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Diabetes in Chronic Pancreatitis: Risk Factors and Natural History

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Abstract

Purpose of review: The purpose of this review is to delineate risk factors for the development of diabetes in patients with chronic pancreatitis. The natural history including progression to diabetes and complications that develop once diabetes occurs in chronic pancreatitis is also reviewed.

Recent findings: Studies have found that predictors of diabetes in chronic pancreatitis include both risk factors for type 2 diabetes (e.g., obesity, genetic variants) as well as pancreas-specific factors (e.g., pancreatic calcification, exocrine insufficiency). Rates of diabetes in chronic pancreatitis are strongly related to the duration of chronic pancreatitis, reflecting progressive dysfunction and damage to the insulin-secreting beta-cells. Patients with diabetes and chronic pancreatitis experience an excess burden of complications, including higher all-cause and cancer-related mortality.

Summary: The high incidence and significant impact of diabetes on the morbidity and mortality of patients with chronic pancreatitis highlights the urgent need for clinically applicable models to predict diabetes in those with chronic pancreatitis, allowing efforts for targeted interventions to prevent diabetes. Research being carried out in the Consortium for the Study of Chronic Pancreatitis, Diabetes, and Pancreatic Cancer (CPDPC) holds promise to fulfill these goals.

Keywords

chronic pancreatitis; diabetes; risk factors; complications; prediction

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Conflicts of interest

There are no conflicts of interest.

Introduction

Diabetes is a frequently observed metabolic comorbidity in subjects with chronic pancreatitis (CP). In cohorts of adults with CP, 30-40% are found to have prevalent diabetes [1, 2]. Prospective studies have demonstrated an exceptionally high cumulative incidence of diabetes in CP during follow-up. A systematic review and meta-analysis of 15 studies, totaling 8,970 subjects with CP, found that the incidence of diabetes was 15% within 3 years and 33% after 5 years, yielding an overall incidence rate of 30% [3].

Diabetes is an important complication of CP. Diabetes in CP can be difficult to treat due to dysfunction of both insulin producing beta-cells and glucagon producing alpha-cells and progresses more rapidly to insulin dependence compared to type 2 diabetes mellitus (T2DM) [4]. Also, the long-term efficacy of antidiabetic medications is different between the two types of diabetes [5]. While subjects with CP are at a heightened risk of pancreatic cancer, the occurrence of diabetes greatly amplifies this risk. The morbid microvascular complications of diabetes (neuropathy, nephropathy, retinopathy) occur as frequently in diabetes in CP as typical diabetes [6]. Furthermore, diabetes amplifies the risk of cardiovascular events (myocardial infarction and stroke), particularly in CP subjects with exocrine pancreatic insufficiency (EPI) [7]. Therefore, there is an unmet clinical need for algorithms to predict which subjects with CP are at highest risk of developing diabetes, facilitating the application of targeted preventive measures.

Risk factors for diabetes in CP

Several studies have examined possible risk factors for diabetes in subjects with CP. Herein, we highlight several of the larger and more recent studies. Bellin et al. conducted a cross-sectional analysis in the North American Pancreatitis Study 2 (NAPS2), a multicenter cohort of subjects with CP of all etiologies [1]. Clinical features were compared between the 383 subjects with CP and diabetes and the 788 subjects with CP and no diabetes, using multivariable logistic regression to characterize the features independently associated with diabetes. This identified traditional risk factors for diabetes such as overweight (odds ratio (OR) 1.62) or obese (OR 2.83) status and family history of diabetes in a first degree relative (OR 1.48). Pancreatitis features associated with diabetes included EPI (OR 2.4), history of pancreatic surgery (OR 1.75), pancreatic calcifications (OR 1.58), duration of CP (OR 1.05), and age at CP onset (OR 1.02). Liu et al. found that in a cohort of 1,633 subjects with idiopathic CP followed for 10 years, independent risk factors for diabetes included adult at onset of CP (versus childhood or adolescent onset), biliary stricture (hazard ratio (HR) 2.52), steatorrhea (HR 2.01), and complex changes in the main pancreatic duct [8**]. These factors were used to construct a nomogram to predict diabetes; however, given that the model was based on CP without an identifiable cause (e.g., alcohol, ductal abnormality, hyperlipidemia), it is not widely applicable. Similar to the studies described above, among 1,287 subjects with CP, diabetes was more frequent in those with adult onset CP compared to childhood onset [2]. Among 587 consecutive CP subjects (excluding any who had had pancreatic surgery) followed for a median of 10 years (20% incident diabetes), independent risk factors for development of diabetes were EPI (OR 6.29), pancreatic duct stricture (OR 3.36), presence of ductal (OR 2.35) or parenchymal (OR 2.28) calcifications, and older

age (OR 1.08) [9*]. Pancreatic duct calcification and tobacco smoking were independent factors associated with earlier onset of diabetes. A cross-sectional analysis of 1,117 CP subjects, of whom 40% had diabetes, found that dyslipidemia (OR 4.42), obesity (OR 3.28), overweight (OR 1.72), age at CP diagnosis (OR 1.02), pancreatic calcification (OR 1.53), EPI (2.33), and history of pancreatic surgery (OR 2.21) were independent risk factors for diabetes [10**]. Overall, both traditional T2DM factors and pancreas-specific factors are associated with prevalent and incident diabetes in CP. A pathophysiologic explanation for this observation is that individuals predisposed to diabetes (whether through lifestyle, environment, and/or genetics) experience an accelerated progression to hyperglycemia when their beta-cells are exposed to the harmful effects of pancreatic inflammation and fibrosis. Another explanation (not mutually exclusive) is that the studied groups with diabetes in CP may consist of a mixture of individuals, some having underlying T2DM and others having diabetes directly caused by CP. In support of this possibility is the observation that, when stratifying the NAPS2 CP subjects with diabetes by timing of diabetes diagnosis relative to CP, obesity and family history were significantly associated with diabetes only in those with diabetes preceding CP [1].

Evidence for a role of substance use and abuse as a predisposing factor for diabetes in CP is mixed. Regarding alcohol use, a possible protective role for light/moderate use was noted in the NAPS2 study, with no association for heavy use [1]. In a 10-year prospective study comparing 404 subjects with alcoholic CP to 1,633 with idiopathic CP, the former had higher risk for developing diabetes, steatorrhea, and biliary stricture [11]. Within the 1,633 with idiopathic CP, smoking or alcohol use were not risk factors for diabetes [8]. In prospective study of 2,011 subjects with CP, alcohol abuse conferred a two-fold increased risk of developing diabetes [12], while in a smaller prospective study of 89 subjects with CP, those with alcoholic CP had similar risk of diabetes to non-alcoholic CP [13]. In a systematic review and meta-analysis of 15 studies, alcohol use did not emerge as a risk factor for incident diabetes [3]. The effects of tobacco smoking are difficult to assess because smoking itself is a risk factor for T2DM and those who smoke may also drink alcohol, making it difficult to assess independent effects. Smoking was found to be associated with deteriorating beta-cell function in a 6-month study of 325 subjects with CP [14*]. On the other hand, smoking was not a risk factor for diabetes among 1,633 subjects with idiopathic CP [8]. In another study, smoking and alcohol use were associated with incident diabetes in univariable analysis but were not significant independent factors in multivariable analysis [9].

The role of genetics in diabetes risk in CP has only recently been explored. A multicohort study calculated a genetic risk score (GRS) for T2DM in 3,544 individuals without diabetes or CP, 423 subjects with T2DM, and 321 subjects with diabetes and CP [15]. The hypothesis of the study was that if diabetes in CP is a distinct disease entity, subjects with this should be genetically distinct from subjects with typical T2DM. The GRS was a weighted sum of the risk alleles of 60 single nucleotide polymorphisms robustly associated with T2DM in prior genome-wide association studies. The mean GRS was identical between the subjects with CP-associated diabetes and those with T2DM (66.53 versus 66.42, p=0.77), and the GRS of both diabetic groups was significantly higher than that of non-diabetic controls. These data suggest that CP-associated diabetes may be a subtype of T2DM, whereby individuals

at genetic risk for T2DM progress to diabetes due to beta-cell function being compromised by CP. This study also established that aggregate genetic predisposition for T2DM is a risk factor for diabetes in CP, opening the possibility that genetics could be useful for prediction.

Natural History of Diabetes in the Course of Chronic Pancreatitis

Diabetes is a common comorbidity of CP with a point prevalence in cross-sectional studies of approximately 30-40% [1]. In prospective studies the incidence rates are approximately 15 to 26% at 10 years [8, 13]. However, in studies with long-term follow-up (>20 years), the cumulative prevalence rates are 46-83%, and may reach 90% at 50 years after CP onset, which more closely reflects an individual patient's lifetime risk [16-18]. Diabetes that develops in subjects with CP is generally assumed to be directly related to the CP, which can be justified by the low frequency of metabolic risk factors for T2DM (e.g., most CP subjects are not obese). However, there are situations (e.g., a patient with risk factors for T2DM with the onset of hyperglycemia years prior to development of CP symptoms) where the relative contributions are less clear. Nevertheless, the increased risk of diabetes over time in CP likely reflects an accumulation of damage to the pancreatic parenchyma. Destruction and loss of islets related to fibrosis and parenchymal atrophy contribute to insulin deficiency, which is generally believed to be the primary deficit in diabetes secondary to CP [6]. However, reductions in insulin secretion (adjusted for insulin sensitivity using the disposition index) have been observed in subjects with an early stage of CP prior to the development of advanced morphologic features [19]. Other potential contributing pathways include hepatic insulin resistance related to pancreatic polypeptide deficiency and decreased incretin hormone responsiveness, but the frequency and relative contributions of these abnormalities remain to be determined [6, 20].

Recent studies by the Clinical and epidemiOlogical inveStigations in Metabolism, nutritiOn, and pancreatic diseaseS (COSMOS) group have compared complications in subjects with diabetes in CP to those with T2DM, finding that diabetes in CP did not differ significantly from T2DM in terms of the risks of hospitalization or mortality for myocardial infarction, peripheral vascular disease, and cerebrovascular disease [21**, 22]. However, diabetes in CP compared to T2DM was associated with significantly higher risks of hospitalization for chronic pulmonary disease (HR 1.7), infectious disease (HR 1.4), and moderate to severe renal disease (HR 1.4), as well as higher all-cause mortality (HR 1.3). In a separate study, diabetes in CP was associated with a significantly higher risk of developing psychiatric disorders (adjusted HR of 3.0) than CP without diabetes [23].

Although CP is associated with an increased risk of pancreatic cancer compared to the general population, this risk is further increased in subjects with concurrent diabetes, as documented in healthcare and population-based databases [24-26]. It remains unclear if this accelerated risk reflects a paraneoplastic syndrome of diabetes similar to what has been observed in sporadic pancreatic cancer, or other pathways. Cancer mortality has been observed to be significantly higher in women with diabetes in CP as compared with either T2DM or type 1 diabetes (T1DM) [21]. The association between diabetes in CP and the risk of developing pancreatic cancer was investigated in an earlier cohort study from Taiwan [25]. The study included subjects with diabetes (including 262 people with diabetes in

CP) and randomly selected controls without diabetes who were matched at a 1:4 ratio and followed up for up to 10 years. In comparison with people without either diabetes or CP, those with diabetes and/or CP had significantly higher risks of developing pancreatic cancer. Specifically, people with diabetes without CP had an adjusted HR of 1.5, people with CP without diabetes had an age-adjusted HR of 29.3, and people with diabetes in CP had an age-adjusted HR of 33.5 [25]. An important limitation of that study was the inclusion of a large fraction of people who are at a negligible risk of pancreatic cancer (less than 55 years old). This limitation was addressed in a 2020 COSMOS study that included adults aged 55 and above with diabetes and/or pancreatitis [26**]. Risk estimates were adjusted for age, sex, tobacco smoking, alcohol abuse, social deprivation index, ethnicity, history of gallstones, cholecystectomy, and Charlson comorbidity index. The study showed that, in comparison with people with T2DM alone, people with pancreatitis without diabetes had an adjusted HR of 4.9, and people with diabetes in CP had an adjusted HR of 12.0 (both statistically significant) [26]. Taken together, the two studies suggest that CP and diabetes have multiplicative effect on the risk of developing pancreatic cancer. This may increase the effectiveness of screening for pancreatic cancer in the future, as outlined in the companion article in this issue of the Journal [ref].

CPDPC Studies Addressing Natural History and Prediction of Diabetes in CP

The PROspective Evaluation of Chronic Pancreatitis for EpidEmiologic and Translational StuDies (PROCEED) cohort is part of the Consortium for the Study of Chronic Pancreatitis, Diabetes, and Pancreatic Cancer, a cooperative agreement jointly funded by the National Cancer Institute and the National Institute of Diabetes and Digestive and Kidney Diseases [27]. The goal of PROCEED is to conduct a prospective study of well-phenotyped populations at different stages of CP and controls to accurately define CP progression and associated complications, including the development of diabetes. Biological samples from subjects provide a platform to develop and validate biomarkers of early diagnosis and prediction of disease progression, understand disease mechanisms, and discover genetic and other factors affecting susceptibility and progression. The study cohort consists of three well-phenotyped subcohorts representing different stages of CP who are being followed longitudinally to assess the development of new-onset diabetes. Currently the period prevalence of diabetes in the PROCEED subcohorts are 38% of ~600 subjects with definitive CP, 23% of ~325 subjects with recurrent acute pancreatitis (RAP), and 13% of 110 subjects with a history of a single episode of acute pancreatitis [Yadav D, personal communication]. Ancillary studies are designed to assess risk factors for the occurrence of diabetes (see below), mechanisms of disease, and possible therapeutic targets for prevention or amelioration of diabetes in CP.

Given the need to predict which subjects with CP will develop diabetes, the CPDPC plans to carry out a study called PREDICT3c. This study will derive and validate models that combine clinical features with genetic susceptibility to allow the prediction of future development of diabetes in subjects with CP. Identification of such subjects will allow clinicians to focus on diabetes prevention efforts in these individuals, as well

as facilitate research in this area. This study will be carried out within the PROCEED cohort. The predictive model will include traditional risk factors for T2DM (e.g., age, sex, BMI, smoking, family history of diabetes), as well as pancreas-specific factors that were observed to predispose to diabetes in CP (e.g., age at onset of CP, duration of CP, biliary stricture, EPI, alcoholic CP, distal pancreatectomy, pancreatic calcifications). Of note, alcohol abuse and tobacco smoking had mixed evidence in their association with diabetes in CP, warranting further evaluation. The model will be built using current (prevalent) cases of diabetes among PROCEED participants with CP or RAP at baseline, then validated in new cases (incident) occurring during follow-up in PROCEED. It will be critical to dissect which factors are independent predictors of diabetes, as several of these risk factors may correlate with each other. For example, imaging changes may reflect CP duration. Similarly, smoking has been associated with pancreatic calcification [28], and habits such as smoking and alcohol use frequently occur together. Given that genetic susceptibility for T2DM was associated with diabetes in CP [14], PREDICT3c will also assess whether a genetic risk score for T2DM can improve the ability of the model based on clinical risk factors to predict diabetes.

Conclusion

We have reviewed the risk factors and complications of diabetes in CP. These complications highlight the need to further understand the mechanistic underpinnings of the endocrine-exocrine interactions of the pancreas. As evidenced by the increased risk of morbidity and mortality, there is an unmet clinical need for algorithms to predict which patients with CP are at highest risk of developing diabetes, facilitating the application of targeted preventive measures. While several models exist for diabetes prediction in the general population [29, 30], this is not yet widely available in CP. Studies of the CPDPC are positioned to fulfill these needs, allowing clinicians to predict, prevent, and better treat diabetes in CP.

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References

1. Bellin MD, Whitcomb DC, Abberbock J, et al.Patient and disease characteristics associated with the presence of diabetes mellitus in adults with chronic pancreatitis in the United States. Am J Gastroenterol2017; 112:1457–1465. [PubMed: 28741615]
2. Schwarzenberg SJ, Uc A, Zimmerman B, et al.Chronic pancreatitis: pediatric and adult cohorts show similarities in disease progress despite different risk factors. J Pediatr Gastroenterol Nutr2019; 68:566–573. [PubMed: 30897605]
3. Zhu X, Liu D, Wei Q, et al.New-onset diabetes mellitus after chronic pancreatitis diagnosis: a systematic review and meta-analysis. Pancreas2019; 48:868–875. [PubMed: 31268977]

4. Woodmansey C, McGovern AP, McCullough KA, et al.Incidence, demographics, and clinical characteristics of diabetes of the exocrine pancreas (type 3c): a retrospective cohort study. Diabetes Care2017; 40:1486–1493. [PubMed: 28860126]
5. Cho J, Scragg R, Pandol SJ, et al.Antidiabetic medications and mortality risk in individuals with pancreatic cancer-related diabetes and postpancreatitis diabetes: A nationwide cohort study. Diabetes Care2019; 42:1675–1683. [PubMed: 31227582]
6. Hart PA, Bellin MD, Andersen DK, et al.Type 3c (pancreatogenic) diabetes mellitus secondary to chronic pancreatitis and pancreatic cancer. Lancet Gastroenterol Hepatol2016; 1:226–237. [PubMed: 28404095]
7. de la Iglesia D, Vallejo-Senra N, Lopez-Lopez A, et al.Pancreatic exocrine insufficiency and cardiovascular risk in patients with chronic pancreatitis: A prospective, longitudinal cohort study. J Gastroenterol Hepatol2019; 34:277–283. [PubMed: 30156337]
8. Liu Y, Wang D, Guo HL, et al.Risk factors and nomogram for diabetes mellitus in idiopathic chronic pancreatitis. J Gastroenterol Hepatol2020; 35:343–352. [PubMed: 31318997] ** Large prospective study of diabetes developing in subjects with idiopathic chronic pancreatitis. First study that used the identified risk factors to build and validate a prediction model.
9. Aslam M, Jagtap N, Karyampudi A, et al.Risk factors for development of endocrine insufficiency in chronic pancreatitis. Pancreatology2021; 21:15–20. [PubMed: 33257226] * Retrospective study that examined risk factors for development of diabetes in patients with chronic pancreatitis. A unique feature of this study was that it also examined factors associated with earlier onset of diabetes.
10. Olesen SS, Poulsen JL, Novovic S, et al.Multiple risk factors for diabetes mellitus in patients with chronic pancreatitis: A multicentre study of 1117 cases. United European Gastroenterol J2020; 8:453–461. ** Large study finding that both risk factors for type 2 diabetes as well as features of pancreatic damage are associated with diabetes in chronic pancreatitis.
11. Hao L, Wang LS, Liu Y, et al.The different course of alcoholic and idiopathic chronic pancreatitis: A long-term study of 2,037 patients. PLoS One2018; 13:e0198365. [PubMed: 29883461]
12. Pan J, Xin L, Wang D, et al.Risk factors for diabetes mellitus in chronic pancreatitis: a cohort of 2011 patients. Medicine (Baltimore)2016; 95:e3251. [PubMed: 27057870]
13. Machicado JD, Chari ST, Timmons L, et al.A population-based evaluation of the natural history of chronic pancreatitis. Pancreatology2018; 18:39–45. [PubMed: 29221631]
14. Gutama BW, Yang Y, Beilman GJ, et al.Risk factors associated with progression toward endocrine insufficiency in chronic pancreatitis. Pancreas2019; 48:1160–1166. [PubMed: 31593013] * Novel study that examined risk factors for longitudinal decline in beta-cell function as measured during mixed meal tolerance testing.
15. Goodarzi MO, Nagpal T, Greer P, et al.Genetic risk score in diabetes associated with chronic pancreatitis versus type 2 diabetes mellitus. Clin Transl Gastroenterol2019; 10:e00057. [PubMed: 31232720]
16. Malka D, Hammel P, Sauvanet A, et al.Risk factors for diabetes mellitus in chronic pancreatitis. Gastroenterology2000; 119:1324–1332. [PubMed: 11054391]
17. Wang W, Guo Y, Liao Z, et al.Occurrence of and risk factors for diabetes mellitus in Chinese patients with chronic pancreatitis. Pancreas2011; 40:206–212. [PubMed: 21404458]
18. Pan J, Xin L, Wang D, et al.Risk Factors for Diabetes Mellitus in Chronic Pancreatitis: A Cohort of 2,011 Patients. Medicine (Baltimore)2016; 95:e3251. [PubMed: 27057870]
19. Lundberg R, Beilman GJ, Dunn TB, et al.Early Alterations in Glycemic Control and Pancreatic Endocrine Function in Nondiabetic Patients With Chronic Pancreatitis. Pancreas2016; 45:565–571. [PubMed: 26918872]
20. Brunicardi FC, Chaiken RL, Ryan AS, et al.Pancreatic polypeptide administration improves abnormal glucose metabolism in patients with chronic pancreatitis. J Clin Endocrinol Metab1996; 81:3566–3572. [PubMed: 8855802]
21. Cho J, Pandol SJ, Petrov MS. Risk of cause-specific death, its sex and age differences, and life expectancy in post-pancreatitis diabetes mellitus. Acta Diabetol2021. ** Nationwide study that examined vascular, cancer, and all-cause mortality in post-pancreatitis diabetes compared to type 1 and type 2 diabetes, with analyses stratified by sex, type of pancreatitis, and age. This was the first study to find sex-related differences in cause-specific mortality in diabetes related to pancreatitis.

22. Cho J, Scragg R, Petrov MS. Risk of mortality and hospitalization after post-pancreatitis diabetes mellitus vs type 2 diabetes mellitus: a population-based matched cohort study. Am J Gastroenterol2019; 114:804–812. [PubMed: 31021833]

23. Cho J, Walia M, Scragg R, et al.Frequency and risk factors for mental disorders following pancreatitis: a nationwide cohort study. Curr Med Res Opin2019; 35:1157–1164. [PubMed: 30614299]

24. Munigala S, Subramaniam DS, Subramaniam DP, et al.Incidence and risk of pancreatic cancer in patients with a new diagnosis of chronic pancreatitis. Dig Dis Sci2021.

25. Liao KF, Lai SW, Li CI, et al.Diabetes mellitus correlates with increased risk of pancreatic cancer: a population-based cohort study in Taiwan. J Gastroenterol Hepatol2012; 27:709–713. [PubMed: 21929650]

26. Cho J, Scragg R, Petrov MS. Postpancreatitis diabetes confers higher risk for pancreatic cancer than type 2 diabetes: Results from a nationwide cancer registry. Diabetes Care2020; 43:2106–2112. [PubMed: 32616613] ** Large population-based study that examined the risk of pancreatic cancer in pancreatitis, post-pancreatitis diabetes, and type 2 diabetes. A unique feature was that the study examined the risk of pancreatic cancer in pancreatitis alone as well as combined with the two types of diabetes.

27. Yadav D, Park WG, Fogel EL, et al.PROspective Evaluation of Chronic Pancreatitis for EpidEmiologic and Translational StuDies: Rationale and study design for PROCEED from the Consortium for the Study of Chronic Pancreatitis, Diabetes, and Pancreatic Cancer. Pancreas2018; 47:1229–1238. [PubMed: 30325862]

28. Maisonneuve P, Frulloni L, Mullhaupt B, et al.Impact of smoking on patients with idiopathic chronic pancreatitis. Pancreas2006; 33:163–168. [PubMed: 16868482]

29. Hippisley-Cox J, Coupland C. Development and validation of QDiabetes-2018 risk prediction algorithm to estimate future risk of type 2 diabetes: cohort study. BMJ2017; 359:j5019. [PubMed: 29158232]

30. Lindstrom J, Tuomilehto J. The diabetes risk score: a practical tool to predict type 2 diabetes risk. Diabetes Care2003; 26:725–731. [PubMed: 12610029]

Key points

- Risk factors for diabetes in chronic pancreatitis include both risk factors for type 2 diabetes as well as pancreas-specific factors.
- The frequency of diabetes in chronic pancreatitis is closely linked to the duration of chronic pancreatitis.
- Patients with diabetes in chronic pancreatitis have greater morbidity and mortality than those with type 1 or type 2 diabetes.
- Current research focused on understanding the natural history and predictors of diabetes in chronic pancreatitis promises to improve the health of these patients.