

National Complication Rates after Pancreatectomy: Beyond Mere Mortality

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Abstract

Introduction National studies on in-hospital pancreatic outcomes have focused on mortality. Non-fatal morbidity affects a greater proportion of patients.

Methods The Nationwide Inpatient Sample 1998–2006 was queried for discharges after pancreatectomy. Rates of major complications (myocardial infarction, aspiration pneumonia, pulmonary compromise, perforation, infection, deep vein thrombosis/pulmonary embolism, hemorrhage, or reopening of laparotomy) were assessed. Predictors of complication(s) were evaluated using logistic regression. Their independent effect on in-hospital mortality, length of stay, and discharge disposition was assessed.

Results Of 102,417 patient discharges, 22.7% experienced a complication. Complication rates did not decline significantly over time, while mortality rates did. Independent predictors of complications included age ≥ 75 [referent, 19–39; adjusted odds ratio (OR) 1.34, 95% confidence interval (CI) 1.2–1.5, $p < 0.0001$], total pancreatectomy (vs proximal, OR 1.29, 95%CI 1.1–1.5, $p = 0.0025$), and low hospital resection volume (vs high, OR 1.61, 95%CI 1.4–1.8, $p < 0.0001$). Complications were a significant independent predictor of death (OR 7.76, 95%CI 6.7–8.8, $p < 0.0001$), prolonged hospital stay (OR 6.94, 95%CI 6.2–7.7, $p < 0.0001$), and discharge to another facility (OR 0.28, 95%CI 0.26–0.3, $p < 0.0001$).

Conclusions Despite improvements in mortality, complication rates remain substantial and largely unchanged. They predict in-hospital mortality, prolonged hospital stay, and delayed return to home. The impact on healthcare costs and quality of life deserves further study.

Keywords Pancreatectomy · Morbidity ·
Nationwide inpatient sample

Introduction

Pancreatic resection is a technically complex operation with significant attendant morbidity and mortality. While much literature has focused on recent improvements in perioperative mortality,^{1–3} complication rates remain high in reported series.^{4,5} The technical nature of the operation with requisite multi-organ resection, usually performed on an older population with significant comorbid illness, contributes to the potential for complications.⁶ The aim of this study was to assess the rates of major perioperative complications and their associated risk factors.

Using a nationally representative administrative database, we assessed rates of major in-hospital complications following pancreatectomy as well as their associated risk

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factors. We also assessed the effect of major postoperative complications on the likelihood of in-hospital mortality, prolonged length of stay, and discharge to another facility rather than home.

Materials and Methods

Patient Sources and Cohort Assembly

The Nationwide Inpatient Sample (NIS) was queried between 1998 and 2006 for patient discharges for pancreatic resection (NCHS⁷; ICD-9-CM procedure codes 52.6, 52.7, 52.51, 52.52, 52.53, and 52.59). As part of the government-sponsored Healthcare Cost and Utilization Project, the NIS is a national, all-payer discharge database containing information for approximately seven million hospital discharges annually. This represents a stratified sample of 20% of nonfederal US community hospitals from participating states, including academic and specialty hospitals. The NIS weighting strategy facilitates population-based estimates to be drawn at the national level. All statistical analyses were performed based on these survey weights; results are presented as either weighted (national) or unweighted (actual) frequencies.

Patient Discharge and Hospital Characteristics

Demographic information, including age at admission, sex, and race was collected. Race information was excluded from all explanatory analyses because of the high rate of missing values. Records for patients aged <18 or >95 years old were also excluded. Patient discharges were assigned a Charlson comorbidity score,⁸ based on concurrent ICD-9-CM diagnoses, following the method described by Deyo et al.⁹ Because of the relative rarity of records with scores greater than 5, Charlson score was collapsed into four groups as follows: group 1, Charlson score of 0 or 1; group 2, score of 2 or 3; group 3, score of 4 through 7; and group 4, score of ≥ 8 . Indication for operation was defined as benign disease (including pancreatitis and cystic disease, ICD-9 577.0-9; and benign neoplasms of islet cells, the duodenum and ampulla, ICD-9 codes 211.7, 211.2, 211.5, respectively; and duodenal diverticular disease, ICD-9 code 562.0), malignant neoplasm (including malignancies of the pancreas, extrahepatic bile ducts, duodenum, ICD-9 codes 157.0-9, 156.1, 152.0, respectively), or other indication (including trauma and those without an indication reported).

Hospital surgical volume for pancreatectomy was assessed over the time period of the study. It was divided into equal thirds and defined as low (average of eight or

less resections per year), medium (average of nine to 32 resections per year), or high (average of >32 resections per year).

Outcome Measures

The identified cohort of patient discharges was analyzed for codes for major postoperative complications. These diagnoses and codes were chosen based on their validation as true complications rather than comorbidities in methods developed by Lawthers et al.¹⁰ These were defined as secondary diagnoses of (1) postoperative infection (except wound and pneumonia), (2) acute myocardial infarction, (3) aspiration pneumonia, (4) deep venous thrombosis and pulmonary embolism, (5) postoperative pulmonary compromise, (6) postoperative gastrointestinal hemorrhage (7) reopening of laparotomy, and (8) procedure-related lacerations or perforations. Complete listing of ICD-9-CM codes used is found in the [Appendix](#). Complications specific to pancreatectomy, such as pancreatic leak or fistula, were not examined since the current ICD-9-CM codes do not capture these accurately.

The secondary outcome of in-hospital mortality was defined as death due to any cause prior to discharge regardless of the time from operation. Prolonged length of stay was defined as a hospital stay that was more than one standard deviation above the mean length of stay for the cohort. Discharge disposition was dichotomized into either discharge to home or discharge to another facility, including skilled nursing facility or nursing home; patients who died in-hospital, who left against medical advice, or whose disposition was unknown were excluded from these analyses. Adjustments were not made for the specific hospital or region when analyzing this endpoint.

Statistical Analysis

Predictors of occurrence of any identified complication were evaluated using logistic regression. Covariates controlled for in this model included: sex, age, indication for operation, Charlson score, hospital teaching status, hospital annual resection volume, and type of resection. Predictors of in-hospital death, prolonged length of stay, and discharge disposition were evaluated in an analogous fashion, but with presence of a complication also used as an additional covariate in these models. Trend analyses were conducted to evaluate yearly overall rates of complications and in-hospital death, as well as the relationship between hospital volume and these outcomes. All statistical analyses were performed with advanced survey procedures using SAS (v9.1, Cary, NC, USA).

Results

Cohort Characteristics

There were 102,417 patient discharge records identified between 1998 and 2006. Of these, mean age at admission was 60.1 years, 51,175 (50.0%) were male, and 58,276 (76.5%) of those with race recorded were white (of note is that race was not available for 25.6% of the cohort). Most patients were in the Charlson group 1, with a score of 0 or 1 (33.2%, $n=33,971$), with group 2 (score of 2 or 3) comprising 28.8% ($n=29,524$), group 3 (score of 4–7) having 5.6% ($n=5,739$), and the highest score group (score ≥ 8) containing 32.4% ($n=33,183$). The majority of operations were performed for malignant disease (52.0%, $n=53,223$), with the most frequent procedure being proximal pancreatectomy (54.9%, $n=56,207$). Most procedures were performed at teaching hospitals (74.4%, $n=76,160$).

Overall, 23,238 (22.7%) experienced a major postoperative complication as defined above. The overall in-hospital mortality rate was 6.3% ($n=6,415$). Mean length of stay was 16.5 days (standard deviation, 16.1). After excluding records for which the discharge disposition was not known, not an in-hospital death, and not recorded as discharge against medical advice, the majority was discharged to home (87.2%, $n=83,571$). A comparison of the demographics for the group with a complication and the group without a complication is provided in Table 1. The most frequent complication was postoperative pulmonary compromise (51.7%, $n=12,013$). On unadjusted analysis, those in the complication group were 8.92 times more likely to die in-hospital than those without a complication [95% confidence interval (CI) 7.69–10.34, $p<0.0001$].

Trend Analyses

There was no significant change in the rate of major complication over the time period studied ($p=0.069$). The rate was 23.3% in 1998 and 22.5% in 2006, with a peak in 2002 of 24.2%. However, there was a significant linear decline in in-hospital mortality over this same period ($p<0.0001$). In 1998, the rate was 8.5%, but declined to 4.8% by 2006, its nadir (Fig. 1).

An inverse correlation was also seen for complication rates and annual hospital resection volume. High-volume hospitals had the lowest overall complication rate (17.8%) compared with medium-volume (23.1%) and low-volume hospitals (27.2%). This was significant on trend test ($p<0.0001$). Similarly for in-hospital death, a significant linear downtrend was seen ($p<0.0001$). For high-volume hospitals, the in-hospital mortality rate was 3.3% compared with medium volume, 6.4%, and low volume, 9.1%.

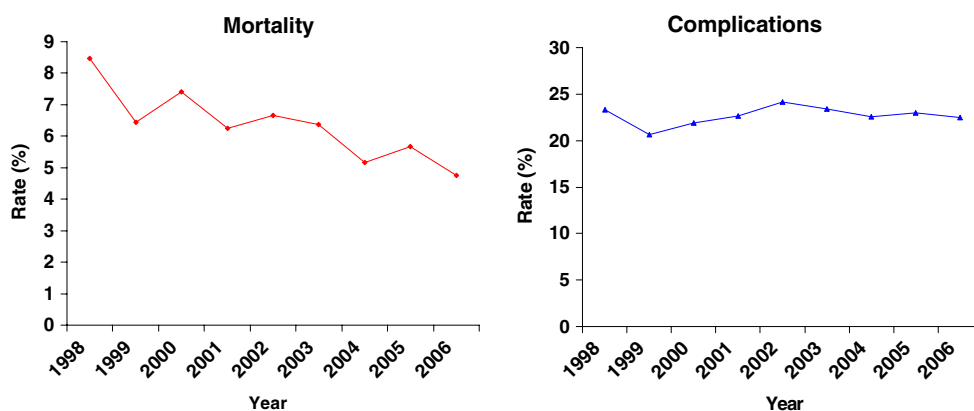
Table 1 Patient Demographics for Patient Discharges with a Complication and Without a Complication

Factor	Complication group	No complication group	<i>p</i> value
Mean age in years (SD)	61.1 (0.33)	59.8 (0.22)	<0.0001
	Weighted <i>N</i> (weighted %)	Weighted <i>N</i> (weighted %)	
Male sex	13,414 (57.7)	37,761 (47.7)	<0.0001
Race	(% missing=23.8)	(% missing=35.4)	<0.0001
White	12,857 (72.6)	45,419 (77.7)	
Black	2,112 (11.9)	5,523 (9.4)	
Other	2,742 (15.5)	7,519 (12.9)	
Died in-hospital	4,395 (18.9)	2,019 (2.6)	<0.0001
Indication for operation			<0.0001
Malignant neoplasm	11,473 (49.4)	41,750 (52.7)	
Benign disease	6,768 (29.1)	26,078 (32.9)	
Other indication	4,998 (21.5)	11,351 (14.3)	
Hospital resection volume			<0.0001
Low (≤ 8)	9,351 (40.2)	25,055 (31.6)	
Medium (9–32)	7,736 (33.3)	25,743 (32.5)	
High (>32)	6,151 (26.5)	28,381 (35.8)	
Hospital teaching status			<0.0001
Teaching	16,084 (69.2)	50,077 (75.9)	
Non-teaching	7,150 (30.8)	19,080 (24.1)	
Charlson score			<0.0001
0–1	7,657 (32.9)	26,314 (33.2)	
2–3	6,570 (28.3)	22,954 (29.0)	
4–7	1,779 (7.7)	3,961 (5.0)	
≥ 8	7,233 (31.1)	25,950 (32.8)	
Pancreatectomy type			<0.0001
Total	1,729 (7.4)	4,237 (5.4)	
Proximal	12,857 (55.3)	43,351 (54.8)	
Distal/middle	8,653 (37.2)	31,591 (39.9)	
Pulmonary compromise	12,013 (51.7)	N/A	N/A
Infection (excludes wound and pneumonia)	1,610 (6.9)	N/A	N/A
Myocardial infarction	793.2 (3.4)	N/A	N/A
Aspiration pneumonia	506.4 (2.2)	N/A	N/A
Deep venous thrombosis and/or pulmonary embolism	1,670 (7.2)	N/A	N/A
Gastrointestinal hemorrhage	4,129 (17.8)	N/A	N/A
Reopening of laparotomy	1,334 (5.7)	N/A	N/A
Procedure-related perforation or laceration	1,183 (5.1)	N/A	N/A

Primary Endpoint, Major Postoperative Complications

After adjusting for other factors, significant predictors of having a complication included age ≥ 75 years [referent,

Figure 1 Trends in in-hospital mortality (a) and complication rates (b), 1998 to 2006.



19–39; adjusted odds ratio (OR) 1.34, 95%CI 1.17–1.52, $p < 0.0001$], total pancreatectomy compared with proximal pancreatectomy (OR 1.29, 95%CI 1.09–1.53, $p = 0.0025$), indication for procedure other than benign or malignant disease (referent, malignant; OR 1.75, 95%CI 1.56–1.97, $p < 0.0001$), hospitals with low annual resection volume (OR 1.61, 95%CI 1.41–1.84, $p < 0.0001$) or medium volume (OR 1.35, 95%CI 1.19–1.54, $p < 0.0001$) compared with high volume, and Charlson score of 4–7 (OR 1.32, 95%CI 1.13–1.55, $p = 0.0006$) as compared with a score of 0 or 1 (Table 2). Significant protective factors included female sex (OR 0.67, 95%CI 0.63–0.72, $p < 0.0001$), age groups 40–54 (OR 0.82, 95%CI 0.72–0.93, $p = 0.0014$) and 55–64 (OR 0.84, 95%CI 0.74–0.96, $p = 0.0083$) versus age 19–39, distal/middle pancreatectomy compared with proximal pancreatectomy (OR 0.74, 95%CI 0.68–0.81, $p < 0.0001$), and procedure at a teaching hospital (OR 0.89, 95%CI 0.80–0.98, $p = 0.0229$).

Secondary Endpoint, In-Hospital Mortality

On multivariable analysis, the presence of complication was the strongest predictor of in-hospital death, increasing the odds nearly eightfold (OR 7.76, 95%CI 6.69–8.78, $p < 0.0001$). Other significant independent predictors included older age (vs <55) with a magnitude of effect ranging from 1.45 for those 55–64 (95%CI 1.08–1.94, $p = 0.0131$) to 3.29 for those ≥ 75 (95%CI 2.49–4.34, $p < 0.0001$), performance of a total pancreatectomy (referent, proximal pancreatectomy; OR 2.90, 95%CI 2.22–3.79, $p < 0.0001$), and both low and medium annual hospital resection volume (referent, high > 32 ; OR 2.33, 95%CI 1.88–2.90, $p < 0.0001$ and OR 1.75, 95%CI 1.43–2.15, $p < 0.0001$, respectively). Significant protective factors included female sex (OR 0.79, 95%CI 0.70–0.89, $p = 0.0002$), benign disease (referent, malignant; OR 0.55, 95%CI 0.42–0.72, $p < 0.0001$), distal/middle pancreatectomy compared with proximal pancreatectomy (OR 0.80, 95%CI 0.68–0.94, $p = 0.0070$) and Charlson score of 2 or 3 (OR 0.57, 95%CI 0.44–0.73, $p < 0.0001$) or ≥ 8 (OR 0.54, 95%CI 0.42–0.70, $p < 0.0001$), both compared

with score of 0 or 1. The complete regression is presented in Table 3.

Secondary Endpoint, Prolonged Length of Stay

On multivariable analysis, the presence of a complication was the strongest predictor of prolonged length of stay, increasing the odds nearly sevenfold (OR 6.94, 95%CI 6.24–7.73, $p < 0.0001$). Operations performed at teaching hospitals (OR 1.41, 95%CI 1.23–1.61, $p < 0.0001$) and

Table 2 Multivariable Analysis of Predictors of Having a Complication

Factor	Adjusted odds ratio (95%CI)	p value
Female sex	0.67 (0.63, 0.72)	<0.0001
Age group (ref=19–39 years)		
40–54	0.82 (0.72, 0.93)	0.0014
55–64	0.84 (0.74, 0.96)	0.0083
65–74	1.03 (0.91, 1.17)	0.6191
≥ 75	1.34 (1.17, 1.52)	<0.0001
Indication for operation (ref = malignant)		
Benign disease	1.10 (0.96, 1.26)	0.1701
Other indication	1.75 (1.56, 1.97)	<0.0001
Hospital resection volume (ref = high > 32)		
Low (≤ 8)	1.61 (1.41, 1.84)	<0.0001
Medium (9–32)	1.35 (1.19, 1.54)	<0.0001
Teaching hospital	0.89 (0.80, 0.98)	0.0229
Charlson score (ref = group 1, score 0 or 1)		
2–3	0.93 (0.82, 1.05)	0.2387
4–7	1.32 (1.13, 1.55)	0.0006
≥ 8	0.90 (0.78, 1.03)	0.1106
Pancreatectomy type (ref = proximal)		
Total	1.29 (1.09, 1.53)	0.0025
Distal/middle	0.74 (0.68, 0.81)	<0.0001

Ref referent

Table 3 Logistic Regression Model of the Independent Effect of Having a Complication on the Odds of In-Hospital Mortality

Factor	Adjusted odds ratio (95%CI)	<i>p</i> value
Complication present	7.76 (6.69, 8.78)	<0.0001
Female sex	0.79 (0.70, 0.89)	0.0002
Age group (ref=19–39 years)		
40–54	1.25 (0.95, 1.65)	0.1158
55–64	1.45 (1.08, 1.94)	0.0131
65–74	2.06 (1.55, 2.74)	<0.0001
≥75	3.29 (2.49, 4.34)	<0.0001
Indication for operation (ref = malignant)		
Benign disease	0.55 (0.42, 0.72)	<0.0001
Other indication	1.46 (1.18, 1.80)	0.0004
Hospital resection volume (ref = high >32)		
Low (≤8)	2.33 (1.88, 2.90)	<0.0001
Medium (9–32)	1.75 (1.43, 2.15)	<0.0001
Teaching hospital	0.96 (0.81, 1.12)	0.5855
Charlson score (ref = group 1, score 0 or 1)		
2–3	0.57 (0.44, 0.73)	<0.0001
4–7	0.77 (0.57, 1.04)	0.0880
≥8	0.54 (0.42, 0.70)	<0.0001
Pancreatectomy type (ref = proximal)		
Total	2.90 (2.22, 3.79)	<0.0001
Distal/middle	0.80 (0.68, 0.94)	0.0070

Ref referent

those with low (OR 2.10, 95%CI 1.78–2.48, $p<0.0001$) or medium (OR 1.68, 95%CI 1.44–1.96, $p<0.0001$) annual resection volumes, compared with high volume, were also more likely to be associated with prolonged lengths of stay. Female sex (OR 0.81, 95%CI 0.73–0.89, $p<0.0001$) and distal/middle pancreatectomy (referent, proximal; OR 0.52–0.67, $p<0.0001$) were significantly protective against prolonged hospital stays (Table 4).

Secondary Endpoint, Discharge to Home

After implementing the exclusion criteria described in “Materials and methods,” 95,899 patient discharges were analyzed. On multivariable modeling (Table 5), the presence of a complication reduced the odds of discharge to home by 72% (OR 0.28, 95%CI 0.26, 0.31, $p<0.0001$). Those aged 65–74 and those ≥75 were also less likely to be discharged home compared to patients aged 19–39 years (OR 0.42, 95%CI 0.34–0.52, $p<0.0001$ and OR 0.15, 95%CI 0.12–0.18, $p<0.0001$, respectively). Compared with hospitals with high annual resection volume, both low- and medium-volume hospitals decreased the

Table 4 Multivariable Analysis of the Independent Effect of Complications on the Odds of Having a Prolonged Length of Stay

Factor	Adjusted odds ratio (95% CI)	<i>p</i> value
Complication present	6.94 (6.24, 7.73)	<0.0001
Female sex	0.81 (0.73, 0.89)	<0.0001
Age group (ref=19–39 years)		
40–54	0.99 (0.81, 1.22)	0.9548
55–64	0.99 (0.80, 1.22)	0.9177
65–74	0.97 (0.80, 1.19)	0.7844
≥75	1.16 (0.94, 1.43)	0.1652
Indication for operation (ref = malignant)		
Benign disease	1.28 (1.06, 1.54)	0.0096
Other indication	1.21 (1.01, 1.45)	0.0342
Hospital resection volume (ref = high >32)		
Low (≤8)	2.10 (1.78, 2.48)	<0.0001
Medium (9–32)	1.68 (1.44, 1.96)	<0.0001
Teaching hospital	1.41 (1.23, 1.61)	<0.0001
Charlson score (ref = group 1, score 0 or 1)		
2–3	0.88 (0.74, 1.05)	0.1512
4–7	0.80 (0.62, 1.04)	0.0880
≥8	0.78 (0.64, 0.95)	0.0906
Pancreatectomy type (ref = proximal)		
Total	1.06 (0.85, 1.32)	0.6186
Distal/middle	0.59 (0.52, 0.67)	<0.0001

Ref referent

odds of discharge to home (OR 0.51, 95%CI 0.42–0.62, $p<0.0001$ and OR 0.81, 95%CI 0.66–0.99, $p=0.0401$, respectively). Distal/middle pancreatectomy, compared with proximal pancreatectomy, increased the odds of discharge to home (OR 1.41, 95%CI 0.52–0.67, $p<0.0001$), as did age 40–54 (referent 19–39; OR 1.48, 95%CI 1.18–1.84, $p=0.0006$).

Discussion

In this study, we found that major postoperative complications occur with far greater frequency than perioperative death, affecting approximately one quarter of all patients. There was a significant inverse correlation between annual hospital resection volume and rates of complication and in-hospital death. For medium-volume hospitals, the complication rate increases by 23% over high-volume hospitals; for low-volume hospitals, the rate of complication increases another 23% over the medium-volume hospital rate. Postoperative complications are also correlated with a nearly eightfold increase in the risk of in-hospital death,

Table 5 Multivariable Analysis of the Independent Effect of Complications on the Odds of Discharge to Home

Factor	Adjusted odds ratio (95%CI)	<i>p</i> value
Complication present	0.28 (0.26, 0.31)	<0.0001
Female sex	0.87 (0.79, 0.96)	0.0043
Age group (ref=19–39 years)		
40–54	1.48 (1.18, 1.84)	0.0006
55–64	0.93 (0.75, 1.15)	0.5126
65–74	0.42 (0.34, 0.52)	<0.0001
≥75	0.15 (0.12, 0.18)	<0.0001
Indication for operation (ref = malignant)		
Benign disease	0.95 (0.78, 1.16)	0.6248
Other indication	0.66 (0.57, 0.77)	<0.0001
Hospital resection volume (ref = high >32)		
Low (≤8)	0.51 (0.42, 0.62)	<0.0001
Medium (9–32)	0.81 (0.66, 0.99)	0.0401
Teaching hospital	0.93 (0.82, 1.06)	0.2866
Charlson score (ref = group 1, score 0 or 1)		
2–3	0.99 (0.83, 1.19)	0.9438
4–7	0.87 (0.69, 1.08)	0.2077
≥8	1.08 (0.89, 1.30)	0.4321
Pancreatectomy type (ref = proximal)		
Total	0.92 (0.73, 1.16)	0.4781
Distal/middle	1.41 (0.52, 0.67)	<0.0001

Ref referent

as well as prolonged hospital stays, and reduced likelihood of discharge to home. Over the time period of the study, a significant decline in in-hospital mortality was seen, while the rate of major complication has not similarly improved. As perioperative death rates improve, complication rates deserve increasing attention.

Several authors have noted a decrease in the perioperative mortality of pancreatectomy in recent years.^{3,11–13} While more patients are surviving operation, this shifts the attention from mere survival to expected recovery from operation and on the morbidity associated with pancreatectomy. Previous studies that have examined morbidity have focused primarily on complications specific to pancreatic surgery, most notably pancreatic fistula.^{11,14–17} Their work has shed much needed light on the risks and benefits or lack thereof of specific practices such as octreotide administration, drain and stent placement, and feeding tube use. While every effort must be made to prevent complications such as pancreatic fistula, biliary leak with possible subsequent intra-abdominal abscess, other more general postoperative complications involving the cardiovascular and pulmonary systems are critically

important and may, in fact, be a more ready target for systematic quality improvement.

Patients undergoing complex surgical procedures including pancreatectomy are at risk for a host of general postoperative complications, including myocardial infarction, pneumonia, and pulmonary embolism. These complications have been shown to increase risk of death, even in previously healthy patients.¹⁸ Complications have also been correlated with longer mean lengths of stay and an increased likelihood of readmission.¹⁹ Additionally, patients who experience one complication have been shown to be at increased risk for subsequent complications.^{20,21} These negative outcomes associated with postoperative complications demonstrate the importance of studying their risk factors in an effort to gain insight into preventative strategies and early intervention.

Our work represents an updated national perspective on this important issue of major postoperative complications after pancreatectomy. Unlike previous studies that report on either single-institution experiences,^{14,19} or less recent time periods,¹¹ this analysis includes patient discharges from across the USA at both teaching and non-teaching hospitals. It also focuses on the impact of general, multi-system complications rather than pancreatectomy-specific technical complications. As the US population ages and an increasing number of operations are performed on older patients with more comorbid illness,^{22,23} this type of complication may have increasing relevance. Unlike pancreatectomy-specific complications that may be best addressed by surgical technique,⁶ these more general complications could be targeted using principles of medical management and perioperative prevention techniques. Care should be taken to reduce both types of complications, since some general complications may arguably be related to the occurrence of a pancreatectomy-specific complication.

Since this study was conducted in an administrative claims database, there is the potential that the ICD-9 diagnosis codes could represent comorbidities rather than complications. In an effort to minimize this risk, we used only codes that had been previously validated.¹⁰ This necessarily limited our analysis to standard postoperative

Table 6 Overall In-Hospital Mortality and Complication Rates for Three Complex Procedures, 1998–2006

Procedure	In-hospital mortality (%)	Postoperative complication (%)
Pancreatectomy	6.3	22.7
Esophagectomy	3.4	16.6
Coronary artery bypass graft	7.3	31.2

complications rather than those specific to pancreatectomy such as pancreatic fistula and intra-abdominal abscess. There have been several reports, mostly from single institutions, on pancreatectomy-specific complications; the rates of pancreatic leak, for example, have ranged widely, from 5% to 20%.^{11,12,24} However, the effect of this, along with the fact that complications in general may be underreported,^{25,26} is that our results thus represent a systematic underestimate of true complication rates. In light of this, our finding of a 22.7% complication rate for pancreatectomy should be viewed as a conservative figure.

In order to provide some context for this work, we also looked at two other complex procedures: coronary artery bypass graft (CABG) and esophagectomy. For comparison, the CABG cohort had an overall in-hospital mortality of 7.3% and an overall complication rate of 31.2%. The esophagectomy cohort had an overall mortality rate of 3.4% and an overall complication rate of 16.6% (see Table 6). On trend analysis of the time period studied, both operations succeeded in displaying a significant downward trend in mortality (both $p < 0.0001$). In contrast to pancreatectomy, both esophagectomy and CABG had significant linear trends in complication rates ($p < 0.0001$), but in opposite directions; esophagectomy complications have significantly decreased (31.5% to 29.8%), while CABG complication rates have increased (15.1% to 20.2%). This underscores the importance of considering these endpoints together, and in context with other findings, in order to generate hypotheses for systematic improvements in patient care. The relationship between perioperative mortality rates and procedural complication rates is complex.

What remains clear is that postoperative complications represent a substantial consideration, particularly as perioperative mortality for pancreatectomy declines. The findings of this study may be useful for preoperative patient counseling, in particular as a way of helping to set appropriate expectations for the postoperative course. The identified cascade of risks for poorer outcomes that accompany a complication also helps to underscore the importance of prevention of complications when possible.

These findings warrant further study, including the use of institutional databases to look at the contribution of specific practices for perioperative medical optimization, such as beta-blockers, deep venous thrombosis prophylaxis, and early extubation guidelines. Also, the effect of major postoperative complications on patient quality of life should be examined. The prevalence of complications and their association with prolonged hospital stays and discharge to other facilities suggests that cost analyses could highlight the importance of prevention strategies.

Conclusion

While mortality rates for pancreatic resection have improved, pancreatectomy remains a morbid operation. Having a complication significantly increases the risk of in-hospital death, prolonged hospital stay, and discharge to another facility rather than to home. The importance of this lies not in dissuading people from undergoing appropriate procedures but in making explicit the risks of pancreatic surgery. If patients and providers share a data-driven, appropriate expectation for the convalescence period, patient satisfaction and quality of life stand to gain immensely.

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Appendix

Codes Used to Identify Postoperative Complications

Diagnosis	ICD-9-CM codes
Postoperative infection	008.45, 320.00-.99, 510.0, 510.9, 513.1, 519.2, 590.10-590.11, 590.80, 683
Myocardial infarction	410.00-410.91
Aspiration pneumonia	507.0
Deep venous thrombosis/ pulmonary embolism	415.1, 451.11, 451.19, 451.2, 451.81, 453.8
Pulmonary compromise	514, 518.4, 518.5, 518.81, 518.82
Gastrointestinal hemorrhage	530.82, 531.00-.21, 531.40-.41, 531.60-.61, 532.00-.21, 532.40-.41, 532.60-.61, 533.00-.21, 533.40-41, 533.60-.61, 534.00-.21, 534.40-.41, 534.60-.61, 535.01, 535.11, 535.21, 535.31, 535.41, 535.51, 535.61, 578.9
Reopening of laparotomy	01.23, 03.02, 06.02, 34.03, 35.95, 39.49, 54.12, 54.61
Procedure-related perforation or laceration	530.4, 569.83, 575.4, 29.51, 31.61, 33.41, 33.43, 42.82, 44.61, 46.71, 46.75, 48.71, 50.61, 51.91, 55.81, 56.82, 57.81, 58.41, 69.41

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