

Update on endoscopic pancreatic function testing

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Abstract

Hormone-stimulated pancreatic function tests (PFTs) are considered the gold standard for measuring pancreatic exocrine function. PFTs involve the administration of intravenous secretin or cholecystokinin, followed by collection and analysis of pancreatic secretions. Because exocrine function may decline in the earliest phase of pancreatic fibrosis, PFTs are considered accurate for diagnosing chronic pancreatitis. Unfortunately, these potentially valuable tests are infrequently performed except at specialized centers, because they are time consuming and complicated. To overcome these limitations, endoscopic PFT methods have been developed which include aspiration of pancreatic secretions through the suction channel of the endoscope. The secretin endoscopic pancreatic function test (ePFT) involves collection of duodenal aspirates at 15, 30, 45 and 60 min after secretin stimulation. A bicarbonate concentration greater than 80 mmol/L in any of the samples is considered a normal result. The secretin ePFT has demonstrated good sensitivity and specificity compared with various reference standards, including the "Dreiling tube" secretin PFT, endoscopic ultrasound, and surgical histology. Furthermore, a standard autoanalyzer can be used for bicarbonate analysis, which allows the secretin ePFT to be performed at any hospital. The secretin ePFT may complement imaging tests like endoscopic ultrasound (EUS) in the diagnosis of early chronic pancreatitis.

This paper will review the literature validating the use of ePFT in the diagnosis of exocrine insufficiency and chronic pancreatitis. Newer developments will also be discussed, including the feasibility of combined EUS/ePFT, the use of cholecystokinin alone or in combination with secretin, and the discovery of new protein and lipid pancreatic juice biomarkers which may complement traditional fluid analysis.

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INTRODUCTION

Direct hormone-stimulated pancreatic function tests (PFTs) are the most sensitive and specific tests for assessing the pancreatic exocrine reserve^[1]. They involve administration of a gastrointestinal hormone, followed by collection and analysis of the resulting pancreatic secretions. Direct PFTs are categorized based on the hormonal stimulants used. The secretin PFT measures bicarbonate and volume, a reflection of duct-cell function. The cholecystokinin (CCK) PFT measures enzymes (e.g., lipase and trypsin), a reflection of acinar-cell function.

Direct PFTs have been performed for over 80 years using double-lumen gastroduodenal collection tubes (Dreiling tubes). The tubes are placed through the mouth, and positioned with the weighted tip passed the ligament of Treitz. The gastric lumen sits in the greater curvature of the stomach and collects gastric secretions to prevent acid contamination of the duodenum. The duodenal lu-

men collects the pancreatic secretions. In secretin PFT protocols, fluid is analyzed for bicarbonate concentration or output for an estimation of duct cell secretion. In CCK PFT protocols, fluid is analyzed for enzyme output for an estimation of acinar cell capacity. Dreiling tubes are long, floppy, and often difficult to place properly. Accurate placement requires prolonged manipulation under fluoroscopy, or endoscopic guide-wire placement^[2]. It is not uncommon for the test to take 2-3 h because of the long time required for tube placement and an additional 60-90 min required for fluid collection. Sophisticated laboratory techniques may be required for fluid analysis, which may not be universally available. Even among the few centers that perform PFTs, the test protocols are not standardized. Various combinations of hormones or analogs, dosing regimens, collection times, laboratory techniques, parameters for analyses, and diagnostic thresholds are used, making it difficult to compare results and assess the tests' performance. Although direct PFTs have been labeled the "gold standard" tests for assessing exocrine function, there is no "gold standard" direct PFT. Based on these limitations, direct PFTs are rarely performed, despite their potential usefulness for diagnosing mild and moderate exocrine insufficiency.

ENDOSCOPIC METHODS

Recently, endoscopes have been used to collect pancreatic fluid under direct visualization. Some investigators have collected pancreatic secretions using a catheter placed in the pancreatic duct at the time of endoscopic retrograde cholangiopancreatography (ERCP)^[3,4]. One potential advantage of this method is that pure pancreatic fluid is obtained, preventing contamination by other fluids found in the duodenum (e.g, bile, mucous, or food). In addition, a pancreatogram can be performed to detect structural abnormalities. A major limitation is that cannulation of the pancreatic duct is required, imparting a risk of acute pancreatitis. The time of fluid collection must also be relatively short (10-15 min). Bicarbonate secretion may not reach maximum until 25-40 min after secretin; thus, false positives are common^[5]. More recently, investigators have performed endoscopic methods in which fluid is aspirated through the suction channel of the endoscope. A common secretin ePFT protocol is as follows: Secretin is administered as an intravenous bolus dose of 0.2 mcg/kg. After sedation, the endoscope is passed through the mouth into the stomach. Gastric fluid is aspirated as completely as possible to prevent contamination of the duodenal contents. The scope is advanced into the duodenum and residual duodenal fluid is thoroughly suctioned. Timed aspirates of duodenal fluid (5-10 mL) are obtained through the suction channel into a fluid collection trap at 15, 30, 45, and 60 min. The fluid samples are placed on ice and taken to the hospital laboratory. The samples are analyzed using a chemistry autoanalyzer for bicarbonate concentration. The maximum bicarbonate concentration from all the samples is termed the peak bicarbonate. A peak bicarbonate concentration less than 80 millimolar is

considered abnormal. The following section will review the literature regarding the endoscopic secretin pancreatic function test (ePFT).

SECRETIN ePFT

Most of the recent validation studies of the ePFT have used secretin for hormonal stimulation. Ceryak *et al*^[6] were the first group to publish the results of a purely endoscopic secretin PFT, in a pilot study of 11 patients who had undergone ERCP for evaluation of abdominal pain. Duodenal aspirates were obtained every 10 min for one hour following intravenous secretin administration. In seven patients with a normal pancreatogram, the peak bicarbonate concentration was greater than 80 mmol/L. Conversely, three of the four patients with ductal changes of chronic pancreatitis (CP) did not achieve the 80 mmol/L threshold. Note that 80 mmol/L is a widely accepted bicarbonate threshold used in most Dreiling tube PFT protocols^[7]. In a similar study, secretin ePFT results were compared in patients with abdominal pain and low suspicion of CP, suspected early CP, and advanced CP^[8]. All patients in the low risk category had a bicarbonate concentration greater than 80 mmol/L. Most patients with calcific pancreatitis had bicarbonate concentrations less than 60 mmol/L. Most of the patients in the early CP category had values between 60 and 80 mmol/L. These studies suggested the feasibility of the secretin ePFT, and demonstrated that it distinguishes the presence or absence of CP when using the cut-off point of 80 mmol/L.

Validation of any new tests requires comparison with a gold standard method. Our group performed crossover studies comparing the secretin ePFT and Dreiling PFT in healthy subjects^[9] and patients evaluated for CP^[10]. The mean difference in peak bicarbonate was 0 mmol (95% CI-3, 9). There was a strong correlation between peak bicarbonate obtained by ePFT and Dreiling PFT ($r = 0.77$, $P < 0.001$). In addition, the time required to perform the ePFT was significantly less compared with the Dreiling PFT.

Structural and functional tests may be used synergistically in the diagnosis of pancreatitis. Past studies comparing PFT with ERCP have shown less than optimal concordance of structural and functional abnormalities. In a recent study, we compared endoscopic ultrasound (EUS) to secretin ePFT^[11]. We found significant inverse correlations of the EUS score with the secretin ePFT peak bicarbonate. However, the concordance of EUS with secretin ePFT in the group with mild EUS changes was only 72%.

The ePFT has been compared to the secretin magnetic resonance cholangiopancreatography (MRCP) in patients evaluated for CP^[12]. Among 24 patients with a normal ePFT, 15 had a normal MRCP pancreatogram, while nine patients had an abnormal MR pancreatogram. Among 12 patients with abnormal ePFT, seven had an abnormal MR pancreatogram, while five patients had a normal MR pancreatogram. Again, this suggests suboptimal correlation of structural and functional tests in the early phase of CP. Utilizing the MRCP functional assessment (duodenal fill-

ing after secretion), all 24 patients with normal ePFT had normal duodenal filling, and all 15 patients with abnormal ePFT had abnormal duodenal filling.

The secretin ePFT has been compared to histology in one retrospective study^[13]. Seventeen patients underwent a secretin ePFT within 12 mo before surgical resection or biopsy of the pancreas. There was a significant negative correlation between the ePFT peak bicarbonate concentration and the histological fibrosis score (Spearman $r = -0.57$). The ePFT was 86% sensitive and 67% specific for the diagnosis of fibrosis. The sensitivity and specificity were similar to those of EUS in the detection of histological fibrosis.

NEW DEVELOPMENTS

Shortened ePFT

A considerable limitation of the secretin ePFT is that it takes approximately 1 h to perform, with fluid collections at 0, 15, 30, 45, and 60 min after secretin injection. As such, we and others have studied shortened ePFT methods^[14,15]. In a retrospective analysis of 240 ePFT results, we found that measuring bicarbonate at 30 and 45 min provides 94% accuracy compared with the full hour long test. We currently administer secretin in the admitting area before transport to the endoscopy suite. By the time the patient is sedated, the scope inserted, and the stomach cleared of gastric fluid, we are able to efficiently collect duodenal aspirates at the 30 and 45 min time points. A careful luminal examination is performed between collections.

Combined EUS/PFT

A combination of structural and functional testing may be required to diagnose CP. We often perform a combined EUS and ePFT in the same endoscopic session. This involves performance of EUS following secretin stimulation, with collection of duodenal fluid at 15, 30, and 45 min. In 252 patients evaluated for suspected minimal change CP (no calcifications), 160 (63.5%) had concordant normal EUS and ePFT results, “ruling out” CP. Thirty-two patients (12.7%) had concordant abnormal EUS and ePFT results, “ruling in” the diagnosis^[16]. The remaining 60 patients had discordant results, which are more difficult to interpret. Patients with abnormal EUS and normal ePFT may have CP with preserved exocrine function. The significance of normal EUS with abnormal ePFT is uncertain, but may suggest a very early form of CP prior to the development of overt structural changes. Long-term studies are needed to better understand the significance of minimal or discordant functional and endosonographic changes.

Use of CCK for ePFT

Many pancreatic referral centers advocate that the CCK PFT is the most sensitive method for detecting early acinar cell loss from pancreatic fibrosis. Most CCK PFT protocols require continuous collection of pancreatic fluid using a gastroduodenal collection tube, with measurement of total enzyme output. Measurement of enzyme output

requires an accurate assessment of volume. Most CCK protocols use a second orogastric tube to perfuse an inert non-absorbable marker, such as polyethylene glycol (PEG). Measurement of recovered PEG from the duodenal juice produces a more accurate volume estimate.

Unlike more labor intensive methods that utilize perfusion markers, ePFT methods do not quantify volume, which would allow an accurate estimation of enzyme outputs. Instead, the ePFT collects timed samples of fluid and relies on concentration measurements. Studies of a CCK ePFT utilizing lipase concentrations have yielded mixed results. A pilot study found a threefold increase in lipase concentrations in healthy volunteers following continuous CCK stimulation (40 ng/kg per hour), with a mean peak lipase value of 1778847 IU^[17]. A subsequent study demonstrated that a peak lipase value of 780000 IU provided 83% sensitivity and 87% specificity for differentiating healthy subjects from patients with established CP^[18]. In a third study, CCK-stimulated endoscopic and Dreiling tube PFTs were compared with measurement of lipase concentrations^[19]. Both collection methods produced excellent discrimination between healthy volunteers and patients with moderate to advanced CP based on the ERCP Cambridge classification. A more recent study of the CCK ePFT yielded less satisfactory results^[11]. Although there was good separation between controls and those with advanced CP, there was substantial overlap in lipase results with the group with suspected early CP.

We have recently studied an ePFT using combined secretin and CCK to assess both duct-cell and acinar-cell function. The bicarbonate and enzyme results from the combined ePFT were compared using EUS as a reference standard^[20]. Of all the diagnostic parameters, peak bicarbonate and amylase appeared to optimize discrimination. Using logistic regression, a predictive score was developed including peak bicarbonate and peak amylase for prediction of CP. A predictive score threshold of 1213 yielded 82.8% sensitivity and 88.9% specificity. Further validation of this combined test is currently underway.

Use of autoanalyzers for bicarbonate measurement

In the secretin PFT, the standard technique for bicarbonate measurement has been back titration. Back titration involves gradual addition of defined quantities of hydrochloric acid to the pancreatic fluid sample until a pre-specified pH is obtained, allowing calculation of the original bicarbonate content of the fluid. Back titration is cumbersome and not available in most hospitals, whereas, chemistry autoanalyzers are widely available in all hospitals. We compared back titration versus an autoanalyzer for bicarbonate measurement in pancreatic fluid^[21]. There was high concordance between the methods (Lin’s concordance coefficient = 0.96), suggesting that the autoanalyzer is a satisfactory method for bicarbonate measurement.

Measurement of proteins and lipids

Fluid analysis for PFTs has focused on the products of pancreatic exocrine secretion (bicarbonate and enzymes).

However, CP is disease of inflammation and fibrosis, not simply functional loss. Therefore, measurement of the byproducts of inflammation may be useful in diagnosing early CP, even before functional decline occurs. A recent study demonstrated the feasibility of measuring the entire complement of proteins from pancreatic fluid using gel electrophoresis followed by tandem mass spectrometry.^[22] The known functions of the discovered proteins were ascertained using gene ontology analysis. In this study, a total of 134 proteins were isolated from the pancreatic fluid, the majority of which were found in multiple samples. Further studies are underway to refine this proteomics approach, and to better understand the discriminative ability of these newly elucidated biomarkers for diagnosis.

Oxidative stress is known to have a role in pancreatic inflammation. Reactive oxidative molecules can cause damage to lipid membranes. Therefore, measurement of oxidized fatty acids may represent a useful biomarker for early CP. We have used a "lipidomics" approach to quantifying oxidized fatty acids in the serum and expressed pancreatic fluid during secretin ePFT, combined with tandem mass spectrometry. Oxidized fatty acids were differentially expressed in both the serum and fluid, suggesting a promising biomarker for early CP^[23,24]. Further work is needed to validate the use of protein or lipid measurement from pancreatic secretions.

ROLE OF THE ePFT

Endoscopic methods have simplified direct PFTs, and made them more accessible to clinicians and patients. However, there are acknowledged limitations. First, even when shortened protocols are used, the ePFT remains a time-consuming test, requiring 30-45 min of prolonged endoscopy. Second, the inability to accurately quantify fluid volume prevents calculation of enzyme output, arguably the optimal measure of acinar capacity. Finally, although intravenous sedation in low doses does not appear to substantially affect exocrine secretion, the effect of higher levels of sedation, as required for many patients with CP, has not been adequately studied.

The actual role of ePFT in the care of patients has yet to be defined. PFT has been considered a diagnostic test for early CP because mild changes in functional capacity may represent an early biomarker for pancreatic fibrosis. However, this is not universal in all patients. Past studies have shown that most patients with mild and severe CP have evidence of exocrine loss. However, some patients with advanced structural changes of CP have preserved exocrine function. We believe the ePFT serves as a complementary diagnostic modality with structural testing, as seen with the combined EUS/ePFT.

The ePFT may also be useful in investigating the cause of malabsorptive diarrhea. We frequently perform a fecal elastase test in the initial workup of patients with malabsorptive diarrhea. Fecal elastase levels are quite useful in diagnosing moderate and advanced exocrine insufficiency. However, if the fecal elastase result is equivocal or if mild exocrine insufficiency is considered, we often proceed

to secretin ePFT. We typically obtain secretin-stimulated duodenal aspirates before obtaining a small intestinal mucosal biopsy in patients evaluated for steatorrhea. In 12 patients who presented with painless steatorrhea, and who lacked structural features of CP on imaging tests, two patients (20%) were found to have concordant abnormal results, suggesting early CP with exocrine insufficiency^[16]. Conversely, 10 patients had a concordant normal EUS and ePFT, ruling out pancreatic insufficiency. Several of these patients were found to have other causes of steatorrhea, such as celiac disease or bacterial overgrowth.

Secretin ePFT may also be considered in patients with established CP to "stage" the disease and determine the need for exogenous enzymes. In our series of 38 patients with established severe CP who underwent EUS/ePFT, there were five patients (13.2%) who had a normal ePFT^[16]. These patients also lacked postprandial diarrhea. Based on the normal ePFT results, these patients were spared the cost and nuisance of taking pancreatic enzymes.

CONCLUSION

Endoscopic fluid collection has made hormone-stimulated pancreatic function tests much more accessible for routine clinical care. The incremental diagnostic utility of the secretin ePFT in the context of other sensitive structural tests, such as EUS and MRCP, remains to be proven. We have found the ePFT to be most useful in patients with suspicion of CP, but with minimal or equivocal radiographic abnormalities. In these patients, a combined secretin ePFT and endoscopic ultrasound is often performed as an efficient structural and functional assessment of the gland. We have also found the ePFT helpful in the workup of malabsorptive diarrhea, allowing a simultaneous small intestinal biopsy to screen for mucosal diseases that cause malabsorption. Further studies are underway to optimize ePFT protocols and to better define their role in the clinical care of patients.

REFERENCES

- 1 **Pandol SJ.** Pancreatic physiology and secretory testing. In: Feldman M, Friedman LS, Sleisenger MH, editors. *Sleisenger and Fordtran's Gastrointestinal and liver disease*. 7th ed. Philadelphia: Saunders, 2002: 871-880
- 2 **Waxman I, Steer ML, Freedman SD.** Endoscopically assisted direct pancreatic function testing: a simplified technique. *Gastrointest Endosc* 1996; **44**: 630
- 3 **Ochi K, Harada H, Mizushima T, Tanaka J, Matsumoto S.** Intraductal secretin test is as useful as duodenal secretin test in assessing exocrine pancreatic function. *Dig Dis Sci* 1997; **42**: 492-496
- 4 **Denyer ME, Cotton PB.** Pure pancreatic juice studies in normal subjects and patients with chronic pancreatitis. *Gut* 1979; **20**: 89-97
- 5 **Draganov P, Patel A, Fazel A, Toskes P, Forsmark C.** Prospective evaluation of the accuracy of the intraductal secretin stimulation test in the diagnosis of chronic pancreatitis. *Clin Gastroenterol Hepatol* 2005; **3**: 695-699
- 6 **Ceryak S, Steinberg WM, Marks ZH, Ruiz A.** Feasibility of an endoscopic secretin test: preliminary results. *Pancreas* 2001; **23**: 216-218
- 7 **Chowdhury RS, Forsmark CE.** Review article: Pancreatic

- function testing. *Aliment Pharmacol Ther* 2003; **17**: 733-750
- 8 **Conwell DL**, Zuccaro G, Vargo JJ, Morrow JB, Obuchowski N, Dumot JA, Trolli PA, Burton A, O'Laughlin C, Van Lente F. An endoscopic pancreatic function test with cholecystokinin-octapeptide for the diagnosis of chronic pancreatitis. *Clin Gastroenterol Hepatol* 2003; **1**: 189-194
 - 9 **Stevens T**, Conwell DL, Zuccaro G, Van Lente F, Purich E, Khandwala F, Fein S. A randomized crossover study of secretin-stimulated endoscopic and dreiling tube pancreatic function test methods in healthy subjects. *Am J Gastroenterol* 2006; **101**: 351-355
 - 10 **Stevens T**, Conwell DL, Zuccaro G, Van Lente F, Lopez R, Purich E, Fein S. A prospective crossover study comparing secretin-stimulated endoscopic and Dreiling tube pancreatic function testing in patients evaluated for chronic pancreatitis. *Gastrointest Endosc* 2008; **67**: 458-466
 - 11 **Stevens T**, Dumot JA, Zuccaro G, Vargo JJ, Parsi MA, Lopez R, Kirchner HL, Purich E, Conwell DL. Evaluation of duct-cell and acinar-cell function and endosonographic abnormalities in patients with suspected chronic pancreatitis. *Clin Gastroenterol Hepatol* 2009; **7**: 114-119
 - 12 **Balci NC**, Smith A, Momtahan AJ, Alkaade S, Fattahi R, Tariq S, Burton F. MRI and S-MRCP findings in patients with suspected chronic pancreatitis: correlation with endoscopic pancreatic function testing (ePFT). *J Magn Reson Imaging* 2010; **31**: 601-606
 - 13 **Albashir S**, Bronner MP, Parsi MA, Walsh RM, Stevens T. Endoscopic ultrasound, secretin endoscopic pancreatic function test, and histology: correlation in chronic pancreatitis. *Am J Gastroenterol* 2010; **105**: 2498-2503
 - 14 **Stevens T**, Conwell DL, Zuccaro G, Lewis SA, Love TE. The efficiency of endoscopic pancreatic function testing is optimized using duodenal aspirates at 30 and 45 minutes after intravenous secretin. *Am J Gastroenterol* 2007; **102**: 297-301
 - 15 **Moolsintong P**, Burton FR. Pancreatic function testing is best determined by the extended endoscopic collection technique. *Pancreas* 2008; **37**: 418-421
 - 16 **Stevens T**, Dumot JA, Parsi MA, Zuccaro G, Vargo JJ. Combined endoscopic ultrasound and secretin endoscopic pancreatic function test in patients evaluated for chronic pancreatitis. *Dig Dis Sci* 2010; **55**: 2681-2687
 - 17 **Conwell DL**, Zuccaro G, Morrow JB, Van Lente F, O'Laughlin C, Vargo JJ, Dumot JA. Analysis of duodenal drainage fluid after cholecystokinin (CCK) stimulation in healthy volunteers. *Pancreas* 2002; **25**: 350-354
 - 18 **Conwell DL**, Zuccaro G, Morrow JB, Van Lente F, Obuchowski N, Vargo JJ, Dumot JA, Trolli P, Shay SS. Cholecystokinin-stimulated peak lipase concentration in duodenal drainage fluid: a new pancreatic function test. *Am J Gastroenterol* 2002; **97**: 1392-1397
 - 19 **Conwell DL**, Zuccaro G, Vargo JJ, Morrow JB, Obuchowski N, Dumot JA, Trolli PA, Burton A, O'Laughlin C, Van Lente F. An endoscopic pancreatic function test with cholecystokinin-octapeptide for the diagnosis of chronic pancreatitis. *Clin Gastroenterol Hepatol* 2003; **1**: 189-194
 - 20 **Law R**, Parsi MA, Costanzo A, Stevens T. Endoscopic Pancreatic Function Testing (ePFT) Using Combined Secretin and Cholecystokinin (CCK) Stimulation for the Evaluation of Chronic Pancreatitis (CP). *Gastroenterology* 2010; **138**: S390
 - 21 **Xiao Z**, Lopez R, Parsi MA, Dodig M, Stevens T. Comparison of autoanalyzer and back titration for measurement of bicarbonate concentration in endoscopically collected pancreatic fluid. *Pancreas* 2011; **40**: 237-241
 - 22 **Paulo JA**, Lee LS, Wu B, Repas K, Banks PA, Conwell DL, Steen H. Proteomic analysis of endoscopically (endoscopic pancreatic function test) collected gastroduodenal fluid using in-gel tryptic digestion followed by LC-MS/MS. *Proteomics Clin Appl* 2010; **4**: 715-725
 - 23 **Stevens T**, Berk MP, Lopez R, Chung YM, Parsi MA, Menon N, Costanzo A, Bronner MP, Feldstein AE. Circulating Lipid Oxidation Products are Elevated in Patients With Early and Advanced Chronic Pancreatitis (CP) and Correlate With Endoscopic Ultrasound (EUS) Abnormalities. *Gastroenterology* 2010; **138**: S391-S392
 - 24 **Stevens T**, Berk MP, Chung YM, Zhang R, Costanzo A, Bronner MP, Feldstein AE. Pancreatic fluid oxidized fatty acids (OxFA) are elevated in non-calcific chronic pancreatitis. *Pancreas* 2010; **39**: 1348

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