Relative Contributions of Complications and Failure to Rescue on Mortality in Older Patients Undergoing Pancreatectomy

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Background: For pancreatectomy patients, mortality increases with increasing age. Our study evaluated the relative contribution of overall postoperative complications and failure to rescue rates on the observed increased mortality in older patients undergoing pancreatic resection at specialized centers.

Methods: We identified 2694 patients who underwent pancreatic resection from the American College of Surgeons' National Surgical Quality Improvement Pancreatectomy Demonstration Project at 37 high-volume centers. Overall morbidity and in-hospital mortality were determined in patients younger than 80 years (N = 2496) and 80 years or older (N = 198). Failure to rescue was the number of deaths in patients with complications divided by the total number of patients with postoperative complications.

Results: No significant differences were observed between patients younger than 80 years and those 80 years or older in the rates of overall complications (41.4% vs 39.4%, $P = 0.58$). In-hospital mortality increased in patients 80 years or older compared to patients younger than 80 years (3.0% vs 1.1%, $P = 0.02$). Failures to rescue rates were higher in patients 80 years or older (7.7% vs 2.7%, $P = 0.01$). Across 37 high-volume centers, unadjusted complication rates ranged from 25.0% to 72.2% and failure to rescue rates ranged from 0.0% to 25.0%. Among patients with postoperative complications, comorbidities associated with failure to rescue were ascites, chronic obstructive pulmonary disease, and diabetes. Complications associated with failure to rescue included acute renal failure, septic shock, and postoperative pulmonary complications.

Conclusions: In experienced hands, the rates of complications after pancreatectomy in patients 80 years or older compared to patients younger than 80 years were similar. However, when complications occurred, older patients were more likely to die. Interventions to identify and aggressively treat complications are necessary to decrease mortality in vulnerable older patients.

Keywords: complications, failure to rescue, mortality, pancreatectomy

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Failure to rescue is defined as the number of patients who die from their postsurgical complications divided by the total number of patients who experience complications.[1] Failure to rescue is a measure of a hospital's ability to recognize and manage postoperative complications.[2] In-hospital mortality can be considered a function of both postoperative complications and failure to rescue rates. A retrospective cohort study using the American College of Surgeons' National Surgical Quality Improvement Project (ACS-NSQIP) data demonstrated that failure to rescue, after nonemergent general surgery operations increased with increasing age.[3] When compared to younger patients, the observed increased mortality in older patients could be due to increased complication rates, increased failure to rescue rates, or a combination of both.

Although mortality rates in pancreatectomy have improved over time, the complication rates remain in excess of 30% in most series.[4–6] Two recent, large, population-based studies demonstrated that advanced age was independently associated with longer lengths of stay and higher mortality rates following pancreatic surgery.[7,8] Previous studies have focused solely on mortality after pancreatectomy in older patients[7,9–11] or failure to rescue for all patients undergoing pancreatectomy.[12] However, for older patients, it is not clear whether the observed increase in mortality rate is attributed to higher rates of postsurgical complications, higher failure to rescue from these postsurgical complications, or both.

We used data from the ACS-NSQIP Pancreatectomy Demonstration Project to determine the relative contribution of overall postoperative complications and failure to rescue rates on mortality in older patients undergoing pancreatic resection. We hypothesized that older patients undergoing pancreatectomy at high-volume centers would experience both higher complication rates and higher failure to rescue rates when compared to younger patients, with both contributing to the observed increase in mortality.

METHODS

As the study involved secondary data analysis of de-identified data, the study was deemed not human subjects research and was designated exempt from review by the institutional review board at the University of Texas Medical Branch.

Data Source

The ACS-NSQIP was established in 2005 to prospectively collect data on 30-day perioperative morbidity and mortality for patients undergoing surgery at participating hospitals. The details of data reporting, acquisition, and reliability have been published previously.[13–15] The ACS-NSQIP Pancreatectomy Demonstration Project is a collaborative of 43 institutions that prospectively collected pancreatectomy-specific variables in addition to standard NSQIP variables for patients undergoing pancreatic resection.

Cohort Selection

We identified 2805 patients undergoing pancreatic resection (pancreaticoduodenectomy, distal pancreatectomy, total pancreatectomy, enucleation) from November 2011 through December 2012 at 43 participating institutions. Patients with missing information on

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30-day mortality were excluded. We also excluded all institutions with fewer than 10 cases (N = 5). One additional institution lacked mortality data and was excluded. Our final cohort consisted of 2694 patients from 37 high-volume centers (Fig. 1).

Variables

The Pancreatectomy Demonstration Project includes pancreas-specific variables in addition to the standard 240 Health Insurance Portability and Accountability Act compliant variables recorded on patient demographics, preoperative risk factors, intraoperative variables, and 30-day postoperative morbidity and mortality in ACS-NSQIP. Morbidity and mortality data do not extend beyond the 30-day postoperative period in the NSQIP data set. This could potentially underestimate the calculated failure to rescue rates if death from complications occurred outside the 30-day observational period. The list and definitions of variables collected in the database can be found at the American College of Surgeons NSQIP Web site and have been described previously.[16,17]

Age was analyzed as a categorical variable with groups categorized as either younger than 80 years or 80 years and older.

Outcome

Overall postoperative morbidity was defined as any 1 or more of the following: delayed gastric emptying, postoperative pancreatic fistula, any surgical site infection (SSI), postoperative sepsis or septic shock, wound disruption, urinary tract infection, acute renal failure, progressive renal insufficiency, postoperative pneumonia, postoperative ventilator dependence, need for cardiopulmonary resuscitation, postoperative myocardial infarction, postoperative coma or stroke, pulmonary embolism, deep venous thrombosis, and reoperation, all within 30 days of operation and as defined within ACS-NSQIP.

Serious morbidity was derived from a previous algorithm for pancreatectomy patients[15] as any 1 or more of the following in the absence of preoperative pneumonia, preoperative SSI, or preoperative ventilator dependence: pancreatic fistula, acute renal failure, organ space SSI, postoperative sepsis or septic shock, wound disruption, reoperation, pulmonary embolism, deep venous thrombosis, need for cardiopulmonary resuscitation, postoperative myocardial infarction, postoperative stroke, and postoperative coma.

In-hospital mortality was defined as occurring in any patient with a discharge destination of "Expired," as recorded by the Pancreatectomy Demonstration Project. Failure to rescue was defined as the number of patients who experienced in-hospital mortality from these complications divided by the number of patients who experienced complications.

$$\text{Failure to rescue} = \frac{\text{No. patients who died from complication}}{\text{Total no. patients with complication}}$$

Unadjusted complication rates and failure to rescue rates were calculated across the 37 included participating institutions.

Statistical Analysis

Summary statistics were calculated for the overall cohort. Chi-square tests and *t* tests were used to test significant differences in patient and treatment characteristics for patients younger than 80 years and patients 80 years or older. The mortality, complication, and failure to rescue rates were also calculated for each age group. Complication rates and failure to rescue rates were calculated for each of the high-volume centers and are represented graphically in Figure 2. For the patients with complications (N = 1111), χ^2 tests and *t* tests were used to compare the characteristics and complications of patients who failed to rescue to those who did not. Fisher exact test was performed where appropriate. For these patients with complications, we reported the unadjusted odds ratio and 95% confidence intervals (CI) relative to a chosen reference group. Statistical significance was accepted at the $P < 0.05$ level. All analyses were performed using SAS 9.2 (SAS, Inc, Cary, NC).

RESULTS

Our final cohort included 2694 patients who underwent pancreatic resection at 37 high-volume institutions (median = 48 cases per institution, range 11–379). Patient characteristics are summarized

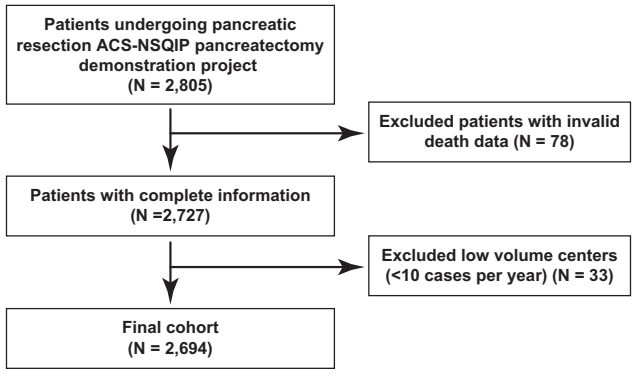

FIGURE 1. Cohort Selection. 2805 patients undergoing pancreatic resection from 2011 to 2012 were identified. Patients with invalid death data and patients from low volume institutions were excluded. The final cohort included 2694 patients.

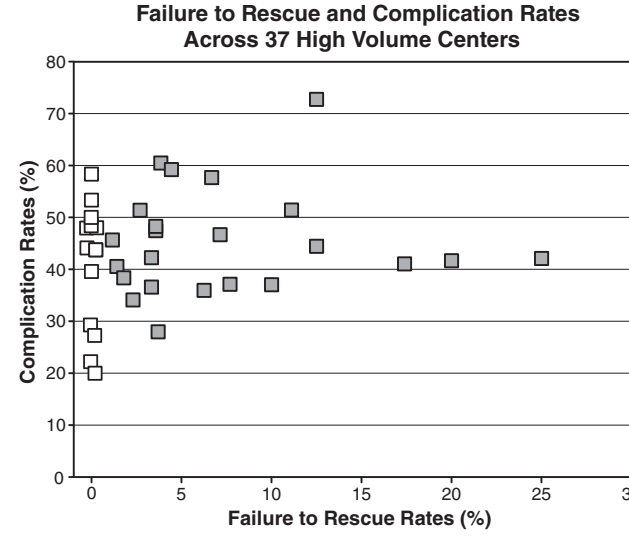

FIGURE 2. Failure to rescue rates and complication rates for 37 high volume centers. Each data point represents a hospital among the 37 high-volume centers. The *x* axis represents the failure to rescue rate and the y axis represents the complication rate for each hospital. Complication rates ranged from 20.0% to 72.2% and failure to rescue rates ranged from 0.0% to 25.0%. The white data points represent those hospitals with 0.0% failure to rescue rates and the gray data points represent those hospitals with greater than 0.0% failure to rescue rates.

in Table 1. The mean age for our cohort was 62.3 ± 13.0. The majority of the patients were white (89.1%), male (50.7%), and 67.3% of patients underwent pancreatic head resection (pancreaticoduodenectomy or total pancreatectomy). The diagnosis was adenocarcinoma in 58.9% of patients.

Patient Characteristics Stratified by Age

When compared to patients younger than 80 years (N = 2496), 80 years and older patients (N = 198) were more likely to be white, nonsmokers, have higher American Society of Anesthesiologists (ASA) classification, hypertension, and present with obstructive jaundice (Table 1). Although adenocarcinoma was the most common diagnosis in both age groups, pancreatectomy was more commonly performed for pancreatic cancer in the older patients (80.8% vs 57.1%, $P \leq 0.0001$). Pancreaticoduodenectomy was more commonly performed in patients 80 years or older compared to patients younger than 80 (72.5% vs 63.7%, $P = 0.05$, Table 1).

Complications and Failure to Rescue Across Participating Hospitals

For the 2694 patients, the overall mortality rate was 1.3% and the complication rate was 41.2%. Of the 1111 patients with complications, the overall failure to rescue rate was 3.1%. Across the 37 high-volume hospitals, unadjusted complications ranged from 20.0% to 72.2% (Fig. 2). Likewise, failure to rescue rates varied across hospitals, from 0% to 25.0% (Fig. 2). Complication rates for each hospital varied across failure to rescue rates. For hospitals with 0.0% failure to rescue rates, complication rates ranged from 20.0% to 58.3% whereas for hospitals with the higher failure to rescue rates, complication rates ranged from 27.9% to 72.2% (Fig. 2).

Morbidity, Mortality, and Failure to Rescue by Age Groups

In-hospital mortality rates increased in patients 80 years or older compared to patients younger than 80 years (3.0% vs 1.1%,

TABLE 1. Patient Characteristics of Patients Undergoing Pancreatic Resection in ≥80 Years and <80 Years Age Groups, ACS-NSQIP Pancreatectomy Demonstration Project, 2011–2012 (N = 2694)

	Overall Cohort, %	Patients ≧ 80, %	Patients < 80, %	*P**
Patient characteristics	N = 2694	N = 198	N = 2496	
Age, mean ± SD	62.3 ± 13.0	82.9 ± 2.8	60.8 ± 12.1	<0.0001
Sex				0.84
Male	1366 (50.7%)	99 (50.0%)	1267 (50.8%)	
Race				0.03
White	2124 (89.1%)	180 (94.7%)	2124 (88.7%)	
Black	201 (7.8%)	7 (3.7%)	194 (8.1%)	
Other	201 (3.1%)	3 (1.6%)	78 (3.3%)	
ASA classification				0.003
I	24 (0.9%)	1 (0.5%)	23 (0.9%)	
II	762 (28.5%)	34 (17.3%)	728 (29.4%)	
III	1789 (66.9%)	154 (78.1%)	1635 (66.0%)	
IV	98 (3.7%)	8 (4.1%)	90 (3.6%)	
Preoperative weight loss	422 (15.7%)	37 (18.7%)	385 (15.4%)	0.22
BMI				<0.0001
Underweight	59 (2.2%)	2 (1.0%)	57 (2.3%)	
Normal	994 (37.0%)	94 (47.5%)	900 (36.1%)	
Overweight	917 (34.1%)	77 (38.9%)	840 (33.7%)	
Obese	719 (26.7%)	25 (12.6%)	694 (27.9%)	
Diabetes	637 (23.7%)	42 (21.2%)	595 (23.8%)	0.40
Smoker	577 (21.4%)	4 (2.0%)	573 (23.0%)	<0.0001
Dyspnea	213 (7.9%)	20 (10.1%)	193 (7.7%)	0.23
Hypertension	1380 (51.2%)	137 (69.2%)	1243 (49.8%)	<0.0001
Obstructive jaundice	836 (31.6%)	75 (38.1%)	761 (31.0%)	0.04
Steroid use	69 (2.6%)	6 (3.0%)	63 (2.5%)	0.66
COPD	121 (4.5%)	7 (3.5%)	114 (4.6%)	0.50
Preoperative biliary stent	862 (32.2%)	65 (33.2%)	797 (32.1%)	0.77
Diagnosis				<0.0001
Adenocarcinoma	1586 (58.9%)	160 (80.8%)	1426 (57.1%)	
Pancreatitis	401 (14.9%)	9 (4.5%)	392 (15.7%)	
Neuroendocrine/Carcinoid	242 (9.0%)	11 (5.6%)	231 (9.3%)	
Other	465 (17.2%)	18 (9.1%)	447 (17.9%)	
Type of operation				0.05
Pancreaticoduodenectomy	1720 (64.4%)	142 (72.5%)	1578 (63.7%)	
Distal pancreatectomy	821 (30.7%)	50 (25.5%)	771 (31.1%)	
Total pancreatectomy	80 (3.0%)	3 (1.5%)	77 (3.1%)	
Enucleation	52 (2.0%)	1 (0.5%)	51 (2.1%)	
Laparoscopy (Yes)	359 (13.4%)	23 (11.7%)	336 (13.5%)	0.47
Intraoperative drain				0.09
Yes	2014 (74.8%)	156 (78.8%)	1858 (74.4%)	
No	446 (16.6%)	22 (11.1%)	424 (17.0%)	
Unknown	234 (8.7%)	20 (10.1%)	214 (8.6%)	
Vascular resection (Yes)	437 (17.9%)	35 (19.2%)	402 (17.8%)	0.63

*P values represent differences between subgroups for each category.

$P = 0.03$) (Table 2). However, across high-volume centers, there was no significant difference in the rate of overall complications between patients 80 years or older and younger than 80 years (41.4% vs 39.4%, $P = 0.59$). Also, no significant difference existed in the rate of major complications between patients 80 years or older and younger than 80 years (28.5% vs 29.3%, $P = 0.79$). The increased mortality in older patients was attributed to higher failure to rescue rates in patients 80 years or older compared to patients younger than 80 years (7.7% vs 2.6%, $P = 0.01$).

Morbidity, Mortality, and Failure to Rescue by Volume

The median number of cases performed across high-volume centers was 48 (range: 11–379) (Table 3). Among the 37 high-volume centers, we used a cutoff of 50 cases performed annually to distinguish between higher- versus lower-volume centers. There were 19 lower-volume institutions that performed 465 cases and 18 higher-volume institutions that performed 2229 cases. Compared to lower-volume centers, higher-volume centers had lower in-hospital mortality rates (2.4% vs 1.0%, $P = 0.02$). However, there was no significant difference in complication rates between higher- and lower-volume centers (43.9% vs 40.7%, $P = 0.21$). The increased mortality in lower-volume centers compared to higher-volume centers was attributed to higher failure to rescue rates (5.4% vs 2.5%, $P = 0.03$).

Other Factors Associated With Failure to Rescue

In a bivariate analysis, we identified additional factors associated with failure to rescue in the 1111 patients who experienced complications. Table 4 shows the rates of failure to rescue and unadjusted odds ratios comparing patients with and without specific preoperative comorbidities and postoperative complications. Comorbidities significantly associated with increased failure to rescue rates were

TABLE 2. Overall Complications, Major Complications, and Mortality for Patients Undergoing Pancreatic Resection Stratified by Age, ACS-NSQIP Pancreatectomy Demonstration Project, 2011–2012 (N = 2694)

	Overall Rates (N = 2694), N (%)	Patients ≧ 80 (N = 198), N (%)	Patients < 80 (N = 2496), N (%)	P*
In-hospital mortality	34 (1.3%)	6 (3.0%)	28 (1.1%)	0.02
Overall complications	1,111 (41.2%)	78 (39.4%)	1,033 (41.4%)	0.58
Major complications†	768 (28.5%)	58 (29.3%)	710 (28.5%)	0.79
Specific complications				
Perioperative bleeding	579 (21.5%)	63 (31.8%)	516 (20.7%)	0.0002
SSI	513 (19.0%)	35 (17.7%)	478 (19.2%)	0.61
Pancreatic Fistula	402 (14.9%)	27 (14.3%)	375 (15.6%)	0.62
Delayed gastric emptying	344 (12.8%)	25 (13.4%)	319 (13.3%)	0.98
Organ space SSI	258 (9.6%)	24 (12.1%)	234 (9.4%)	0.21
Superficial SSI	226 (8.4%)	10 (5.1%)	216 (8.7%)	0.08
Postoperative sepsis	208 (7.7%)	9 (4.6%)	199 (8.0%)	0.08
DVT and pulmonary embolism	110 (4.1%)	11 (5.6%)	99 (4.0%)	0.30
Urinary tract infection	103 (3.8%)	5 (2.5%)	98 (3.9%)	0.32
Postoperative pneumonia	101 (3.7%)	11 (5.6%)	90 (3.6%)	0.16
Reoperation	93 (3.5%)	10 (5.1%)	83 (3.4%)	0.20
Septic shock	92 (3.4%)	12 (6.1%)	80 (3.2%)	0.03
Unplanned intubation	87 (3.2%)	13 (6.6%)	74 (3.0%)	0.006
Ventilator >48 h	80 (2.9%)	9 (4.6%)	71 (2.8%)	0.17
Deep SSI	56 (2.1%)	2 (1.0%)	54 (2.2%)	0.27
Acute renal failure and renal insufficiency	45 (1.7%)	3 (1.5%)	42 (1.7%)	0.86
Wound disruption	40 (1.5%)	4 (2.0%)	36 (1.4%)	0.52
MI	26 (0.9%)	4 (2.0%)	22 (0.9%)	0.11
CPR	19 (0.7%)	2 (1.0%)	17 (0.7%)	0.59
CVA	9 (0.3%)	0	9 (0.4%)	0.40
Failure to rescue overall	34 (3.1%)	6 (7.7%)	28 (2.7%)	0.01

*P values represent differences between subgroups for each category; The denominator for failure to rescue is the number of patients with postoperative complications.

†Major complications defined as 1 or more of the following in the absence of preoperative pneumonia, preoperative SSI, or preoperative ventilator dependence: organ space SSI, postoperative sepsis or septic shock, wound disruption, reoperation, pulmonary embolism, deep venous thrombosis, need for cardiopulmonary resuscitation, postoperative myocardial infarction.

TABLE 3. Overall Complications, Major Complications, and Mortality for Patients Undergoing Pancreatic Resection Stratified by Hospital Volume, ACS-NSQIP Pancreatectomy Demonstration Project, 2011–2012 (N = 2694)

	Overall (N = 2694)	High Volume (N = 2229), N (%)	Low Volume (N = 465), N (%)	P
In-hospital mortality	34/2694 (1.3%)	23/2229 (1.0%)	11/465 (2.4%)	0.02
Overall complications	1,111/2694 (41.2%)	907/2229 (40.7%)	204/465 (43.9%)	0.21
Major complications	768/2,694 (28.5%)	639/2229 (28.7%)	129/465 (27.7%)	0.69
Failure to rescue*	34/1,111 (3.1%)	23/907 (2.5%)	11/204 (5.4%)	0.03

*The denominator for failure to rescue is the total number of patients with complications.

TABLE 4. Preoperative Factors and Complications Associated With Failure to Rescue* in Patients Who Experienced Postoperative Complications (N = 1111)

Preoperative Factors			
	% Failure to Rescue With Factor	**% Failure to Rescue Without Factor**	**Odds Ratio (95% CI)**
Ascites (N = 10)	40.0%	2.7%	23.8 (6.38–88.75)
COPD (N = 58)	10.3%	2.7%	4.2 (1.68–10.65)
Diabetes (N = 251)	5.2%	2.4%	2.2 (1.08–4.42)
Postoperative Complications			
	% Failure to Rescue With Complication	**% Failure to Rescue Without Complication**	**Odds Ratio (95% CI)**
Acute renal failure (N = 24)	50.0%	2.0%	48.41 (19.59–119.63)
CVA (N = 9)	44.4%	2.7%	28.6 (7.31–111.82)
CPR (N = 19)	36.8%	2.5%	23.0 (8.40–63.01)
Unplanned intubation (N = 87)	27.6%	0.9%	38.6 (7.70–84.29)
Septic Shock (N = 92)	23.9%	1.2%	26.4 (12.53–55.49)
Ventilator >48 h (N = 80)	21.3%	1.7%	16.1 (7.84–33.03)
Progressive renal insufficiency (N = 24)	16.7%	2.7%	7.0 (2.27–21.88)
Reoperation (N = 93)	11.8%	2.2%	5.9 (2.81–12.79)
DVT (N = 76)	10.5%	2.5%	4.6 (1.99–10.47)
Postoperative pneumonia (N = 101)	7.9%	2.6%	3.3 (1.43–7.39)
Postoperative bleeding (N = 298)	5.0%	2.3%	2.2 (1.11–4.42)

*Failure to rescue defined as death from complications divided by the total number of complications.

ascites, chronic obstructive pulmonary disease (COPD), and diabetes. Complications associated with failure to rescue were acute renal failure, cerebrovascular accident (CVA), postoperative cardiopulmonary resuscitation, unplanned intubation, septic shock, progressive renal insufficiency, reoperation, postoperative pneumonia, and postoperative bleeding.

DISCUSSION

We used a multi-institutional, prospectively collected database to identify in-hospital mortality, complications, and failure to rescue rates for patients undergoing pancreatectomy. When stratified by age, older patients had a higher ASA class compared to their younger counterparts, but no significant difference was observed in the overall rate of postoperative complications between these groups. However, older patients still had higher in-hospital mortality rates. Our study could implicate higher failure to rescue rates as a potential contributor to the observed increased mortality rates in older patients undergoing pancreatectomy at high-volume institutions.

Considerable debate exists in the literature regarding the safety of pancreatectomy in older patients.[18,19] In population-based studies of patients undergoing pancreatectomy, advancing age was identified among others as an independent predictor of increased perioperative mortality.[7,20] To explain the observed increased mortality in older patients undergoing major surgery, several studies have evaluated the impact of postoperative complications on patient survival.[6,20,21] A population-based study by Finlayson et al demonstrated higher complication rates in older patients undergoing pancreatic resection for cancer.[8] Likewise, in a retrospective cohort study by Haigh et al using NSQIP data, age of more than 70 years was found to be an independent prognostic factor for increased postoperative complications after pancreaticoduodenectomy.[4] A prospective multicenter study using the NSQIP database demonstrated that 30-day postoperative complications were the most important determinant of survival in patients undergoing major general surgery operations.[21] In contrast, our study, which included only patients operated on at high-volume centers, found no difference in overall complication rates between patients 80 years or older and patients younger than 80 years (41.4% vs 39.4%, $P = 0.58$). This finding suggests that at high-volume centers both careful patient selection and improved operative technique related to surgeon experience led to fewer complications in older patients.

A volume-outcome relationship in pancreatic surgery is well established.[22–24] In evaluating high-volume centers only, our findings have significant implications regarding postoperative management of complications. Previous studies have demonstrated improved postoperative outcomes for high-volume compared to low-volume centers.[12] A population-based study from Texas evaluated outcomes for pancreatectomy patients at high-volume centers only and identified significant variability in mortality, length of stay, and total hospital charges.[25] In our study, complication rates and failure to rescue rates varied widely. We found that even across high-volume centers, the very high-volume centers (>50 cases per year) had lower mortality rates but similar complications rates compared to lower-volume centers. At lower-volume centers, the observed increased mortality rates were attributed to higher failure rescue rates.

These data suggest that identification of preoperative risk factors, early recognition, and timely management of complications strongly associated with failure to rescue, especially in older patients, could decrease mortality rates for patients undergoing pancreatectomy in high-volume centers. The inciting events that lead to failure to rescue likely originate in complications such as pancreatic fistula. Cardiopulmonary resuscitation, acute renal failure, and reintubation are often downstream events of such complications. Although the NSQIP data describes the presence or absence of abscess, infection, fistula, and other complications, the temporal relations of these complications are unknown. Given that these are downstream complications, our data suggest that early and aggressive management can prevent the cascade of complications leading to cardiopulmonary resuscitation, acute renal failure, and reintubation.

In a study using a nationwide database, Ghaferi et al[12] identified teaching hospitals, high-volume centers, increased nurse to patient ratios, and increased hospital technology as hospital characteristics significantly associated with lower failure to rescue rates after pancreatectomy for all patients. In a qualitative study by Johnston et al,[26] escalation of care was identified as the common initial factor in the recognition and management of the deteriorating patient. Barriers to escalating care in patients with complications were lack of an established protocol and lack of support from senior team members. In an effort to improve failure to rescue rates, Johnston et al[27] created a guide for the development of technology-based communication interventions to address issues with barriers to escalation of care. In various institutions, the increase in failure to rescue rates for elderly patients may also be explained by unmeasured factors such as resource and provider factors that impact the recognition and management of complications. In addition, clarifying physician, patient, and caregiver goals of care by qualitative techniques can provide insight into differences in management of complications within the aging population.

Several limitations are inherent to this study. As with all observational data sets, it is difficult to assess whether the population included in the study is a truly representative sample for most patients undergoing pancreatectomy. During the ACS-NSQIP pancreatectomy demonstration project, there was a learning curve for the pancreas-specific variables. This learning curve could have lead to inaccuracy in capturing complications. Any hospital participating in ACS-NSQIP employs surgical clinical reviewers (SCRs) who are trained through a standardized process to systematically abstract clinical data at an institutional level throughout the 30-day postoperative period. All pancreatectomy-specific variables were clearly defined and collected by trained ACS-NSQIP SCRs. All SCRs were trained in the new variable collection, and support was available for questions during the demonstration project. As such, we expect reasonable accuracy of the collected data. The ACS-NSQIP data collection process has been shown to have high interrater reliability and high accuracy in capturing complications.[28–30] In addition, all patients in our study underwent surgery at high-volume institutions defined by Leapfrog criteria as less than 10 cases per year. In hospitals only performing 10 or 20 cases during the period of the demonstration project, 1 or 2 complications could lead to large changes in the percentage of complications. Overtime, as more data are collected, we expect some regression to the mean. Across these high-volume institutions, some hospitals contributed a much smaller number of cases when compared to others between 2011 and 2012. A larger sample size from such institutions could yield large differences in outcomes. In this study, the number of patients undergoing pancreatectomy who were 80 years or older is a small subset of the population (N = 198) and this study is likely underpowered to detect significant factors associated with failure to rescue between age groups. Older patients had more comorbid illness and were more likely to undergo higher-risk pancreatic resections, including pancreaticoduodenectomy and total pancreatectomy, than younger patients. In addition, assessment of patient motivation for treatment choices, which can result in a selection bias, is difficult. Patients 80 years or older could have had a do not resuscitate status precluding escalation of care in the event of a serious complication. These individual characteristics are not captured in this observational data set. However, for those patients who agreed to undergo pancreatectomy and are included in the data set, it is assumed that by signing consent, patients agreed to pursue surgical intervention with a clear understanding of the potential complications. In addition, unmeasured intraoperative variables such as the difficulty of the operation may not have been captured. Our study identifies preoperative comorbidities and postoperative complications associated with failure to rescue, the incidence of many of these were low, with resulting large confidence intervals around our unadjusted estimates. Although postoperative complications can occur within 30 days, for pancreatectomy patients, the risk of mortality extends beyond 30 days and death from these complications can occur much later. In a study using Surveillance, Epidemiology and End Results-Medicare data to evaluate mortality after pancreatic resection, in-hospital and 30-day mortality were similar, but mortality increased significantly within 60 days after resection.[31] Given that NSQIP data only includes 30-day postoperative morbidity and mortality data, the failure to rescue from postoperative complications could potentially be underestimated in this study.

It is always true that avoiding complications will decrease mortality for all patients undergoing pancreatectomy. Complication rates are also included in the failure to rescue pathway. Therefore, complications can be addressed before they occur (avoiding complications) or once they occur by addressing those complications that are associated with higher rates of failure to rescue. Several factors, such as individual surgeon volume, impact patient outcomes and failure to rescue rates are a significant but not the sole contributor to increased mortality rates in older patients undergoing pancreatectomy.

CONCLUSIONS

We used a multi-institutional database to identify the relative contributions of failure to rescue and complications on the observed increased mortality rates for older patients undergoing pancreatic resection. We found that patients 80 years and older had no difference in complication rates but higher failure to rescue rates compared to patients younger than 80 years. Especially with regard to the variation in failure to rescue rates even at high-volume hospitals, earlier recognition and more effective management of postoperative complications is key to improving outcomes. Protocols to escalate care based on timely recognition and treatment of the complications strongly associated with failure to rescue can improve outcomes in older patients undergoing pancreatectomy.

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