Radiological and endoscopic imaging methods in the management of cystic pancreatic neoplasms

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Abstract

The management of cystic pancreatic neoplasm (CPN) is a clinical dilemma because of its clinical presentations and malignant potential. Surgery is the best treatment choice ; however, pancreatic surgery still has high complication rates, even in experienced centers. Imaging methods have a definitive role in the management of CPN and computed tomography, magnetic resonance imaging, and endoscopic ultrasonography are the preferred methods since they can reveal the suspicious features for malignancy. Therefore, radiologists, gastroenterologists, endoscopists, and surgeons should be aware of the common features of CPN, its discrete presentations on imaging methods, and the limitations of these modalities in the management of the disease. This study aims to review the radiological and endoscopic imaging methods used for the management of CPN. (Acta gastroenterol. belg., **2017**, 80, **283-291**).

Key words : Pancreas ; radiology ; cystic pancreatic neoplasm ; computed tomography ; magnetic resonance imaging ; endoscopic ultrasonography.

Introduction

The extensive use of imaging methods has improved the detection of asymptomatic pancreatic cysts. The key point in the management of cystic pancreatic masses is to determine which cyst has clinical significance and requires further evaluation (1-3). Ninety percent of the cystic pancreatic neoplasm (CPN) consists of neoplasia arising from the ductal epithelium and solid pseudopapillary tumors (SPN) (Fig. 1) (4, 5). The remaining 10% of the CPN consists of cystic degeneration of solid pancreatic neoplasms, cystic neuroendocrine tumors, cystic adenocarcinomas, lymphoepithelial cysts, metastases, and teratomas with cystic nature (1, 2).

Computed tomography (CT), magnetic resonance imaging (MRI) with magnetic resonance cholangiopancreatography (MRCP), and endoscopic ultrasonography (EUS) with or without cyst fluid aspiration (CFA) are the major diagnostic methods that are commonly used in the differential diagnosis of CPN, and these methods could eventually demonstrate suspicious features of malignancy (6, 7). However, there are still overlaps between some imaging features of CPN that complicate the diagnosis of malignancy (1, 7, 8). This study aimed to introduce the radiologic and endoscopic imaging features of CPN and to present a perspective for the management of CPN.

Common cystic pancreatic neoplasms

Serous cystic neoplasm

Serous cystic neoplasms (SCN) comprise 10-20% all CPNs, and it is typically seen in women in the seventh decade of life (9). SCN is a benign lesion and often found incidentally on CT or MRI (1). Majority of the patients are asymptomatic but can present with nonspecific symptoms such as abdominal mass feeling, pain, gastric outlet obstruction, or jaundice if the SCN is larger than 4 cm in size (10). SCN has four subtypes according to the morphological features : microcystic, macrocystic, mixed micro- and macrocystic, and solid types (11). Serous microcystic adenoma is the most common form of SCN often found in the pancreatic head as a multilocular mass with multiple (> 6) thin-walled small cysts. These small cysts form a cluster around a central hyalinized fibrous scar that may contain calcifications in up to 30% of cases (honeycomb appearance) (Fig. 2) (10, 12). Serous oligocystic (macrocystic) adenoma is located in the pancreatic head, with a few larger cysts (up to 2.5 cm) filled with brownish or clear fluid. Patients can present with jaundice because of the compression of the common bile duct (12). It has no central scar or calcification and can be misdiagnosed as a mucinous cystic tumor or branch-duct intraductal papillary mucinous neoplasm (BD-IPMN) (1, 10, 12). The mixed micro- and macrocystic type is a combination of small and large cysts, while the solid type is characterized by the absence of cystic appearance on imaging methods (11).

Mucinous cystic neoplasm

Mucinous cystic neoplasm (MCN) is seen at a rate of about 20-25% of all resected CPNs with a predilection for women in the fourth to sixth decades of life (1, 2, 9,10, 12). They are benign tumors with a malignant potential of

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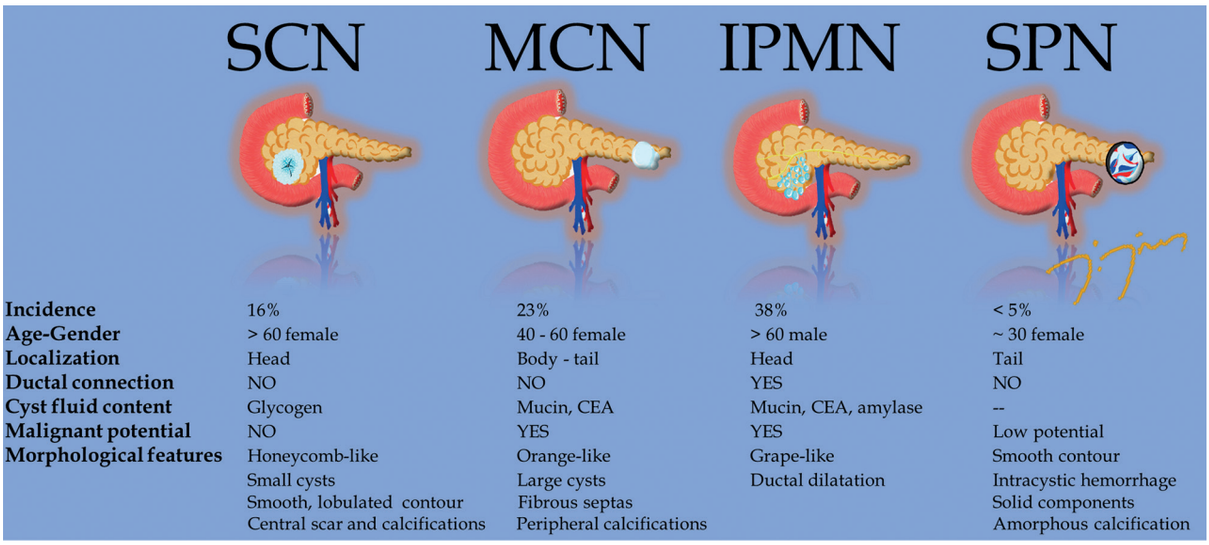

	SCN	MCN	IPMN	SPN
Incidence	16%	23%	38%	< 5%
Age-Gender	> 60 female	40 - 60 female	> 60 male	~ 30 female
Localization	Head	Body - tail	Head	Tail
Ductal connection	NO	NO	YES	NO
Cyst fluid content	Glycogen	Mucin, CEA	Mucin, CEA, amylase	--
Malignant potential	NO	YES	YES	Low potential
Morphological features	Honeycomb-like	Orange-like	Grape-like	Smooth contour
	Small cysts	Large cysts	Ductal dilatation	Intracystic hemorrhage
	Smooth, lobulated contour	Fibrous septas		Solid components
	Central scar and calcifications	Peripheral calcifications		Amorphous calcification

Fig. 1. — Characteristics of frequently encountered cystic pancreatic neoplasms.
Abbreviations: SCN; serous cystic neoplasm, MCN; mucinous cystic neoplasm, IPMN; intraductal papillary mucinous neoplasm, SPN; solid pseudo-papillary neoplasm, CEA; carcinoembryonic antigen, CA; carbohydrate antigen.
Note: Data from references 1-6, 9, 10, 12, 27, 28.

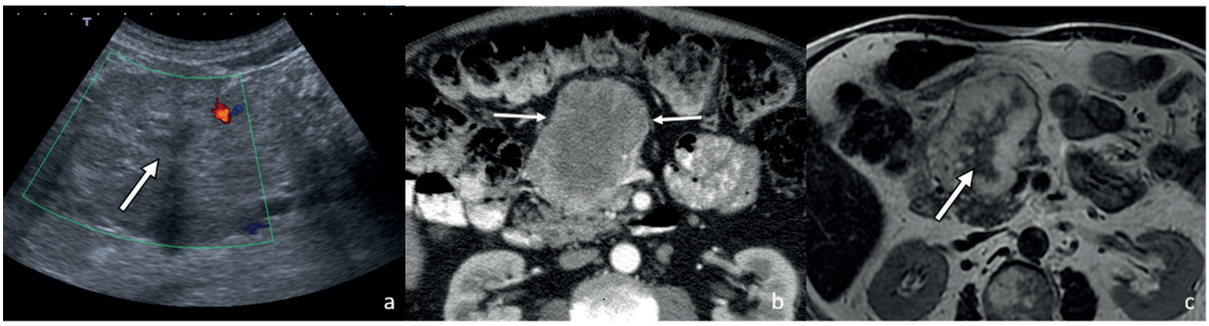

Fig. 2. — Color Doppler ultrasonography image of a 73-year-old male patient demonstrates a well-circumscribed hyper-echogenic solid appearing mass with vascular signals. Note the central hypo-echogenic scar (arrow) (a). Contrast-enhanced CT section shows the mass with lobulated contour located in the uncinate process of the pancreas. Significant peripheral enhancement is observed. It is hard to distinguish whether the lesion is solid or cystic on CT image (b). On T2 weighted axial MR image, the mass has a high signal intensity due to the microcystic structure of the lesion with a hypointense central scar (arrow), typical for a serous cystic neoplasm (c).

15-20% (1, 4, 13). The typical morphological features are a unilocular, single cyst located in the body and tail with a smooth contour, peripheral eggshell calcifications, thick cyst wall, and no communication with pancreatic ducts (Fig. 1 and 3) (1, 8, 10). Patients can show symptoms such as abdominal or back pain, fever, recurrent pancreatitis, or gastric outlet obstruction because of a mass effect (4, 7). Jaundice and unintentional weight loss are also seen in patients with malignant MCN. MCN can be misdiagnosed as a pseudocyst. However, pseudocyst appears as a unilocular cystic lesion with water isodense/isointense content without a solid component or internal septations (12). The increased serum carbohydrate antigen (CA) 19.9 levels observed during the follow-up of patients with MCN can be associated with malignancy (5). The imaging characteristics of malignant MCN include enhanced thick wall or septa, cysts larger than 6 cm, solid component extruding from the cyst wall, and mural nodularity (12).

Intraductal papillary mucinous neoplasm

Intraductal papillary mucinous neoplasm (IPMN) is a mucin-secreting CPN that originates from the duct epithelium and can cause dilatation in the main and/or side branches of pancreatic duct (7, 12). Connection

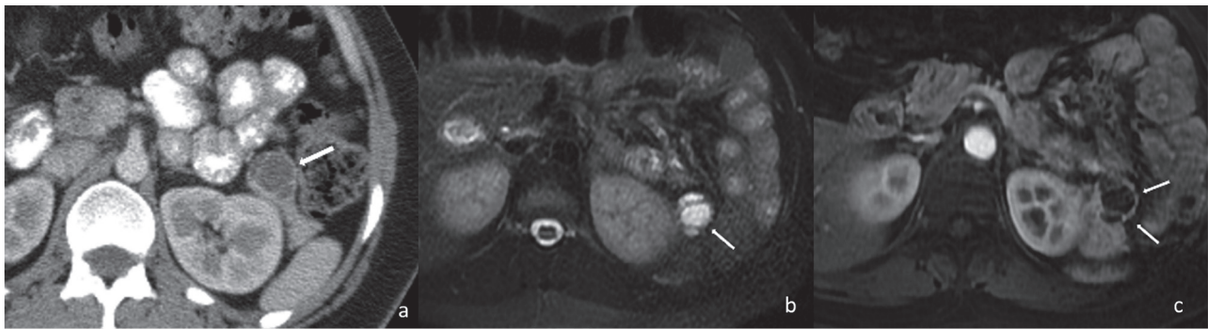

Fig. 3. — A cystic lesion (arrows) in the pancreatic tail, which is incidentally detected on contrast-enhanced CT of a 28-year-old female. The lesion consists of one large and two smaller cysts and has no solid component. Note the smooth surface of the lesion, which is characteristic for MCN (a). On MRI, the lesion has a high signal intensity on fat saturated T2 weighted image (b), and enhancement of septa and wall is observed on fat saturated T1 weighted image after intravenous gadolinium administration (c). These findings are suggestive of a mucinous cystic neoplasm.

to the pancreatic ducts is typical for IPMN since other CPNs do not have communication (14). It is the most commonly detected CPN with a rate of 38% in resected CPN, and men are found to be more likely affected than women (3/2) at an average age between 60 and 70 years (9, 12). Pancreatic head is the common site for IPMN, but it can be multifocal as well. IPMNs are often detected incidentally and classified according to their location in the pancreatic ducts : main duct IPMN (MD-IPMN), BD-IPMN, and mixed-type IPMN (Figs. 4 and 5) (4, 7, 12). The malignant potential is higher than for other CPNs, and it is 6.3–46.5% for BD-IPMN and 45–60% for MD-IPMN (3, 15-17). On cross-sectional imaging methods, polycystic mass (grape-like appearance) accompanied with connection with the pancreatic ducts is typical for BD-IPMN, while focal or diffuse dilatation of the main pancreatic duct (MPD) is observed for MD- IPMN and mixed-type IPMN (14). MPD stricture and intraductal calcifications are usually not observed in MD-IPMN contrary to chronic pancreatitis (7). Mixed-type IPMN displays both the features of MD-IPMN and BD-IPMN. The malignancy criteria for IPMN are MPD dilatation (> 1 cm), thick septa or irregular cyst walls, solid components or mural nodularity, interval growth time (> 2 mm/per year), large cyst (> 3 cm), pancreatitis-like symptoms, abdominal pain, and jaundice (2, 3, 5-7, 12, 18).

Solid pseudopapillary neoplasm

Solid pseudopapillary neoplasm is a well-demarcated and smoothly contoured mass with solid and cystic parts and comprises less than 5% of all resected CPN with a malignancy potential of 15% (4, 9, 10, 12). Patients are asymptomatic but can present with mass feeling, abdominal or back pain, or nausea (10, 19). These lesions have a thick, irregular, contrast-enhanced, and well-defined capsule (Fig. 6) (12). The cystic appearance and fluid-debris levels are attributable to intratumoral hemorrhage and necrosis (1). Discontinuity of the capsule and eccentric lobulation with nodular or amorphous calcifications may indicate malignancy (7, 12).

Rare cystic pancreatic neoplasms

Cystic pancreatic neuroendocrine tumors are generally nonfunctioning and discovered incidentally (12). Men and women are equally affected, and it is commonly seen in the fifth and seventh decades of life. Hypervascular rim, septations, or solid components can be detected via imaging methods (12). Peripheral or central calcifications, contrast-enhanced mural nodules, vascular invasion, liver metastases, and periportal or peripancreatic lymphadenopathy are associated with malignancy.

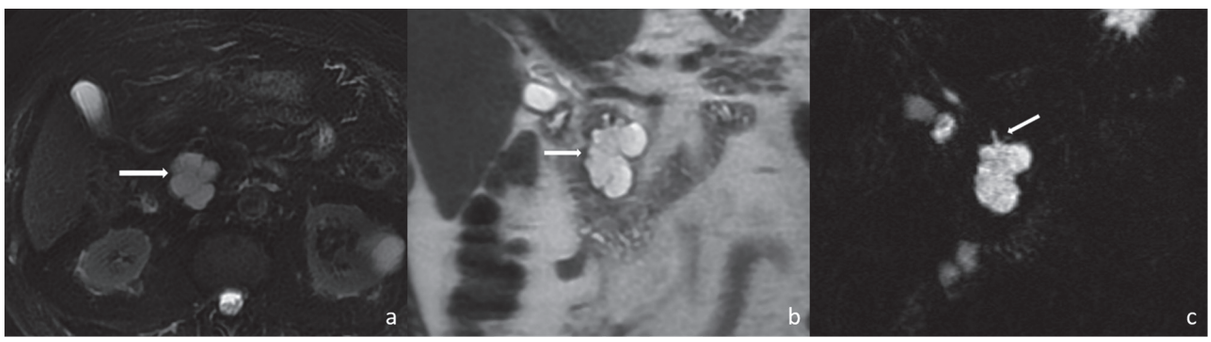

Fig. 4. — Axial fat saturated (a), and coronal without fat saturation (b) T2 weighted MR images of a 76-year-old male demonstrate a multilocular cystic lesion with thin septa located in the uncinate process compatible with branch duct type IPMN (arrows). Thin MRCP section is helpful to prove the connection between the pancreatic duct and the cystic lesion (arrow), which is diagnostic (c).

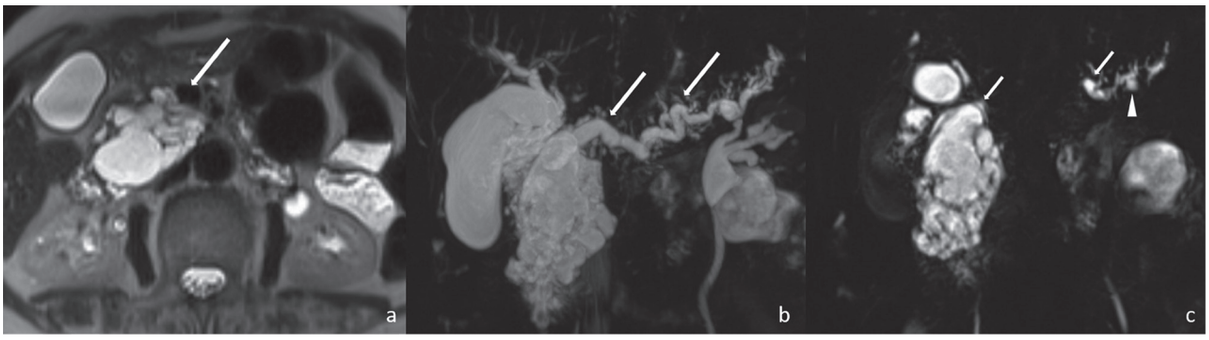

Fig. 5. — On MRI of a 66-year-old female, a multilocular cystic lesion in the pancreatic head is observed on T2 weighted image, which has multiple thin and thick septa (a). 3D MRCP image reveals diffuse dilatation of the main pancreatic duct (arrows) (b). On a coronal section of MRCP, cystic dilatation of the pancreatic duct (arrow) is observed in addition to small peripheral branch duct cysts (arrowhead) (c). These findings are compatible with mixed-type IPMN. The lesion was diagnosed as malignant IPMN after histopathologic evaluation.

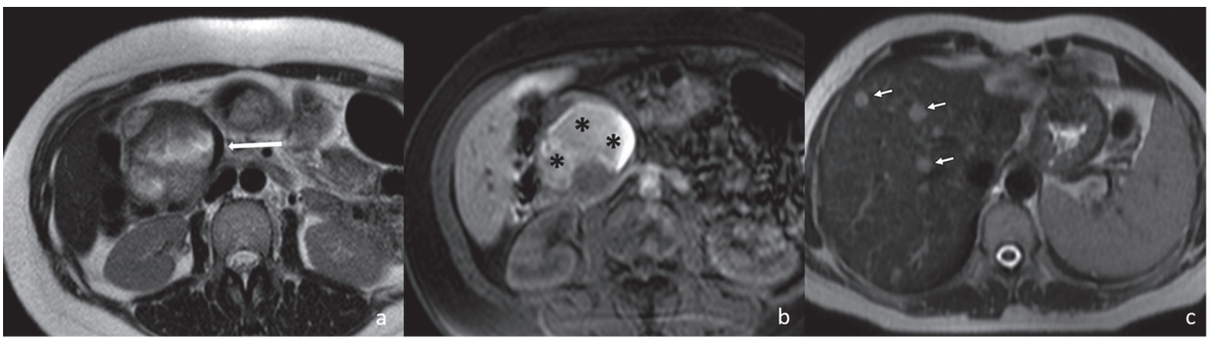

Fig. 6. — MRI of a 40-year-old female. T2 weighted image reveals a mass in the uncinate process of the pancreas that has heterogeneous signal intensity (a). Note that the mass has a smooth margin and hypointense capsule (arrow). T1 weighted image with fat saturation shows high signal intensity due to intratumoral hemorrhage (asterisk) (b). After surgery, histopathologic assessment of the lesion was compatible with SPN. T2 weighted image after 3-year follow-up shows multiple metastatic lesions in the liver. Larger lesions are indicated by arrows (c).

Lymphoepithelial cyst, cystic lymphangioma (triglyceride-rich cystic fluid), necrosis of adenocarcinomas, and ovarian, lung and renal cell carcinoma metastasis may present as a CPN.

Radiological and endoscopic imaging methods

Radiological and endoscopic imaging methods are essential for decision making in the management of CPN since these methods can demonstrate typical and suspicious characteristics of CPN. The detection of calcification in a CPN can be done using CT and EUS, whereas MRI does not detect calcification. In malignant CPN, CT and MRI can be used in the preoperative evaluation of the patient by determining the metastasis, local invasion, and relation with intra-abdominal organs and major vessels (6). MRI and EUS can display the communication between the cyst and the MPD. If there is no communication with the pancreatic duct system, MRI with MRCP or CT can show the details of CPN such as location in the pancreas and relation with other intraabdominal organs to make a differential diagnosis between SCN and MCN (Figs. 2-6) (6). Nevertheless, the accuracy rate to differentiate CPN by cross-sectional imaging methods ranges between 47% and 78% (20). Additionally, the imaging features predictive of malignancy in CPN are size (> 3cm) (sensitivity, 74% ; specificity, 49% ; Odd's ratio (OR), 2.97), solid component in the cyst (sensitivity, 48% ; specificity, 91% ; OR, 7.73), and dilatation in the pancreatic duct (sensitivity, 32% ; specificity, 80% ; OR, 2.38) preoperatively (4). Therefore, it is important to know the advantages of the imaging methods and take their limitations into consideration.

Transabdominal ultrasonography

A CPN can be detected incidentally when transabdominal ultrasonography (US) imaging is performed. The location and size of the CPN can be assessed on US ; however, its connection with the MPD cannot be clearly determined. Moreover, the retroperitoneal location of the pancreas and overlying gastric and bowel gas adversely affects the utility of transabdominal US to display the internal structure of CPN. Therefore, the discrimination of CPN using transabdominal US is not satisfactory, and further evaluation is always required.

Computed tomography

Computed tomography is the first-line method in the assessment of CPN with high-quality 3D contrast-

enhanced images. Thin-slice CT images of the arterial and portal venous phases need to be obtained. (2-4). CT can easily demonstrate the size, location in the pancreas, uni- or multilocular nature, the thickness of cyst wall and septa, MPD size and its continuity, and presence and location of calcifications and mural nodules. Contrast-enhanced CT can distinguish an enhancing mural nodule from the mucus in CPN. However, the sensitivity of CT for detecting a mural nodule is low, while the specificity is high (47% and 89%, respectively) (21). On the other hand, CT has several limitations. First, if the CPN is smaller than 1 cm, the resolution is low. Second, dysplastic changes in the cysts do not have typical CT features (2, 22). Moreover, CT cannot precisely detect the internal structure of CPN. Therefore, microcystic or small solid components may not be visible (Figs. 2b and 3a) (12). Additionally, associated pancreatitis can conceal the morphologic features (2). CT scanners with a high number of detector rows have been compared with older-generation scanners to see whether the former can overcome the limitations mentioned above ; however, they failed (23).

Magnetic resonance imaging

Owing to the limitations and radiation exposure of CT and the advantages such as high soft tissue and contrast resolution of MRI with MRCP, the latter is considered as a further imaging method for all CPNs. (2 ,4, 6, 24, 25). 3D high-resolution MRCP facilitates the diagnosis of IPMN by localizing and displaying the extension of IPMN within MPD using thin-section, heavily T2-weighted imaging (WI) (24, 25). The cystic nature of small (< 10 mm), numerous cysts that form a honeycomb pattern in the SCN and hemorrhage in the cyst can be distinguishable (Fig. 6). MRI with MRCP can precisely identify an increase in size, mural nodules, wall thickening, and MPD dilatation (> 10 mm) (6, 25).

MRI scanning protocols should include T1- and T2-weighted thin-slice images covering the whole pancreas with contrast administration and MRCP. T1-WI with fat suppression is useful for evaluating pancreaticparenchyma, while T2-WI is used to examine pancreatic ducts, biliary tract, pancreatic or peripancreatic edema, inflammation, and fluid collections (25). MRI with MRCP can distinguish solid nodules with high sensitivity values (ranging from 58.3% to 89%) (24). However, CT and MRI present similar results while staging a malignant CPN (6). On follow-up, contrast administration can be waived (26). Secretin-enhanced MRCP, a modified technique of MRCP, can be used to improve the accuracy rate of MRCP for detecting the communication of small cysts to pancreatic ducts, and it effectively depicts the pancreatic ductal anatomy by stimulation of pancreatic secretions (2). Diffusion-weighted imaging was evaluated to predict the malignancy, but heterogeneous cystic and solid components can alter the effectiveness and accuracy of this technique (25). Moreover, MRI has several limitations such as failure to detect calcifications, long scanning times, and motion artifacts, and it cannot be performed on claustrophobic patients and patients with metallic implants.

Endoscopic ultrasonography

Endoscopic ultrasonography is an invasive method with a complication rate of less than 1% (2-7, 27). It is a useful tool to show internal structures of the cyst and its relation with MPD and the presence and location of calcifications (Fig. 7) (2, 6, 28). In contrast to CT and MRI, EUS is a dynamic, real-time imaging method and can distinguish mucus from solid mural nodules by specific maneuvers and sonographic features such as echogenicity, edge, and rim (21). However, the accuracy rate of EUS to identify CPN is 50%-73%. Therefore, it is recommended as a complementary method to CT or MRI with MRCP to classify the CPN or assess the stage in case of malignancy (6, 20). Additionally, when fine-needle aspiration biopsy and CFA are performed along with EUS, it improves the diagnostic accuracy (27-30).

Cyst fluid analysis can distinguish mucinous and nonmucinous CPN with a sensitivity of 63% and specificity of 88% (6, 29, 30). Cyst fluid can also be analyzed for macromolecules such as amylase, lipase, glycogen, and carcinoembryonic antigen (CEA) to determine the type of CPN. SCN cyst fluid cytology could show cuboidal glycogen-rich cells and low levels of amylase and CEA (5, 10, 31). The pseudocyst fluid has high levels of amylase and lipase, whereas the MCN and IPMN fluids have high levels of mucin and CEA (1, 2, 5, 31). However, the IPMN fluid has high amylase levels that indicate its connection with the pancreatic ductal system (5, 31). Similar to SCN, cystic pancreatic neuroendocrine has low levels of CEA and amylase in the cyst fluid (30). The sensitivity and specificity of cyst amylase concentration below 250 U/L are 44% and 98% to identify the SCN or mucinous cyst and those of the CEA level below 5 ng/mL are 50% and 95% to identify the SCN or pseudocyst, respectively (32). The cyst CEA concentration above 800 ng/mL has a sensitivity of 48% and specificity of 98% to predict the mucinous nature of the CPN (32). Furthermore, cellular content of cyst fluid, and K-ras and GNAS mutations can be investigated in order to detect malignancy (3-7, 28, 33).

Intraductal ultrasound with peroral pancreatoscopy

Intraductal ultrasound (IDUS) with peroral pancreatoscopy (POPS) plays no role in the detection and management of CPN, but it can be used for further evaluation of intraductal mucin-secreting tumors (34). IDUS and POPS can allow the direct visualization of the MPD and small protrusions and vessels that are signs of malignancy in MD-IPMN (34). Additionally, the cytological analysis of collected pancreatic juice during

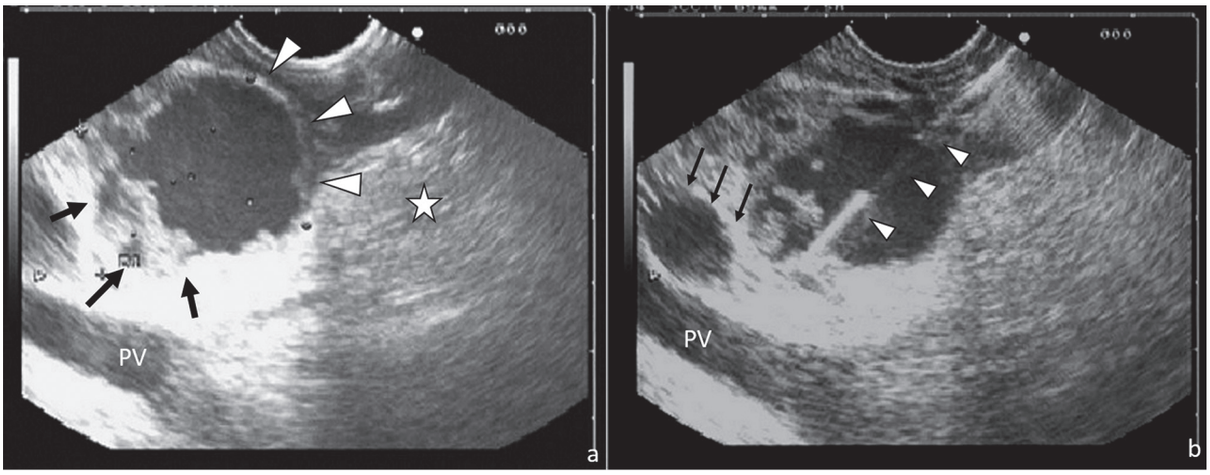

Fig. 7. — 78-year-old male patient presented with jaundice and acute cholangitis. MRI revealed a cystic mass with solid components located at the head-neck of the pancreas, and this was interpreted as main duct IPMN (not shown here). EUS displayed a cystic mass (arrowheads) with a solid component (arrows) at the head-neck junction of the pancreas (white star) (a). The common bile duct was infiltrated and dilated (black arrows), but the mass did not invade the portal vein (b). The patient was diagnosed with mucin secreting adenocarcinoma by performing EUS guided CFA and fine needle aspiration biopsy (white arrowheads), compatible with the initial diagnosis (b).

POPS can provide additional data about the IPMNs (34). IDUS can display small adenocarcinomas located in the pancreatic ducts. However, the depth that high-frequency US probes can show is lower than shown using EUS. Therefore, the accuracy of the technique for diagnosing and staging adenocarcinomas is lower than that of EUS (34). Complications such as pancreatitis, limited availability, high cost of the procedure, limited data about the safety of the technique, display of a small area in the pancreas, and the need for experience are the limitations of POPS and IDUS (6, 34).

EUS-guided confocal laser endomicroscopy

EUS-guided confocal laser endomicroscopy (EUS-CFL) can allow the in vivo visualization of the mucosal layer of the pancreatic ductal system in real time (8, 35). After the administration of intravenous fluorescent contrast agent, low power laser from miniprobes illuminates the tissue. The fluorophores in the tissue absorb the light and fluorescence. The reflected fluorescence is transferred back to the system through miniprobes (8, 35). The sensitivity and specificity of EUS-CFL to diagnose CPNs are 59% and 100%, for MCN : 80% and 100%, and for SCN : 69% and 100%, respectively (8). Finger-like projections, dark rings, parallel thick bands, and the absence of "superficial vascular network" and "bright, floating particles" are indicative of IPMN ; superficial vascular network, multiple blood vessels, and the lack of finger-like projections are indicative of SCN ; and solitary epithelial bands, large caliber blood vessels, and clusters of bright particles are indicative of MCN (8, 35). EUS-CFL may replace the role of biopsy since it can display the dysplastic changes in tissue structures by demonstrating in vivo goblet cells, mucosal glands, and capillaries (8, 35). However, EUS-CFL has a limited role in the management of CPN because of its limited availability, limited data on the reproducibility and accuracy of the technique, risk of pancreatitis, and sampling errors (8, 35).

Other imaging methods

Endoscopic retrograde cholangiopancreatography (ERCP) can demonstrate the communication of IPMN to pancreatic ducts, dilatation in the main or side branches of pancreatic ducts, and filling defects from solid components or mucus. A bulging and mucus extruding papilla is typical for MD-IPMN, and it can be detected during ERCP (10). However, ERCP has a limited role in the imaging of CPN because it cannot display cyst that has any communication with pancreatic ducts and is an invasive method.

18-fluoro-2-deoxyglucose positron emission tomography/computed tomography (^{18}F-FDG-PET/CT) has been proposed to have a role in CPN management. Minimally invasive disease, tumor extent, local or distant metastasis, and solid components in a CPN can be displayed, but the ability to detect borderline, low-grade and in situ tumors is low. Moreover, the ^{18}F-FDG uptake is affected by the presence of pancreatitis or prior diagnostic interventions (2, 36). Additionally, the utility of ^{18}F-FDG PET/CT is limited because of the high cost and limited availability of the method.

Management of cystic pancreatic neoplasms

Surgery is suggested for the MD-IPMN, mixed IPMN, MCN, SPN, and cystic pancreatic neuroendocrine tumors and for symptomatic SCN with worrisome features (Fig 8) (1-7, 10-14, 37). The Fukuoka Clinical

Guidelines have been established for the management of IPMN and MCN, and resection is recommended for patients with high risk for malignancy (enhancing solid component, MPD size > 10 mm, and obstructive jaundice) without further evaluation (3). EUS with CFA should be performed if CPN has "worrisome features" (cyst size ≥ 3 cm, enhancing thick walls, non-enhanced mural nodules, MPD size of 5-9 mm, an abrupt change in MPD size, additional features of distal pancreatic atrophy and adjacent lymphadenopathy) (3). A summary of the suggestions for the management of CPN is shown in Fig. 8.

Transabdominal US, ERCP, FDG PET/CT, POPS, IDUS, and EUS-CFL have no defined role in the surveillance of CPN. For follow-up imaging, both CT and MRI with MRCP are the preferred methods, but owing to the lack of ionizing radiation and improved demonstration of tiny cysts and the communication to MPD, MRI and EUS are one step ahead (1-3, 6, 10, 37). On follow-up, different approaches are commonly related to the type, size, location, and symptoms and comorbidities of the patient. The follow up for SCN is generally based on the symptoms of the patient and worrisome features (3, 6). In the BD-IPMN with worrisome features, if EUS-guided CFA reveals benign cytology, follow-up CT or MRI with MRCP should be repeated at 6- and 12-months intervals. If there are no worrisome features, annual or biennial follow-up for 4 years is recommended (3, 4). If the BD-IPMN is smaller than 3 cm without worrisome features, follow-up CT or MRI should be repeated after 1 year. If stable, follow-up CT or MRI with MRCP should be biennially performed for 5 years (2, 3, 6, 36). There are discrepancies between the guidelines for follow-up after five years if there were no morphological change. European experts consensus statement recommends CT or MRI for every 6 months because of the increased risk of malignancy related to the age of CPN (4, 6). However, American Gastroenterological Association Institute against surveillance if there is no significant morphologic change (37). If the lesions are not stable (growth > 1 cm per year or worrisome features), EUS should be performed (2, 3, 6, 36). If a mural nodule, MPD involvement, or suspicious cytological findings are present on EUS, then surgery should be considered (3, 6, 37). Contrast-enhanced CT or MRI can improve the detection of worrisome features, but contrast injection can be waived in elderly patients, patients with renal insufficiency, or patients having a CPN with low risk of malignancy (2).

There is no evidence-based data or well-established criteria for the optimal imaging method and time intervals for follow-up imaging after the resection of CPN, and suggestions are generally based on expert opinions (4, 6, 10, 12, 37). If the resected cyst is histopathologically benign or if MCN has no sign of local invasion, surveillance is not recommended (3, 6, 37). In patients with histopathologically proven IPMN, annual follow-up with CT or MRI is suggested for 5 years (3). In patients with confirmed invasive carcinoma, CT or MRI studies should be performed every 3-6 months for 2 years after

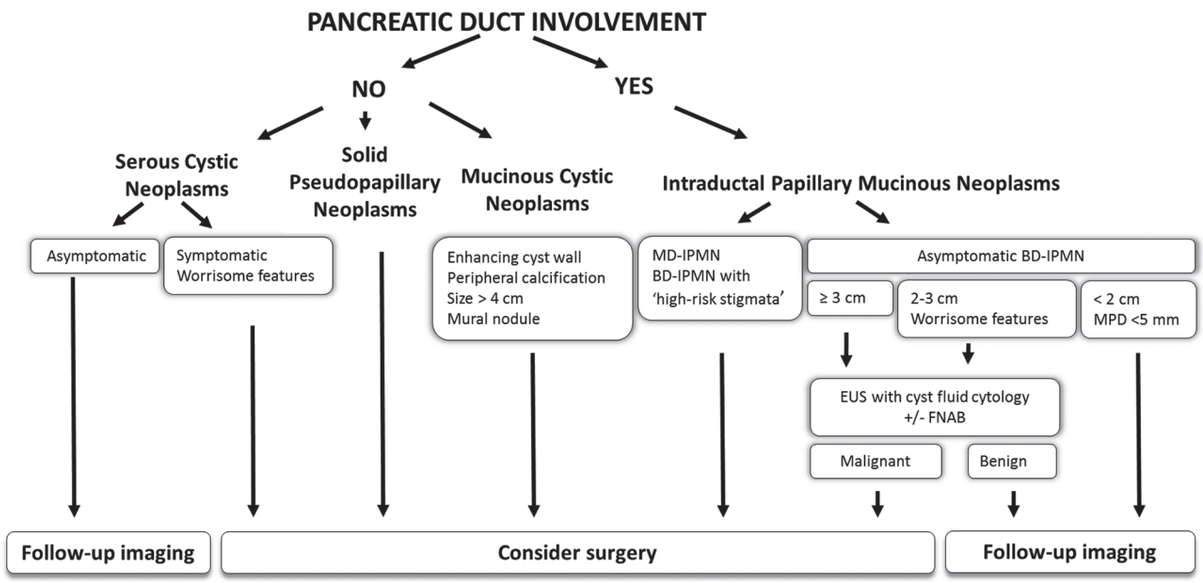

Fig. 8. — A management algorithm for the pancreatic cystic neoplasms.
Note: Data from references 1-7, 10-14, 37.
Symptomatic patient: Having like symptoms like abdominal pain, weight loss, and jaundice
High-risk stigmata: Enhancing solid component in the BD-IPMN, MPD size > 10 mm.
Worrisome features: Cysts ≥ 3 cm, enhancing thick walls, mural nodule or solid component, main pancreatic duct size of 5-9 mm, abrupt change of main pancreatic duct size, common bile duct dilatation, accompanying distal pancreatic atrophy and adjacent lymphadenopathy.
Abbreviations: MD-IPMN; main duct intraductal papillary mucinous neoplasm, BD-IPMN; branch duct intraductal papillary mucinous neoplasm, MPD: main pancreatic duct, EUS; endoscopic ultrasonography, FNAB; fine needle aspiration biopsy.

surgery and annually after 2 years for 5 years (5, 12). A surveillance program is generally not recommended at the end of 5 years after surgery in the absence of recurrent disease.

Conclusion

Cystic pancreatic neoplasms require multidisciplinary management that involves radiologists, gastroenterologists, endoscopists, and surgeons because radiologic and endoscopic imaging methods are essential for differentiating the type, assessing the malignant potential, and for the follow-up of CPN. Therefore, they should use the optimal combination of these imaging methods and be aware of findings that can guide them to devise an appropriate management strategy. CT and MRI with MRCP have a definitive role in both diagnosis and follow-up, but MRI is the preferred imaging surveillance modality over CT. EUS can be used as a problem solver or for guiding CFA in CPN.

References

1. ACAR M., TATLI S. Cystic tumors of the pancreas : a radiological perspective. *Diagn. Interv. Radiol*., 2011, **17** : 143-149.
2. SAHANI D.V., KAMBADAKONE A., MACARI M., TAKAHASHI N., CHARI S., FERNANDEZ-DEL CASTILLO C. Diagnosis and management of cystic pancreatic lesions. *AJR Am. J. Roentgenol*., 2013, **200** : 343-335.
3. TANAKA M., FERNÁNDEZ-DEL CASTILLO C., ADSAY V., CHARI S., FALCONI M., JANG J.Y., *et al*. International Association of Pancreatology. International consensus guidelines 2012 for the management of IPMN and MCN of the pancreas. *Pancreatology*, 2012, **12** : 183–197.
4. SCHEIMAN J.M., HWANG J.H., MOAYYEDI P. American gastroenterological association technical review on the diagnosis and management of asymptomatic neoplastic pancreatic cysts. *Gastroenterology*, 2015, **148** : 824-848.e22.
5. BUSCARINI E., PEZZILLI R., CANNIZZARO R., DE ANGELIS C., GION M., MORANA G., ZAMBONI G., ARCIDIACONO P., BALZANO G., BARRESI L., BASSO D., BOCUS P., CALCULLI L, CAPURSO G., CANZONIERI V., CASADEI R., CRIPPA S., D'ONOFRIO M., FRULLONI L., FUSAROLI P., MANFREDI G., PACCHIONI D., PASQUALI C., ROCCA R., VENTRUCCI M., VENTURINI S., VILLANACCI V., ZERBI A. Italian Association of Hospital Gastroenterologists and Endoscopists ; Italian Association for the Study of the Pancreas et al.Italian consensus guidelines for the diagnostic work-up and follow-up of cystic pancreatic neoplasms. *Dig. Liver Dis*., 2014, **46** : 479-493.
6. DEL CHIARO M., VERBEKE C., SALVIA R., KLÖPPEL G., WERNER J., MCKAY C. *et al*. European experts consensus statement on cystic tumours of the pancreas. *Dig. Liver Dis*., 2013, **45** : 703-711.
7. PALMUCCI S., CAPPELLO G., TROMBATORE C., TILOCCA C., TODARO R., MAURO L.A. *et al*. Cystic pancreatic neoplasms : diagnosis and management emphasizing their imaging features. *Eur. Rev. Med. Pharmacol. Sci*., 2014, **18** : 1259-1268.
8. KRISHNA S.G., LEE J.H. Appraisal of needle-based confocal laser endomicroscopy in the diagnosis of pancreatic cysts. *World J. Gastroenterol*., 2016, **22** : 1701-1710.
9. VALSANGKAR N.P., MORALES-OYARVIDE V., THAYER S.P., FERRONE C.R., WARGO J.A., WARSHAW A.L. *et al*. 851 resected cystic tumors of the pancreas : a 33-year experience at the Massachusetts General Hospital. *Surgery*, 2012, **152** : S4-12.
10. FARRELL J.J., FERNÁNDEZ-DEL CASTILLO C. Pancreatic cystic neoplasms : management and unanswered questions. *Gastroenterology,* 2013, **144** : 1303-1305.
11. JAIS B., REBOURS V., MALLEO G., SALVIA R., FONTANA M., MAGGINO L., *et al*. Serous cystic neoplasm of the pancreas : a multinational study of 2622 patients under the auspices of the International Association of Pancreatology and European Pancreatic Club (European Study Group on Cystic Tumors of the Pancreas). *Gut*, 2016, **65** : 305-312.
12. BUERKE B., DOMAGK D., HEINDEL W., WESSLING J., Diagnostic and radiological management of cystic pancreatic lesions : Important features for radiologists. *Clin. Radiol*., 2012, **67** : 727e737.
13. CRIPPA S., SALVIA R., WARSHAW A.L., DOMÍNGUEZ I., BASSI C., FALCONI M., *et al*. Mucinous cystic neoplasm of the pancreas is not an aggessive entity : lessons from 163 resected patients. *Ann. Surg*., 2008, **247** : 571-579.
14. KETWAROO G.A., MORTELE K.J., SAWHNEY M.S. Pancreatic cystic neoplasms : An update. *Gastroenterol. Clin. North Am*., 2016, **45** : 67-81.
15. OHNO E., ITOH A., KAWASHIMA H., ISHIKAWA T., MATSUBARA H., ITOH Y., *et al*. Malignant transformation of branch duct-type intraductal papillary mucinous neoplasms of the pancreas based on contrast-enhanced endoscopic ultrasonography morphological changes : focus on malignant transformation of intraductal papillary mucinous neoplasm itself. *Pancreas*, 2012 , **41** : 855-862.
16. SALVIA R., FERNÁNDEZ-DEL CASTILLO C., BASSI C., THAYER S.P., FALCONI M., MANTOVANI W., *et al*. Main-duct intraductal papillary mucinous neoplasms of the pancreas : clinical predictors of malignancy and long-term survival following resection. *Ann. Surg*., 2004 , **239** : 678-885 : discussion 685-687.
17. CRIPPA S., FERNÁNDEZ-DEL CASTILLO C., SALVIA R., FINKELSTEIN D., BASSI C., DOMÍNGUEZ I., *et al*. Mucin-producing neoplasms of the pancreas : an analysis of distinguishing clinical and epidemiologic characteristics. *Clin. Gastroenterol. Hepatol*., 2010, **8** : 213–219.
18. KWONG W.T., LAWSON R.D., HUNT G., FEHMI S.M., PROUDFOOT J.A., XU R., *et al*. Rapid growth rates of suspecleuted pancreatic cyst branch duct intraductal papillary mucinous neoplasms predict malignancy. *Dig. Dis. Sci.,* 2015 , **60** : 2800-2806.
19. SUZUKI S., HATORI T., FURUKAWA T., SHIRATORI K., YAMAMOTO M. Clinical and pathological features of solid pseudopapillary neoplasms of the pancreas at a single institution. *Dig. Surg*., 2014 , **31** : 143-150.
20. DEL CHIARO M., SEGERSVÄRD R., POZZI MUCELLI R., RANGELOVA E., KARTALIS N., ANSORGE C., *et al*. Comparison of preoperative conference-based diagnosis with histology of cystic tumors of the pancreas. *Ann. Surg. Oncol*., 2014, **21** : 1539–1544.
21. ZHONG N., ZHANG L., TAKAHASHI N., SHALMIYEV V., CANTO M.I., CLAIN J.E., *et al*. Histologic and imaging features of mural nodules in mucinous pancreatic cysts. *Clin. Gastroenterol. Hepatol*., 2012 , **10** : 192-198.
22. SAHANI D.V., SAINANI N.I., BLAKE M.A., CRIPPA S., MINO-KENUDSON M., DEL-CASTILLO C.F. Prospective evaluation of reader performance on MDCT in characterization of cystic pancreatic lesions and prediction of cyst biologic aggressiveness. *AJR Am. J. Roentgenol*., 2011, **197** : 53-61.
23. IPPOLITO, DALLEGRANZA P., BONAFFINI P.A., TALEI FRANZESI C., LEONE F., SIRONI S. Diagnostic accuracy of 256-detector row computed tomography in detection and characterization of incidental pancreatic cystic lesions. *Gastroenterol. Res. Pract*., 2015, **2015** : 707546.
24. KIM Y.C., CHOI J.Y., CHUNG Y.E., BANG S., KIM M.J., PARK M.S. *et al*. Comparison of MRI and endoscopic ultrasound in the characterization of pancreatic cystic lesions. *AJR Am J Roentgenol*., 2010, **195** : 947-952.
25. O'NEILL E, HAMMOND N, MILLER FH. MR imagings of the pancreas. *Radiol. Clin. North. Am*., 2014, **52** : 757-777.
26. MACARI M., LEE T., KIM S., JACOBS S., MEGIBOW A.J., HAJDU C. *et al*. Is gadolinium necessary for MRI follow-up evaluation of cystic lesions in the pancreas? Preliminary results. *AJR Am. J. Roentgenol*., 2009, **192** : 159-164.
27. DYE C.E., WAXMAN I. Endoscopic ultrasound. *Gastroenterol. Clin. North Am*., 2002, **31** : 863-879.
28. LU X., ZHANG S., MA C., PENG C., LV Y., ZOU X. The diagnostic value of EUS in pancreatic cystic neoplasms compared with CT and MRI. *Endosc. Ultrasound*, 2015, **4** : 324-329.
29. THOSANI N., THOSANI S., QIAO W., FLEMING J.B., BHUTANI M.S., GUHA S. Role of EUS-FNA-based cytology in the diagnosis of mucinous pancreatic cystic lesions : a systematic review and meta-analysis. *Dig. Dis. Sci*., 2010, **55** : 2756-2766.
30. MORALES-OYARVIDE V., YOON W.J., INGKAKUL T., FORCIONE D.G., CASEY B.W., BRUGGE W.R., *et al*. Cystic pancreatic neuroendocrine tumors : the value of cytology in preoperative diagnosis. *Cancer Cytopathol*., 2014, **122** : 435-444.
31. PARK W.G., MASCARENHAS R., PALAEZ-LUNA M., SMYRK T.C., O'KANE D., CLAIN J.E., *et al*. Diagnostic performance of cyst fluid carcinoembryonic antigen and amylase in histologically confirmed pancreatic cysts. *Pancreas*, 2011, **40** : 42-45.
32. VAN DER WAAIJ L.A., VAN DULLEMEN H.M., PORTE R.J. Cyst fluid analysis in the differential diagnosis of pancreatic cystic lesions : a pooled analysis. *Gastrointest Endosc*., 2005 , **62** : 383-389.

33. SCHOEDEL K.E., FINKELSTEIN S.D., OHORI N.P. K-Ras and microsatellite marker analysis of fine-needle aspirates from intraductal papillary mucinous neoplasms of the pancreas. *Diagn. Cytopathol*., 2006, **34** : 605-608.
34. TRINGALI A., LEMMERS A., MEVES V., TERHEGGEN G., POHL J., MANFREDI G., *et al*. Intraductal biliopancreatic imaging : European Society of Gastrointestinal Endoscopy (ESGE) technology review. *Endoscopy*, 2015, **47** : 739-753.
35. NAKAI Y., ISAYAMA H., SHINOURA S., IWASHITA T., SAMARASENA J.B., CHANG K.J., *et al*. Confocal laser endomicroscopy in gastrointestinal and pancreatobiliary diseases. *Dig. Endosc*., 2014, **26** : 86-94.
36. HONG H.S., YUN M., CHO A., CHOI J.Y., KIM M.J., KIM K.W., *et al*. The utility of F-18 FDG PET/CT in the evaluation of pancreatic intraductal papillary mucinous neoplasm. *Clin. Nucl. Med*., 2010, **35** : 776-779.
37. VEGE S.S., ZIRING B., JAIN R., MOAYYEDI P., Clinical Guidelines Committee ; American Gastroenterology Association. American gastroenterological association institute guideline on the diagnosis and management of asymptomatic neoplastic pancreatic cysts. *Gastroenterology,* 2015, **148** : 819-822 ; quize12-3.