From simple to complex cystic pancreatic lesions: imaging aspects

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Learning objectives

• To list, describe and illustrate imaging characteristics of the most common pancreatic cystic masses, using computer tomography (CT) and magnetic resonance imaging (MRI) techniques.
Background

Introduction

Epidemiology

- The increased use of sectional imaging has led to incidental discovery of pancreatic cystic lesions.
- Studies using MRI imaging established an overall prevalence of pancreatic cystic lesions of 15%, in comparison with studies using CT imaging, which report a prevalence of 3%. [1]
- The prevalence of pancreatic cystic lesions varies upon different age groups, between 0.5% and 37%. [1]
- These lesions are often identified incidentally, on imaging performed for other reasons. [2]

Classification (Table 1-3)

- Pancreatic cystic lesions are divided into primary and secondary cystic lesions. [2,3]
- Primary pancreatic cystic lesions include true cysts, pseudocysts, serous cystadenomas, mucinous cystic neoplasms (mucinous cystadenomas, mucinous cystadenocarcinomas), intraductal papillary mucinous neoplasms (Table 1). [2,3]
- Secondary pancreatic cystic lesions are solid neoplasms with cystic degeneration and they include pancreatic adenocarcinoma, cystic islet tumors (insulinoma, glucagonoma, gastrinom), metastasis, cystic teratoma, sarcoma. [2,3]

The most common pancreatic cystic lesions are true cysts, pseudocysts, serous cystadenomas, mucinous cystic neoplasms and Intraductal papillary mucinous neoplasms (IPMN).

Table 1. Classification of pancreatic cystic masses [2,3]

<table>
<thead>
<tr>
<th>Benign</th>
<th>Premalignant</th>
<th>Malignant</th>
</tr>
</thead>
<tbody>
<tr>
<td>True pancreatic cyst</td>
<td>Mucinous cystadenoma</td>
<td>Mucinous cystadenocarcinoma</td>
</tr>
<tr>
<td>Pancreatic pseudocyst</td>
<td>IPMN:</td>
<td>Pancreatic adenocarcinoma</td>
</tr>
<tr>
<td>Serous cystadenoma</td>
<td>Main duct IPMN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Branch duct IPMN</td>
<td></td>
</tr>
</tbody>
</table>
Mixed type IPM

· Solid neoplasms with cystic degeneration

It is important in establishing the approach, this being a significant challenge for the physician.

- Benign lesions can be safely followed-up, while pre-malignant and malignant ones generally impose a surgical approach and close follow-up. [4]
- Pancreatic cystic neoplasms include mucinous cystic neoplasms, intraductal papillary neoplasms, serous cystadenomas and serous pseudopapillary neoplasms. [5]

Recommended CT and MRI technique

CT examination protocol

Regarding CT examination, guidelines suggest a three phase protocol:

# native phase

# two post i.v contrast injection phases (300 or 370 mg I/ml; 100-150 ml - depending on the patient's weight) using a power injector at a rate of 3.5-4 ml/sec; pancreatic phase starts at 40 seconds after the onset of the injection, with cranio-caudal movement (from the diaphragm muscles to the iliac bones); late phase starts at 70 seconds post i.v. contrast with cranio-caudal scan as well.

#after the examination images can be processed, by multiplanar reconstruction (MPR), maximum intensity projection reconstruction (MIP) or volumetric rendering technique (VRT).[6,7]

MRI examination protocol

In case of an MRI examination, performed on 1.5-T MR scanner, it is necessary to use a torso phase array coil (TORSOPA) and administration of i.v. gadolinium contrast agent, Gd-BOPTA (0.1ml/kg corp) using a power injector at a rate of 2.5-3 ml/sec.

The MRI protocol must include:

# breath-hold sequences, axial and coronal T2 fast-spin echo (FSE) with fat saturation, T1 in-phase/out-of-phase, single shot T2 FSE with long time of echo (TE) and short TE, coronal FSE single-shot heavily T2 weighted MR cholangiography with fat saturation (3D-MRCP), with the possibility of mapping the biliary tree and the Wirsung duct.
# three phase 3D-T1-weighted with fat saturation after dynamic i.v Gd-BOPTA injection: arterial phase (after 20-30 sec), portal phase (after 70 sec), equilibrium/late phase (180 seconds post-administration). [6,7]

**Imaging considerations**

# The imaging techniques used for the assessment of pancreatic cystic lesions are CT and MRI (Table 2).

# Their accuracy in establishing the correct diagnosis ranges from 40-60%.

# CT scan requires less scan time and is frequently more accessible, and this is probably why it is more widely used.

# MRI requires longer scan time, but it may be more useful in identifying the communication between the cyst and the pancreatic duct, as well as in differentiating IPMN from other lesions.

# Calcifications can be seen on CT, but septations and cyst contents are better seen on MRI. [2,4]

Table 2. Characteristics of benign pancreatic cystic masses [2,4,5,8-11]

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>CT aspects</th>
<th>MRI aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pancreatic true cysts</td>
<td>lined by epithelium</td>
<td>thin wall, fluid content, usually</td>
</tr>
<tr>
<td></td>
<td>unilocular, well circumscribed, non-enhancing lesions</td>
<td>-T1 hypointense</td>
</tr>
<tr>
<td>Pseudocysts</td>
<td>-fluid collection</td>
<td>-T2 hyperintense (fluid signal)</td>
</tr>
<tr>
<td></td>
<td>has a fibrotic wall</td>
<td>non-enhancing lesion</td>
</tr>
<tr>
<td></td>
<td>-after an episode of pancreatitis</td>
<td>-T1 hypointense center, with a mild early enhancing wall</td>
</tr>
<tr>
<td></td>
<td>-evidence of acute or chronic pancreatitis</td>
<td>-T2 hyperintense layering or dependent debris (highly specific)</td>
</tr>
<tr>
<td></td>
<td>-round/oval pancreatic collection surrounded</td>
<td>(highly specific)</td>
</tr>
</tbody>
</table>
Serous cystadenomas

- 30% of the pancreatic cystic neoplasms,
- female, 70th decade of life
- often localized in the body and tail
- well-defined lobulated contour
- usually < 5 cm in diameter
- cluster of small cysts (honeycomb-like), a few mm up to 2-3 cm
- enhancing central scar +/- associated stellate calcification
- microcystic aspect (the most significant CT feature)
- surface lobulations
- cluster of small cysts
- no visible communication between the cysts and the pancreatic duct
- a well-defined enhancing wall

Mucinous cystic neoplasms

- 10% to 45% of the pancreatic cystic neoplasms
- female, the 5th or 6th decade of life;
- localized: in the pancreatic body or tail;
- mucin producing epithelial lining and ovarian stroma;
- single large cyst with multiple locules round or oval,
- near-water-density
- thick outer wall
- septations
- enhancing intramural nodules +/- amorphous calcifications, solid excrescences
- fluid content: low signal on T1WI, high signal on T2WI; increased signal on T1WI may also be seen
- calcified components are hypointense on T1 and T2

Table 3. Characteristics of premalignant and malignant pancreatic cystic masses [2,4,5,10-13]
- macrocystic spaces with thin septations
- thick wall
- wall may enhance on the delayed phase
- pure cystic components are hypointense on T1, hyperintense on T2

**Mucinous cystadenoma**
- *pre-malignant* lesion
- may progress to *carcinoma in-situ or invasive mucinous cystadenocarcinoma*
- localized in the *body or tail* of the pancreas
- from 6 to 35 cm in size
- *no communication* with the main pancreatic duct, except through fistulae
- hemmoragic, necrotic or mucinous material content

**Mucinous cystadenocarcinoma**
Characteristics that increase the *likelihood for malignancy*:
- intracystic nodules
- irregular wall thickening
- size > 3-4cm

**Intraductal papillary mucinous neoplasm (IPMN)**
- 21% to 33% of pancreatic cystic neoplasms
- incidence: higher in *male, 6th and 7th decades* of life
- frequently localized in the *head of the pancreas*
- classified into *three categories*:
  - main duct IPMN
  - branch duct IPMN
  - mixed type IPMN
- the risk for *malignant transformation is higher in main-duct types* (prevalence of malignancy in resected lesion 57%-92%) than in branch duct IPMN ones (prevalence of malignancy in resected lesions 6%-46%)
- MRI is more accurate than CT in evidentiating ductal communication and in differentiating IPMN from other lesions
Findings and procedure details

- We present a series of cases which illustrate the most specific imaging characteristics of pancreatic cystic masses.
- Pancreatic cysts, pseudocysts, mucinous cystic neoplasms, serous cystadenomas and intraductal papillary mucinous neoplasms (IPMN) were considered.

Techniques

- In order to obtain the best information, we used a three phase CT protocol after contrast iv injection.
- MRI evaluation grouped T2, T1 weighted sequences, MRCP, long and short TE ssFSE acquisition and 3D FSPGR, multiphase acquisition, without and with gadolinium iv injection.

Imaging findings

Pancreatic cysts

*CT aspect: Fig. 1 on page 25*

- unilocular hypointense, well circumscribed
- non-enhanching lesion

![CT images of pancreatic cyst](image)

**Fig. 1:** Pancreatic cyst: Unenhanced CT (a) and CT after CM injection (b,c): small cystic lesion (fluid content with a thin wall in the periphery), located in the body of the pancreas (arrow)

**References:** Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO
MRI aspect: Fig. 2 on page 25

- T1 - hypointense (fluid signal) non-enhancing lesion
- T2 - hyperintense (fluid signal)

Fig. 2: Pancreatic cyst: Axial T2 short TE (a) and coronal T2 long TE (b), 3DT1 FSPGR acquisition without (c) and with Gd injection(d): a hyper-intense (fluid signal) round-oval non-enhancing lesion (arrow), with no visible communication with the Wirsung duct.

References: Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

Pseudocysts

CT aspect: Fig. 3 on page 26

- well-circumscribed
- round or oval peripancreatic fluid collections
- surrounded by a well-defined enhancing wall

**Fig. 3**: Pancreatic pseudocyst: Unenhanced CT (a), and CT after CM injection (b,c): well circumscribed, round-oval pancreatic fluid collection, surrounded by well defined enhancing wall (arrow).

**References**: Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

**MRI aspect**: *Fig. 4 on page 26*

- T1: hypointense center, wall demonstrates mild early enhancement
- T2: hyperintense layering or dependent debris, highly specific
Fig. 4: Pancreatic pseudocyst: Coronal T2 long TE (a), coronal T2 short TE (b), axial 3DT1 FSPGR acquisition without (c) and with Gd injection (d): hyperintense (fluid signal) round lesion with mild enhancing wall in the corporeal region of the pancreas (arrow), with internal layering debris (arrowhead), highly specific.

References: Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

Serous cystadenomas

CT aspect: Fig. 5 on page 27

- multicystic, lobulated pancreatic mass
- enhancing central scar may be present which can show associated stellate calcification
Fig. 5: Serous cystadenoma: Unenhanced CT (a), and CT after CM injection (b,c): well defined lobulated contour lesion in the caudal region of the pancreas (arrow), with small stelate calcifications included (arrowhead).

References: Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

MRI aspect: Fig. 6 on page 27

- a cluster of small cysts within the pancreas
- no visible communication between the cysts and the pancreatic duct
- T1 Wi- low signal
- T2: the central fibrous scar has a low signal while cystic components are in highsignal
- T1+Gd: fibrous septa between them may enhance on delayed contrast enhanced images
**Fig. 6**: Serous cystadenoma: coronal T2 with short TE (a,b), coronal 3DT1 FSPGR acquisition without (c) and with Gd injection (d): cluster of small cysts with central fibrous scar (arrow) in low signal, cystic components appearing in high signal, low T1 signal with thin fibrous septa and central enhancing scar (arrowhead) on the delayed images.

**References**: Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

**Mucinous cystadenoma:**

**CT aspect:**

- round to ovoid, externally smooth, near-water-density cystic lesions
- amorphous calcifications, septations and solid excrescences may be seen

**MRI aspect**: *Fig. 7 on page 28*
- signal characteristics of the cyst can vary depending on content: mucin components are hyperintense on T1; calcified components are hypointense on T1 and T2; pure cystic components are hypointense on T1 and hyperintense on T2

![Image](image-url)  
**Fig. 7**: Mucinous cystadenoma: axial 3D T1 FSPGR acquisition, without (a) and with gadolinium (b), thin slice 3D MRCP (c): hyperintense T1, non-enhancing cephalic pancreatic mass (arrow); normal aspect of the choledoc and the pancreatic duct.  
**References**: Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

**Cystadenocarcinoma**

*CT aspect: Fig. 8 on page 29*

- round to ovoid, externally smooth, near-water-density cystic lesions
- amorphous calcifications, septations and solid excrescences may be seen
- cystadenocarcinomas do not have central scars
Fig. 8: Cystadenocarcinoma: Unenhanced CT (a), and CT after CM injection (b,c): large cyst with thick outer wall (arrow), thin septations and enhancing intramural nodules (arrowhead).

References: Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

MRI aspect:

- unilocular, or mildly septated lesion
- wall of cyst and septa typically thick and enhancing on delayed contrast enhanced MRI
- signal characteristics of the lesion can vary depending on content
- calcified components are hypointense on T1 and T2
- mucin components can be high signal on T1

However, in these cases histopathological findings are essential for the final diagnosis.

Fig. 9 on page 29
**Fig. 9**: Cystadenocarcinoma: Ob. x200, H&E: small irregular glands and single cells with high-grade nuclear dysplasia invading the stroma and eliciting a desmoplastic stromal response, proliferating fibroblast surrounding infiltrating malignant epithelium

*References*: Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

**IPMN**

*CT aspect: Fig. 10 on page 30*

- well localised cystic lesion
- no calcifications
- communication with the duct system should be evidentiated

**Fig. 10**: IPMN: Unenhanced CT (a), and CT after CM injection (b,c): hypodense nonenhancing lesion in the uncinate process of the pancreas (arrow).

**References**: Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

# main duct IPMN (dilatation of main duct >5 mm)

- proximal localization - the distal pancreatic duct may be dilated without direct involvement
- enhancing nodules after i.v. contrast injection - suggest malignancy

# branch duct IPMN

- cystic mass appearance
- "bunch of grapes" aspect
- in order to establish the diagnosis, the communication with a pancreatic duct must be evidentiated

**MRI aspect: Fig. 11 on page 31**

- appearance similar to CT
- mural nodules are hypointense to surrounding fluid/ mucin, contrast-enhancing
- T2 images demonstrate the multicystic lesion with the connection to the pancreatic duct or a branch-duct
- MRCP can diagnose both main-duct and branch-duct IPMN
Fig. 11: Branch duct IPMN: coronal T2 weighted MRI sequences with short TE (a) and long TE (b), thin slice 3D MRCP (c), axial T2 with fat saturation (d): small multicystic lesion (arrow) in connection with a small pancreatic duct (arrowhead).

**References:** Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

In case of main duct IPMN or branch duct IPMN, correlation between imaging findings and histopathological findings, is the only method of clear diagnosis. Fig. 12 on page 31
**Fig. 12**: IPMN: ob. x200, H&E: neoplastic proliferation of mucinous epithelium, cystically dilated ducts which contain mucin-producing cells.

**References**: Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

**Differential diagnosis**

· Pancreatic abscess; **Fig. 13** on page 32
**Fig. 13:** Pancreatic abscess: Unenhanced CT (a), and CT after CM injection (b,c): well circumscribed oval pancreatic collection, with enhancing wall (arrow) and heterogeneous content (gas bubbles included) (arrowhead).

**References:** Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

· Pancreatic arterialized pseudocyst; **Fig. 14** on page 32

![UNCT](image1.png) ![APP](image2.png)

**Fig. 14:** Arterialized pancreatic pseudocyst: Unenhanced CT (a), and CT after CM injection (b), coronal arterial phase MIP (c): pancreatic pseudocyst with hyperintense content (arrow), pseudoaneurysm from the inferior pancreatic-duodenal artery (arrowhead) with extravasation of contrast material into the pseudocyst.

**References:** Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

· Chronic pancreatitis; **Fig. 15** on page 33
**Fig. 15:** Chronic pancreatitis: Axial T2 sequences with short TE (a) and long TE (b), thin slice MRCP mapping (c), 3DT1 FSPGR acquisition with Gd injection (d): multiple cystic lesions (arrow) in connection with the dilated main pancreatic duct (arrowhead).

**References:** Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

- Cystic/ necrotized pancreatic adenocarcinoma; **Fig. 16** on page 34
Fig. 16: Necrotized pancreatic adenocarcinoma: Unenhanced CT (a), and CT after CM injection (b,c): Hypoattenuating, hypoenhancing mass involving the tail of the pancreas (arrow) with central small areas of necrosis.

References: Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

- Neuroendocrine tumors/ Gastrointestinal stromal tumor. Fig. 17 on page 34

Fig. 17: Cystic GIST: axial T2 with fat saturation (a), coronal T2 with long TE (b), 3DT1 FSPGR acquisition without (c) and with Gd injection (d): paraduodenal-prepancreatic heterogeneous enhancing mass (arrow) with hyperintense (fluid) component (arrowhead)

References: Fundeni Clinic Institute, Fundeni Clinic Institute - Bucharest/RO

Structured results
Regardless of the method used, an accurate description of the lesion should include:

# Detailed description of the pancreatic cystic lesion

- localization
- number
- dimension
- shape
- contour/ outline
- structure (density/ signal)-delineation between serous and mucinous tumors
- iodinated/ gadolinum contrast enhancement
- signs of malignant degeneration

# Other primary or secondary changes to the pancreatic parenchyma

# Changes of the Wirsung duct, intrahepatic or extrahepatic biliary ducts, duodenum

# Relation to the adjacent vessels and others anatomical structures

# Lymphadenopathies, metastasis
**Fig. 1:** Pancreatic cyst: Unenhanced CT (a) and CT after CM injection (b,c): small cystic lesion (fluid content with a thin wall in the periphery), located in the body of the pancreas (arrow)

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**Fig. 3:** Pancreatic pseudocyst: Unenhanced CT (a), and CT after CM injection (b,c): well circumscribed, round-oval pancreatic fluid collection, surrounded by well defined enhancing wall (arrow).

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![Fig. 4](image1)

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![Fig. 5](image2)
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Conclusion

• Pancreatic cystic masses are often diagnosed incidentally on a cross sectional scan.
• The first imaging study that identifies pancreatic cystic lesions is the ultrasonography, followed by CT and MRI.
• Even though imaging studies can accurately describe the pancreatic cystic masses, differential diagnosis of benign, premalignant and malignant masses is difficult.
• Although CT is the most used imaging method in pancreatic cystic lesions diagnosis, MRI is the best noninvasive imaging tool of pancreatic cystic lesions evaluation adding specific findings and details.
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References


