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Tracking Early Readmission after Pancreatectomy to Index and Non-index Institutions: A More Accurate Assessment of Readmission

Jeffrey J. Tosoian, MD, MPH, **Caitlin W. Hicks, MD, MS**, **Vicente Valero III, MD**, **John L. Cameron, MD**, **Frederic E. Eckhauser, MD**, **Kenzo Hirose, MD**, **Martin A. Makary, MD, MPH**, **Timothy M. Pawlik, MD, MPH, PhD**, **Nita Ahuja, MD**, **Matthew J. Weiss, MD**, and **Christopher L. Wolfgang, MD, PhD**

Department of Surgery, Johns Hopkins University School of Medicine, Baltimore, MD 21287

Abstract

Importance—Readmission after pancreatectomy is common, but there is a paucity of data comparing patterns of readmission to index and non-index hospitals.

Objective—To evaluate the rate of readmission to index and non-index institutions following pancreatectomy at a tertiary high-volume institution, and to identify patient-level factors predictive of those readmissions

Design, Setting, Participants—Retrospective analysis of a prospectively-collected institutional database linked to statewide data of patients who underwent pancreatectomy at a tertiary care referral center (01/2005-12/2-2010).

Exposure—Pancreatectomy

Main Outcome Measure—The primary outcome was unplanned 30-day readmission to the index or non-index hospitals. Risk factors and reasons for readmission were measured and compared by site using univariable and multivariable analyses.

Results—Among all 623 patients who underwent pancreatectomy during the study period, 134 (21.5%) were readmitted to either our institution (n=105, 78.4%) or an outside institution (n=29, 21.6%). Fifty-six patients (41.8%) were readmitted due to gastrointestinal or nutritional problems related to surgery and 42 (31.3%) due to a postoperative infection. On multivariable analysis, factors independently associated with readmission included age ≥65 (OR 1.80, 95% CI 1.19-2.71), pre-existing liver disease (OR 2.28, 95% CI 1.23-4.24), distal pancreatectomy (OR 1.77, 95% CI 1.11-2.84), and postoperative drain placement (OR 2.81, 95% CI 1.10-7.14).

Conclusions and Relevance—In total, 21.5% of patients required early readmission after pancreatectomy. Even in the setting of a tertiary care referral center, nearly 22% of these

Corresponding Author and Requests for Reprints: Christopher L. Wolfgang MD, PhD, Department of Surgery, 685 Blalock Building, 600 N. Wolfe Street, Baltimore, MD 21287, Phone: (410) 502-4194, Fax: (410) 955-8110, cwolfga2@jhmi.edu.

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readmissions were to non-index institutions. Specific patient-level factors were associated with increased risk of readmission.

Introduction

Hospital readmission has emerged as a central topic in the setting of healthcare policy and reform.[1,2] Multiple healthcare organizations, including the Hospital Quality Alliance, Institute for Healthcare Improvement, and Department of Health and Human Services, now consider readmission rates a measure of healthcare quality,[3-6] and the Centers for Medicare & Medicaid Services (CMS) has begun reducing reimbursements to hospitals with high readmission rates for some patient conditions.

One major criticism of linking reimbursement to readmission rates is that readmission may not always correlate with quality of care.[7,8] This is particularly true following surgical procedures such as pancreatectomy, for which follow-up is inherently complex.[9] Patient-level factors, admission diagnoses, indicated procedures, and disease-specific prognosis all likely play a role in determining whether a patient risks early hospital readmission. Furthermore, current methods that aim to adjust for these factors are imprecise and largely unproven.[10-15]

While research aimed at readmission after pancreatectomy has increased dramatically in recent years, previous studies have been limited by an inability to track readmissions to institutions that did not perform the initial procedure (i.e. non-index institutions). This flaw may be particularly prevalent in studying complex surgical procedures, where patients are more likely to travel to undergo treatment at a high-volume center. As such, it is likely that readmission rates in patients undergoing pancreatectomy have been consistently underestimated. Lacking an accurate baseline measure of readmissions, the possibility of linking this metric to reimbursement is increasingly problematic.

The objective of the current study was to evaluate the rate of readmission to index and non-index institutions following pancreatectomy at a tertiary high-volume institution, and to identify patient-level factors predictive of those readmissions. Using a statewide dataset in conjunction with an institutional database, we were uniquely able to capture readmissions to other institutions in addition to our own.

Methods

We analyzed records from the Institutional Review Board-approved Johns Hopkins Pancreatic Resection Database (PRD) for patients undergoing pancreatic resection at Johns Hopkins Hospital (JHH) from 2005 through 2010. Information provided by the PRD was supplemented by data from the Maryland HSCRC Non-Confidential Inpatient Discharge data set (NCID) in an effort to account for readmissions to other non-index Maryland hospitals. Because patients who reside outside of Maryland are more likely to present for readmission out of state, we excluded all non-Maryland residents. Further details on the PRD, NCID, and the methods used to link the two data sources, as well as a validation assessment of the technique and rationale for the included study cohort, can be found in the *Supplementary Methods*.

Our primary outcome was early readmission, defined as unplanned admission to an acute care hospital within 30 days of discharge from the index admission. Patients who suffered 30-day mortality (including death during index admission) or underwent planned readmission were excluded from the analysis.[17-19] Primary and secondary diagnoses were identified using ICD-9 codes (Supplementary Tables 1-2. As in previous studies, the principal diagnosis code was considered the reason for readmission and grouped into clinically relevant categories.[18,20]

Statistical Analysis

Descriptive statistics were reported for preoperative, operative, and postoperative factors using threshold values previously described in the literature.[21,22] The association between patient-level factors and readmission (index institution [JHH] or non-index institution [outside institution]) were compared using the chi-squared or Fisher's exact test, as appropriate. Univariable and multivariable analysis were used to explore the association of specific covariates with readmission. Variables with univariablee significance <0.05 were entered into the multivariable model along with important clinical variables designated *a priori*. All statistical tests were two-sided, and p-values <0.05 were considered statistically significant. Statistical analysis was performed using Intercooled Stata, version 11.0 (Stata Corp., College Station, TX).

Results

Patient Demographics

Of the 623 patients admitted to our institution for pancreatic resection, 13 (2.1%) died within 30 days of the operation [77% (10/13) during index hospitalization and 23% (3/13) after index discharge], and 15 (2.4%) were readmitted for planned re-interventions. A total of 134 patients were readmitted to a Maryland hospital within 30 days of discharge, yielding a readmission rate of 21.5%. Patient demographics and preoperative data associated with readmission are shown in Table 1. As compared to the non-readmitted cohort, readmitted patients were more frequently ≥65 years (p=0.006), but were otherwise similar in terms of race, gender, and marital status. Among comorbidities, pre-existing liver disease (defined by concurrent diagnosis of viral hepatitis, cirrhosis, necrosis, other chronic liver disease, or liver disorder NOS) was significantly more common in the readmitted group (p=0.040). Hypertension showed a trend toward higher prevalence in the readmitted group but failed to reach statistical significance (p=0.062). The proportion of patients with diabetes mellitus, hyperlipidemia, ischemic heart disease, and obesity did not differ based on readmission status (p=NS).

Operative and Perioperative Course

A comparison of operative and perioperative factors based on readmission status is summarized in Table 2. The type of resection and indication for surgery did not differ significantly between the readmitted and non-readmitted patients, and operative characteristics such as intraoperative time and need for blood transfusion were similar between groups (p=NS). Notably, patients who experienced a postoperative complication were significantly more likely to be readmitted. Specifically, the incidence of wound

complications and intra-abdominal abscess, as well as the need for treatment with intravenous antibiotics and placement of an abdominal drain, were greater in the readmitted group ($p \leq 0.039$). Initial hospital length of stay ≤6 days was significantly more prevalent in the non-readmitted group ($p=0.037$), while length of stay ≥14 days showed a trend toward occurring more frequently in the readmitted group ($p=0.064$).

Independent Predictors of Readmission

Multivariate modeling was used to control for potential confounding and identify patient-level factors independently associated with readmission. On multivariable analysis, factors independently associated with readmission included age ≥65), pre-existing liver disease, distal pancreatectomy, and postoperative drain placement ($p \leq 0.03$; Table 3).

Reason for Readmission by Site

Of the 134 subjects readmitted, 105 (78.4%) were readmitted to our institution and 29 (21.6%) were readmitted to an outside institution (Table 4). Gastrointestinal/nutritional problems (e.g. pain, obstruction, dehydration) and surgical infections were the most common reasons for readmission (41.8% and 31.3%, respectively). Compared to those patients who presented for readmission to another institution, a greater proportion of patients presenting to our institution had a gastrointestinal/nutritional ($p=0.208$) problem or a surgical infection ($p=0.183$), although these trends did not reach statistical significance. Nine patients (6.7%) were readmitted due to a vascular problem, while genitourinary, pulmonary, and cardiac concerns each accounted for <5% of readmissions. Other diagnoses (e.g. uncontrolled diabetes, abnormal hematologic findings, orthopedic conditions, psychiatric conditions) accounted for 12.7% of all readmissions and were more likely to present to an outside institution ($p<0.001$).

Discussion

The use of early readmission as a measure of healthcare quality is controversial, especially for complex diagnoses that may require multiple high-risk interventions. These concerns are particularly relevant when considering pancreatic surgery. Although the mortality associated with pancreatectomy has improved significantly over the past several years,[23,24] early readmission after pancreatectomy is a frequent occurrence and imposes a significant burden on the healthcare system.[20,25]

In an effort to better understand this phenomenon, research aimed at post-pancreatectomy readmission has increased dramatically in recent years.[18,26-31] Despite this, several essential tasks remain incomplete, such as establishing a reasonable baseline rate of expected readmissions, or a “norm” for this metric.[32] Studies of post-pancreatectomy readmission have been performed in both single-institutional settings and larger, population-based databases, with cited rates of readmission ranging from 12% to 59%.[18,26-31,41] Much of this variation can be accounted for by the wide range of follow-up times studied. For example, estimates of 30-day readmission have ranged from 12 to 20% and report surgical complications as a frequent reason for readmission.[30,31] Other studies have measured readmissions occurring months to years after the index admission and in some cases report

rates in excess of 30%.[26,33-35] Not surprisingly, up to 60% of these "late" readmissions are secondary to cancer progression and are not related to the index operation.[33,34]

After accounting for time course, however, a persistent obstacle to establishing a baseline rate of readmission is the inability to track readmissions to non-index hospitals. This limitation leads to underestimating the true readmission rate. Yermilov et al. have shown that up to 47% of all readmissions occurring within one year of pancreatectomy occur at an institution other than where the original surgery was performed.[26] Certainly, the frequency of presenting to a non-index institution may be lower in the early postoperative phase, but this finding underscores the critical limitation presented by the failure to account for outside readmissions. While Yermilov and colleagues helped characterize readmission patterns, the characteristics surrounding 30-day and one-year readmissions differ greatly.

In the current study, we analyzed the records of 623 patients who underwent pancreatectomy at our institution in an attempt to identify an overall rate of early readmissions to both our institution and others. We selected 30-day readmissions because we believe this time course is most reflective of postoperative complications, and, perhaps more importantly, because this is the time course outlined in the Patient Protection and Affordable Care Act for which hospitals are held financially accountable for readmissions.[4] Our analysis revealed an overall 30-day readmission rate of 21.5%, which is slightly greater than studies which did not account for non-index institutions and those excluding admissions deemed unrelated to the initial procedure, but similar to the recently reported readmission rate of 21.3% reported by Hyder et al.[41] In that study, the authors report 30-day readmissions following pancreaticoduodenectomy using Medicare data from the Surveillance, Epidemiology, and End Results (SEER) database, which is able to capture readmissions to multiple institutions from a large population. The 30-day readmission rate to our (index) institution was 17.6% overall, or 78.4% of all readmissions. These findings are consistent with the 12-20% overall index readmission rate previously described in the literature.[30,31]

One objective in studying readmission after pancreatectomy is to identify risk factors that may predispose a patient to returning after discharge.[18,26-31] For example, Hyder et al. recently demonstrated that patient-level factors are the biggest predictors of readmission, more so than hospital- or surgeon-level factors.[41] Specifically, the authors show that patient comorbidities are the biggest risk factor for postoperative readmission within 30 days of surgery. However, that study evaluated comorbidities as a single score in a binary fashion, so specific patient-level characteristics were not identified. In our study, we demonstrate that baseline patient-level factors including age and pre-existing liver disease were predictive of readmission. The independent association between pre-existing liver disease and more frequent readmission described herein had not been shown previously. One explanation for this is that previous studies simply have not considered liver disease among baseline comorbidities. Given a prevalence of nearly 10% in our population and the physiologic plausibility that comorbid liver disease would contribute to increased postoperative morbidity, we thought this was a pertinent consideration. The role of hepatic insufficiency should be studied further in additional populations, as the ability to risk-stratify will be essential in comparing readmission rates among diverse patient populations.

Of interest, patients undergoing distal pancreatectomy in our study also exhibited a higher risk of readmission than patients undergoing pancreaticoduodenectomy. Previous comparisons of these two procedures are limited, but our findings are consistent with those of Reddy et al., who found an increased readmission rate among those who underwent distal pancreatectomy.[18] This may be reflective of an increased risk for pancreatic leak after distal pancreatectomy,[36] likely due to a tendency for softer pancreas texture, higher blood loss in the setting of concomitant splenectomy, or other factors.[37,38] Postoperative morbidity rates following distal pancreatectomy range from 22% to 37% based on currently available data,[39,40] including a 26% incidence of pancreatic fistula.[37] New trends toward fewer concomitant splenectomies and improved pancreatic stump closure methods may facilitate lower postoperative morbidity rates in the future. Nonetheless, the significant difference in readmission rates between procedures points to the importance of establishing procedure-specific baseline readmission rates, rather than relying on more generalized organ- or diagnosis-based benchmarks.

While identifying preoperative characteristics predicting readmission has proven to be difficult, certain postoperative factors have been consistently associated with readmission. The length of stay during the index hospitalization has been studied extensively.[18,31,32] Fong et al. found that an admission ≥7 days was associated with increased risk of readmission,[32] and Reddy and colleagues demonstrated similar findings using a threshold of 10 days.[18] On univariate analysis we found that the quartile of patients with the shortest length of stay (≤6 days) was less likely to be readmitted, while the quartile with the longest length of stay (≥14 days) showed a trend toward more frequent readmission. In the multivariate model accounting for confounding factors, however, length of stay was not associated with readmission rate. Our findings are consistent with those reported by Hyder et al., who demonstrated that index length of stay was not independently associated with readmission following pancreaticoduodenectomy.[41] The data suggest that length of hospital stay in and of itself does not contribute to frequent readmission, but rather is associated with other factors such as surgical complications that ultimately lead to more frequent readmissions.

Not surprisingly, the occurrence of any postoperative complication has been associated with readmissions in multiple studies.[27,30-33,35] Intra-abdominal abscess, pancreatic fistula, and wound complications are common after pancreatectomy and well-demonstrated to be associated with readmission.[27,31,32,35] We sought to build on this body of knowledge by identifying not only complications, but also in-hospital interventions, that were associated with readmission. On multivariate analysis, undergoing intra-abdominal drain placement was the intervention which remained an independent predictor of subsequent readmissions. Regardless of the indication for drain placement, patients who underwent this intervention were almost three times more likely to be readmitted. The need for drain placement was likely an indicator of the severity of abdominal complications such as abscess and pancreatic fistula, and its presence in the model reflects a more extensive intra-abdominal process which ultimately led to readmission. It is also possible that patients discharged with a drain in place are suffering complications of the device itself. As such, interventions to ensure that patients are comfortable caring for their drains prior to discharge are a simple and effective way to potentially decrease readmissions.

Similar to others [27,28,31,32,41] , we found the most common reasons for readmission were gastrointestinal and nutritional concerns. A number of these readmissions are secondary to dehydration or failure to thrive, indicating that even after demonstrating adequate oral intake in the hospital setting, maintaining sufficient intake after discharge remains a challenge. Also consistent with previous findings, we observed a high rate of readmission secondary to infection. Gastrointestinal, nutritional, and infectious concerns are most intuitively related to complex abdominal surgery; together they accounted for greater than 70% of readmissions. It is notable that patients presenting with these concerns tended to return to our institution. Notably, patients readmitted for vascular, genitourinary, pulmonary, or cardiac problems were no more likely to present to our institution than an outside institution. On the other hand, patients readmitted for reasons not clearly related to the above categories were more likely to present to an outside institution. Regardless of the diagnosis for readmission, nearly 22% of readmissions took place at an institution other than ours. While previous studies have asserted that the vast majority of patients will return to the specialty center where their surgery was performed, these data do not fully support that notion. Our study population consisted of only those patients who reside in the state of Maryland, yet even being in relative proximity, and despite our insistence on patients returning to our institution, more than one in five were readmitted elsewhere. This serves to emphasize that some patients will simply present to the hospital within their immediate means, and readmissions are significantly underestimated when outside admissions cannot be tracked. As such, it is imperative that even those institutions that do not routinely perform pancreatectomy be familiar with the nature and risk factors of post-pancreatectomy readmissions, as patients may present to smaller institutions closer to home for post-operative assessment and initial management of related complications.

The limitations of our study deserve discussion. First, this was a retrospective review of a prospectively maintained database, and as such is susceptible to potential errors in data records such as inaccurate coding or missing values. Second, although we extended our matching algorithm to capture all patient readmissions within Maryland, we were unable to capture potential out-of-state readmissions. In light of this, our cohort was restricted to Maryland residents, which limited our sample size and study power. Finally, as indicated, our novel method of probabilistic matching in rare instances may have incorrectly matched or failed to match patients who were readmitted to other hospitals. Although our algorithm was highly sensitive and specific on internal validation (91% and 98%, respectively; *Supplementary Methods*), this method has not been validated in other datasets. Despite these shortcomings, our study was able to combine the strengths of institutional studies (e.g. consistent postoperative pathways and care teams, recording of operative details, specific complication rates) and population-based records (e.g. readmissions to outside institutions) to uniquely establish a baseline readmission rate after pancreatectomy and compare readmissions to the index and non-index institutions. To our knowledge, no previous studies have assessed specific reasons for readmission based on readmission site. Furthermore, our study differs from large, population-based studies in its ability to track specific postoperative complications contributing to readmission (i.e. post-operative drain placement) and identify specific comorbidities that may play a role as well.[41]

Ultimately, early readmission after pancreatectomy is a common phenomenon, occurring in one-fifth of patients. Specific patient-level factors may identify patients at increased risk of early readmission, as well as those at increased risk of subsequent mortality. We have utilized novel methods to assess readmissions to both our institution and others, and have validated the 21.3% readmission rate reported by Hyder et al.[41] as a realistic baseline when accounting for readmissions to both index and non-index hospitals. Pancreatectomy is a complex procedure for which we believe the vast majority of readmissions are not a reflection of healthcare quality, but rather the expected variation in a complicated postoperative course. Plans to associate reimbursement schemes with readmission rates will need to consider these factors, particularly in the setting of complex procedures such as pancreatectomy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1
Patient Demographics and Preoperative Characteristics

	Total Cohort (n = 595)	Readmitted (n =134)	Non-readmitted (n = 461)	P-value
Variable	**n (%)**	**n (%)**	**n (%)**	
Age ≥65	257 (43.2)	72 (53.7)	185 (40.1)	0.006*
Female gender	303 (50.9)	70 (52.2)	233 (50.5)	0.769
Black race	91 (15.3)	20 (14.9)	71 (15.4)	1.000
Married	381 (64.0)	91 (67.9)	290 (62.9)	0.308
Comorbidities				
Hypertension	290 (48.7)	75 (56.0)	215 (46.6)	0.062
Diabetes mellitus	157 (26.4)	37 (27.6)	120 (26.0)	0.739
Hyperlipidemia	148 (24.9)	38 (28.4)	110 (23.9)	0.307
Obesity	75 (12.6)	17 (12.7)	58 (12.6)	1.000
Ischemic heart disease	70 (11.8)	21 (15.7)	49 (10.6)	0.127
Liver disease	55 (9.2)	19 (14.2)	36 (7.8)	0.040*
Abnormal laboratory values				
Albumin ≤2.5 g/dL	97 (16.3)	23 (17.2)	74 (16.1)	0.791
Creatinine ≥1.3 mg/dL	42 (7.1)	11 (8.2)	31 (6.7)	0.567

SI conversion factors: To convert albumin level to grams per liter,multiply by 10; to convert creatinine level tomicromoles per liter, multiply by 88.4.

*Statistically significant.

Table 2

Operative and Perioperative Course

	Total Cohort (n = 595)	Readmitted (n = 134)	Non-readmitted (n = 461)	P-value
Variable	**n (%)**	**n (%)**	**n (%)**	
Procedure				
Pancreaticoduodenectomy	368 (61.9)	80 (59.7)	288 (62.5)	0.614
Distal pancreatectomy	203 (34.1)	50 (37.3)	153 (33.2)	0.408
Total pancreatectomy	24 (4.0)	4 (3.0)	20 (4.3)	0.622
Malignant indication	409 (68.7)	94 (70.2)	315 (68.3)	0.751
Operative time > 8 hours	80 (18.9)	22 (24.2)	58 (17.4)	0.173
Transfusion	150 (29.2)	38 (32.8)	112 (28.2)	0.355
Postoperative complications				
Any complication	279 (46.9)	75 (56.0)	204 (44.3)	0.018*
Delayed gastric emptying	101 (17.0)	23 (17.2)	78 (16.9)	1.000
Wound complication	75 (12.6)	24 (17.9)	51 (11.1)	0.039*
Pancreatic fistula	77 (12.9)	15 (11.2)	62 (13.5)	0.560
Abdominal abscess	35 (5.9)	19 (14.2)	16 (3.5)	<0.001*
Anastomotic leak	34 (5.7)	11 (8.2)	23 (5.0)	0.202
Other[a]	68 (11.4)	20 (14.9)	48 (10.4)	0.165
Postoperative interventions				
Intravenous antibiotics	101 (17.0)	37 (27.6)	64 (13.9)	<0.001*
Parenteral nutrition	73 (12.3)	23 (17.2)	50 (10.9)	0.053
Endoscopy	49 (8.2)	13 (9.7)	36 (7.8)	0.478
Non-operative drain	44 (7.4)	23 (17.2)	21 (4.6)	<0.001*
Reoperation	26 (4.4)	7 (5.2)	19 (4.1)	0.631
Length of stay – quartile (days)				
≤6	162 (27.2)	27 (20.2)	135 (29.3)	0.037*
7-8	151 (25.4)	35 (26.1)	116 (25.2)	0.822
9-13	142 (23.9)	32 (23.9)	110 (23.9)	1.000
≥14	140 (23.5)	40 (29.9)	100 (21.7)	0.064

Operative time and transfusion calculated from smaller total sample due to missing data points.

[a] Bleed, cardiac event, pneumonia, sepsis, DVT/PE, pancreatitis

* Statistically significant.

Table 3
Logistic Regression Analysis for Variables Associated with Readmission

	Univariable		Multivariable	
Predictive Factor	**OR (95% CI)**	**P-value**	**OR (95% CI)**	**P-value**
Age ≥ 65 years	1.73 (1.18-2.55)	0.005	1.80 (1.19-2.71)	0.005*
Liver disease	1.95 (1.07-3.52)	0.027	2.28 (1.23-4.24)	0.009*
Procedure				
Pancreaticoduodenectomy	1.00		1.00	
Distal pancreatectomy	1.20 (0.80-1.79)	0.376	1.77 (1.11-2.84)	0.017*
Total pancreatectomy	0.68 (0.23-2.02)	0.486	0.88 (0.28-2.74)	0.821
Wound complication	1.75 (1.03-2.98)	0.037	1.59 (0.85-2.97)	0.148
Abdominal abscess	4.60 (2.29-9.21)	<0.001	1.74 (0.63-4.78)	0.284
Intravenous antibiotics	2.37 (1.49-3.75)	<0.001	1.41 (0.78-2.56)	0.212
Postoperative drain	4.34 (2.32-8.13)	<0.001	2.81 (1.10-7.14)	0.030*
Length of stay – quartile (days)				
≤6	1.00		1.00	
7-8	1.51 (0.86-2.64)	0.150	1.78 (0.99-3.20)	0.055
9-13	1.45 (0.82-2.57)	0.198	1.57 (0.84-2.93)	0.159
≥14	2.00 (1.15-3.47)	0.014	1.32 (0.67-2.63)	0.424

* Statistically significant.

Table 4

Reason for Readmission by Site

	Total (%)	Index Institution	Non-Index Institution	P-value
Gastrointestinal/nutritional	56 (41.8)	47 (44.8)	9 (31.0)	0.208
Surgical infection	42 (31.3)	36 (34.3)	6 (20.7)	0.183
Vascular problem	9 (6.7)	9 (8.6)	0 (0.0)	0.204
Genitourinary problem	4 (3.0)	3 (2.9)	1 (3.4)	1.000
Pulmonary problem	3 (2.2)	2 (1.9)	1 (3.4)	0.522
Cardiac problem	3 (3.0)	1 (1.0)	2 (6.9)	0.118
Other	17 (12.7)	7 (6.7)	10 (34.5)	<0.001*
Total	134	105	29	

*Statistically significant.