is a thick solid capsule that is enhanced after contrast injection [15].

Ductal Adenocarcinoma with Cystic Degeneration

Ductal adenocarcinoma is the most serious cancer of the pancreas; both morbidity and mortality are high. Depending on location, the tumor presents as an infiltrative lesion with resultant obstruction of the pancreatic duct, common bile duct, or both. The tumor may also invade the surrounding vasculature. The tumor is predominantly solid in nature, but cystic degeneration may be (rarely) evident on imaging. On CT and MR imaging, a pancreatic ductal adenocarcinoma presents as a hypovascular, infiltrative soft-tissue mass. Complex cystic areas reflecting internal tumor necrosis, or side-branch ductal obstruction, may be noted. The tumor is usually associated with vascular invasion and pancreatic ductal obstruction even at early developmental stages, and is thus very evident on cross-sectional imaging [5].

Congenital Pancreatic Cysts

Solitary congenital pancreatic cysts are extremely rare, being more common in females than males. Such cysts typically present as palpable abdominal masses but may be symptomatic secondary to compression of surrounding structures [16]. Multiple congenital pancreatic cysts are associated with underlying congenital diseases including autosomal dominant polycystic kidney disease (ADPKD) and Von Hippel-Lindau. ADPKD is a common hereditary disorder characterized by the progressive formation and enlargement of renal cysts. Other organs, including the liver, spleen, and pancreas, are also involved. One study found that pancreatic cysts were present in 5,7% of patients with ADPKD [17].

Congenital pancreatic cysts demonstrate the classical MR and CT features of simple cysts. The pancreatic manifestations of VHL include development of microcystic adenomas and pancreatic endocrine tumors, and careful evaluation of the pancreas for additional lesions is thus essential [18].

Solid Pancreatic Lesions

Ductal Pancreatic Adenocarcinoma

Ductal pancreatic adenocarcinoma constitutes ~90% of all malignant pancreatic neoplasms [19]. About 80% of all tumors occur in patients 60–80 years of age, predominantly in males (about 66% of all patients) [9]. In up to 70% of cases, the tumor is located within the pancreatic head [10] As the pancreatic head is closely associated with the common bile duct and the duodenum, pancreatic adenocarcinoma in the head generally presents at an earlier stage than do tumors in the pancreatic body or tail. At clinical presentation, two-thirds of patients have advanced-stage tumors, with metastatic disease evident in 85% of cases [20]. As no distinct capsule confines the pancreas, invasion of surrounding structures, especially peripancreatic vessels, is common [21].

On non-enhanced CT scans, tumors may appear slightly hypodense in comparison with the pancreatic parenchyma. On contrast-enhanced CT images, they present as markedly hypodense masses. Detection of pancreatic adenocarcinoma is based on analysis of unenhanced T1W (fat-suppressed) images and pancreatic-phase post-gadolinium T1W-spoiled GRE images [22]. On T1W (fat-suppressed) images, pancreatic cancers present as masses of low signal intensity, and small tumors are clearly separated from the normal hyperintense pancreatic tissue [9] (fig. 6). A pancreatic ductal adenocarcinoma is typically hypovascular in nature (because desmoplasia is abundant)

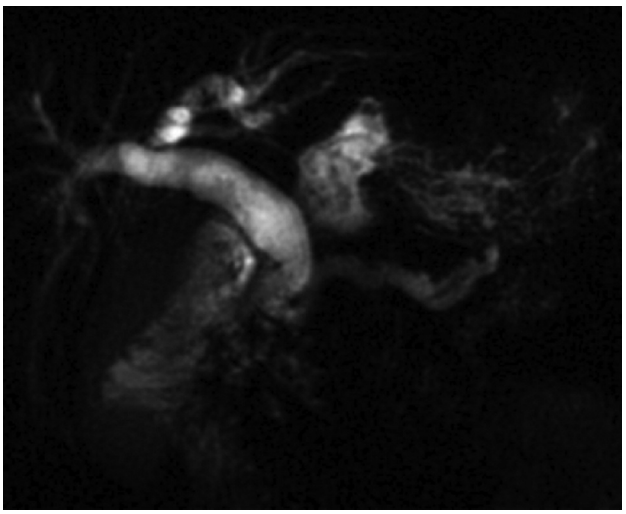

Fig. 6. Double duct sign. A pancreatic tumor located in the head of pancreas causes dilatation of common bile duct and main pancreatic duct

and appears as a mass of low signal intensity on T1W images during the pancreatic phase after gadolinium administration [23-25]. On T2W images, such tumors usually present as isointense or hyperintense lesions. Secondary findings associated with pancreatic adenocarcinoma are pancreatic duct dilatation (50% of patients) (fig. 7), atrophy of the pancreatic tail (20%), and dilated collateral veins suggestive of venous invasion. Analysis of post-gadolinium breath-hold GRE images (specifically those taken during the portal venous phase) is important in terms of detection of hepatic metastases [8].

Neuroendocrine Tumors

Neuroendocrine tumors of the pancreas are either non-functional or functional in nature. Of all functional islet cell tumors, 60–75% are insulinomas and 20% gastrinomas. Rare islet cell tumors include glucagonomas, VIPomas, somatostatinomas, and APUDomas. Nonfunctional endocrine tumors are the third most common form of islet cell neoplasm, accounting for ~15% of all endocrine pancreatic tumors [26]. Patients with such tumors are usually symptom-free until stomach or biliary tract obstruction develops. At that time, 90% of tumors are malignant and small, frequently measuring <3 cm in diameter. Resection can thus be difficult [8].

On CT imaging, nonfunctional tumors are large when detected, whereas functional tumors are smaller when detected because clinical abnormalities develop. Small tumors are usually isodense with the pancreatic tissue on nonenhanced CT but become strongly enhanced during the arterial phase after contrast administration. Hypodense areas exhibiting necrosis may be seen in large tumors and calcifications are common, too. Islet cell tumors are hypervascular, thus they can be detected best in the early phases of pancreatic enhancement [26, 27]. Metastasis to the liver or local lymph nodes is the most striking evidence of malignancy. In contrast to what is noted in ductal adenocarcinoma patients, vascular encasement is usually not macroscopically evident.

On MR imaging, insulinomas and gastrinomas exhibit low signal intensities on T1WI and high signal intensities on T2WI [9]. Fat-suppression sequences may help to emphasize the signal intensity differences between a tumor and normal pancreatic tissue [9] (fig. 8). Administration of IV gadolinium-DTPA is helpful, particularly for detection of islet cell tumors, which are hypervascular [27, 28]. Ringlike enhancement of the tumor periphery is frequently noted, whereas the center may remain hypointense as a result of fibrosis.

Less common hyperfunctional (e.g., glucagonoma, somatostatinoma, vipoma) and non-hyperfunctional tumors exhibit slightly lower signal intensities on T1WI and moderate intensities on T2WI [9, 27, 28]. Contrast administration is associated with an enhancement pattern resembling to that of smaller insulinomas or gastrinomas. Hemorrhage or necrosis may develop in large tumors; such events can readily be detected by imaging [28].

Pancreatoblastoma

Pancreatoblastoma is a rare pancreatic neoplasm. This tumor affects children, but cases affecting neonates and the elderly have also been reported. Most cases are sporadic, but there is also a congenital form associated with Beckwith-Wiedemann syndrome. In adults, a slight male predominance is evident, and >50% of all cases have been reported to affect Asian populations [29]. Pancreatoblastomas are clinically occult and typically large when diagnosed due to slow growing nature.

Treatment of localized tumors consists of surgical resection; any role for adjuvant chemotherapy remains poorly defined. Radiation and chemotherapy may be

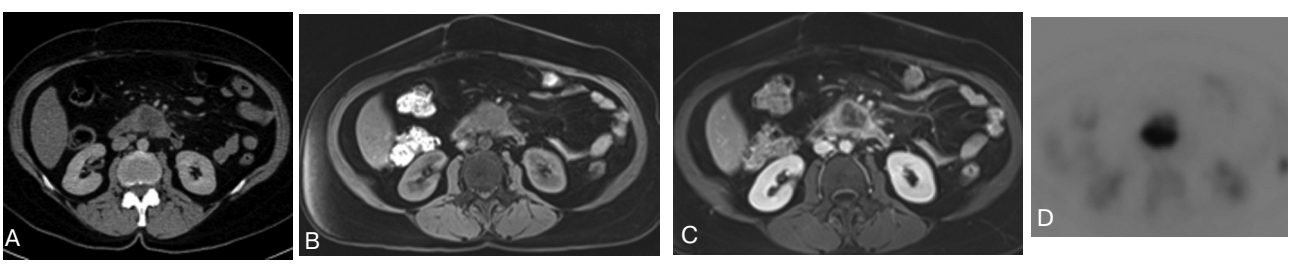

Fig. 7. Pancreatic adenocarcinoma. **A.** Axial contrastenhanced CT image shows infiltrative hypodense lesion in neck of pancreas **B**. On unenhanced T1-weighted MR image, this hypovascular tumor presents as a low-signal-intensity mass . **C**. On post- gadolinium T1-weighted MR image, it is clearly separated from normal enhancing pancreatic tissue. This sequence also shows the secondary finding of pancreatic duct dilatation and atrophy of the tail of the pancreas. **D**. On PET CT image the lesion shows FDG-uptake

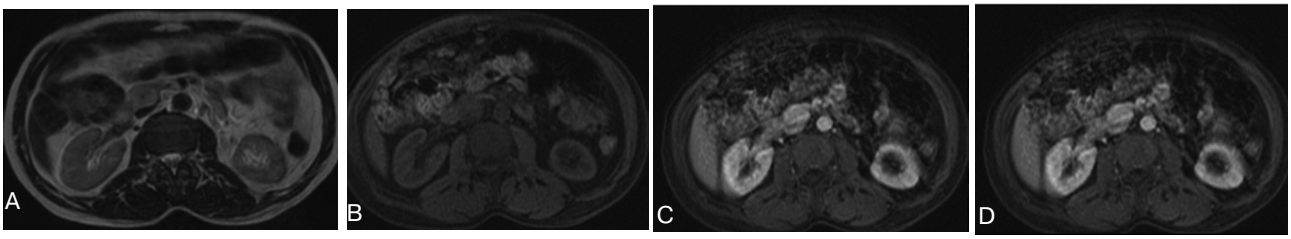

Fig. 8. Insulinoma. **A**. T2-weighted MR image shows a well-circumscribed slightly hyperintense lesion in the head of pancreas. **B**. On T1-weighted MR image the lesion appears slightly hypointense. **C**. Lesion shows clear enhancement on a postgadolinium T1-weighted sequence in early arterial phase image. Figure part **D** is the portal phase image

used to treat non-resectable tumors [29]. The prognosis of patients with localized disease is generally good but is poor for those with non-resectable tumors.

Pancreatoblastomas typically present as well-defined lobulated masses most commonly located in the pancreatic head [30]. These tumors may present cystic degeneration and clustered or rim-like calcifications. Tumors showing infiltrative pattern may extend to peri-pancreatic tissues and invade neighbouring structures and organs. Such tumors are often large when diagnosed, and to specify the origin of the tumor may thus be difficult. The tumors usually show contrast-uptake on enhanced CT and MR sequences [29].

Lymphoma

Primary pancreatic lymphoma is rare neoplasm of pancreas. These tumors are usually an extranodal manifestation of B cell non-Hodgkin's lymphoma that constitute <1% of all extralymphatic lymphomas and 0,7% of all pancreatic malignancies [31]. Secondary pancreatic lymphoma may develop as a direct extension of peri-pancreatic lymphadenopathy. Vague symptoms including abdominal pain, nausea, vomiting, and weight loss may be seen in patients with primary pancreatic lymphoma [32]. Primary pancreatic lymphoma presents in two morphological types, localized type, presenting as a well-defined focal mass or infiltrative pattern replacing the pancreas [33]. The localized type of tumor presents as a low-density mass on unenhanced CT. Minimal but homogenous enhancement of the involved region of the pancreas is revealed after contrat administration [34]. Imaging features of the infiltrative tumor type may resemble those of acute pancreatitis. Peripancreatic lymph node enlargement is usually evident, often in combination with disseminated lymphadenopathy. When lymphadenopathy is evident below the level of the renal veins, and a tumor of the pancreatic head without pancreatic duct dilatation is present, the occurrence of a pancreatic lymphoma should be considered [34].

Metastases

Metastatic pancreatic tumors are rare neoplasms that account for ~2–5% of all pancreatic tumors [35-37]. Renal cell carcinoma, lung cancer, breast cancer, colorectal carcinoma, malignant melanoma, leiomyosarcoma, and many other neoplasms can be counted for primary tumors of the pancreatic metastases [35, 37]. The metastases of pancreas have a median interval of approximately 9 years, between primary tumor resection and detection of metastases [36, 38]. Three distinct patterns of metastatic disease may be noted on CT; these are localized, multifocal, or diffuse enlargement [39]. Although most metastatic tumors present as well-defined solitary, solid, lesions, cystic metastases can occur, too, usually secondary to cystadenocarcinoma of the ovary or melanoma [40]. The metastatic lesion shows an enhancement pattern which often resembles that of the primary tumor [40]. On MR imaging, pancreatic metastases are typically hypointense on T1-weighted sequences but hyperintense on T2-weighted sequences, and most exhibit avid enhancement (fig. 9). Metastases from renal cell carcinomas have a long mean interval of development and can present many years after nephrectomy [41]. Early and correct diagnosis of pancreatic metastases is crucial, because resection may increase the 5-year survival rate [42].

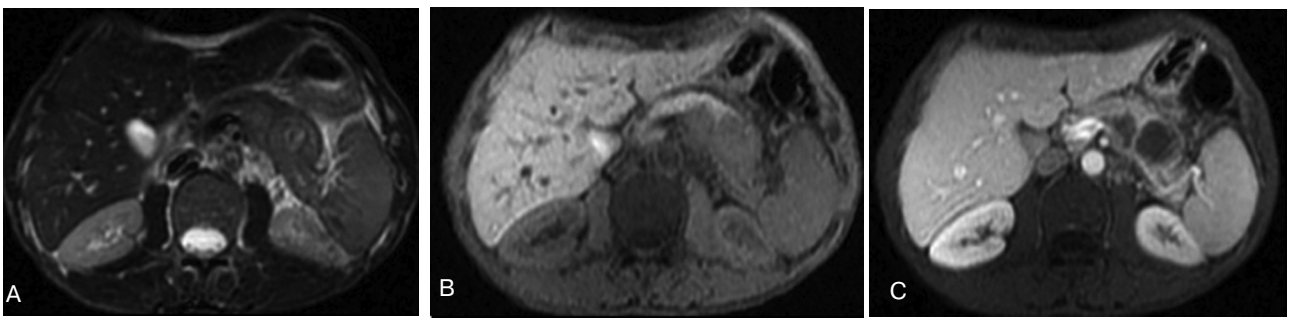

Fig. 9. Pancreatic metastases of non-small cell lung cancer. **A**. T2-weighted MR image shows a slightly hyperintense lesion in the tail of the pancreas. **B**. On T1-weighted image the lesion appears hypointense. **C**. After i.v. administration of gadolinium, the lesion is clearly depicted

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РЕЗЮМЕ. В лекции представлены наиболее часто встречающиеся новообразования поджелудочной железы, их КТ- и МРТ-семиотика.
Ключевые слова: образование поджелудочной железы, МРТ.

РЕЗЮМЕ. У лекції представлені новоутворення підшлункової залози, що зустрічаються найбільш часто, їх КТ- та МРТ-семіотика.
Ключові слова: утворення підшлункової залози, МРТ.

SUMMARY. In the present work, MRI signs of cystic and solid tumors of the pancreas.
Keywords: tumors pancreas, MRI.