Evidence based imaging of the pancreas

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Non-invasive imaging tests available for the diagnosis of pancreatic disease

1. Ultrasound
   - Transabdominal
     - Color Doppler US, Power Doppler US, CE-US
   - Endoscopic ultrasound
     - Conventional EUS, Color Doppler EUS, CE-EUS, Intraductal US, EUS-guided fine needle aspiration (FNAC)

2. Computed tomography
   - MSCT
   - PET-CT

3. Magnetic Resonance Imaging
   - Ultrafast breath-hold dynamic contrast-enhanced imaging
   - High field strength magnet systems (3T)
Learning objectives

• 1. Current status of basic imaging techniques
  - Application
  - Value

• 2. How to determine a logical approach
  - Imaging strategies
    • pancreatic inflammatory disease
    • pancreatic malignancy
Acute pancreatitis
Question 1

• Is US a useful diagnostic imaging technique to confirm the clinical suspicion of acute pancreatitis?
Transabdominal ultrasound (US)

• Can identify:
  - Pancreatic enlargement
  - Reduction in parenchymal reflectivity
  - Fluid accumulation
Severe pancreatitis
Transabdominal ultrasound (US)

A. Limited in the initial phase
   - less successful
     • in early diagnosis/staging
   - effective
     • in diagnosing gallbladder stones and biliary obstruction $\rightarrow$ ERCP
     • in extremely ill patients too unstable to undergo CT

B. Valuable in the follow-up
   - pseudocysts
   - vascular complications

Endoscopic ultrasound (EUS)

• Pro:
  - More sensitive than transabdominal US in the identification of cholelithiasis
  - Can distinguish mild from severe pancreatitis

• Contra:
  - Little information regarding the viability of pancreatic tissue

Hayakawa et al. JOP (2000) 1: 46-48
Question 2:

• What is the imaging technique of choice for the diagnosis and staging of acute pancreatitis?
Computer tomography (CT)

• **Modality of choice**
  - accuracy, reproducibility, availability

• **Imaging features:**
  - pancreatic swelling, stranding
  - acute fluid collections
  - pancreatic necrosis

Severe pancreatitis
### The Balthazar classification and CT severity index

<table>
<thead>
<tr>
<th>Prognostic indicators</th>
<th>Characteristics</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>pancreatic inflammation</strong></td>
<td>normal pancreas</td>
<td>0/A</td>
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<tr>
<td></td>
<td>focal or diffuse enlargement of the pancreas</td>
<td>1/B</td>
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<tr>
<td></td>
<td>intrinsic pancreatic abnormalities with inflammatory changes in peripancreatic fat</td>
<td>2/C</td>
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<tr>
<td></td>
<td>single, ill-defined fluid collection or phlegmon</td>
<td>3/D</td>
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<tr>
<td></td>
<td>two or more poorly defined collections or presence of gas in or adjacent to the pancreas</td>
<td>4/E</td>
</tr>
<tr>
<td><strong>pancreatic necrosis</strong></td>
<td>no necrosis</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>30 % or less</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>30 %- 50 %</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>greater than 50 %</td>
<td>6</td>
</tr>
</tbody>
</table>
The Balthazar classification and CT severity index

CT: complications

- Pseudocyst
  - Collection of pancreatic juice enclosed by a wall of granulation tissue

- Infected necrosis
  - Infection of a focal or diffuse area of nonviable pancreatic parenchyma

- Pancreatic abscess
  - Circumscribed collection of pus containing little or no necrosis

*vanSonnenberg et al. Radiology (1989) 170: 757-761*
Pancreatic abscess
Role of interventional radiology in the management of acute pancreatitis
CT: complications

- Vascular complications
Question 3:

• At what timepoint is CT best performed?
Recommendations for the use of CT

- CT should be guided by the natural history of the disease
- Should be timed to yield maximum diagnostic information, which will alter clinical management

Recommendations for the use of CT

1. When the clinical diagnosis is in doubt.
2. Patients with hyperamylasemia and severe clinical pancreatitis, abnormal distension, tenderness, high fever >102° and leukocytosis should have a CT on admission.
3. Patients with a Ranson score >3 or APACHE score of >8 should have immediate CT.
4. Patients who do not improve clinically within 72 hours of initial conservative medical therapy should have a CT scan.
5. Patients who demonstrate improvement during initial medical therapy but then manifest acute change in clinical status with fever, pain, inability to tolerate oral intake, hypotension or falling hematocrit should have immediate CT.

Balthazar et al. Radiology (1994);193:297-306
Question 4:

• Is MRI - MRCP useful in patients with acute pancreatitis?
Magnetic resonance imaging (MRI)

• Imaging features
  - pancreatic edema (low T1 / high T2)
  - acute fluid collections (T2 WI)
  - hemorrhage (T1 high)
  - pancreatic necrosis
Role of MRI

- Limited BUT superior to CT
  - for detection of mild acute pancreatitis
  - for staging
    - in the depiction of necrosis
    - drainability of the collections
  - for choledocholithiasis MRCP

- Replace CT in patients with renal failure

Kalra et al. JCAT (2002) 26:661-675
Acute pancreatitis: imaging strategies

(E)US in the early management
- to select those who would benefit from endoscopic stone extraction and drainage

\[\downarrow\]

CT in severe pancreatitis
- to detect complications

(MRI)?
- patients with severe pancreatitis are generally too ill to cooperate for an MRI examination
Chronic pancreatitis
Question 1:

• Is US a useful diagnostic imaging technique to confirm the clinical suspicion of chronic pancreatitis?
Transabdominal US

Features
- Calcifications
- Parenchymal atrophy
- Pancreatic duct dilatation
Transabdominal US

- Accurate for the diagnosis of:
  - advanced/complicated pancreatitis

- Rather limited:
  - For the diagnosis of early chronic pancreatitis
  - For differentiating adenocarcinoma from chronic pancreatitis

Endoscopic US

• High sensitivity in diagnosing CP
  - ALSO of early chronic pancreatitis *

• Problem solving
  - For differentiating adenocarc × chron pancreatitis
  • EUS + FNAC

Question 2:

• What is the most appropriate imaging technique for the identification of the site and the topography of pancreatic stones?
Computed Tomography (CT)

- Superior for detecting calcifications
- **ONLY** in advanced stages
  - Insensitive in the diagnosis of early CP

CT features

- Features
  - calcifications
  - duct dilation
  - parenchymal atrophy
  - intra- and peripancreatic pseudocysts
  - tapering of common bile duct
  - enhancement (heterogeneous)
CT: complicated chronic pancreatitis

- inflammatory masses, pseudocysts, calculi in the pancreatic duct or pseudo-aneurysms
Endoscopic US

- EUS is comparable to CT
  - in depicting site and topography of pancreatic stones
  - also very small stones (< 3mm)

Question 3:

• What is the imaging technique of choice to diagnose early chronic pancreatitis?
MRI after secretin stimulation

- enhance the diagnosis of early chronic pancreatitis in the absence of marked ductal alteration

MRI

- Imaging features
  - T1: decreased signal intensity
  - T2: variable (may be normal)
  - enhancement (less and delayed)
  - MRCP: extent of morphologic ductal changes classifies severity of disease
  - calcifications
MRI

• MRI is less sensitive than CT
  – for detection of calcifications *

• MRI is more sensitive than CT
  – for parenchymal changes **
    • abnormal low signal intensity on fat-suppressed T1-weighted sequence
  – for glandular enhancement **
    • decreased enhancement on the immediate and delayed postgadolinium images

Endoscopic US

• Has recently shown its ability to diagnose early chronic pancreatitis by assessing morphological and structural changes of the pancreatic parenchyma

• Risk of overdiagnosis?

Question 4:

- What is the imaging technique of choice to identify pancreatic malignancy in patients with chronic pancreatitis?
Mass lesion in chronic pancreatic: benign or malignant?

“Duct penetrating sign”
Mass lesion in chronic pancreatic: benign or malignant?

Negative duct-penetrating sign "corona sign"
The duct penetrating sign on MRCP images was more helpful to distinguish inflammatory mass from pancreatic adenocarcinoma than were the enhancement patterns on CT or MR images.

Endoscopic US

• Used as problem solving
  • Indeterminate mass on CT and MRI
  • EUS-guided FNAB can increase the diagnostic accuracy.

Chronic pancreatitis: imaging strategies

• US as initial step for screening

• CT/EUS more accurate
  - for the detection of calcifications
  - in the diagnosis of complications
  - in the differential diagnosis of focal pancreatitis and pancreatic cancer
Chronic pancreatitis: imaging strategies

- MRI + MRCP: best modality
  - EARLY detection of chronic pancreatitis
    - prior to the development of calcifications
  - PROBLEM SOLVING
    - atypical presentation of CP
    - differentiation CP from neoplasms
  - FOLLOW-UP of parenchymal and duct abnormalities associated with CP
Pancreatic tumors
Key issues

• Early diagnosis of cancer

• Differentiation between cancer and inflammation

• Correct staging
  - appropriate management options
    • Identification of patients who would profit from radical surgery and of those who would not
  - ultimate prognosis of the disease
Question 1:

- Is US a useful diagnostic imaging technique to confirm the clinical suspicion of a pancreatic tumor?
Transabdominal US

• Features
  - Echo-poor/heterogeneous mass
  - Duct dilatation
  - Atrophy
  - Abnormal contour
Transabdominal US

- Primary screening method

- Detection of pancreatic carcinoma
  - Sensitivity: 44-95%
    - 80 - 95% (head)
    - < 50 % for lesions < 1 cm

BUT,... sensitivity of US depends on:

- Size and location of the tumor
  - small tumors
  - tumors in the body and tail
- Patient-dependent factors
  - Overlying bowel gas
  - Obesity
- Operator’s degree of training
- Technical quality of US equipment
Transabdominal US

- Less frequently employed for staging
- US is inferior to CT staging
Endoscopic US: complementary to CT and MRI

• Important imaging modality
  - in assessing small pancreatic tumors (< 2 cm), undetectable by CT or MRI
  - in the management of cystic lesions

Limitations of EUS

- Need for patient sedation
- Operator dependency
- Inability to examine the entire liver
- To detect peritoneal metastases
Question 2:

• What is the imaging technique of choice for the diagnosis and staging of suspected pancreatic cancer?
Helical CT: primary imaging modality

• Detection
  - Overall accuracy of CT: 80% to 97%
    • Sensitivity lower for small tumors

• Staging
  - PPV unresectability
    Conv 88-100%  Helical 92-100%
  - PPV resectability
    Conv 45-72%  Helical 76-90%

Legmann et al. AJR (1998) 170:1315-1322
Kalra et al. JCAT (2002) 26: 661-675
Ductal adenocarcinoma: CT findings

• Primary tumor
  - focal mass (95%)
    • low density area (75%)
  - ill-defined borders

• Secondary findings
  - duct dilation
    • pancreatic duct (50%)
    • CBD (40%)
  - atrophy of the tail (20%)
  - dilated collateral veins (12%)
  - duodenal invasion
Staging: tumor is resectable or not?

- Need to access
  - Vascular involvement
    - Tumor contact > 1/2 circumference
    - Dilated peripancreatic veins
    - Focal decrease in vessel calibre
  - Local invasion into retroperitoneal structures
  - Metastases to liver, peritoneum, lymph nodes
Staging: tumor is resectable or not?

- Need to access
  - Vascular involvement
    - Tumor contact > $\frac{1}{2}$ circumference of vessel
    - Dilated peripancreatic veins
    - Focal decrease in vessel calibre
  - Local invasion into retroperitoneal structures
  - Metastases to liver, peritoneum, lymph nodes
CT-limitations in the staging of pancreatic carcinoma

- Poor sensitivity for detecting small metastatic peritoneal implants

- **Multi-slice CT**
  - earlier detection of enlarged lymph nodes
  - BUT does not allow differentiation between benign and malignant causes
PET- CT: “add-on” procedure?

• Additional staging information
  - detection of unsuspected metastases

• Helps in the evaluation of
  - masses with equivocal CT and MRI diagnosis
  - locoregional recurrence

• Documentation of tumor cell vitality
  - susceptibility to adjuvant treatment
Question 3:

- Is MRI with MRCP useful in patients with suspected pancreatic cancer?
MRI

- Diagnosis of tumor
  - Sensitivity: 95% (42/44)

- Cancer non-resectability
  - PPV: 90%
  - NPV: 83%

MRI superior to CT

- For detection of
  - small pancreatic lesions
  - small liver metastasis
Malignant cystic neuroendocrine tumor with small liver metastasis
MRI is superior to CT: in the differential diagnosis of cystic neoplasms
IPMN
Malignant IPMN
Limitations of MRI

- Availability
- Detection of
  - small peripancreatic lymph nodes
  - peritoneal implants
Pancreatic tumors: imaging strategies

• Detection
  - US (large/head)
  - CT → EUS, MRI: smaller/cystic pancreatic tumors

• Staging
  - CT and MRI
  - (EUS)
CONCLUSION

• Single “correct” approach does not exist

• Imaging tests have a much higher PPV than NPV

• All of the available diagnostic methods have their strengths and weakness

• Ultimate chosen strategy depends on local expertise and availability of equipment
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