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IN THE EXPERT'S FOCUS

Features of Chronic Pancreatitis and Associated Masses: A Focus on Endosonography ☆

Bronte A. Holt, Shyam Varadarajulu*

Center for Interventional Endoscopy, Florida Hospital, 601 East Rollins Street, Orlando, FL 32803, USA

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Abstract
EUS is highly accurate in the diagnosis of chronic pancreatitis. Pancreatic calcifications or five or more endosonographic criteria are consistent with chronic pancreatitis. Less than three criteria essentially rules out chronic pancreatitis. Three or four criteria are the best overall cutoffs. The number of criteria is used to estimate the *likelihood* of pancreatitis (i.e. low/medium/high), and is not recommended to stage the *severity* (i.e. mild/moderate/severe) of disease. Obtaining histology by FNA is not recommended in all patients with chronic pancreatitis changes. EUS is useful in distinguishing inflammatory from malignant masses in the pancreas. FNA is often not required as the EUS appearance of inflammatory changes alone or bulkiness without any perceptible mass has good negative predictive value. In indeterminate masses, FNA for cytology is recommended. Follow-up imaging after one to two months can be performed to catch the rare EUS false-negatives, and confirm resolution or stability of inflammatory masses.

Video related to this article

Video related to this article can be found online at http://dx.doi.org/10.1016/j.vjgien.2014.07.001.

1. Background

- EUS is highly accurate in diagnosing chronic pancreatitis
- There are nine standard diagnostic criteria:
  - Four parenchymal criteria: hyperechoic foci, hyperechoic strands, hypoechoic lobules, and cysts
  - Five ductal criteria: dilatation, dilated side branches, main duct irregularity, hyperechoic duct margins, and stones

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*Corresponding author. Tel.: +1 407 303 2570; fax: +1 407 303 2585.
E-mail addresses: bronteholt@gmail.com (B.A. Holt), svaradarajulu@yahoo.com (S. Varadarajulu).

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Calcifications or ductal stones are very specific for chronic pancreatitis, and is considered diagnostic for
- chronic pancreatitis.
- Pancreatic calcifications, or five or more endosonographic criteria is consistent with chronic pancreatitis. Less than three criteria essentially rules out chronic pancreatitis. Three or four criteria are the best overall cutoffs.
- The EUS features of a normal pancreas will be demonstrated, followed by the features of chronic pancreatitis.

2. Materials

- Linear and Radial Echoendoscope (UCT180; Olympus America, Center Valley, PA).

3. Endoscopic procedure

- Upper gastrointestinal tract EUS performed with examination of the pancreas, as previously described [1].

4. Tips and tricks

- The whole pancreas must be examined when chronic pancreatitis is suspected. This is to exclude conditions that can mimic chronic pancreatitis, such as main duct intraductal papillary mucinous neoplasms, identify potential causes and complications of chronic pancreatitis (such as cancer, pseudocysts, main duct stones) and identify potential interventions (e.g. distal pancreatectomy for severe chronic pancreatitis sparing the head of pancreas).
- The examination can be performed with either a linear and radial scope.
- Each feature of chronic pancreatitis, apart from calcifications, can be seen in the normal pancreas. The diagnostic probability of chronic pancreatitis increases with each additional feature, with three to four criteria being the best overall cutoffs for disease.
- A high index of suspicion is required for pancreatic cancer, however distinguishing a neoplastic from inflammatory mass can be challenging. Fine needle aspiration should be performed of any concerning lesion, ideally with inroom cytology to confirm diagnostic sufficiency of aspirated tissue.

5. Discussion

5.1. Normal pancreas

The normal pancreas appears as a homogeneous structure with a single anechoic smooth duct running within. The body and tail have a fine diffusely speckled ("salt and pepper") pattern. A small amount of fine diffuse heterogeneity is normal, as can small echogenic foci or short echogenic strands when a high degree of magnification is used. The gland contour is generally smooth but some margin lobularity can occur. The dorsal pancreas is generally more echogenic than the embryological ventral pancreas (the ventral anlage). The transition zone between the darker ventral anlage (head) to the brighter dorsal pancreas (uncinate, body/tail) is seen in approximately 50% of cases on EUS. The pancreatic head is generally more heterogeneous than the body and tail. The duct wall is barely perceptible, with similar echotexture to surrounding pancreatic tissue. Small side-branches can be seen in the normal pancreas, and should only be considered abnormal when larger than 1 mm. The course of the main pancreatic duct can be mildly tortuous, but beading with alternating duct size is abnormal. The duct normally tapers from the head to the tail, with 3 mm, 2 mm, and 1 mm being average duct sizes in the head, body and tail, respectively. In patients over 60 years old, an additional 1 mm for the main duct in each section is generally allowed due to expected gland atrophy.

5.2. Features of chronic pancreatitis

EUS uses parenchymal and ductal criteria to make a diagnosis of chronic pancreatitis. There are 9 accepted criteria, including four parenchymal (hyperechoic foci, hyperechoic strands, hypoechoic lobules, and cysts) and five ductal features (dilatation, dilated side branches, main duct irregularity, hyperechoic duct margins, and stones) (Table 1). Calcifications or ductal stones are very specific for chronic pancreatitis, and is considered diagnostic. EUS is a very sensitive test for calcifications or stones. In patients without calcifications, the number of endosonographic criteria (out of the remaining 8) is critical. Three or four criteria are the best overall cutoffs. Less than three criteria essentially rules out chronic pancreatitis, and five or more criteria are highly suggestive of chronic pancreatitis [2,3]. It should be noted that each EUS feature of chronic pancreatitis can be seen in a normal pancreas, and may be more common in the elderly and in people who smoke, drink alcohol regularly, or are obese. Other features such as gland atrophy and diffuse echogenicity have also been described on EUS, which are not part of the standard scoring system. The Rosemont classification system is another grading system [4], which divides EUS features of chronic pancreatitis into major and minor criteria (Table 1). It has not been fully validated and has similar interobserver agreement as the standard classification system [5]. The standard classification system will be used for this video demonstration.

The EUS criteria thresholds and ranges have been well validated to assess for the *probability* of disease, but not to stage the severity of disease. The severity of pancreatitis can be graded using the ERCP Cambridge classification system of severity of pancreatitis (Table 2) [6], which uses the features of stones, strictures, and duct and sidebranch dilation. These features can also be seen on EUS and as such, EUS can anticipate the ERCP Cambridge severity class. However, there is little correlation between the *probability*

Table 1 Conventional and Rosemont EUS criteria for diagnosis of chronic pancreatitis.

Conventional EUS criteria for diagnosis of chronic pancreatitis	
Parenchymal criteria	
Hyperechoic foci	
Hyperechoic strands	
Hypoechoic lobules, foci or areas	
Cysts	
Duct criteria	
Irregular duct contour	
Visible side branches	
Hyperechoic duct margin	
Dilated main duct	
Intraductal stones	
Rosemont EUS criteria for diagnosis of chronic pancreatitis	
Major criteria A	
Hyperechoic foci	>2 mm in length/width with shadowing
Major duct calculi	Echogenic structure(s) within the MPD with acoustic shadowing
Major criteria B	
Lobularity	≥3 contiguous lobules="honeycombing"
Minor criteria	
Cyst[a]	Anechoic, round/elliptical with or without septations
Dilated duct[a]	≥3.5 mm in body or >1.5 mm in tail
Irregular duct contour	Uneven or irregular outline and ectatic course
Dilated side branch[a]	>3 tubular anechoic structures each measuring ≥1 mm in width, budding from the MPD
Hyperechoic duct wall	Echogenic, distinct structure >50% of the entire MPD in the body and tail
Hyperechoic strands	≥3 mm in at least 2 different directions with respect to the imaged plane
Hyperechoic foci[a]	>2 mm in length/width that are non-shadowing
Lobularity	>5 mm, non-contiguous lobules

[a]If any of these minor criteria are present, patient cannot be classified as "normal".

and *severity* of chronic pancreatitis using the two scoring systems. For example, a patient diagnosed with high probability disease with >5 EUS criteria, may not necessarily have severe disease on the ERCP Cambridge classification system.

5.3. Inflammatory or neoplastic masses

The risk of pancreatic cancer is increased in chronic pancreatitis. Acute inflammatory exacerbations of chronic pancreatitis can result in focal edema, which may be indistinguishable from a neoplastic mass on CT. Painless presentations, weight loss, jaundice, persistent or progressive cholestasis, recent onset or worsening of diabetes, or vascular invasion on cross-sectional imaging can all be helpful in distinguishing benign and malignant masses. The absence of risk factors for pancreatitis raises the suspicion further.

At EUS, neoplastic masses may obscure the normal parenchymal and ductal features, and are generally more homogeneous and hypoechoic compared to surrounding tissue. Neoplastic masses are rarely calcified, and so masses with internal calcification are more likely benign. Malignancies within a calcified pancreas often push the calcified parenchyma towards the periphery. Acoustic shadowing from calcifications in calcific chronic pancreatitis can make assessment of the entire gland challenging. Signs of vascular invasion are highly suggestive of malignancy, however, in some cases, inflammation-related compression or adherence of vascular structures, and/or thrombosis can be deceptive. The diagnostic accuracy of fine needle aspiration is decreased in the setting of an indeterminate mass arising within chronic pancreatitis [7,8], and multiple needle passes are often required before a positive cytology diagnosis can be made. The accuracy of differentiating between chronic pseudotumoral pancreatitis and pancreatic cancer may be improved using a combination of contrast enhanced Doppler and sonoelastography during EUS [9].

6. Summary

EUS is a highly useful test to diagnose chronic pancreatitis, evaluate for underlying causes and complications of the disease, and plan future endoscopic or surgical management.

7. Scripted voiceover

Voiceover text
EUS is highly accurate in diagnosing chronic pancreatitis. Information can be gained on the pancreatic parenchyma and duct, and nine standard diagnostic criteria have been defined to estimate the likelihood of chronic pancreatitis. EUS is also very useful in distinguishing between inflammatory and malignant masses.
The normal pancreas appears as a homogeneous structure with a single anechoic smooth duct running. The body and tail have a fine diffusely speckled ("salt and pepper") pattern. The gland contour is generally smooth but some margin lobularity is normal. The dorsal pancreas is generally more echogenic than the embryological ventral pancreas (the ventral anlage). The transition zone between the darker ventral anlage (head) to the brighter dorsal pancreas (uncinate, body/tail) is seen in approximately 50% of cases. The pancreatic head is generally more heterogeneous than the body and tail. The duct wall normally has similar echotexture to surrounding tissue. The duct tapers from the head to the tail, with 3 mm, 2 mm, and 1 mm being average duct sizes in the head, body and tail, respectively. In patients over 60

Table 2 ERCP Cambridge severity class [6].

Terminology	Main duct	Abnormal side branches	Additional features
Normal	Normal	None	
Equivocal	Normal	Fewer than 3	
Mild changes of chronic pancreatitis	Normal	3 or more	
Moderate changes of chronic pancreatitis	Abnormal	More than 3	
Marked changes of chronic pancreatitis	Abnormal	More than 3	One or more of: large cavity, obstruction, filling defects, severe dilation or irregularity

Voiceover text

years old, an additional 1 mm for the main duct in each section is allowed due to gland atrophy.

Here is a normal pancreas on EUS and the corresponding histology.

There are 9 accepted EUS criteria for chronic pancreatitis, including four parenchymal and five ductal. Calcifications are very specific for chronic pancreatitis, and are considered diagnostic. In patients without calcifications, the number of endosonographic criteria is critical. Three or four criteria are the best overall cutoffs. Less than three criteria essentially rules out chronic pancreatitis, and five or more criteria are highly suggestive of chronic pancreatitis. The Rosemont classification system divides EUS features of chronic pancreatitis into major and minor criteria. It has not been fully validated, and the standard classification system will be used for this demonstration.

This is a patient with chronic calcific pancreatitis. Multiple hyperechoic stones are seen throughout the pancreas, seen as bright round, oval and linear structures. Calcifications typically have associated shadowing, which appears as a hypoechoic or dark area stretching behind the stone. Calcifications can occur within the main pancreatic duct or the side-branches.

This is the EUS image of a patient with a dilated main pancreatic duct, and the corresponding histologic finding.

Dilation of a ductal side branch above 1 mm in diameter is considered abnormal.

Hyperechoic or bright main pancreatic duct walls, with a rail track appearance is a further feature of chronic pancreatitis.

Some degree of main duct tortuosity is normal; however beading or alternating narrow or dilated duct is not.

Hyperechoic strands appear as bright linear structures within the pancreatic parenchyma. Of note, small echogenic foci or short echogenic strands may be normal when a high degree of magnification is used.

Here we can see a patient with a number of hyperechoic foci and strands on EUS, and on histology we see the corresponding fibrotic strands.

Lobulations appear as defined areas of hypoechoic or dark parenchyma. They may be associated with confluent hyperechoic strands.

EUS and the corresponding histological image show the marked lobularities and fibrotic strands.

Cysts are anechoic areas within the pancreatic parenchyma. They can be due to focal side branch dilation or inflammatory foci.

Voiceover text

All in all there are nine EUS criteria for chronic pancreatitis, and an increasing number of EUS criteria correspond well with an increasing fibrosis score.

This is a 56 year old female with chronic calcific pancreatitis diagnosed 3 years ago, presumed to be hereditary pancreatitis. She had main pancreatic duct calcifications, and had had a number of ERCPs for attempted duct clearance. She usually responded well, however her pain rapidly recurred following the last pancreatic stent placement, and she underwent EUS evaluation. The pancreatic body and tail had multiple stones and a normal diameter duct. On uncinate pull through, the uncinate parenchyma was preserved. However, there were multiple large calcifications in the pancreatic head and the surrounding parenchyma was hypoechoic.

In the apical view, the pancreatic duct was traced to the ampulla, and a hypoechoic mass was identified. It was significantly darker than the surrounding parenchyma, and it was not due to stone shadowing. Adenocarcinoma was diagnosed on EUS-FNA.

In summary, the EUS assessment for features of chronic pancreatitis is relatively quick and simple. EUS is accurate in estimating the likelihood of chronic pancreatitis, and it has an important role in distinguishing inflammatory from neoplastic masses.

Ethics

The work described in this article has been carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.

Disclosures

S. Varadarajulu consultants for Boston Scientific and Olympus. The other author has no disclosures to report. No financial relationships relevant to this publication are disclosed.

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