Surgical Trends in Chronic Pancreatitis From 2014 to 2021

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Objectives: We analyzed annual surgical trends for benign chronic pancreatitis (CP), studying specifically mortality, morbidity, and pancreatic fistula rates. We also aimed to identify predictors of pancreatic fistula formation.

Materials and Methods: For this analysis, we used data from the American College of Surgeons National Surgical Quality Improvement Program from 2014 to 2021. The study included patients who underwent surgery for benign CP. Data collected included patient demographics, preoperative variables, and postoperative outcomes. Data were analyzed with univariate and multivariate analyses, with significance defined as $P \leq 0.05$.

Results: Over the study period, the number of pancreatic surgical procedures increased by 49.3%, although surgery specifically for CP declined by 31.7%. The rate of pancreatic fistula formation decreased 44.9%, and mortality decreased 31.9%. Significant predictors of a pancreatic fistula included no diabetes, preoperative sepsis, soft texture of the pancreatic gland, and greater patient weight.

Conclusion: Surgery for benign CP decreased substantially despite the established efficacy of surgical intervention for long-term pain management. The concurrent decline in mortality and rates of pancreatic fistula formation suggest advances over the study years in surgical and postoperative care.

Key Words: chronic pancreatitis, National Surgical Quality Improvement Program, pancreatic fistula, surgical trends

Abbreviations: ACS NSQIP — American College of Surgeons National Surgical Quality Improvement Program, CP — chronic pancreatitis, EUS — endoscopic ultrasound

(*Pancreas* 2025;54:e310–e316)

Chronic pancreatitis (CP), a fibroinflammatory disorder, presents with exocrine and endocrine deficiencies, extensive fibrosis, and persistent abdominal pain.[1] The complex nature of CP makes managing symptoms, especially abdominal pain, a challenge.[2] Treatment strategies include supplementing pancreatic enzymes, managing diabetes, and progressively approaching pain management—from lifestyle modifications to medical, endoscopic, and surgical interventions.[3] Surgical options are considered for suspected malignancy, relentless pain, duodenal obstruction, or obstructions in the pancreatic and bile ducts.[3]

Advances in surgical techniques and perioperative care have substantially reduced the morbidity and mortality associated with pancreatic surgery. Currently, mortality rates are below 5%, with excellent long-term outcomes.[3] The choice of surgical technique is heavily influenced by the pancreatic morphology and the specific site of inflammation and disease.[4]

Recent studies reported findings for outcomes of different surgical techniques for CP. In a 2023 study, the Frey procedure was associated with a 90-day mortality rate of 1%, and 31% of patients experienced postoperative complications.[5] In a study from 2020, the Puestow procedure had a 30-day mortality rate of 1%, and 20% of patients had at least 1 clinically significant complication at 30 days.[6] In another recent study, multivariable analysis identified factors that influenced rates of pancreatic fistula formation, which decreased significantly between 2014 and 2017.[7]

Even with these few published studies, the best type of surgical procedure for treating CP remains inadequately defined. A retrospective analysis of 1120 pancreatic resections showed an increase in resection over time, with CP accounting for the diagnosis in one-third of these procedures.[8] Because CP is increasing in prevalence,[1] in this study we aimed to analyze annual surgical trends for benign CP, examining specifically mortality, morbidity, and rates of pancreatic fistula formation.[1] We also aimed to identify predictors of pancreatic fistula formation after CP surgery. We believe that identifying these predictors will help clinicians and patients understand the risk of developing this adverse outcome.

MATERIALS AND METHODS

We used data from the American College of Surgeons National Surgery Quality Improvement Program (ACS NSQIP), focusing on pancreatectomy procedures from the years 2014 to 2021. ACS NSQIP is a nationally recognized, risk-adjusted, outcomes-based program designed to measure and improve the quality of surgical care in hospitals. It collects clinical data on surgical procedures from participating institutions, focusing on 30-day postoperative outcomes such as complications, mortality, and morbidity. The data are then used to benchmark performance across hospitals, identify areas for improvement, and drive evidence-based changes to enhance patient safety and surgical outcomes.[9] In addition to these data, there is a specialized dataset within the ACS NSQIP framework that focuses on collecting detailed clinical data specific to pancreatectomy procedures. This file includes information on variables and outcomes specifically related to pancreatectomy, such as complications (eg, pancreatic fistula, delayed gastric emptying), mortality, length of stay, and other relevant metrics.[10] This specific pancreatectomy data set did not include lateral pancreaticojejunostomy and total pancreatectomy with islet cell autotransplantation procedures; therefore, lateral

Received for publication April 30, 2024; accepted November 8, 2024.
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Presented at the American Pancreatic Association Annual Meeting; November 15–18, 2023; Coronado, California.
The authors declare no conflict of interest.

DOI: 10.1097/MPA.0000000000002438

pancreaticojejunostomy was not included in pancreatic fistula analysis. Approval was not needed to use the data.

Patient Selection and Inclusion Criteria

Adult patients older than 18 years with benign CP were included. Patients with malignant histologic findings after pancreatic resection were excluded, as were patients with severe acute pancreatitis. Patients who underwent lateral pancreaticojejunostomy were also included, regardless of the need for specific pathological findings. We assumed that this procedure is indicated specifically for CP, and those with signs of malignancy would undergo a different procedure. We also analyzed for pancreatic fistula formation; however, these analyses did not include cases of total pancreatectomies with islet cell autotransplantation or lateral pancreaticojejunostomy because of a lack of specific pancreatic data in the ACS NSQIP database for these types of surgical procedures. Data for pancreatic fistula are not available for lateral pancreaticojejunostomy procedures. A clinically relevant pancreatic fistula was defined as grade B or C for the purpose of this study.

Surgical Categories and Sample Size

Surgical procedures were categorized into 5 types: distal pancreatectomy, lateral pancreaticojejunostomy, total pancreatectomy, total pancreatectomy with islet cell autotransplantation, and the Whipple procedure (pancreaticoduodenectomy). The study comprised a total of 3250 patients who underwent these procedures from 2014 to 2021.

Data Analysis and Statistical Methods

A composite outcome variable was used to assess morbidity and included mortality and the following complications: cardiac, neurologic, pulmonary, kidney, surgical wound, deep vein thrombosis, and pulmonary embolism. The number and percentage of adverse outcomes were determined for each of the 5 surgery groups. Mean and median were used to describe operative times and hospital length of stay. Mortality was also compared for 2 time frames: 2014 through 2017 and 2018 through 2021 to look for differences by years. Percent mortality between the 2 time periods was compared. Data for the specified periods were obtained from the ACS NSQIP database, and temporal trends in pancreatic surgical procedures for benign CP were analyzed for all pancreatic surgical procedures from 2014 to 2021, which included all indications and diagnoses, such as cancer and acute pancreatitis.

Univariate analysis was used to determine the number of pancreatic surgical procedures per year from 2014 to

TABLE 1. Demographic Characteristics of the Study Cohort*

Characteristic	All Surgical Procedures (N = 3250)	Lateral Pancreatico-Jejunostomy (n = 487)	Distal Pancreatectomy (n = 1074)	Whipple Procedure (n = 1207)	Total Pancreatectomy/ Total With IAT† (n = 482)
Age, mean (SD)	52.2 (14.0)	53.2 (13.3)	52.9 (14.1)	55.2 (12.3)	42.4 (14.1)
BMI, mean (SD)	26.1 (6.2)	24.8 (6.2)	27.1 (6.2)	25.5 (5.7)	26.7 (6.8)
Obesity (BMI ≥ 30)	739 (22.7)	72 (14.8)	293 (27.3)	230 (19.1)	144 (29.9)
Death, 30 d postoperative	34 (1.0)	2 (0.4)	9 (0.8)	18 (1.5)	5 (1.0)
Sex					
Women	1462 (45.0)	223 (45.8)	460 (42.8)	504 (41.8)	275 (57.1)
Men	1788 (55.0)	264 (54.2)	614 (57.2)	703 (58.2)	207 (42.9)
Race					
Black	361 (11.1)	69 (14.2)	109 (10.1)	156 (12.9)	27 (5.6)
White	2578 (79.3)	358 (73.5)	851 (79.2)	935 (77.5)	424 (88.0)
Other/unknown	321 (9.9)	60 (12.3)	114 (10.6)	116 (9.6)	31 (6.4)
Transfusions (≥ 1 unit PRBC 72 h before surgery)	40 (1.2)	2 (0.4)	26 (2.4)	9 (0.7)	3 (0.6)
Ascites	18 (0.6)	2 (0.4)	10 (0.9)	4 (0.3)	2 (0.4)
Current smoker (within 1 y)	1352 (41.6)	210 (43.1)	421 (39.2)	590 (48.9)	131 (27.2)
Diabetes requiring insulin	634 (19.5)	110 (22.6)	206 (19.2)	219 (18.1)	99 (20.5)
Non–insulin-dependent diabetes	337 (10.4)	53 (10.9)	122 (11.4)	132 (10.9)	30 (6.2)
Functional health, partial or totally dependent	29 (0.9)	6 (1.2)	12 (1.1)	12 (1.0)	3 (0.6)
COPD	175 (5.4)	30 (6.2)	54 (5.0)	79 (6.5)	12 (2.5)
Ventilator dependent	12 (0.4)	1 (0.2)	10 (0.9)	1 (0.1)	0 (0.0)
Heart failure (30 d before surgery)	16 (0.5)	3 (0.6)	7 (0.7)	3 (0.2)	3 (0.6)
Hypertension requiring medication	1461 (45.0)	226 (46.4)	511 (47.6)	566 (46.9)	158 (32.8)
Dialysis, preoperative	19 (0.6)	3 (0.6)	7 (0.7)	6 (0.5)	2 (0.4)
Disseminated cancer	16 (0.5)	4 (0.8)	4 (0.4)	7 (0.6)	1 (0.2)
Bleeding disorders	91 (2.8)	8 (1.6)	42 (3.9)	31 (2.6)	10 (2.1)
Immunosuppressive therapy	115 (3.5)	16 (3.3)	42 (3.9)	38 (3.1)	19 (3.9)
Sepsis/septic shock/SIRS	79 (2.4)	15 (3.1)	42 (3.9)	15 (3.1)	7 (1.4)
ASA classification III	2379 (73.2)	355 (72.9)	763 (71.0)	908 (75.2)	353 (73.2)
ASA classification IV	159 (4.9)	23 (4.7)	67 (6.2)	59 (4.9)	10 (2.1)
ASA classification V	3 (0.1)	0 (0.0)	2 (0.2)	1 (0.1)	0 (0.0)

*Data are presented as no. (%) unless indicated otherwise.

†Total pancreatectomy and total pancreatectomy with IAT were grouped together for analysis.

ASA indicates American Society of Anesthesiologists; BMI, body mass index (calculated as weight in pounds divided by height in inches squared × 703); COPD, chronic obstructive pulmonary disease; IAT, islet cell transplantation; PRBC, packed red blood cells; SIRS, systemic inflammatory response syndrome.

2021, the number of pancreatic surgical procedures for benign CP from 2014 to 2021, mortality trends for pancreatic surgical procedures for benign CP from 2014 to 2021, temporal trend by type of procedure for CP, and trends in clinically relevant pancreatic fistulas. Univariate analysis was also used to create the tables of patient demographics, adverse outcomes, and composite adverse outcomes. The focus was patient outcomes within 30 days after surgery. Multivariate regression analysis was also performed. Significance was established at a P value ≤ 0.05. SPSS software, version 29 (IBM), was used for all statistical analyses.

RESULTS

Demographic Characteristics and Surgical Categories

Our cohort consisted of 3250 patients. Demographic characteristics, preoperative values, and surgical outcomes for each category of surgery were tabulated and are presented in Table 1. Pancreaticoduodenectomy was the predominant surgery in 1207 (37.1%) cases, followed by distal pancreatectomy in 1074 (33.0%) cases, lateral pancreaticojejunostomy in 487 (15.0%) cases, total pancreatectomy with islet cell autotransplantation in 337 (10.4%) cases, and total pancreatectomy in 145 (4.5%) cases. The mean (SD) patient age was 52.2 (14.0) years, 45.0% (1462) of the study cohort were women, and 79.3% (2578) identified as White. The mean (SD) body mass index was 26.1 (6.2) (calculated as weight in kilograms divided by height in meters squared). Notably, 41.6% (1,352) of the patients were current smokers, and 19.5% (634) had diabetes requiring insulin therapy (Table 1).

Morbidity and the Composite Outcome Variable

Adverse outcomes for each type of surgical procedure are shown in Table 2, with organ space surgical site infection, pneumonia, bleeding requiring transfusion, and sepsis being among the most common adverse outcomes. Of the cohort, 22.3% had composite comorbid conditions (Table 3).

Mortality Analysis

Mortality was defined as death within 30 days after surgery. During the study period, 1.0% of the patients died.

TABLE 2. Adverse Outcomes*

Outcome	All Surgical Procedures (N = 3250)	Lateral Pancreatico-Jejunostomy (n = 487)	Distal Pancreatectomy (n = 1074)	Whipple Procedure (n = 1207)	Total Pancreatectomy/ Total With IAT† (n = 482)
Superficial incisional SSI	171 (5.3)	33 (6.8)	41 (3.8)	72 (6.0)	25 (5.2)
Deep incisional SSI	46 (1.4)	10 (2.1)	12 (1.1)	17 (1.4)	7 (1.5)
Organ space SSI	349 (10.7)	31 (6.4)	135 (12.6)	145 (12.0)	38 (7.9)
Wound disruption	35 (1.1)	4 (0.8)	5 (0.5)	17 (1.4)	9 (1.9)
Pneumonia	131 (4.0)	16 (3.3)	31 (2.9)	63 (5.2)	21 (4.4)
Unplanned intubation	103 (3.2)	9 (1.8)	27 (2.5)	51 (4.2)	16 (3.3)
Pulmonary embolism	31 (1.0)	2 (0.4)	16 (1.5)	9 (0.8)	4 (0.8)
Ventilator >48 h	90 (2.8)	7 (1.4)	30 (2.8)	36 (3.0)	17 (3.5)
Postoperative dialysis (acute renal failure), no.	14 (0.4)	3 (0.6)	2 (0.2)	7 (0.6)	2 (0.4)
Urinary tract infection	60 (1.8)	10 (2.1)	14 (3.1)	22 (1.8)	14 (2.9)
Stroke/CVA with neurologic deficit	7 (0.2)	1 (0.2)	4 (0.4)	1 (0.1)	1 (0.2)
Cardiac arrest requiring CPR	26 (0.8)	0 (0.0)	5 (0.5)	17 (1.4)	4 (0.8)
Myocardial infarction	14 (0.4)	3 (0.6)	6 (0.6)	5 (0.4)	0 (0.0)
Bleeding requiring perioperative transfusion	630 (19.4)	36 (7.4)	216 (20.1)	219 (18.1)	159 (33.0)
DVT/thrombophlebitis requiring therapy	72 (2.2)	5 (1.0)	14 (1.3)	31 (2.6)	22 (4.5)
Sepsis	225 (6.9)	26 (5.3)	77 (7.2)	95 (7.9)	27 (5.6)
Septic shock	79 (2.4)	6 (1.2)	23 (2.1)	37 (3.1)	13 (2.7)
Return to OR	162 (5.0)	19 (3.9)	38 (3.5)	52 (4.3)	53 (11.0)
Hospitalization >30 d	58 (1.8)	9 (1.8)	18 (1.7)	23 (1.9)	8 (1.7)
At least 1 unplanned reoperation	162 (5.0)	19 (3.9)	38 (3.5)	52 (4.3)	53 (11.0)
Clostridioides difficile, no.	38 (1.2)	5 (1.0)	10 (0.9)	15 (1.2)	8 (1.7)
Preoperative biliary stent	565 (17.4)	NA‡	124 (11.5)	420 (34.8)	21 (4.4)‡
Drain	2069 (63.7)	NA‡	949 (88.4)	1057 (87.6)	63 (13.1)‡
Operative drain present at POD 30	204 (6.3)	NA‡	99 (9.2)	102 (8.5)	3 (0.6)‡
Delayed gastric emptying	264 (8.1)	NA‡	68 (6.3)	179 (14.8)	17 (3.5)‡
Operative time, mean (SD), min	319.3 (155.1)	234 (100.8)	237.1 (109.2)	357.4 (125.5)	493.3 (172.2)
Hospital length of stay, median (IQR), d	7 (5–12)	7 (5–9)	6 (5–9)	8 (6–12)	10 (8–14)

*Data are presented as no. (%) unless otherwise indicated.
†Total pancreatectomy and total pancreatectomy with IAT were grouped together for analysis.
‡Data are not available for lateral pancreaticojejunostomy or total pancreatectomy with islet cell autotransplantation.
CPR indicates cardiopulmonary resuscitation; CVA, cerebrovascular accident; DVT, deep vein thrombosis; IAT, islet cell transplantation; NA, not applicable; OR, operating room; POD, postoperative day; SSI, surgical site infection.

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TABLE 3. Composite Adverse Outcomes

Variable	No. (%)*
Mortality	34 (1.0)
Complication	
Cardiac†	37 (1.1)
Neurologic‡	7 (0.2)
Pulmonary§	204 (6.3)
Renal‖	14 (0.4)
DVT/PE	91 (2.8)
Surgical wound¶	532 (16.4)
Urinary tract infection	60 (1.8)
Perioperative transfusion	630 (19.4)
Return to operating room	162 (5.0)
Unplanned readmission	560 (17.2)
Operative time, mean (SD)	319.3 (155.1)
Hospital length of stay, mean (SD)	9.0 (3.1)
Composite outcome#	725 (22.3)

*Data are presented as no. (%) unless specified otherwise.
†Myocardial infarction, cardiac arrest.
‡Stroke.
§Reintubation, ventilator >48 h, pneumonia.
‖Postoperative dialysis.
¶Superficial, deep, organ space, wound disruption.
#Mortality, cardiac, neurologic, pulmonary, renal, DVT/PE, surgical wound complications.
DVT indicates deep vein thrombosis; PE, pulmonary embolism.

The time period comparison showed that mortality decreased from 1.22% in 2014 through 2017 to 0.83% in 2018 through 2021, equating to a 31.9% decrease. However, this difference was not statistically significant ($P = 0.30$) (Fig. 1).

Trends in Surgical Procedures

An increase of 49.3% in pancreatic surgical procedures for all indications was observed from 2014 to 2021 (Fig. 2). In contrast, surgery specifically for benign CP decreased by 31.7% in the same time frame (Fig. 3). Temporal trends for the 5 types of surgery are shown in Figure 4.

Trends in Pancreatic Fistula Formation and Predictors

A substantial 44.9% decrease in the formation of pancreatic fistulas occurred from 2014 to 2021 (Fig. 5). Significant predictors ($P < 0.05$) of clinically relevant pancreatic fistula were identified as absence of diabetes, preoperative sepsis, soft texture of the pancreatic gland, and greater patient weight (Table 4).

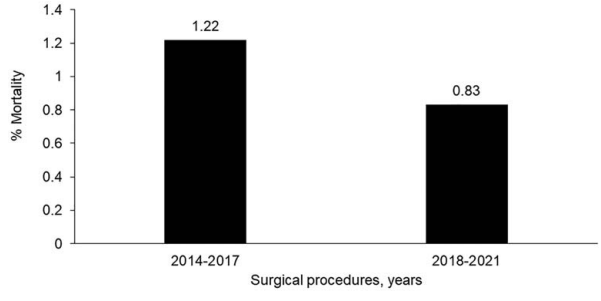

FIGURE 1. Change in % mortality in pancreatic surgical procedures for benign chronic pancreatitis between the 2 compared time periods.

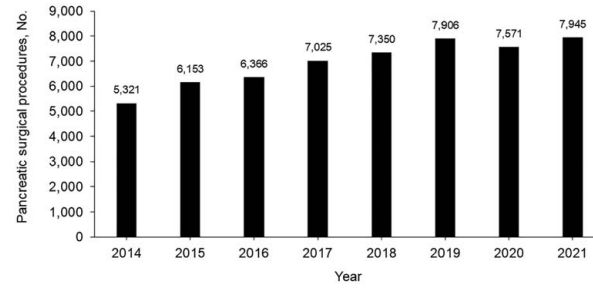

FIGURE 2. Number of pancreatic surgical procedures by year from 2014 to 2021.

DISCUSSION

Our study showed a 31.7% decline in surgery for CP from 2014 to 2021, which was different from our expectations, which were based on the effectiveness of surgery as a long-term treatment for benign CP. This decrease contrasts to the overall 49.3% increase in all pancreatic surgery, indicating a specific decline in surgery for CP, despite the known benefits. This finding differs from a study that reported a general increase in pancreatic procedures.[8]

Our study had similar outcomes for mortality and morbidity as in studies by Ray et al[5] and Napolitano et al.[6] Napolitano et al[6] reported a 1.2% 30-day mortality rate and a 19.7% morbidity rate. Ray et al[5] reported a 1% 90-day mortality rate and a 31% morbidity rate. These similarities across studies suggest a consistency in surgical outcomes. Moreover, the observed trend in fewer surgical procedures for CP seems independent of the COVID-19 pandemic, as indicated by the consistent decrease since 2014.

Over the course of our study, the incidence of pancreatic fistula formation decreased markedly, consistent with trends reported by Panni et al.[7] Our analysis identified several predictive factors associated with the development of pancreatic fistulas, offering new insights into the etiology of this challenging surgical complication. However, it is important to acknowledge the limitations of the ACS NSQIP database, particularly its 30-day postoperative follow-up period as well as the heterogeneity of CP presentations. Our discovery of significant risk factors aligns with the known pathophysiology of CP. For instance, in patients with long-standing diabetes, the pancreas is often more fibrotic and scarred than it is in patients without diabetes, whose pancreatic tissue tends to be more

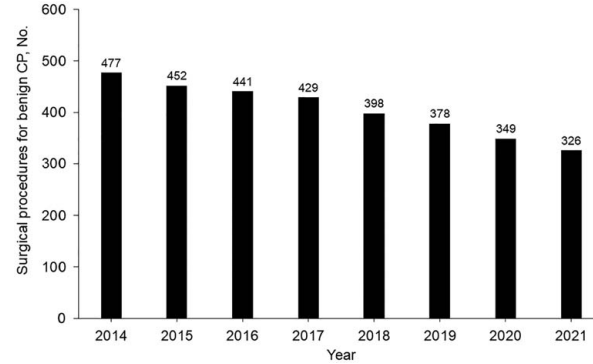

FIGURE 3. Surgical procedures for benign CP from 2014 to 2021. CP indicates chronic pancreatitis.

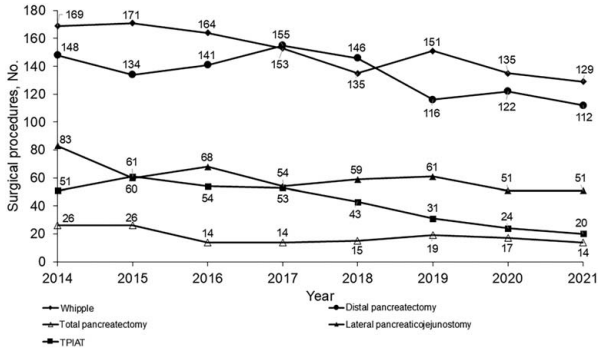

FIGURE 4. Temporal trend by type of surgery for chronic pancreatitis. TPIAT indicates total pancreatectomy with islet cell autotransplantation.

vascularized and pliable.[11,12] Our finding of increased pancreatic fistulas in those without diabetes can be explained partly because exocrine function is preserved in patients without diabetes, which results in the release of proteolytic enzymes in the pancreatic juice. With any anastomotic leakage, these enzymes can activate, causing local and systemic reactions.[13] Additionally, soft gland texture, which has been independently linked to an increased risk of fistula formation, likely contributes by complicating the creation of a secure anastomosis—one cause being the increased likelihood of sutures tearing through the soft tissue parenchyma.[13] The presence of sepsis further exacerbates this risk, as its associated inflammatory and vasodilatory effects can compromise tissue integrity and anastomotic healing.[14,15] Furthermore, greater patient body weight may augment the technical challenges of pancreatic surgery, potentially leading to higher complication rates, including fistula development. By elucidating these factors, our findings may facilitate more precise preoperative patient selection and allow surgeons to anticipate and mitigate potential adverse outcomes, ultimately improving surgical outcomes for high-risk populations.

The observed decline in surgical procedures for CP and the corresponding decrease in mortality rates may reflect improvements in surgical techniques, more refined patient selection, and advances in both medical and endoscopic therapies. Innovative endoscopic approaches, such as pancreatoscopy-guided electrohydraulic lithotripsy, have emerged as promising treatment options for patients with obstructive chronic calcifying pancreatitis, potentially

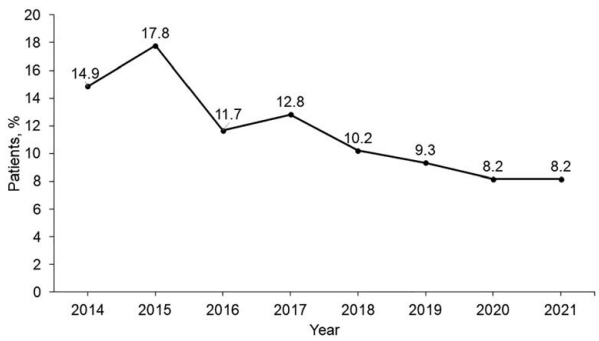

FIGURE 5. Temporal trend by year for formation of clinically relevant pancreatic fistulas.

reducing the need for surgical intervention.[16] Historically, surgical management was the mainstay for CP complicated by pseudocyst formation. However, more recent studies have shown the efficacy of endoscopic treatments, significantly altering the treatment paradigm. A 2013 study comparing surgical cystogastrostomy with endoscopic cystogastrostomy for the treatment of pancreatic pseudocysts revealed no superiority of the surgical approach. Furthermore, endoscopic therapies were associated with lower costs, reduced hospital stays, and improved physical and mental health outcomes for patients, further reinforcing their value in clinical practice.[17] Another factor potentially contributing to reduced surgical rates has been the advent and refinement of endoscopic ultrasound (EUS) with biopsy capabilities, which has substantially improved the ability to exclude concurrent malignant lesions in patients with CP. Surgical intervention was often pursued previously because malignancy could not be definitively excluded. With the enhanced diagnostic precision offered by EUS, many patients can avoid unnecessary surgical procedures. Although the patients in our study were ultimately diagnosed with benign CP, the possibility of malignancy may have influenced surgical decisions in prior eras, underscoring the importance of these diagnostic advances in guiding contemporary clinical decision making.

A 2007 study by Cahen et al[18] looked at pain reduction outcomes between endoscopic therapies and surgical drainage for management of CP with pancreatic duct obstruction. At 2-year follow-up, they found that the surgical drainage group had significantly lower pain scores than the endoscopic group. This same study group was followed up again 5 years postintervention, and the surgery group continued to have more pain relief and fewer procedures than the endoscopy group.[19] A 2020 study by Issa et al[20] compared early surgery versus endoscopy for treatment of CP. This study found that the surgery group had lower pain scores over 18 months than the endoscopy group, although complete and partial pain relief, quality of life, and pancreatic function between the 2 groups were not statistically significant.

Current clinical guidelines recommend that celiac plexus nerve block may be considered when medical management fails, although its efficacy remains uncertain.[21] If pain persists, either endoscopic or surgical interventions are recommended. For a pancreatic duct less than 6 mm, surgical resection is preferred, whereas a dilated duct (>6 mm) warrants either endoscopy or surgery, both aimed at improving ductal flow.[22] Although surgery offers superior long-term pain relief, both physicians and patients may prefer endoscopic treatments in clinical practice due to their less invasive nature. This may contribute to a reduction in surgical procedures, despite their proven efficacy of better long-term pain outcomes. Given the complexity of treating CP, endoscopic intervention may ultimately improve outcomes without the risks associated with pancreatic surgery. If true, the current opinion that surgery is the best option for long-term pain management for patients with benign CP may change. More studies comparing surgery to endoscopy are needed.

This study has limitations. The ACS NSQIP database only includes 30-day follow-up, making it difficult to evaluate surgery for chronic conditions, such as CP. In addition, the database does not include data on important factors, such as pain levels, quality of life, or surgical techniques used. The database also does not differentiate

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TABLE 4. Predictors for Formation of a Clinically Relevant Pancreatic Fistula

Predictor	Reference	Adjusted OR (95% CI)	P*
Diabetes (insulin)	No	1.59 (1.11–2.33)	0.01
	Diabetes, noninsulin	1.62 (0.99–2.65)	0.05
Smoke (no)	Yes	0.90 (0.68–1.18)	0.45
Emergency (no)	Yes	3.29 (0.90–11.69)	0.06
Sepsis (no)	Sepsis	6.57 (2.41–17.75)	< 0.001
	Septic shock	1.54 (0.19–8.22)	0.64
	SIRS	0.33 (0.05–1.33)	0.18
Pancreatic duct size (< 3 mm)	6 mm	0.64 (0.37–1.07)	0.10
	3–6 mm	0.70 (0.47–1.04)	0.07
	Unknown	0.81 (0.55–1.19)	0.28
Gland texture (hard)	Intermediate	1.22 (0.71–2.02)	0.45
	Soft	2.07 (1.46–2.94)	< 0.001
	Unknown	1.12 (0.80–1.57)	0.49
Type of surgery (pancreaticoduodenectomy)	Distal pancreatectomy	1.24 (0.91–1.69)	0.18
	Total pancreatectomy	0.46 (0.18–0.98)	0.06
Age		1.00 (0.99–1.01)	0.40
Weight		1.01 (1.00–1.01)	< 0.001
Preoperative WBC count		1.00 (0.99–1.01)	0.69

*Logistic regression.
OR indicates odds ratio; SIRS, systemic inflammatory response syndrome; WBC, white blood cells.

between high-volume and low-volume surgical centers, which can affect outcomes, nor does it include lateral pancreatojejunostomy or total pancreatectomy with islet cell autotransplantation surgeries in the pancreas-specific data file. Although attempts are made to ensure the collection of reliable and accurate data, potential inconsistencies or inaccuracies may be possible among the participating institutions.

In conclusion, this study showed a significant decrease in surgery for benign CP from 2014 to 2021, despite the established efficacy of surgical intervention for long-term pain management for these patients and increases in CP. The concurrent decrease in mortality and rates of pancreatic fistula formation suggest advances in surgical and postoperative care and possibly endoscopic intervention. Our findings call for further research into the management of CP, especially concerning surgical decision making and the increasing role of alternative therapies.

ACKNOWLEDGMENTS

Marianne Mallia, ELS, MWC, senior scientific/medical editor, Mayo Clinic, substantively edited the manuscript. The Scientific Publications staff at Mayo Clinic provided proofreading, administrative, and clerical support.

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