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Exocrine Pancreatic Insufficiency and Malnutrition in Chronic Pancreatitis:

Identification, Treatment, and Consequences

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Abstract

Objectives: The purpose of this study was to examine the impact of exocrine pancreatic insufficiency (EPI) on chronic pancreatitis (CP) patients and to identify challenges with its diagnosis and treatment.

Methods: Ninety-one patients with CP diagnosed with endoscopic ultrasound were identified and assessed for symptoms of EPI, fat-soluble vitamin levels, dual-energy x-ray absorptiometry scan T-scores, and treatment with pancreatic enzyme replacement therapy. All patients were also screened with the Malnutrition Universal Screening Test.

Results: Exocrine pancreatic insufficiency was diagnosed in 84.6% (77/91) of patients based on symptoms of bloating, steatorrhea, or weight loss. Of these patients, 35.2% (19/54) had vitamin A deficiency, 62.5% (55/88) had vitamin D deficiency, and 17.7% (9/51) had vitamin E deficiency. Either osteopenia or osteoporosis was found in 68.9% (3/45). A medium or higher risk for malnutrition based on Malnutrition Universal Screening Test score of 1 or higher was found in 31.5% (28/89). Malnutrition Universal Screening Test score of 1 or higher was associated with an increased risk for osteopenia and osteoporosis on Fisher's exact test ($P = 0.0037$).

Conclusions: There is a high prevalence of fat-soluble vitamin deficiencies, osteopathy, and malnutrition in CP patients, which is underestimated due to a lack of effective diagnosis and suboptimal therapies for EPI.

Keywords

chronic pancreatitis; exocrine pancreatic insufficiency; malnutrition

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Exocrine pancreatic insufficiency (EPI) is a potential complication of chronic pancreatitis (CP) characterized by decreased production of pancreatic digestive enzymes. Exocrine pancreatic insufficiency can lead to maldigestion, malabsorption, and ultimately malnutrition. It is often underrecognized due to challenges with its diagnosis and the difficulty of identifying high-risk patients. Even when recognized, optimal management with pancreatic enzyme replacement therapy (PERT) is not always achieved.¹

Direct pancreatic function testing is currently the most sensitive and specific modality for assessing EPI.² The endoscopic secretin stimulation test (ePFT) involves serial measurement of duodenal bicarbonate concentration after administration of secretin. Endoscopic secretin stimulation test is becoming increasingly routine in the diagnostic workup of CP; however, it is not yet available at all medical centers. Indirect pancreatic function tests include quantitative and qualitative fecal fat assay, fecal elastase, mixed triglyceride breath testing, and spot steatocrit. Because of their variable sensitivity, specificity, safety, and availability, providers often forego indirect pancreatic function testing and diagnose EPI based on patient report of symptoms such as steatorrhea and bloating.³

As expected, patients with EPI are known to have a higher prevalence of fat-soluble vitamin deficiencies due to fat malabsorption.⁴ Of particular clinical significance is the increased risk for vitamin D deficiency in EPI, as this places patients with CP at higher risk for metabolic bone diseases including osteopenia and osteoporosis.⁵⁻⁷ Other contributing factors for malnutrition in CP include decreased dietary intake secondary to pain and alcohol abuse. Despite the high risk for malnutrition in the CP population, few studies have examined the nutritional status in patients with CP. Verhaegh et al⁸ evaluated the use of 3 nutritional surveys in CP patients and found that none of these surveys were sensitive enough to identify all patients with impaired nutrition. In our study, we examined the impact of exocrine pancreatic insufficiency on CP patients and the challenges with its diagnosis and treatment. We also investigated the use of a nutrition screening tool in identifying CP patients who are at higher risk for malnutrition and fat-soluble vitamin deficiency.

MATERIALS AND METHODS

Study Design and Patient Population

We enrolled patients between January 2014 and December 2016 for our Chronic Pancreatitis Database through the CP clinic at the University of Massachusetts Medical Center, a tertiary care academic hospital in Worcester, Mass. Only those patients who were previously diagnosed with CP by endoscopic ultrasound (EUS) criteria and/or secretin stimulation testing were included in this study. Secretin stimulation test was considered to be positive if bicarbonate concentration was less than 75 mEq/L in all 3 aliquots collected over 45 minutes. Patients who did not have at least one prior EUS for evaluation of CP were excluded. All patients were given surveys assessing for active tobacco abuse, alcohol use, and symptoms of EPI (bloating, steatorrhea, and weight loss). Patients were also given the Malnutrition Universal Screening Test (MUST) during their clinic visits.

Additional data including qualitative fecal fat assays, fat-soluble vitamin levels, albumin levels, dual-energy x-ray absorptiometry (DEXA) scan T-scores, TIGAR-O classification,

PERT dosing, and CP severity based on EUS were obtained through retrospective chart review.⁹ Vitamin D was measured as total serum 25-hydroxyvitamin D level. Severity of CP was determined to be mild, mild to moderate, moderate, moderate to severe, or severe based on conventional EUS criteria.¹⁰ Exocrine pancreatic insufficiency was diagnosed based on symptoms including steat-orrhea, diarrhea, bloating, and weight loss and requirement for treatment with PERT on retrospective chart review. Average bicarbonate levels were calculated for each patient with available ePFT. Dual-energy x-ray absorptiometry scans results were expressed as T-scores compared with values in young women. Based on the World Health Organization's classification, patients with T-scores between -1.0 and -2.5 standard deviations (SDs) were diagnosed with osteopenia and those with T-scores below -2.5 were diagnosed with osteoporosis.

Malnutrition Screening

All patients were screened with the Malnutrition Universal Screening Test (MUST), which is a validated 5-step screening tool developed by the British Association of Parenteral and Enteral Nutrition to identify adults who are malnourished or at risk for malnutrition.^{11,12} Body mass index (BMI) was calculated by using the formula weight (kilogram)/height (square meter). Percent of weight loss was calculated based on the highest and lowest weight (kilogram) measured in clinic over a 6-month period. Patients were also asked in a survey if they have experienced unintentional weight loss over the past 6 months. Recent acute illness or absence of nutritional intake for more than 5 days was assessed by asking the patient in the survey. A MUST score of 0 was considered low risk for malnutrition, score of 1 was medium risk, and scores 2 or higher were high risk.

Statistical Analysis

Data were recorded in REDCap (Vanderbilt University, Nashville, Tenn), which is a secure, Web-based application for managing online databases. Continuous variables were expressed as a mean (SD). Categorical variables were expressed as a percentage (ratio). Fisher's exact test was used for assessing associations between categorical variables. All Fisher tests were 1-tailed, and cutoff for significance was set at a *P* value of less than 0.05. Pearson's correlation coefficient was computed to evaluate the relationship between variables on linear regression. Linear regression was performed to evaluate the correlation between MUST scores and severity of CP based on EUS and fat-soluble vitamin levels. Fisher exact test was used to evaluate the relationship between MUST scores and osteopathy (osteopenia or osteoporosis).

RESULTS

Patient Demographics

We enrolled a total of 91 patients with CP (see Table 1). The mean (SD) age in years was 48.6 (10.4). A total of 62.6% (57/91) of our patients were women and 37.4% (34/91) were men. The mean (SD) duration of CP in years was 4.3 (4.2) and was calculated based on year of EUS diagnosis. The most common etiology of CP based on the TIGAR-O classification was toxic-metabolic, which included 59.3% (54/91) of our patients. A total of 68.1% (62/91) of our patients reported a history of tobacco use; however, 8 of these patients had another

alternative etiology for CP based on TIGAR-O. In addition, 18.6% (17/91) of our patients had no identifiable etiology of CP, 14.3% (13/91) were attributed to genetic mutations, 5.5% (5/91) due to autoimmune disease, and 2.2% (2/91) due to obstruction.

Evaluation and Treatment of EPI

A total of 84.6% (77/91) of patients reported symptoms of EPI including steatorrhea, diarrhea, bloating, and weight loss. Ten patients had available qualitative fecal fat assays, and 6 of these patients (60.0%) had positive tests. Fourteen patients had available secretin stimulation tests, of which 9 (64.3%) had a positive test. All of the 77 patients who reported EPI symptoms were eventually started on PERT. Three of the patients with positive secretin tests (33.3%) did not report symptoms of EPI and were not treated with PERT. Only one of the patients with positive fecal fat assays (16.7%) did not have symptoms of EPI and was not treated with PERT. Patients treated with PERT were receiving a median of 96,000 units of lipase with each meal. Eight patients (10.3%) reported having continued steatorrhea despite taking PERT.

Prevalence of Fat-Soluble Vitamin Deficiency

A large proportion of patients were found to have fat-soluble vitamin deficiencies, including 35.2% (19/54) with vitamin A deficiency, 62.5% (55/88) with vitamin D deficiency, and 17.7% (9/51) with vitamin E deficiency. None of our patients had available vitamin K levels. Women had higher rates of vitamin A (38.7% vs 30.0%), vitamin D (67.3% vs 54.5%), and vitamin E (22.2% vs 12.5%) deficiency when compared with men. Smokers had higher rates of vitamin D (67.4% vs 57.1%) and vitamin E (21.4% vs 13.0%) deficiency when compared with nonsmokers. There was no significant correlation between average or peak bicarbonate levels on ePFTs and any of the vitamin levels. Interestingly, 84.2% (16/19) of patients with vitamin A deficiency, 89.1% (49/55) with vitamin D deficiency, and 77.8% (7/9) with vitamin E deficiency were already being treated for EPI with PERT.

Prevalence of Osteopathy

Forty-five patients had available DEXA scans within the past 5 years. A total of 46.7% (21/45) of patients were found to have osteopenia, 22.2% (10/45) of patients were diagnosed with osteoporosis, and 68.9% (31/45) had either osteopenia or osteoporosis. The mean (SD) T-score was found to be -1.6 (1.3). Women had a slightly higher rate of osteopathy at 69.7% versus 66.7% in men. Smokers had a significantly higher rate of osteopathy at 63.0% versus 22.2% in nonsmokers. There was a positive correlation between average bicarbonate on ePFT and T-scores ($r = 0.8012$). There was no significant association between treatment with PERT and incidence of osteopathy on Fisher 1-tailed t -test. A total of 80.6% (25/31) of patients with osteopathy were already on PERT.

Severity of Chronic Pancreatitis

The pooled mean (SD) of average bicarbonate levels in mEq/L obtained during secretin stimulation testing was 59.5 (16.3). Based on EUS criteria, 64.0% (55/86) of our patients were classified as having at least moderate severity of CP. A total of 17.4% (15/86) had severe CP. A total of 25.6% (22/86) had mild CP and 10.5% (9/86) had mild to moderate CP.

There was no significant correlation between CP severity on EUS and vitamin A, D, or E levels on regression analysis. There was also no significant correlation between CP severity by EUS criteria and DEXA scan T-scores on regression analysis.

Malnutrition Screening

The mean (SD) BMI was 26.1 (7.8) kg/m², and 12.1% (11/91) patients had a BMI of 18.5 kg/m² or less. The mean (SD) albumin level was 3.9 (0.67) g/dL. There was no significant correlation between either BMI or albumin and vitamin A, D, E levels, or DEXA scan T-scores on multivariate regression analysis. A total of 31.5% (28/89) of patients were found to be at medium or higher risk for malnutrition based on the MUST score of 1 or higher. A higher proportion of patients with MUST score of 1 or higher had vitamin D deficiency 67.9% (19/28) when compared with 57.4% (35/61) in patients with MUST score lower than 1. A MUST score of 1 or higher was associated with an increased risk for osteopenia and osteoporosis on Fisher's exact test ($P=0.0037$). There was no statistically significant correlation between MUST score and severity of CP based on EUS criteria or fat-soluble vitamin levels on regression analysis.

DISCUSSION

Exocrine pancreatic insufficiency is an underrecognized complication of CP that is associated with fat-soluble vitamin deficiencies, osteopathy, and malnutrition. We noted a high prevalence of fat-soluble vitamin deficiencies in our population particularly in women and smokers. Vitamin D was the most commonly deficient fat-soluble vitamin affecting 62.5% of our patients, which is similar to previous studies reporting vitamin D deficiency in 40% to 66% of CP patients.^{6,7,13} Relatively fewer patients had vitamin A deficiency (35.2%) and vitamin E deficiency (17.7%), which is contrary to prior studies, which had found that vitamin E deficiency was more common than deficiencies of vitamin A or D.^{14,15} The high prevalence of vitamin D deficiency in our study is significant primarily because of its association with osteopathy.^{16,17} A total of 68.9% of our patients had either osteopenia or osteoporosis, which is comparable to a previously reported pooled prevalence rate of 65% in CP patients.¹⁸

Despite the high prevalence of nutritional deficiencies and osteopathy in CP, identification of EPI has remained somewhat elusive due to the lack of an effective diagnostic test.¹⁹ Many providers rely on patient reporting of the symptoms of EPI including steatorrhea, weight loss, and bloating to decide when to initiate and change dosing of PERT. In our study, a large proportion (84.6%) of patients reported EPI symptoms such as steatorrhea. However, DiMagno et al showed that steatorrhea is not observed until lipase output is less than 10% of normal, therefore suggesting that it is a late manifestation of EPI.¹³ Furthermore, Midha et al found that 36% of their patients had fecal fat measurements greater than 7 g, whereas only 5% of patients reported clinical steatorrhea. This suggests that the mean (SD) duration of CP in our study of 4.3 (4.2) years based on year of EUS diagnosis likely far underestimates disease duration given that the pathophysiologic changes of CP are thought to far precede the clinical symptoms, which prompt EUS evaluation.^{20,21} This is one of the limitations of

our study, and further studies are needed to identify methods for early identification and diagnosis of patients with CP.

One method of diagnosing EPI is direct pancreatic function testing through ePFT. This method is currently considered the most sensitive test for diagnosis of early CP and EPI.² Although ePFT is being increasingly utilized, it has not yet been widely adopted as a routine part of EPI diagnosis and has not been validated for predicting malnutrition. Other indirect tests for EPI include quantitative fecal fat assays, fecal elastase, serum trypsin, and mixed triglyceride breath tests. Quantitative fecal fat assays are thought to be both sensitive and specific for EPI; however, these tests are rarely used in the clinical setting because they require strict dietary changes and stool monitoring for 72 hours.²² One study showed that fecal elastase has high sensitivity of 100% for moderate and severe EPI, but only 63% sensitivity in detecting mild EPI and therefore may have more limited yield in detecting early EPI.²³ Similarly, serum trypsin is only thought to be sensitive for detecting more advanced EPI and has limited specificity as levels may be elevated in other conditions such as acute pancreatitis.²⁴ Finally, mixed triglyceride breath testing is another indirect test for EPI; however, it is not widely available in the United States and therefore has not been widely utilized in the clinical setting. All of the indirect tests have relatively lower sensitivity for detecting EPI compared with secretin testing, particularly in early CP.²

Given the limitations of direct and indirect testing for EPI, only a small proportion of patients were diagnosed with EPI through objective measures in our study. Most of our patients were diagnosed with EPI based on their need for PERT to treat symptoms such as steatorrhea, weight loss, and bloating. Of those patients who had available ePFT in our study, there was no correlation between peak/average bicarbonate concentrations and malnutrition severity based on MUST or fat-soluble vitamin levels. This may be in part due to the relatively small number of available ePFT in our study. Further studies are needed to evaluate the use of ePFT in diagnosing early EPI and predicting the nutritional sequelae of EPI.

An alternative approach to assessing the risk for malnutrition in CP patients would be to implement a malnutrition screening methodology such as the MUST. The MUST is a validated tool to screen for patients at risk for malnutrition as well as to identify patients who are already malnourished. In our study, we found that the MUST had unclear significance in predicting those at risk for malnutrition, which is similar to findings from Verhaegh et al.⁸ The MUST scores were not predictive of fat-soluble vitamin deficiencies, and there was no correlation between MUST scores and bicarbonate levels on ePFT. Interestingly, MUST score of 1 or higher (medium-high risk of malnutrition) was associated with an increased risk for osteopenia and osteoporosis in our study. This suggests a potential role for this simple screening tool in identifying patients who should be evaluated for osteopathy with DEXA scans.

The challenges we face with diagnosing EPI and malnutrition are reflected in how we treat EPI in CP patients. Currently, PERT is the cornerstone of EPI management and is usually titrated until steatorrhea is reduced or eliminated. This method is limited as it relies on patient reporting and is not necessarily correlated with improved nutritional status. Prior

studies have suggested that patients with EPI are often undertreated with PERT, which is thought to be due to challenges with PERT titration and patient noncompliance.^{25,26} Only 10% of normal pancreatic lipase replacement (ie, 70,000–100,000 units per meal) is thought to be required to correct for steatorrhea and malnutrition due to EPI.²⁷ The median lipase dose in our study was 96,000 units per meal, which is well within current guidelines for appropriate PERT dosing. Striking in our study was that despite already being on therapeutic doses of PERT, 84.2% of our patients were vitamin A deficient, 89.1% were vitamin D deficient, and 77.8% were vitamin E deficient. A high proportion (80.6%) of patients who had osteopathy were already on PERT. These findings suggest that CP patients are either being undertreated for PERT, noncompliant with PERT, or that PERT alone is not sufficient to completely reverse fat-soluble vitamin deficiencies and metabolic bone disease in EPI.

In conclusion, our study shows that there is a high prevalence of fat-soluble vitamin deficiencies, osteopathy, and malnutrition in CP patients. This highlights the importance of early identification and management of EPI. Although assessing symptoms such as steatorrhea, bloating, and weight loss can be useful in identifying EPI, it can overlook those patients with milder forms of EPI who may still experience vitamin deficiencies and be at risk for malnutrition. The lack of a widely used, validated method for early diagnosis of EPI and suboptimal utilization of available therapies limits our ability to provide optimal care for our CP patients. Therefore, we recommend the following: (1) further studies to validate objective measures of EPI such as ePFT for early identification and monitoring malnutrition in the CP population, (2) evaluation of all patients with CP for fat-soluble vitamin deficiencies and osteopathy, and (3) consideration of PERT in all CP patients with vitamin deficiencies or osteopathy even in the absence of EPI symptoms.

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TABLE 1.

Baseline Patient Characteristics and Etiology of Chronic Pancreatitis as Toxic/Metabolic, Idiopathic, Genetic, Autoimmune, Recurrent Acute Pancreatitis, or Obstructive (TIGAR-O Classification)

All Patients (n = 91)	
Sex, n (%)	
Female	57 (62.6)
Male	34 (37.4)
Age, mean (SD), y	48.6 (10.4)
Smokers, n (%)	62 (68.1)
TIGAR-O Classification, n (%)	
Toxic/metabolic	54 (59.3)
Idiopathic	17 (18.7)
Genetic	13 (14.3)
Autoimmune	5 (5.8)
Recurrent AP	0 (0.0)
Obstructive	2 (2.2)
Duration of CP, mean (SD), y	4.3 (4.3)