Pancreas

Routine intensive care unit admission among patients undergoing major pancreatic surgery for cancer: No effect on failure to rescue

Marcelo Cerullo, MD, MPH [a], Faiz Gani, MBBS [b], Sophia Y. Chen, MD, MPH [b],
Joseph K. Canner, MHS [b], Mary Dillhoff, MD [c], Jordan Cloyd, MD [c], Timothy M. Pawlik, MD,
MPH, PhD [c],*

[a] Department of Surgery, Duke University Medical Center, Durham, NC
[b] Department of Surgery, Johns Hopkins University School of Medicine, Baltimore, MD
[c] Department of Surgery, The Ohio State University Wexner Medical Center, Columbus

A B S T R A C T

Background: An understanding of the overall routine intensive care unit utilization, and characterization of the factors associated with a routine intensive care unit stay, may help identify ways to decrease overutilization of this resource after pancreatic surgery.
Methods: Patients undergoing major pancreatic resection were identified in the Truven Health Analytics (Ann Arbor, MI) MarketScan Commercial Claims and Encounters Database from 2010 to 2014. Routine postoperative intensive care unit admission was defined as an admission to the intensive care unit of 24 hours or less on postoperative day zero. The association between routine intensive care unit admission and postoperative outcomes, including extended length of stay, failure to rescue, and total inpatient costs were evaluated.
Results: Of 3,280 patients who underwent a major pancreatic resection, 1,715 patients (52.3%) had a routine intensive care unit admission, which trended down over time (2010, $n = 349$; 53.0% versus 2014, $n = 299$; 47.5%; $P = .019$). The incidence of failure to rescue among patients who were routinely admitted to the intensive care unit (3.7%) was comparable to those admitted to the floor (1.7%, $P = .098$). Patients who were routinely admitted to the intensive care unit after major pancreatic resection had a median length of stay of 10 days (IQR: 7–15 days) versus 8 days (IQR: 7–12 days) for patients who were not admitted to the ICU ($P < .001$). Routine intensive care unit admission was not associated with higher overall payments (ratio of adjusted total payments: 1.02, 95% CI: 0.98–1.06, $P = .297$).
Conclusion: Routine intensive care unit admission was associated with a longer length of stay but did not translate into lower failure to rescue among patients.

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Introduction

Despite advances in surgical technique and perioperative care, major pancreatic resection (eg, pancreaticoduodenectomy and total pancreatectomy) continues to have a high incidence of postoperative complications.[1] To facilitate early detection and quick mitigation of possible complications, many institutions have adopted a practice of routinely admitting patients to an intensive care unit (ICU) after major pancreatic surgery. In fact, although postoperative enhanced-care pathways have been implemented after many surgical procedures, protocols that include routine ICU admission after major surgery have remained in place in many institutions.[2,3] Critical care units are, however, an expensive and an otherwise scarce resource in terms of staff, equipment, and clinician expertise. In an era of patient-centered care, the ICU experience can also be disruptive to the patient, interrupt continuity of nursing care, and be more difficult for family members.[4,5] As such, a better understanding of overall routine ICU utilization in the postoperative setting, in addition to a characterization of the factors associated with a routine ICU stay, may help target ways to lower possible overutilization of this resource.

To date, routine ICU admission has been examined after certain high-risk operations and among specific subsets of higher-risk patients in other nonhepatopancreatobiliary surgical subspecialties. For example, Bertges et al.[6] reported that admission to the surgical floor rather than to the ICU among select patients undergoing infrarenal abdominal aortic aneurysm repair at a

single high-volume center was associated with comparable morbidity and mortality. In a separate nationwide study, Hicks et al.[7] noted that institutional factors, rather than patient-specific factors, were associated with routine the postoperative use of the ICU after elective endovascular repair of infrarenal aortic aneurysms. Other investigators have demonstrated that routine postoperative ICU monitoring to detect cardiopulmonary complications among patients undergoing bariatric procedures was likely unnecessary and more expensive.[8]

The prevalence of routine ICU use, and the possible factors associated with a routine admission, have not been examined in a national sample of patients undergoing major pancreatic surgery. Although ICU admission certainly is necessary for some patients, routine ICU use for all patients after major pancreatic surgery may be unnecessary and lead to a longer length of stay and higher costs without any added benefits. Therefore, the objective of the current study was to define the incidence of, and the factors associated with, routine postoperative ICU admission after major pancreatic resection for a cancer diagnosis, using a national claims database. We also sought to evaluate the association between routine postoperative ICU admission with hospital length of stay and overall inpatient payments, as well as determine whether routine ICU admission was associated with reduced risk of failure to rescue after inpatient complications.

Methods

Data source and patient population

A retrospective analysis was performed of data from the Truven Health Analytics (Ann Arbor, MI) Marketscan Commercial Claims and Encounters Database collected between January 1, 2010, and December 31, 2014. The Truven Health Analytics MarketScan Research Database is a medical and drug insurance claims database that has collected data from more than 140 million unique, deidentified patients, including active employees, early retirees, Consolidated Omnibus Budget Reconciliation Act (COBRA) continuers, and their dependents who are insured by more than 100 different employer-sponsored plans. Variables in the database include inpatient admission records, outpatient services, prescription drug claims, eligibility status, and payments for services.[9]

Patients ≥18 years of age, with a primary diagnosis of pancreatic cancer (International Classification of Diseases, 9th edition [ICD-9-CM] code 157*), who underwent total pancreatectomy or pancreaticoduodenectomy (ICD-9-CM 52.6*, 52.7) were identified. Major vascular reconstruction was identified using current procedural terminology (CPT) codes (37140, 37145, 37180, 37181, 35221, 35251, 35281). Routine postoperative ICU admission was determined by identifying patients who had an ICU-specific claim on postoperative day zero and remained in the ICU for less than 24 hours. Patients who were admitted to the ICU on or after postoperative day one or who remained in the ICU for longer than 24 hours were deemed to have a nonroutine ICU admission. Perioperative administration of blood products (ie, transfusion on or before postoperative day two) was identified by revenue codes for inpatient services. The administration of adjuvant or neoadjuvant chemotherapy or radiation therapy was determined by database-specific procedure codes in inpatient, outpatient, and pharmacy claims. Patient comorbidity was classified as the Charlson comorbidity index (CCI) by mapping secondary diagnosis codes with a previously validated algorithm. Inpatient complications were similarly coded, using a specific methodology for administrative data.[10,11] Patients with missing data or data coded as "Unknown" for any included covariates were excluded from analysis. As described elsewhere, postoperative major complications included surgical site infection, pneumonia, respiratory failure, cardiac

complication, gastrointestinal complication, renal failure, thromboembolic event, and postoperative shock or hemorrhage.[12] Failure to rescue was defined as inhospital death among patients who had a major postoperative complication.[13,14]

Statistical analysis

Categorical variables were reported as total frequencies and proportions, and median values with interquartile range (IQR) and means with standard deviation were used to describe continuous data. Univariable analysis was performed using the Pearson χ^2 test and Fisher exact test for categorical data. The Kruskal-Wallis test, or one-way unpaired/paired Student t test was used for continuous data, as appropriate. The association between routine ICU admission and postoperative outcomes, including extended length of stay and total inpatient costs (defined by total payments for the hospital stay) was then evaluated. Although the MarketScan databases detailed the claims that characterize patients' day-to-day hospital course, in addition to itemized total and net payments, more recently the data inadequately identified single institutions.[9,15] As such, to determine the degree of variation accounted for by factors outside of patients' clinical or demographic factors, the following three separate sensitivity analyses were conducted to assess the impact on length of stay and total payments: (1) instead of including hospital region as a covariate, hospital state was included as a random effect in each model of patient outcomes (2) the same analyses were conducted on the limited sample of patients for whom a primary physician identifier was available, and (3) hospitals were further categorized by whether patients were treated in dedicated surgical ICU versus nondesignated critical care units. Because ICU admission was common (ie, greater than 10% of inpatients undergoing surgery), modified Poisson regression was used to determine the association between patients' clinical factors and routine postoperative ICU admission and to determine the association between routine postoperative ICU admission and extended length of stay.[16] The impact on inpatient payments was assessed using multivariable linear regression models on log-transformed payments.

To determine whether routine postoperative ICU admission affected inpatient mortality among patients who experienced postoperative complications, failure to rescue was evaluated. As failure to rescue was a relatively rare event, penalized logistic regression, using the method described by Firth,[17] was employed.[18] All analyses were conducted using Stata 14.0 MP (StataCorp LLC, College Station, TX, USA). All patient data were deidentified and compliant with the Health Insurance Portability and Accountability Act of 1996. Patient consent was therefore waived, and the study was approved by the Johns Hopkins University Institutional Review Board (Baltimore, MD).

Results

Study population

Among patients with pancreatic cancer who met the selection criteria, median patient age was 57 years (IQR 51–61) and most patients were male ($n = 1,721$, 52.5%). Although 165 (5.0%) patients had no preoperative medical comorbidities, 3,053 (93.1%) patients had a CCI score of 2 or greater. At the time of surgery, the majority ($n = 3,059$, 93.3%) underwent a Whipple operation (eg, pylorus-preserving or nonpylorus-preserving pancreaticoduodenectomy) and a smaller subset of patients had a total pancreatectomy ($n = 221$, 6.7%). Among the 3,280 patients who underwent a major pancreatic resection, 1,715 patients (52.3%) had a routine ICU admission. Among the 1,198 patients who had a "straightforward" major pancreatic resection (ie no vascular resection, no perioper-

Table 1
Univariable and multivariable modified Poisson regression results of factors associated with routine ICU admission.

Variable	Relative risk (95% CI)	P value	Relative risk (95% CI)	P value
Age (years)				
Younger than 45	Reference		Reference	
45–54	1.03 (0.91–1.17)	.661	0.99 (0.87–1.12)	.869
55 and older	1.03 (0.92–1.16)	.613	0.99 (0.88–1.12)	.900
Female (versus male)	0.96 (0.90–1.03)	.259	0.95 (0.89–1.01)	.112
Year	0.97 (0.95–0.99)	.011	0.97 (0.95–1.00)	.028
Receipt of neoadjuvant therapy	1.11 (1.03–1.21)	.009	1.07 (0.98–1.16)	.138
Charlson comorbidity index				
0	Reference		Reference	
1	1.33 (1.02–1.74)	.035	1.31 (1.01–1.69)	.046
2+	1.17 (0.99–1.39)	.072	1.09 (0.92–1.30)	.308
Vascular reconstruction	1.17 (1.07–1.29)	.001	1.12 (1.02–1.23)	.022
Perioperative transfusion	1.38 (1.29–1.47)	< .001	1.36 (1.27–1.45)	< .001
Whipple (versus total pancreatectomy)	1.06 (0.93–1.22)	.374	1.08 (0.95–1.24)	.251
Region				
Northeast	Reference		Reference	
North Central	1.07 (0.97–1.18)	.187	1.08 (0.98–1.19)	.142
South	1.09 (0.99–1.19)	.076	1.07 (0.98–1.17)	.143
West	1.06 (0.95–1.18)	.337	1.06 (0.95–1.18)	.318

ative transfusion, and no complication), 488 patients (40.7%) were admitted to the ICU immediately after surgery and stayed less than 24 hours in the ICU. In addition, 436 (13.3%) of patients had a nonroutine ICU admission (>24 hours or admitted from the surgical ward), among whom the incidence of complications was 24.5% ($n = 107$), the median length of stay was 10 days (IQR: 8–16 days), and the failure to rescue rate was 2.8% ($n = 3$).

Several procedure-level and patient-level factors were associated with routine ICU utilization after major pancreatectomy. In particular, concomitant vascular reconstruction at the time of major pancreatic resection was associated with a 12% higher relative risk of routine ICU admission, and receipt of a perioperative transfusion was associated with a 36% higher risk of routine ICU admission. In contrast, patient-specific factors, such as age (RR [> 55 years]: 1.03, 95% CI: 0.92–1.16, ref: < 45 years) and sex (RR [female sex]: 0.96, 95% CI: 0.90–1.03) were not associated with odds of routine ICU admission. A CCI of 2 or greater was also not associated with increased risk of being admitted to the ICU immediately after a major pancreatic resection. After adjustment, no association between geographic region and likelihood of routine ICU admission was detected. Of note, the proportion of patients routinely admitted to the ICU after major pancreatic resection trended down over time (2010, $n = 349$; 53.0% versus 2014, $n = 299$; 47.5%; $P = .019$). Specifically, after adjustment for patient age, comorbidity, type of operation and operative complexity, patients undergoing surgery had a 3% lower annual risk of routine ICU admission over the time period examined (Table 1).

Association between routine ICU admission and patient outcomes

The incidence of experiencing any complication after complex pancreatic resection was 28.1%. The most common complications were gastrointestinal ($n = 474$, 14.5 %) and pulmonary, such as pneumonia or respiratory insufficiency or failure ($n = 342$, 10.4%). Perhaps not surprisingly, the incidence of postoperative complications among patients routinely admitted to the ICU (33.6%) was higher compared with patients not routinely admitted (22.0%; $P < .001$; Table 2). After adjusting for patient and clinical risk factors, we found that patients routinely admitted to the ICU still had a 47% higher risk of experiencing a postoperative complication. Of note, the relative risk of complications decreased by 7% with each subsequent year. Failure to rescue occurred in 27 (2.9%) of patients who experienced complications. The incidence of failure to rescue was comparable among patients who were routinely admitted to the ICU (3.7%) compared with patients admitted

postoperatively to the floor (1.7%; $P = .098$). Furthermore, failure to rescue did not vary among patients regarding age, higher CCI, and whether the patient had undergone a Whipple versus a total pancreatectomy (all $P > .05$). However, patients who underwent vascular reconstruction had 2.55 higher odds of failure to rescue after experiencing a complication. Similarly, patients who received a perioperative transfusion had nearly 5 times higher odds of failure to rescue after experiencing a complication. Of interest, the adjusted odds of failure to rescue after complex pancreatic surgery decreased by 27% each subsequent year variable was *not* associated with and remained not associated with routine ICU admission over time (Table 3).

Patients who were routinely admitted to the ICU after major pancreatic resection had a median length of stay of 10 days (IQR: 7–15 days) vs 8 days (IQR: 7–12 days) for patients who did not have a routine ICU admission ($P < .001$). In addition, patients who had an inpatient complication or a perioperative transfusion had a 69% and 90% higher relative risk of extended length of stay, respectively. Among patients who received neoadjuvant therapy, routine ICU admission was associated with a 37% increased risk of extended length of stay versus patients who did not receive neoadjuvant therapy. Although routine ICU admission was not associated with a greater likelihood of having an extended length of stay among patients who underwent vascular reconstruction, patients who did not undergo vascular reconstruction had a 45% increased risk of extended length of stay if routinely admitted to the ICU. Overall, an immediate postoperative ICU stay that lasted less than 24 hours was associated with a 41% increased risk of an extended length of stay compared with patients who were not routinely admitted to the ICU (Table 4). Of note, routine ICU admission was also associated with a slight increase risk of 90-day readmission (RR 1.14, 95% CI 1.01–1.28; $P = .035$, data not presented).

A multivariable linear regression model of log-transformed total payments for each surgical admission was constructed, which adjusted for patient age, comorbidity, and operative risk factors. Receiving a perioperative transfusion, concomitant vascular reconstruction, postoperative complication, and nonroutine ICU admission were each associated with higher total payments for inpatient care (all $P < .05$). In contrast, routine ICU admission was not associated with higher overall total payments (Table 5).

Sensitivity analysis

Additional sensitivity analyses were conducted to assess the impact of routine ICU utilization on length of stay. Institutions were

Table 2
Descriptive statistics of the overall study population (stratified by routine postoperative ICU admission).

	Ward admission (n = 1,565)	Routine ICU admission (n = 1,715)	Total (n = 3,280)	P value
Sex				
Male	805 (51.44)	916 (53.41)	1,721 (52.47)	.258
Female	760 (48.56)	799 (46.59)	1,559 (47.53)	
Median age (IQR), years	57 (52 – 61)	57 (51 – 61)	57 (51 – 61)	
Region				
Northeast	365 (23.32)	357 (20.82)	722 (22.01)	.338
North Central	361 (23.07)	405 (23.62)	766 (23.35)	
South	571 (36.49)	661 (38.54)	1,232 (37.56)	
West	268 (17.12)	292 (17.03)	560 (17.07)	
Year				
2010	309 (19.74)	349 (20.35)	658 (20.06)	.019
2011	318 (20.32)	385 (22.45)	703 (21.43)	
2012	331 (21.15)	409 (23.85)	740 (22.56)	
2013	277 (17.70)	273 (15.92)	550 (16.77)	
2014	330 (21.09)	299 (17.43)	629 (19.18)	
Charlson comorbidity index				
0	91 (5.81)	74 (4.31)	165 (5.03)	.078
1	25 (1.60)	37 (2.16)	62 (1.89)	
2+	1,449 (92.59)	1,604 (93.53)	3,053 (93.08)	
Procedure				
Total pancreatectomy	112 (7.16)	109 (6.36)	221 (6.74)	.361
Whipple-type procedure	1,453 (92.84)	1,606 (93.64)	3,059 (93.26)	
Vascular reconstruction				
No	1,426 (91.12)	1,505 (87.76)	2,931 (89.36)	.002
Yes	139 (8.88)	210 (12.24)	349 (10.64)	
Receipt of blood transfusion				
No	957 (61.15)	763 (44.49)	1,720 (52.44)	< .001
Yes	608 (38.85)	952 (55.51)	1,560 (47.56)	
Inpatient complications				
No	1,221 (78.02)	1,139 (66.41)	2,360 (71.95)	< .001
Yes	344 (21.98)	576 (33.59)	920 (28.05)	
Neoadjuvant therapy				
No	1,325 (84.66)	1,395 (81.34)	2,720 (82.93)	.012
Yes	240 (15.34)	320 (18.66)	560 (17.07)	
Discharge disposition				
Home	1,514 (96.74)	1,583 (92.30)	3,097 (94.42)	< .001
To facility	40 (2.56)	100 (5.83)	140 (4.27)	
Died	11 (.70)	32 (1.87)	43 (1.31)	
Nonroutine ICU admission				
No	1,190 (76.04)	1,654 (96.44)	2,844 (86.71)	< .001
Yes	375 (23.96)	61 (3.56)	436 (13.29)	
Median LOS (IQR), days	8 (7–12)	10 (7–15)	9 (7–14)	
Median total hospital payments (IQR), 2014 US dollars	56,704.32 (39,841.30–80,583.49)	59,364.58 (39,991.27–89,798.39)	57,826.64 (39,899.84–85,010.20)	

IQR, interquartile range; *LOS*, length of stay.

Table 3
Results from multivariable regression models evaluating the association between routine ICU admission and hospital: Failure to rescue.

	Odds ratio (95% CI)	P value
Age (years)		
Younger than 45	Reference	
45–54	1.28 (0.20–8.20)	.795
55 and older	1.93 (0.35–10.56)	.449
Female (versus male)	0.76 (0.34–1.67)	.490
Year	0.73 (0.54–1.00)	.049
Neoadjuvant therapy	1.87 (0.79–4.43)	.153
Charlson comorbidity index		
0	Reference	
1	1.79 (0.03–97.65)	.775
2+	2.09 (0.12–37.27)	.615
Vascular reconstruction	2.55 (1.01–6.43)	.047
Perioperative transfusion	4.97 (1.57–15.72)	.006
Whipple (versus total pancreatectomy)	0.37 (0.12–1.16)	.089
Region		
Northeast	Reference	
North Central	1.00 (0.17–5.92)	.997
South	4.45 (1.16–17.10)	.030
West	2.67 (0.55–12.98)	.223
Nonroutine ICU admission	0.93 (0.25–3.52)	.918
Routine ICU admission	1.37 (0.49–3.79)	.547

initially clustered at the state level, using a random effects model that included extended length of stay, inpatient complications, and total hospital payments. Routine ICU admission remained associated with a higher risk of extended length of stay (RR: 1.43, 95% CI: 1.18–1.73, $P < .001$). In a separate analysis, the 769 patients who had a known physician identifier were clustered by admitting physician. Routine ICU admission was associated with a 76% higher relative risk of an extended length of stay (95% CI: 1.33–2.33, $P < .001$), and a 13% higher adjusted total payments (95% CI [ratio of total payments]: 1.04–1.24, $P = .006$). Further analyses demonstrated that, even when a patient was treated in a dedicated surgical ICU, routine ICU admission was still associated with a 44% higher relative risk of extended length of stay (95% CI: 1.23–1.68, $P < .001$).

Discussion

Routine ICU admission after a major pancreatic operation for a cancer diagnosis remains a common practice at many institutions. In fact, data from the current study demonstrated that 1 in 2 patients were admitted to the ICU after major pancreatic surgery for less than a 24-hour stay. Of note, even among those who had a

Table 4

Results from multivariable regression models evaluating the association between routine ICU admission and hospital outcomes: Extended length of stay.

	Relative risk (95% CI)	P value
Age (years)		
Younger than 45	Reference	
45–54	1.02 (0.79–1.30)	.904
55 and older	1.00 (0.79–1.26)	.986
Female (versus male)	0.89 (0.78–1.01)	.069
Year	0.99 (0.95–1.04)	.674
Neoadjuvant therapy	0.66 (0.54–0.80)	< .001
Charlson comorbidity index		
0	Reference	
1	0.97 (0.61–1.52)	.885
2+	0.76 (0.59–0.97)	.027
Any complication	1.69 (1.48–1.92)	< .001
Vascular reconstruction	1.01 (0.81–1.25)	.953
Perioperative transfusion	1.90 (1.65–2.19)	< .001
Whipple (versus total pancreatectomy)	0.93 (0.73–1.20)	.587
Region		
Northeast	Reference	
North Central	1.05 (0.86–1.29)	.625
South	1.11 (0.92–1.33)	.276
West	1.24 (1.01–1.53)	.038
Nonroutine ICU admission	1.56 (1.31–1.85)	< .001
Routine ICU admission	1.41 (1.21–1.63)	< .001

Table 5

Results from multivariable regression models evaluating the association between routine ICU admission and hospital outcomes: Total hospital payments.

	Ratio of adjusted payments (95% CI)	P value
Age (years)		
Younger than 45	Reference	
45–54	1.01 (0.94–1.08)	.847
55 and older	0.98 (0.91–1.05)	.559
Female (versus male)	0.99 (0.95–1.03)	.514
Year	1.03 (1.01–1.04)	< .001
Neoadjuvant therapy	0.99 (0.95–1.05)	.819
Charlson comorbidity index		
0	Reference	
1	0.95 (0.77–1.16)	.596
2+	1.00 (0.91–1.10)	.984
Any complication	1.13 (1.09–1.18)	< .001
Vascular reconstruction	1.24 (1.17–1.32)	< .001
Perioperative transfusion	1.15 (1.11–1.19)	< .001
Whipple (versus total pancreatectomy)	1.07 (0.98–1.17)	.155
Region		
Northeast	Reference	
North Central	0.99 (0.94–1.04)	.720
South	0.89 (0.84–0.93)	< .001
West	1.30 (1.22–1.38)	< .001
Extended length of stay	1.94 (1.84–2.05)	< .001
Nonroutine ICU admission	1.10 (1.04–1.17)	.001
Routine ICU admission	1.02 (0.98–1.06)	.297

"routine" major pancreatic cancer resection (ie, no vascular resection, no perioperative transfusion, and no complication), more than 1 in 3 patients were admitted to the ICU immediately after surgery and remained in the ICU for 24 hours or less. In addition, among the 3,054 patients with a diagnosis of pancreatic cancer who underwent a major resection, routine ICU admission was associated with a 40% increased risk of having an extended length of stay even after adjusting for patient comorbidity, operation complexity, and perioperative morbidity. Of importance, routine ICU admission did not improve failure-to-rescue rates among patients undergoing complex pancreatic surgery. Somewhat surprisingly, patients who were routinely admitted to the ICU did not have higher total adjusted payments. To our knowledge, these findings represent the first investigation of routine postoperative ICU admission for major pancreatic cancer surgery in a national cohort of privately insured patients. Although the practice has decreased during the past decade, the routine utilization of routine ICU admission for pancreatic cancer surgery remained very high and was associated with a longer length of stay.

Trends in perioperative care and ICU utilization have been studied for other major surgical procedures.[7,19,20] For example, the advent of endovascular technologies in vascular surgery has revolutionized practices in the perioperative care of patients with cardiovascular disease, leading to lower routine ICU utilization.[7,19] Whether improvements in surgical techniques and improved perioperative management has similarly led to lower routine ICU utilization for complex alimentary procedures has not been defined. Potential overutilization of the ICU is an important topic because the ICU represents a specialized, relatively constrained resource. Although ICU admission may enable early detection of postsurgical complications, recent single-center investigations have suggested a marginal clinical benefit and potentially an adverse impact on healthcare costs.[20] Although we are unable to assess an association between these two outcomes in the aggregate, we noted that, after adjustment, patients in the Western region of the United States had a 24% higher risk of extended length of stay compared with patients in the Northeast of the United States and, similarly, 30% higher adjusted total hospital payments. For example, Cunningham et al.[21] reported comparable procedure-specific complications and mortality among patients undergoing minimally invasive pancreaticoduodenectomy who were routinely admitted to the ICU versus patients who were sent directly to the surgical ward. In addition, the authors noted that avoidance of routine ICU admission was associated with a reduced length of stay.[21] Other data on "fast-tracking" the postoperative recovery of patients after liver transplant also demonstrated that, in select patients, overall hospital stay and costs could be reduced.[22] Similarly, in the current study, there was an average 2-day shorter length of stay among patients who were not routinely admitted to the ICU after complex surgery for pancreatic cancer. In particular, the median length of the hospital stay was 1 day longer among patients who had a "routine" pancreatectomy but were admitted to the ICU postoperatively for less than 24 hours. In aggregate, the data would strongly suggest that routine ICU utilization translated into a longer hospital stay for patients after pancreatecomy.[23]

Selective use of routine ICU admission after complex surgery among patients who are older, have more comorbidities, and have more complex operations may be warranted. Of interest, in the current study, age, sex, and CCI were not associated with increased risk of routine ICU utilization. Rather, neoadjuvant chemotherapy (a likely surrogate for more advanced disease) and technical complexity (eg, vascular reconstruction) were associated with a greater likelihood to be admitted to the ICU immediately after surgery. Perhaps of no surprise, patients who were routinely admitted to the ICU had a higher overall incidence of complications—likely reflecting patient selection of patients at higher risk of complications for admission to the ICU postoperatively. Although previous data have suggested that many complications may not be readily preventable after hepatopancreaticobiliary surgery, the ability to rescue a patient from the complication may be more important.[24] In fact, our own group reported that the reduction in mortality at higher-volume hospitals was largely attributable to a better ability to rescue patients from major complications.[25] One proposed rationale for routine ICU utilization is that it may allow for earlier identification and rescue of patients from a potential complication. Data from the current study demonstrated, however, that failure to rescue was comparable among patients who were and were not routinely admitted to the ICU among patients after complex pancreatic cancer surgery. Other investigators have noted that routine ICU use for nonpancreatic procedures was also not necessarily associated with better clinical outcomes.[8] Rather, postoperative risk-stratification strategies to guide decisions regarding ICU

admission should be employed.[26] The analyses we have presented cannot be used to dictate practice across institutions, but rather ought to serve as a foundation for efforts to wisely deploy institutional resources and establish protocols with respect to staffing and patient care.

Results from the current study should be interpreted in light of several limitations. Although the Truven Health Analytics MarketScan databases allowed for analysis of a nationally representative sample of patients, certain sociodemographic, clinical, and institutional variables were unavailable for inclusion.[27] Although the analyses accounted for factors indicative of operative complexity (eg, vascular reconstruction, perioperative transfusion), other factors, such as operative time, could not be assessed. In addition, the MarketScan database no longer collects institution-specific data and therefore institution-level factors (eg, teaching status, bed size, etc) could not be examined. To that end, specific extensions of our analyses aimed at assessing specific associations between hospital volume and routine ICU admission could not be determined, thereby limiting conclusions about the use of routine ICU admission across institutions. However, several sensitivity analyses were conducted on a subset of data for which physician identifiers were available to determine the degree to which the correlation between institutional practice and clinical decision-making were associated.

In conclusion, among a large, national sample of patients undergoing complex surgical resection for pancreatic cancer, routine immediate postoperative ICU admission was widely employed. Specifically, more than half of patients undergoing either a pancreaticoduodenectomy or total pancreatectomy were admitted to an ICU for less than 24 hours after surgery. Routine ICU admission was associated with a longer length of stay but did not translate into a lower failure to rescue among patients. In fact, the failure to rescue was comparable among patients who were and were not admitted to the ICU routinely after complex pancreatic surgery. Future studies should focus on variations in individual institutional practices and develop postoperative care pathways to better select patients who will truly benefit from admission to the ICU after pancreatectomy.

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