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Predictors and outcomes of jejunostomy tube placement at the time of pancreatoduodenectomy

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ABSTRACT

Background: Clinically relevant postoperative pancreatic fistula and delayed gastric emptying cause substantial morbidity after pancreatoduodenectomy. Per international guidelines, the placement of jejunostomy tubes may be considered for patients at risk for malnutrition, such as those with a high risk for clinically relevant postoperative pancreatic fistula and related complications. This study determined predictors and postoperative outcomes of jejunostomy tube placement.

Methods: Patients undergoing pancreatoduodenectomy in 2014 to 2015 were identified using the American College of Surgeons National Surgical Quality Improvement Program and Procedure-Targeted Pancreatectomy Participant Use Files. Multivariable logistic regressions were used to identify factors associated with concurrent jejunostomy tube placement and postoperative outcomes.

Results: Of 3,600 patients, 8.9% underwent jejunostomy tube placement. Patients given a jejunostomy tube were more likely white (odds ratio 1.46, $P = .016$), to have low preoperative serum albumin levels (odds ratio 2.13, $P < .001$), to have received neoadjuvant radiotherapy (odds ratio 2.14, $P < .001$), and to have received an intraoperative transfusion (odds ratio 1.50, $P = .004$). We observed no association between jejunostomy tube placement and an increasing number of risk factors for clinically relevant postoperative pancreatic fistula ($P = .96$) or delayed gastric emptying ($P = .54$). Overall, jejunostomy tube placement was associated with increased morbidity (odds ratio 1.34, $P = .020$) and duration of stay ($P < .001$), but not mortality ($P = .12$). Among patients with low serum albumin or those who developed clinically relevant postoperative pancreatic fistula or delayed gastric emptying, jejunostomy tube utilization was not associated with morbidity or mortality.

Conclusion: Jejunostomy tube placement during pancreatoduodenectomy was not driven by risk factors for clinically relevant postoperative pancreatic fistula or delayed gastric emptying, suggesting that practice patterns play a role. Among patients with at-risk preoperative albumin or who developed these complications, jejunostomy tube placement was not associated with worse outcomes, supporting selective utilization per guideline recommendations.

Introduction

Perioperative malnutrition is a well-documented risk factor for postoperative morbidity and mortality in patients undergoing pancreatoduodenectomy (PD).[1–3] This subset of patients is at a particularly high risk because of not only the catabolic nature of pancreatic surgery, but also the specific complications related to PD, including an incidence of clinically relevant grade B/C (defined by the International Study Group of Pancreatic Surgery [ISGPS]) postoperative pancreatic fistula (CR-POPF) and delayed gastric emptying (DGE) in 11% to 13% and 6% to 23% of patients, respectively.[4–9]

Historically, jejunostomy tube (JT) placement at the time of operation, and other forms of enteral and parenteral nutrition, have been used to help mitigate the impact of these complications.[5,10] In more recent years, early postoperative oral feeding after PD has been shown to be safe and to improve outcomes related to

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infectious complications, overall morbidity, and hospital duration of stay.[11–15] Even when oral nutrition is tolerated, however, patients may need nutritional support because of insufficient intake or PD-related complications, such as CR-POPF or DGE.[5,13]

When artificial nutritional support is required, the majority of studies recommend enteral rather than parenteral feeding owing to fewer infectious complications; optimal nutritional status; and earlier return of bowel, liver, and kidney function.[2,10,13,16–19] Enteral feeding methods include jejunal, nasojejunal, or gastrojejunal tubes. The decision-making for when and which type of feeding method to use has largely been institution specific or surgeon specific.[5]

Owing to potential tube-related complications, there is no evidence supporting routine, prophylactic JT placement[5,10,20,21]; however, selective placement of feeding tubes in patients who are already malnourished or at risk of malnutrition due to a high risk of CR-POPF and related complications may be reasonable and has been recommended by several international guidelines.[13,22,23] The primary aim of this study was to determine the current national practice in patient selection for JT placement at the time of PD. Specifically, we hypothesized that JT placement may be practice dependent rather than driven by preoperative and intraoperative risk factors for CR-POPF and DGE. Second, the 30-day postoperative outcomes of morbidity and mortality in patients with and without JT placement were determined.

Methods

Data sources

A retrospective study was performed using the 2015 Participant Use Files of the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) and the Procedure Targeted Pancreatectomy databases. The NSQIP is a quality improvement database that captures preoperative variables and postoperative outcomes through 30 days after an operative procedure.[24] The Procedure Targeted Pancreatectomy Participant Use File is a database within NSQIP that includes additional pancreas-surgery–specific variables and outcomes.[25] All data included are compliant with the Health Insurance Portability and Accountability Act requirements.[26] Because of the deidentified nature of the data and blinding to individual patients and hospitals, the Institutional Review Board of the University of Pennsylvania (Philadelphia, PA) deemed the study exempt from full review.

Study population

Only patients who were included in both the general NSQIP and Pancreatectomy Participant Use Files were selected for the study. The 2015 Pancreatectomy Participant Use File captured data from 120 hospitals across the United States.[26] Patients who underwent PD in the years 2014 to 2015 were identified by the primary Current Procedure Terminology code for PD (48150, 48152, 48153, 48154). Patients were excluded if they had an emergent procedure, disseminated cancer, or missing data for preoperative patient characteristics and intraoperative procedural variables used for analyses.

Variables analyzed

Concurrent JT placement at the time of PD was identified by the Current Procedure Terminology codes 44015 and 44300. Pancreatic fistula was defined in the Pancreatectomy Participant Use File as either a clinical diagnosis associated with drain maintenance for greater than 7 days, percutaneous drain placement, reoperation, or spontaneous wound drainage; or persistent drain output of amylase-rich fluid along with drain maintenance of greater than 7 days, percutaneous drainage, or reoperation.[26] CR-POPF was determined based on the ISGPS definition for grade B/C fistula and was defined as the presence of a fistula in addition to one of the following complications: drain in place for >21 days with a postoperative duration of stay ≥14 days; organ space infection; postoperative percutaneous drain placement; reoperation; sepsis; shock; respiratory failure; or renal failure.[27,28] Hemorrhage related to a CR-POPF is not identified separately in the NSQIP and was therefore not included in the criteria for CR-POPF. DGE was defined by the Pancreatectomy Participant Use File as no oral intake by postoperative day 14 or nasogastric tube presence or reinsertion.[26]

The preoperative and intraoperative independent variables utilized for analyses included patient age (<75 vs ≥75 years), sex, body mass index ([BMI] < 18 vs ≥ 18 kg/m^2), functional status, American Society of Anesthesiologists class, preoperative serum albumin level (<3 vs ≥3 g/dL), preoperative serum bilirubin level (<2 versus ≥2 mg/dL), inpatient admission before operation, medical comorbidities (diabetes, smoking, chronic obstructive pulmonary disease, presence of ascites, congestive heart failure, hypertension, acute renal failure or dialysis, preoperative wound infection, preoperative sepsis, bleeding disorder), >10% weight loss within 6 months before the operation, preoperative red blood cell transfusion within 72 h of the operation, chronic steroid use, utilization of chemotherapy or radiotherapy within the 90 days before the operation, operative time, pancreas duct size (<3 vs ≥3 mm), pancreas texture (soft, intermediate, hard), method of pancreatic reconstruction, concurrent vascular resection, and intraoperative or postoperative red blood cell transfusion within 72 h of the operation. Intraoperative transfusion was defined as occurring on postoperative day 0. Indication for operation was categorized into malignant and benign disease based on the postoperative diagnosis code of the International Classification of Disease, 9th or 10th revision.

The measured 30-day postoperative outcomes included CR-POPF, DGE, superficial and deep incisional infection, wound dehiscence, organ space infection, percutaneous drain placement, venous thromboembolism (deep venous thrombosis or pulmonary embolism), other medical complications (pneumonia, unplanned reintubation, failure to wean from ventilator for >48 h postoperatively, renal insufficiency, urinary tract infection, stroke, cardiac arrest, myocardial infarction, sepsis, or septic shock), unplanned reoperation, readmission, mortality, and postoperative duration of stay.

Statistical analysis

All statistical analyses were performed using R for Windows v 3.5.1.[29] P values <.05 were considered statistically significant. The preoperative and intraoperative characteristics of patients with and without JT placement were compared using the Pearson χ^2 test for categorical variables and Wilcoxon rank-sum test for continuous variables.

Univariable logistic regression analyses were used to identify preoperative and intraoperative clinical factors associated with JT placement. Among the variables described, those associated with JT placement with $P < .10$ by univariable analyses were entered into a multivariable logistic regression model. A step-down approach was taken with sequential removal of statistically nonsignificant factors ($P > .05$). Factors associated with CR-POPF and DGE were similarly identified. The number of risk factors for CR-POPF and DGE were divided into patient tertiles, and frequencies of JT utilization in each tertile were compared by the Pearson χ^2 test.

Table I
Preoperative characteristics of 3,600 PD patients, stratified by JT placement

	JT N = 322 (8.9%) N (%), median (IQR)	No JT N = 3,278 (91.1%) N (%), median (IQR)	*P* value
Age, y	66 (57–74)	65 (57–73)	.88
≥75 y	73 (22.7)	620 (18.9)	.10
Sex, male	167 (51.9)	1,735 (52.9)	.71
Race			.047
White	268 (83.2)	2,558 (78.0)	
Black	29 (9.0)	292 (8.9)	
Hispanic	11 (3.4)	131 (4.0)	
Other	8 (2.5)	120 (3.7)	
Unknown	6 (1.9)	177 (5.4)	
BMI, kg/m^2	26.2 (23.2–30.0)	26.5 (23.3–30.4)	.30
<18 kg/m^2	11 (3.4)	59 (1.8)	.045
Independent functional status	317 (98.4)	3 252 (99.2)	.16
American Society of Anesthesiologists class			.66
Class I	0 (0)	10 (0.3)	
Class II	79 (24.5)	750 (22.9)	
Class III	229 (71.1)	2,355 (71.8)	
Class IV	14 (4.3)	163 (5.0)	
Admission before surgery	45 (14.0)	326 (9.9)	.023
Malignancy	234 (72.7)	2,444 (74.6)	.46
Diabetes	83 (25.8)	816 (24.9)	.73
Smoking	74 (23.0)	656 (20.0)	.21
Chronic obstructive pulmonary disease	16 (5.0)	148 (4.5)	.71
Ascites	2 (0.6)	5 (0.2)	.068
Congestive heart failure	2 (0.6)	9 (0.3)	.28
Hypertension	184 (57.1)	1,752 (53.4)	.20
Renal failure	1 (0.3)	3 (0.1)	.26
Wound infection or open wound	2 (0.6)	10 (0.3)	.35
Sepsis	8 (2.5)	29 (0.9)	.007
Weight loss > 10% in past 6 months	75 (23.3)	573 (17.5)	.010
Serum albumin, g/dL	3.6 (3.1–3.9)	3.9 (3.5–4.2)	<.001
< 3.0 g/dL	52 (16.1)	262 (8.0)	<.001
Total serum bilirubin, mg/dL	0.7 (0.4–1.9)	0.7 (0.4–1.5)	.86
< 2 mg/dL	243 (75.5)	2,594 (79.1)	.12
Bleeding disorder	8 (2.5)	87 (2.7)	.86
Transfusion within 72 h before operation	4 (1.2)	20 (0.6)	.18
Chronic steroids	7 (2.2)	89 (2.7)	.57
Chemotherapy within 90 days preoperation	55 (17.1)	544 (16.6)	.82
Radiotherapy within 90 days preoperation	48 (14.9)	243 (7.4)	<.001

IQR, interquartile range.

To account for differences between the JT and no JT populations, multivariable logistic regressions for postoperative morbidity and mortality were adjusted for factors associated ($P < .10$) by univariable analysis with either JT placement or the outcome. Because the distribution of the durations of stay was positively skewed, linear regressions were performed using logarithmically transformed duration of stay. Subgroup analyses on postoperative outcomes were performed in (1) patients with preoperative serum albumin < 3.0 g/dL and (2) those who developed CR-POPF or DGE.

Results

Patient characteristics

A total of 3,600 patients met the study inclusion and exclusion criteria. Of these, 322 (8.9%) underwent JT placement at the time of PD. The two groups of patients differed in baseline characteristics (Table I). Patients who received a JT were somewhat more likely to be white (83.2% vs 78.0%, $P = .047$), have a BMI < 18 kg/m^2 (3.4% vs 1.8%, $P = .045$), and be admitted as an inpatient before PD (14.0% vs 9.9%, $P = .023$). They also had greater rates of preoperative sepsis or septic shock (2.5% vs 0.9%, $P = .007$), >10% weight loss within 6 months (23.3 vs 17.5%, $P = .010$), preoperative albumin < 3.0 g/dL (16.1% vs 8.0%, $P < .001$), and receipt of neoadjuvant radiotherapy (14.9% vs 7.4%, $P < .001$). Notably, JTs were not placed more frequently among patients with a greater American Society of Anesthesiologists class ($P = .66$), malignant diagnosis (72.7% vs 74.6%, $P = .46$), or who received neoadjuvant chemotherapy (17.1% vs 16.6%, $P = .82$). Patients who received a JT had a greater operative time (median 399 vs 352 minutes, $P < .001$; Table II). Moreover, JT placement was associated with other intraoperative practices, such as intraperitoneal drain placement (98.8% vs 85.7%, $P < .001$) and performing a pancreaticogastrostomy (5.3% vs 1.6%, $P < .001$) rather than pancreaticojejunostomy. In addition, intraoperative (19.6% vs 13.2%) and postoperative (6.2% vs 3.8%) transfusions were more common in patients who received a JT ($P < .001$).

Clinical factors associated with jejunostomy tube placement

Preoperative and intraoperative clinical factors associated with JT placement were characterized. Operative time was not included in these analyses because it was directly affected by JT placement. By univariable analyses, BMI < 18 kg/m^2, albumin < 3.0 g/dL, white race, preoperative admission, presence of ascites, preoperative sepsis, >10% weight loss within 6 months of the operation, neoadjuvant radiotherapy, and intraoperative transfusion were associated with JT placement. By multivariable analysis, albumin < 3.0 g/dL (odds ratio [OR] 2.13, $P < .001$), white race (OR 1.46, $P = .016$), neoadjuvant radiotherapy (OR 2.14, $P < .001$), and intraoperative

Table II
Intraoperative characteristics of 3,600 PD patients, stratified by JT placement

	JT *N* = 322 (8.9%) *N* (%), median (IQR)	No JT *N* = 3,278 (91.1%) *N* (%), median (IQR)	*P* value
Operative time, min	399 (315–481)	352 (273–436)	<.001
Pancreas duct size <3 mm	105 (32.6)	958 (29.2)	.20
Pancreas texture			.97
Hard	143 (44.4)	1,432 (43.7)	
Intermediate	32 (9.9)	328 (10.0)	
Soft	147 (45.7)	1,518 (46.3)	
Intraperitoneal drain placement	318 (98.8)	2,809 (85.7)	<.001
Pancreas reconstruction			<.001
Pancreaticojejunostomy	305 (94.7)	3,226 (98.4)	
Pancreaticogastrostomy	17 (5.3)	52 (1.6)	
Vascular resection performed	56 (17.4)	495 (15.1)	.28
Transfusion <72 h after operation			<.001
Intraoperative	63 (19.6)	433 (13.2)	
Postoperative	20 (6.2)	125 (3.8)	
No transfusion	239 (74.2)	2,720 (83.0)	

IQR, interquartile range.

Table III
Preoperative and intraoperative factors associated with JT placement, CR-POPF, and DGE (*N* = 3,600)

Variable	OR (95% CI)	*P* value
JT placement		
Serum albumin < 3.0 vs ≥ 3.0 g/dL	2.13 (1.52–2.95)	<.001
White versus nonwhite race	1.46 (1.08–2.00)	.016
Preoperative radiotherapy versus no radiotherapy	2.14 (1.51–2.97)	<.001
Intraoperative transfusion versus no transfusion	1.50 (1.14–1.97)	.004
CR-POPF		
Male versus female	1.47 (1.18–1.84)	<.001
BMI < 18 versus ≥ 18 kg/m^2	0.13 (0.01–0.61)	.045
Total serum bilirubin < 2 vs ≥ 2 mg/dL	1.57 (1.16–2.16)	.005
Pancreas duct size < 3 vs ≥ 3 mm	1.66 (1.33–2.08)	<.001
Pancreas texture soft versus intermediate/hard	2.43 (1.92–3.10)	<.001
Malignant versus benign diagnosis	.69 (0.55–0.87)	.002
DGE		
Male versus female	1.46 (1.21–1.75)	<.001
Admission before operation versus no admission	1.51 (1.13–1.99)	.004
Preoperative sepsis versus no sepsis	0.22 (0.04–0.73)	.039
Total serum bilirubin < 2 vs ≥ 2 mg/dL	1.40 (1.11–1.78)	.006
Intraoperative transfusion versus no transfusion	1.54 (1.23–1.92)	<.001
Pancreas texture soft versus intermediate/hard	1.50 (1.25–1.80)	<.001

transfusion (OR 1.50, P = .004) remained statistically significant factors (Table III).

The primary PD-related complications of interest were CR-POPF and DGE. CR-POPF developed in 391 patients (10.9%). By multivariable analysis, the factors most strongly associated with the development of CR-POPF were male sex (OR 1.47, *P* < .001), pancreas duct size < 3 mm (OR 1.66, *P* < .001), and soft pancreas texture (OR 2.43, *P* < .001). We observed no overlap between the preoperative and intraoperative clinical factors associated with CR-POPF and those associated with JT placement. DGE developed in 571 patients (15.9%), of which 161 (28.2%) also had a CR-POPF. The factors most strongly associated with DGE coincided with those associated with CR-POPF, including male sex (OR 1.46, *P* < .001) and soft pancreas texture (OR 1.50, *P* < .001). Only intraoperative transfusion was a common factor between DGE (OR 1.54, *P* < .001) and JT placement.

The rate of JT placement was further analyzed by the number of risk factors for CR-POPF and DGE (Fig 1). The number of risk factors for CR-POPF and DGE were divided into patient tertiles, with the first tertile representing patients who had up to one, the second tertile with two, and the third tertile with three or more risk factors. Rates of CR-POPF (one, 4.2%; two, 8.9%; three or more, 7.2%; *P* < .001) and DGE (one, 10.2%; two, 16.2%; three or more, 20.6%; *P* < .001) increased with an increasing number of risk factors for each complication. JT placement, however, did not differ by the number of risk factors for CR-POPF (one, 9.1%; two, 8.7%; three or more, 9.0%; *P* = .96) or DGE (one, 8.4%; two, 8.8%; three or more, 9.7%; *P* = .54).

Postoperative morbidity and mortality

Among JT patients, 57.1% developed at least one postoperative complication compared with 48.4% of patients who did not receive a JT (*P* = .003; Fig 2). We observed no difference in the rate of CR-POPF (10.9% vs 10.9%, *P* = 1.00) between the groups, but the proportion of patients classified as having DGE was greater in the JT than the non-JT group (25.5% vs 14.9%, *P* < .001). Other medical complications (23.3% vs 16.8%, *P* = .004) and unplanned reoperations (9.3% vs 4.7%, *P* < .001) were also more common in the JT cohort. In addition, postoperative duration of stay was somewhat greater among JT patients (median 9 vs 8 days; *P* < .001) and there was no difference in 30-day mortality (0.6% with JT vs 1.7% without JT, *P* = .14).

By multivariable analysis, JT placement was associated with increased overall morbidity (OR 1.34, *P* = .020) and 14% greater LOS

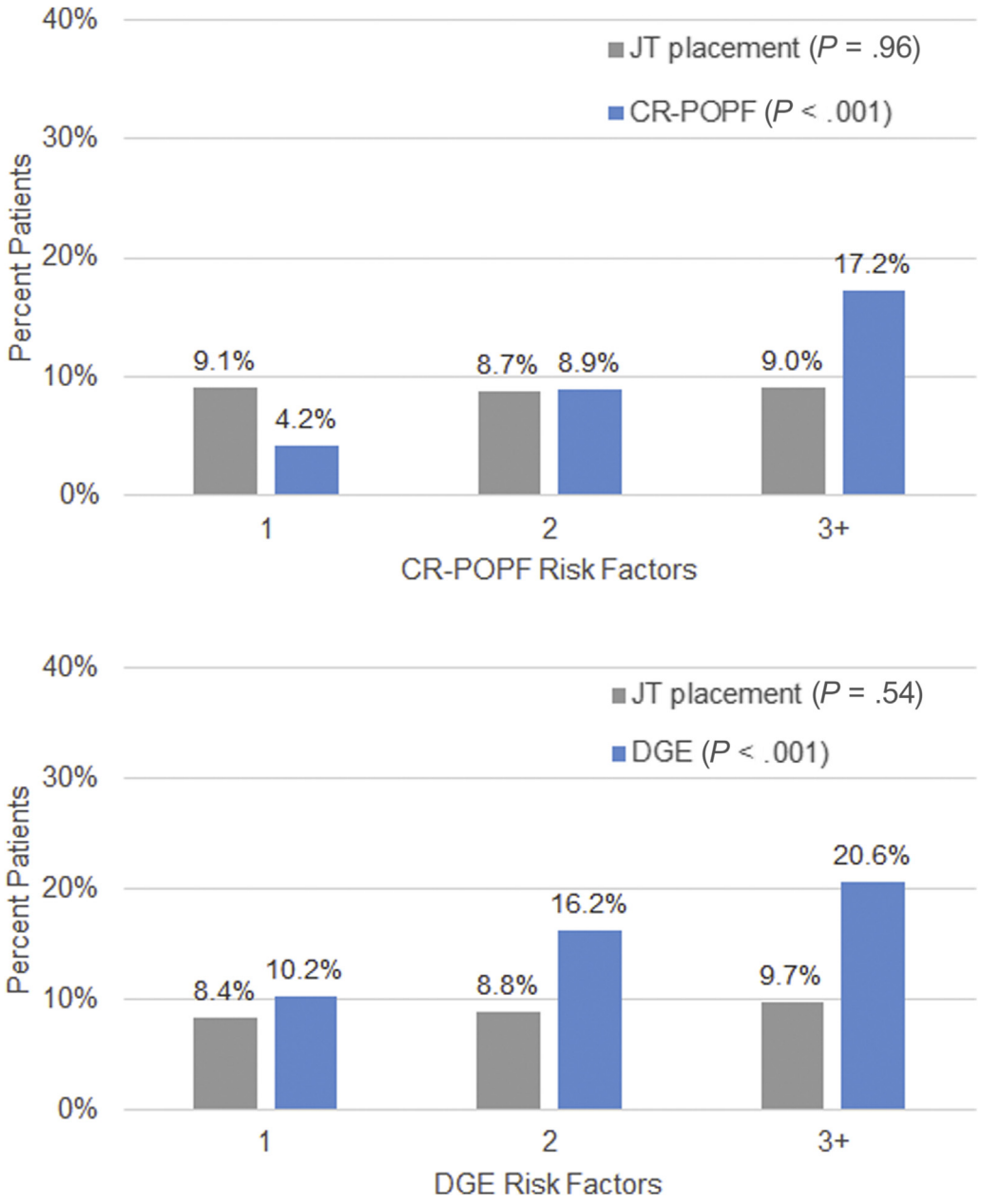

Fig 1. Rates of JT placement, clinically relevant postoperative pancreatic fistula CR-POPF, and DGE by the number of CR-POPF and DGE risk factors. The number of CR-POPF and DGE risk factors were divided into the following patient tertiles: the first tertile represented patients with up to one, the second tertile with two, and the third tertile with three or more risk factors. Rates of CR-POPF and DGE increased significantly with the number of respective risk factors, but JT placement did not change. *JT*, jejunostomy tube, *CR-POPF*, clinically relevant postoperative pancreatic fistula; *DGE*, delayed gastric emptying.

($P < .001$), but not with mortality (OR 0.32, $P = .12$) (Table IV). Specifically, JT placement was associated with DGE (OR 1.85, $P < .001$), other medical complications (OR 1.36, $P = .040$), and unplanned reoperation (OR 1.96, $P = .002$), but not with CR-POPF (OR 0.97, $P = .87$).

Postoperative outcomes were further analyzed in subgroups of patients believed most likely to benefit from JT placement, including patients with preoperative serum albumin < 3.0 g/dL ($N = 314$) and in those who developed CR-POPF or DGE ($N = 801$). In the population with low nutritional parameters, JT placement was not associated with overall morbidity ($P = .88$), mortality ($P = .99$), or duration of stay ($P = .081$). Similarly, among those who developed CR-POPF or DGE, JT placement was not associated with developing other complications ($P = .84$), mortality ($P = .84$), or duration of stay ($P = .083$).

Discussion

PD continues to be associated with substantial morbidity and a postoperative complication rate of 40% to 50%.[8,30–33] Patients undergoing PD are often already malnourished before operative exploration, and severe postoperative complications limiting tolerability of oral intake could increase the need for nutritional support.[8,30,34] Several studies have demonstrated inferior postoperative outcomes with routine JT placement at the time of PD, but little is known regarding the current national trend in JT utilization in relation to PD-related morbidities.[35,36] This study

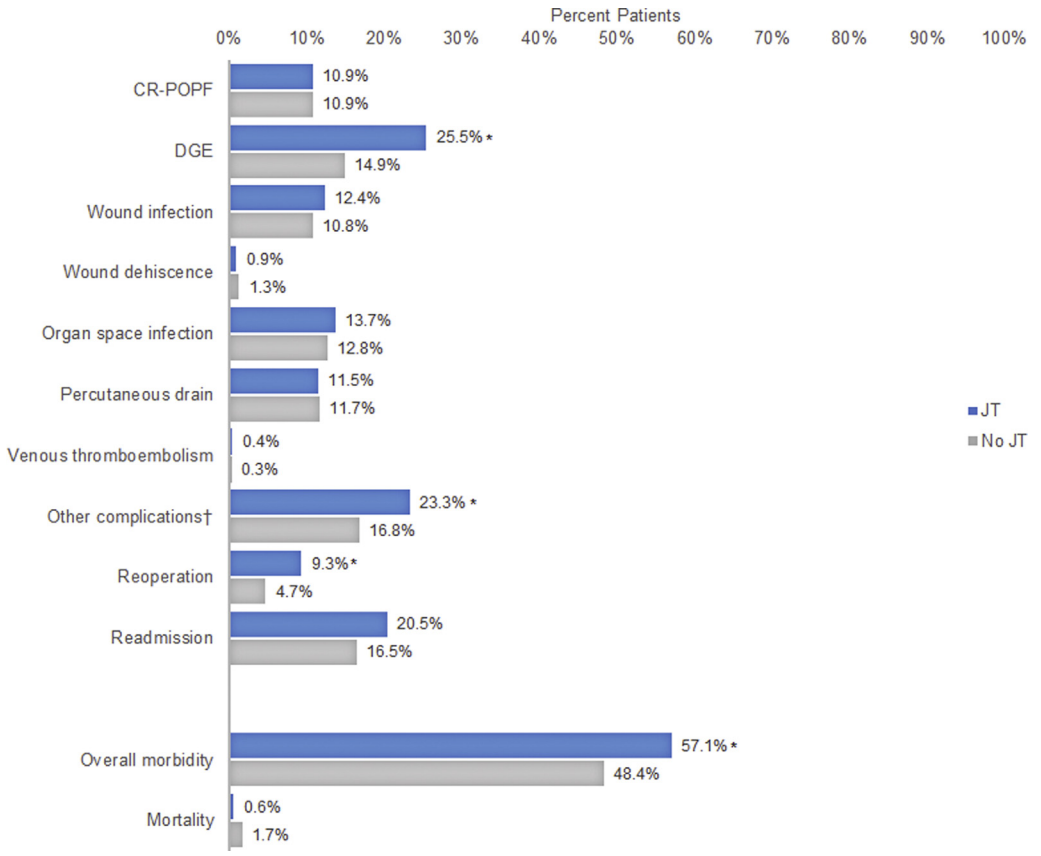

Fig 2. Rates of 30-day postoperative morbidity and mortality among patients with and without JT placement during pancreatoduodenectomy. Rates of CR-POPF did not differ by JT placement, but a greater proportion of JT patients were classified as having DGE. The category of other complications includes pneumonia, unplanned reintubation, failure to wean from ventilator for > 48 h, renal insufficiency, urinary tract infection, stroke, cardiac arrest, myocardial infarction, sepsis, or septic shock. *$P < .05$. *JT*, jejunostomy tube, *CR-POPF*, clinically relevant postoperative pancreatic fistula; *DGE*, delayed gastric emptying.

Table IV
Univariable and multivariable analyses of postoperative morbidity and mortality associated with JT placement at the time of PD ($N = 3,600$)

	Univariable analysis OR (95% CI)	*P* value	Multivariable analysis OR (95% CI)	*P* value
CR-POPF	1.00 (0.68–1.43)	1.00	0.97 (0.65–1.41)	.87
DGE	1.95 (1.48–2.54)	<.001	1.85 (1.39–2.44)	<.001
Wound infection	1.17 (0.82–1.64)	.37		
Wound dehiscence	0.71 (0.17–1.95)	.56		
Organ space infection	1.07 (0.76–1.48)	.68		
Percutaneous drain placement	0.98 (0.68–1.39)	.93		
Venous thromboembolism	1.22 (0.65–2.12)	.50		
Other medical complications*	1.50 (1.13–1.96)	.004	1.36 (1.01–1.81)	.040
Unplanned reoperation	2.10 (1.37–3.12)	<.001	1.96 (1.25–2.99)	.002
Readmission	1.30 (0.97–1.73)	.068	1.28 (0.94–1.71)	.10
Overall morbidity	1.42 (1.13–1.79)	.003	1.34 (1.05–1.71)	.020
Mortality	0.36 (0.06–1.16)	.16	0.32 (0.05–1.07)	.12
Duration of stay†	1.20 (1.13–1.27)	<.001	1.14 (1.08–1.20)	<.001

* Pneumonia, unplanned reintubation, failure to wean from ventilator for >48 h postoperative, renal insufficiency, urinary tract infection, stroke, cardiac arrest, myocardial infarction, sepsis, or septic shock.
† Included 3,592 patients with available data.

demonstrated that, although some clinical factors played a role, the decision for JT placement was not associated with major risk factors for CR-POPF and DGE. Because JT placement did not appear to align with guideline recommendations, institutional or surgeon-specific practice patterns likely played a primary role in this decision.

JT placement during PD occurred in only 8.9% of the study population. This lesser incidence than reported may reflect a decrease in routine JT utilization in PD patients over time. Earlier population-based studies have reported incidences of 12.8% and 23%, respectively.[17,36] In single-institutional series, JT utilization in up to 57% of patients has been reported.[10,21,35]

Few studies have reported predictors of JT placement at the time of PD. Among patients diagnosed with pancreatic adenocarcinoma, T3 disease has been associated with JT placement (OR 1.40, $P < .002$).[17] Single-institutional studies have reported JT utilization as either routine practice or at the individual surgeon's discretion consistent with the current study hypothesis.[10,20,35] Because of the limitations of the NSQIP database, however, JT utilization rates at

the individual surgeon or hospital level could not be analyzed. In this study, although some patient factors, such as nutritional status and receipt of neoadjuvant radiotherapy, played a role, patient selection could be further improved by adherence to the guidelines offered by several groups. Although JT placement was associated with increased 30-day morbidity and duration of stay in the entire study population, it was not associated with worse outcomes in subgroups with low preoperative nutritional parameters or those who developed CR-POPF or DGE. These findings support selective JT utilization.

Preoperative and intraoperative risk factors for CR-POPF have been well characterized[9,27]; however, few preoperative characteristics have been identified as predictors of DGE. To maintain consistency in methodology for both complications, this study analyzed risk factors for CR-POPF and DGE in a similar fashion and did not utilize the NSQIP-validated, modified fistula risk score developed by Kantor et al[27]; nevertheless, the risk factors for CR-POPF identified in the current study aligned closely with the validated risk score.[27] Of note, DGE shared many of the same preoperative and intraoperative risk factors as CR-POPF, consistent with earlier findings of a strong association between intra-abdominal abscess or CR-POPF with the development of secondary DGE.[4,6,34,37,38]

Similar to findings from other studies, JT placement was associated with increased rates of postoperative complications after PD.[36] In addition, tube-specific complications are well-known, including increased rates of abdominal wall infections at the site of JT insertion.[10,20,36,39,40] Other complications include clogging, fracture, dislodgement, and, rarely, small bowel leakage, torsion, pneumatosis, or raely intestinal ischemia.[10,20,21,40] An increase in readmissions among JT patients was not identified in this study, but any tube-related complications managed on an outpatient basis in the clinic, in the emergency room, or by referral to interventional radiology would not have been identifiable because of database limitations with only at best 30-day follow-up.

Although JT placement was not associated with CR-POPF, it appeared to be associated with DGE in this study. DGE is a clinical diagnosis and has historically been defined variably, leading to different reports of incidence and risk factors.[41] The ISGPS published a consensus definition of DGE in 2007.[41] The DGE definition used in the Pancreatectomy Participant Use File is not the ISGPS definition and could perhaps be variably interpreted across institutions.[26] For example, JT patients could be more readily classified as having DGE owing to the use of enteral nutrition. An artificial association between JT utilization and DGE could also arise if surgeons who routinely maintain nasogastric tubes for a greater period also routinely place JTs at the time of PD. The strong association between DGE and JT placement, but no association between CR-POPF and JT utilization despite a strong relationship between the two complications, suggest a possible artificial relationship related to difficulties in classifying patients as having DGE. Other studies using well-defined ISGPS criteria for DGE diagnosis did not find an increased risk of DGE among patients receiving enteral nutrition.[10,42]

Routine JT placement during PD is not advisable, but selective utilization may benefit patients who are unable to tolerate an oral diet because of PD-related complications. Although neither enteral nor parenteral nutritional support is superior to oral intake when tolerated, the benefits of enteral over parenteral nutrition in postoperative patients are well established.[5,10,16,18,19,30] Concurrent CR-POPF and DGE is common, and many of these patients will require nutritional support.[4,6,34,37,43,44] Early initiation of enteral tube feeds among patients with DGE has been associated with earlier resumption of oral diet and decreased 30-day readmission rates.[44]

Several limitations of the study should be acknowledged. Because of the retrospective nature of the study, causal relationships could not be determined. Although the multivariable analyses took into consideration possible confounders, there are likely other unmeasured patient and clinical factors influencing the decision to place a JT that could impact postoperative outcomes. Because the NSQIP database does not identify individual surgeons or hospitals, provider or facility volume and experience could not be considered and likely represents a residual confounder. In addition, only JT placement during the same admission could be identified, so those who had JTs placed before PD, such as before initiating neoadjuvant therapy, could not be included in the JT group. Also, although the procedure itself could be identified, whether enteral tube feeds were actually administered is not recorded in the NSQIP. Finally, outcomes recorded in the NSQIP are limited to the 30-day postoperative period. Thus, the long-term impact of nutritional support on nutritional parameters, functional status, quality of life, and time to or rate of adjuvant therapy are unknown.

Despite these limitations, this study revealed important characteristics of JT placement at a national level. Although guidelines recommend JT placement among patients at greatest risk for CR-POPF and related complications, there was no association between JT placement and risk factors for severe PD complications. Rather than routine utilization, effort should be made to place JTs only when necessary among patients most likely to benefit from postoperative nutritional support.

Disclosure

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