Quantitative Imaging of Pancreas

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Quantitative Imaging of Pancreas

- Secretin MRCP
- DWI and DCE
- Elastography
- T1 Mapping
Secretin

- 27-amino acid polypeptide hormone secreted by duodenal mucosa in response to luminal acid
- numerous physiological effects
  - stimulates pancreatic secretion of bicarbonate-rich fluid
  - transiently increases tone of sphincter of Oddi
- visualization of pancreatic ductal anatomy substantially improves
  - allows detailed evaluation of pancreatic duct
  - gives qualitative indication of exocrine function of pancreas
- safe; very low incidence of serious side effects
Dynamic secretin study. MRCP done at 0, 3, 7, and 10 min after IV secretin. Pancreatic duct (arrowheads) is most visible at 7 minutes when maximum response to IV secretin occurs. Note progressive filling of duodenum with high signal fluid (arrows). The exocrine response to secretin can be semi-quantitatively determined by duodenal high signal.
Pancreatic Ductal Abnormalities and Normal Variants

- Inflammatory
  - acute pancreatitis with disconnected duct
  - acute pancreatitis with pseudocyst
  - recurrent acute pancreatitis
  - chronic pancreatitis
- Congenital
  - pancreas divisum
- Sphincter of Oddi dysfunction
- Neoplastic
  - IPMN
  - serous cystadenoma (SCA)
  - mucinous cystic neoplasm (MCN)
- Post-Whipple changes
Acute Pancreatitis with Pseudocyst

- Pseudocyst is an inflammatory fluid collection usually occurring as a consequence of pancreatitis.
- Complications include perforation, abscess formation, compression and hemorrhage.
- Uncomplicated pseudocysts usually bright on T2W images, may have mixed signal characteristics depending on fluid content (blood products, necrotic debris).

![Image Description]
Pancreatic ductal disruption

Pre-secretin image (above) shows apparent discontinuity in pancreatic duct (white arrowhead). Adjacent fluid collection appears bright (black arrowhead). S-MRCP at 7 min (right) shows main pancreatic duct is stenosed (white arrowhead) and not disconnected. Fluid collection adjacent to pancreatic neck (black arrowhead) appears brighter than on pre-secretin suggesting ongoing leak. Note ascites (arrow).
Pancreatic ductal disconnection

(Above) 3D PACE image shows abrupt disconnection of the pancreatic duct (arrow). There is a complex large fluid collection. (Top right) Axial HASTE image confirms duct is disconnected and empties into the fluid collection. (Right) Large fluid collection adjacent to the pancreas obscures the pancreatic duct on MIP MRCP images.
Chronic Pancreatitis - Mild

- MR image obtained 5 minutes after secretin injection
- normal main pancreatic duct
- dilatation of several side branches
- findings are consistent with mild chronic pancreatitis
Chronic Pancreatitis - Severe

- Poor exocrine response to secretin (lack of high signal intensity in duodenum)
- S-MRCP and axial HASTE images demonstrate irregular dilatation of the main pancreatic duct including sidebranches.
- There are low-signal intensity filling defects representing ductal calculi (arrow)
Congenital – Pancreas Divisum

A) Normal
B) Accessory duct is not patent at the minor papilla
C) Incomplete pancreas divisum
D) Variant of pancreas divisum
E) Typical pancreas divisum
F) Reversed pancreas divisum
Complete Pancreas Divisum

- Secretin enhanced MRCP image shows main pancreatic duct (open arrow) drainage through the minor papilla.
- The ventral duct (solid arrow) of the pancreas drainage is through the major papilla together with the common bile duct.
Incomplete Pancreas Divisum

- Secretin enhanced MRCP image shows continuity of main duct (curved white arrow) with the dorsal duct (black arrowhead)
- also demonstrated is continuity of ventral duct (black arrow) with the distal common bile duct (straight white arrow)
- Filamentous connection (white arrowhead) between the ventral and dorsal duct systems indicates incomplete division
The pancreatic duct course varies greatly but is most commonly a descending course (50% of cases).

Other courses include sigmoid, vertical, and loop configurations.

MRCP image showing the loop configuration (arrow).
Santorinocele

- Post-secretin MRCP image shows increased signal intensity in duodenum from exocrine response to secretin
- There is fusiform enlargement (santorinocele) of the terminal dorsal duct is well-demonstrated
Wirsungocele

- Secretin enhanced MRCP image shows fusiform enlargement (wirsungocele) at the terminal duct of Wirsung
Sphinctor of Oddi Dysfunction (SOD)

- The diagnosis is based on a high index of clinical suspicion in patients with persistent or recurrent biliary pain after cholecystectomy.

- Difficult to diagnose:
  - Gold standard defined by sphincter of Oddi manometry showing a basal sphincter pressure >40 mm Hg.
  - Biliary and/or pancreatic sphincterotomy helps symptoms but 15-20% post-ERCP pancreatitis.
SOD

- SOD may be due to benign histological fibrosis of sphincter or, more commonly, functional stenosis
- Sphincter of Oddi manometry is most commonly abnormal in Type I. Many studies show Type II and III have similar frequency of SOD and it is > 50%

<table>
<thead>
<tr>
<th>Milwaukee classification of SOD</th>
<th>Biliary type pain</th>
<th>Abnormal LFT</th>
<th>Bile (pancreatic) duct dilation</th>
<th>Delayed drainage</th>
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<tbody>
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<td>Type I</td>
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<tr>
<td>Type II</td>
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<tr>
<td>Type III</td>
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*In type II any one of the three criteria must be present

*Abnormal LFT*: Transaminase level of > 1.5 x normal during 2+ acute episodes

*Duct dilation*: CBD > 12 mm or PD > 6 mm in head or > 5 mm in body

*Delayed drainage*: Biliary drainage of > 45 min or pancreatic drainage of > 9 min
Potential uses of S-MRCP in SOD

• SOD is a popular discussion topic
• May account for a substantial proportion of intermittent abdominal pain, esp. after cholecystectomy.
• S-MRCP may allow evaluation of
  ▪ Quantitative rate of pancreatic drainage and changes in duct caliber
  ▪ Opening of biliary sphincter in a 15-minute period
  ▪ Shape of the PD and CBD at the sphincter
58-year-old with intermittent unexplained abdominal pain. There is moderate distention (7-10 mm) of main pancreatic duct (arrowheads) at 7 min which persist at 15 min. In normal patients, the PD dilation is usually up to 6 mm and returns to normal by 10 min post-secretin. There is also hardly any pancreatic exocrine juice in the duodenum (dashed arrow) at 7 min with delayed drainage of juice at 15 min. The maximal exocrine output seen at 15 min. The CBD is also dilated at 7 min (black arrow). The increased ductal caliber and delayed drainage suggests SOD, that was subsequently proven on ERCP manometry (pancreatic basal sphincter pressure of 110 mmHg and biliary basal sphincter pressure of 94 mmHg).
Main duct caliber (mm) in pancreatic head in 24 patients with normal sphincter pressures and 20 patients with pancreatic SOD without chronic pancreatitis. Note rapid increase in PD in SOD patients. The caliber does not normalize at 10 min.

Mean area signal intensity of fluid in duodenum. The measurements, taken at 4, 7 and 10 min after secretin, are normalized with 1 being the measurement on pre-secretin image. Note the slow drainage of fluid into duodenum in patients with SOD, even though the 10 min “volume” is not different between the two groups.
Assessing Exocrine Function

• There are no good noninvasive tests for measuring exocrine pancreatic function
• Semiquantitative or quantitative measurements have been used following S-MRCP
• Functional measurements may be superior to assessment of ductal abnormalities in categorizing chronic pancreatitis
Semi-quantitative assessment of exocrine function

**Grade 0**: Virtually no output in response to secretin. It is important to ensure that the secretin injection did not extravasate. This grade of function suggests very poor pancreatic reserve.

**Grade 1**: Maximal fluid output only fills duodenal bulb (D1). The pancreatic duct shows stricture consistent with severe chronic pancreatitis.

**Grade 2**: Maximal fluid output only fills D1 and D2 only. The ductal anatomy appears remarkably normal.

**Grade 3**: Normal exocrine output filling the entire duodenum.
DWI

- DWI forms part of the state-of-the-art pancreatic MR protocols
- Easy to perform and no need for contrast
- Net motion of water molecules is directly related to motion of water in intra, extra cellular space and intravascular space.
- The image contrast on DWI relies on intrinsic differences in water diffusion between tissues.
Elastography

- US and MR elastography
- Evaluate tissue stiffness
- Stiffness of tissues are different
- Pathological changes results in changes in stiffness of tissues
- Stiffness may change in chronic pancreatitis
- USE and MRE of pancreas is challenging due to retroperitoneal location and small size.
T1 Mapping Techniques

Look- locker

- MOLLI
- DFA GRE
- SR
T1 Mapping

- T1 mapping has been used in cardiac imaging
- Pulse sequences and post-processing available from all vendors
- Pre- and post-contrast evaluation allows estimation of the extracellular volume fraction (ECV)
- Abdominal applications emerging.
T1 Mapping of chronic pancreatitis

T1 relaxation time threshold value of 900 msec was 80 percent sensitive for mild chronic pancreatitis.