Risk Factors for 30-Day Hospital Readmission among General Surgery Patients

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BACKGROUND: Hospital readmission within 30 days of an index hospitalization is receiving increased scrutiny as a marker of poor-quality patient care. This study identifies factors associated with 30-day readmission after general surgery procedures.

STUDY DESIGN: Using standard National Surgical Quality Improvement Project protocol, preoperative, intraoperative, and postoperative outcomes were collected on patients undergoing inpatient general surgery procedures at a single academic center between 2009 and 2011. Data were merged with our institutional clinical data warehouse to identify unplanned 30-day readmissions. Demographics, comorbidities, type of procedure, postoperative complications, and ICD-9 coding data were reviewed for patients who were readmitted. Univariate and multivariate analysis was used to identify risk factors associated with 30-day readmission.

RESULTS: One thousand four hundred and forty-two general surgery patients were reviewed. One hundred and sixty-three (11.3%) were readmitted within 30 days of discharge. The most common reasons for readmission were gastrointestinal problem/complication (27.6%), surgical infection (22.1%), and failure to thrive/malnutrition (10.4%). Comorbidities associated with risk of readmission included disseminated cancer, dyspnea, and preoperative open wound ($p < 0.05$ for all variables). Surgical procedures associated with higher rates of readmission included pancreatectomy, colectomy, and liver resection. Postoperative occurrences leading to increased risk of readmission were blood transfusion, postoperative pulmonary complication, wound complication, sepsis/shock, urinary tract infection, and vascular complications. Multivariable analysis demonstrates that the most significant independent risk factor for readmission is the occurrence of any postoperative complication (odds ratio = 4.20; 95% CI, 2.89–6.13).

CONCLUSIONS: Risk factors for readmission after general surgery procedures are multifactorial, however, postoperative complications appear to drive readmissions in surgical patients. Taking appropriate steps to minimize postoperative complications will decrease postoperative readmissions. (J Am Coll Surg 2012;215:322–330. © 2012 by the American College of Surgeons)

In June of 2009, the Centers for Medicare and Medicaid Services (CMS) began publishing 30-day readmission data for selected medical diseases. As a result, hospital readmissions quickly became an important metric for measuring quality of patient care. In March 2010, the Patient Protection and Affordable Care act was signed into law and within it, Section 3025 brought substance to holding hospitals accountable for 30-day hospital readmissions.[1] When implemented, hospital reimbursements will be reduced based on an adjustment factor determined by an institution's expected vs observed 30-day readmission rate. Section 3025 started the focus on readmissions for selected medical diseases, but left the door open for CMS to extend this readmission policy to surgical procedures in fiscal year 2015. The CMS has already confirmed it will begin monitoring readmissions for vascular surgery procedures. Con-

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Abbreviations and Acronyms

ASA = American Society of Anesthesiologists
CMS = Centers for Medicare and Medicaid Services
NSQIP = National Surgical Quality Improvement Project
OR = odds ratio
UTI = urinary tract infection

sequently, there is an intense focus on decreasing unnecessary surgical readmissions.[2,3]

From 2003 to 2004, 19.5% of all Medicare beneficiaries who were discharged from a hospital were readmitted within 30 days, leading to a cost of $17.4 billion. Kent and colleagues estimate that a single readmission after pancreatic resection costs an average of $16,000 or more.[4] In addition to the financial implications of hospital readmission, a patient's unplanned return to the hospital further limits hospital resources. For each patient readmitted, there is an opportunity lost to treat another patient who needs care. Regardless of the strain a readmission places on the health care system, it negatively impacts the patient's quality of life. Reducing the number of 30-day readmissions after surgery is important not only for institutions, but also for patients.

The readmission problem is fundamentally different in surgical patients compared with medical patients.[5,6] A majority (70.5%) of readmissions after a surgical procedure are due to a medical condition. Of Medicare beneficiaries undergoing major bowel surgery in 2003 and 2004, 16.6% were readmitted for gastrointestinal problems, and only 6.4% were readmitted with a postoperative infection.[7] Surgical patients have underlying comorbidities similar to medical patients; however, what differentiates the surgical patient is the notion that they undergo a specific procedure that, in and of itself, carries an associated risk of readmission. The other major differentiating factor for surgical patients is that the intervention that puts these patients at risk for readmission, ie, their operation, is planned. This suggests that there is an opportunity to intervene preoperatively to decrease the risk of readmission postoperatively.

There is a paucity of information that focuses on readmission rates among surgical patients. Most of the studies that do exist focus on procedure-specific readmission rates within precise patient populations.[4,8-13] A recent study that followed 33,936 patients after coronary artery bypass graft surgery showed that 16.5% were readmitted within 30 days or discharge.[13] The most common reason for readmission was postoperative infection (16.9%). The authors identified a risk profile for patients who were at increased risk for postoperative infection. High-risk factors included women, obesity, unplanned reoperations, and patients who had a longer hospital length of stay. Similarly, a recent series investigated readmission after 149,622 colorectal surgery cases for colon cancer.[11] The authors note that hospital length of stay, comorbidities, and postoperative complications are each significantly associated with readmission. Finally, in a series that analyzed 1,643 pancreaticoduodenectomies, younger age, considerable blood loss, postoperative complications, and vessel resection were found to be independent risk factors for readmission.[8]

These previous studies highlight the importance of decreasing readmissions after complex general surgery procedures. The purpose of this study is to examine factors associated with 30-day hospital readmission after a variety of general surgery procedures among a diverse patient population. We acknowledge that factors associated with 30-day readmission after general surgery procedures are multifactorial. The current study was undertaken to better understand which factors appear to be most commonly associated with readmission. Specifically, we hypothesize that postoperative complications in particular increase the chance of a patient returning to the hospital.

METHODS

Study population and methods

This is a retrospective study using patients who were enrolled in American College of Surgeons National Surgical Quality Improvement Program (NSQIP) and underwent inpatient general surgery procedures at Emory University Hospital between October 2009 and July 2011. Outpatient procedures were excluded. Standard NSQIP data were gathered prospectively by the American College of Surgeons NSQIP trained nurses at our institution. One hundred and thirty-five variables were analyzed, including preoperative risk factors, intraoperative variables, and 30-day postoperative morbidity and mortality outcomes for patients undergoing general surgery procedures in the inpatient setting.[14]

After a protocol approved by our Institutional Review Board, each patient's index admission was linked via identifier codes to our institution's clinical data warehouse to search for unplanned readmissions within 30 days of discharge. Comorbid factors for each patient were obtained and outcomes data were ascertained at 30-day follow-up as described previously. We further determined if patients experienced a postoperative complication and, if so, when this occurred relative to readmission. Lastly, we identified the ICD-9 codes associated with readmission in an effort to determine why the patient was readmitted. Patients were excluded from the study if they died during their index hospitalization or if the readmission was a planned aspect of their postoperative course (eg, chemotherapy).

Study variables and definitions

The primary outcomes of interest included 30-day hospital readmission after an inpatient general surgery procedure. To facilitate data analysis based on type of procedure, we created general surgery procedure categories based on the prioritized diagnostic groups identified by Schilling and colleagues.[15] To allow for additional analysis, the following complication categories were created based on process improvement opportunities that would target and prevent specific postoperative complications: transfusion; postoperative pulmonary complications (eg, prolonged postoperative ventilation >48 hours, pneumonia, or unplanned intubation); wound (eg, superficial surgical site infection, organ space surgical site infection, deep incisional surgical site infection, or wound disruption); sepsis/shock (eg, sepsis and septic shock); urinary tract infection (UTI); renal (eg, acute renal failure or progressive renal insufficiency); cardiac (eg, myocardial infarction or cardiac arrest requiring CPR); neurologic (eg, peripheral nerve injury, cerebrovascular accident, or coma >24 hours); vascular (eg, pulmonary embolism, deep vein thrombosis requiring therapy, or graft/prosthesis/flap failure); and a category for patients with no complications.

Statistical analysis

Univariate analysis was used to identify factors associated with 30-day readmission. The association between demographic characteristics or preoperative comorbid conditions and 30-day readmission was analyzed using chi-square tests for categorical variables (or Fisher's exact tests if needed) and ANOVA tests for continuous variables. In addition to preoperative comorbid conditions, we examined the association among operative procedure and postoperative complications and 30-day readmission. The association between these variables and the probability of readmission was assessed using chi-square tests. Multivariable logistic regression was used to evaluate the independent association between complications and readmissions, controlling for possible confounders. Confounders were tested one at a time in a model along with complications to see if the association between complications and readmission changed. A final model was created using all of the most influential variables. A p value <0.05 was considered significant. Cochran-Armitage trend test was used to determine the association between number of complications and rate of readmission. All statistical analyses were performed using SAS 9.2 (SAS Institute, Inc.) and SPSS 17 (IBM SPSS Inc).

RESULTS

Patient demographics

A total of 1,442 patients that underwent general surgery procedures from October 2009 up to July 2011were identified in our NSQIP database. A total of 163 patients were readmitted within 30 days of discharge from their index hospitalization, for an overall readmission rate of 11.3%. Patient demographics and risk factors associated with readmission are listed in Table 1. Age, race, sex, and transfer status were not associated with an increased risk of readmission. American Society of Anesthesiologists (ASA) class significantly differed between the 2 groups, with ASA 4 and ASA 5 patients at significantly higher risks of readmission (odds ratio [OR] = 11.60 and 23.50, respectively). Of patients requiring readmission, 28.8% were hospitalized for longer than 24 hours before their surgical procedure, and only 17.8% of patients not requiring readmission were admitted more than 1 day preoperatively ($p = 0.0008$).

Reason for readmission

Reasons for readmission, based on administrative ICD-9 coding data, are listed in Table 2. Gastrointestinal problems and complications (eg, nausea, vomiting, or bowel obstruction) combined with surgical infections accounted for nearly half of all readmissions (27.6% and 22.1%, respectively). When subdivided by procedure category, >50% of readmissions after colectomy, liver resection, and pancreatectomy were also gastrointestinal problems/complications and surgical infections. After these top 2 reasons for readmission, the ICD-9 diagnoses varied widely for the entire cohort and when further subdivided by procedure.

Comorbidities

Figure 1 shows readmission rates based on patients' comorbidity profile. Patients with a diagnosis of disseminated cancer (n = 56) or an open wound (n = 110) preoperatively were more than 2 times more likely to be readmitted ($p = 0.015$ and 0.0003, respectively). Additionally, patients with a history of dyspnea (n = 138) were >50% more likely to be readmitted (OR = 1.55; $p = 0.036$). Comorbidities without a statistically significant impact on risk of readmission included diabetes (n = 228), smoker (n = 261), COPD (n = 63), preoperative ventilator dependence (n = 11), ascites (n = 24), hypertension requiring medication (n = 674), chronic steroid use (n = 97), unintentional preoperative weight loss (n = 139), history of bleeding disorders (n = 56), acute renal failure (n = 3), and chronic renal failure requiring dialysis (n = 37).

Table 1. Demographics and Risk Factors for Readmission

Patient variable	No readmission (n = 1,279)		Readmission cohort (n = 163)		p Value	Odds ratio	95% CI
Age, y, mean (SD)	55.8 (15.1)		56.0 (15.8)		<0.9096		
	n	%	n	%			
Sex					0.9858	1.00	0.72–1.39
Male	552	88.6	71	11.4			
Female	733	88.6	94	11.4			
Race					0.7145	1.06	0.76–1.48
White	920	89.1	113	10.9			
Non-white	459	88.4	60	11.6			
ASA class					0.0013		
1	47	97.9	1	2.1		1.00	
2	397	91.9	35	8.1		4.14	0.55–30.95
3	753	87.6	107	12.4		6.68	0.91–48.91
4	77	80.2	19	19.8		11.60	1.50–89.49
5	2	66.7	1	33.3		23.50	1.05–528.1
Transfer status					0.4484	1.27	0.69–2.33
Yes	82	86.3	13	13.7			
No	1,197	88.9	150	11.1			
Preoperative length of stay >24 h	228	17.8	47	28.8	0.0008	1.87	1.29–2.70
No complication	925	93.7	62	6.3			
Any complication	354	77.8	101	22.2	<0.0001	4.26	3.03–5.98
Complication type*							
Transfusion	196	82.0	43	18.0	<0.0001	1.98	1.35–2.90
PPC	61	71.8	24	28.2	<0.0001	3.45	2.08–5.71
Wound complication	132	73.7	47	26.3	<0.0001	3.52	2.40–5.17
Sepsis/shock	70	66.7	35	33.3	<0.0001	4.73	3.03–7.37
UTI	25	62.5	15	37.5	<0.0001	5.08	2.62–9.86
Cardiac	11	84.6	2	15.4	0.6508	1.43	0.31–6.52
Vascular	14	56.0	11	44.0	<0.0001	6.36	2.84–14.25
Renal	20	71.4	8	28.6	0.0106	3.19	1.38–7.35
Neurologic	10	83.33	2	16.67	0.6364	1.58	0.34–7.26
Timing of first complication							
During index admission	293	82.1	64	17.9	<0.0001	0.36	0.22–0.59
After discharge	61	62.2	37	37.8			

In some cases, numbers do not add up to 1,442 secondary to missing data points.
*Multiple patients had >1 complication, so numbers and percentages for this category will be >2,242 and 100%, respectively.
ASA, American Society of Anesthesiologists; PPC, postoperative pulmonary complications; UTI, urinary tract infection.

Procedures

Readmission frequency for the most common operative procedures within our cohort is listed in Table 3. Patients undergoing a pancreatectomy had the highest readmission rate (17.9%) for any procedure at our institution, followed by patients undergoing colectomy with or without colostomy (12.6%), small bowel resection (11.8%), gastrectomy (11.4%), and ventral hernia repair (11.0%). Procedures with low 30-day readmission rates in our analysis included parathyroidectomy (7.7%), thyroidectomy (2.9%), and mastectomy (2.0%).

Complications

Patients who had ≥1 complication after their surgical procedure were more than 4 times more likely to be readmitted (OR = 4.26, 95% CI, 3.03–5.98). Multivariable modeling was conducted controlling for demographic variables (Table 1) and comorbidities (Fig. 1), but none made a substantial impact on the relationship between complications and readmissions. A final model with all variables that made a >2% change to the OR for complications is shown in Table 4. After controlling for preoperative open wound, preoperative sepsis, ASA class,

Table 2. Readmission Reasons by ICD-9 Codes

Reason for readmission	ICD-9 codes	n	%
Gastrointestinal complication	8.45, 289.59, 531.4, 534.4, 536.8, 540.9, 552.2, 552.21, 552.8, 558.9, 560.1, 560.39, 560.81, 560.89, 560.9, 564, 569.62, 569.69, 576.1, 577, 577.1, 578, 787.01, 997.4	45	27.6
Surgical infection	38.19, 567.22, 996.62, 996.63, 996.69, 997.62, 998.51, 998.59, 999.31	36	22.09
Failure to thrive/malnutrition	262, 263.9, 275.3, 276.5, 276.51, 458, 783.7	17	10.43
Wound complication	553.21, 718.46, 998.12, 998.13, 998.32, 998.6, 998.83	13	7.98
Genitourinary complication	403.91, 584.9, 599, 599.71, 599.84, 996.64	8	4.91
Vascular complication	440.24, 441.01, 441.4, 557, 557.1, 557.9, 996.1, 996.74	6	3.68
Pulmonary problem	415.19, 486, 511, 511.19, 518.81, 786.52, 997.39	6	3.68
Cardiac problem	410.21, 414.01, 414.06, 427.89, 428, 428.23	5	3.07
Pain	338.18, 789.07, 789.09	3	1.84
Fever	507, 780.6, 780.62	4	2.45
Transplant complication	996.81, 996.82, 996.84	3	1.84
Neurologic problem	780.2, 786.59	2	1.23
Other	155.1, 157, 158.8, 189, 195.2, 198.3, 249, 250.13, 250.7, 250.8, 252.1, 289.7, 311, 482.42, 620.2, 996.52, 998.89	15	9.20

and procedure (pancreatectomy), odds of readmission decreased only slightly (OR = 4.20; 95% CI, 2.89–6.13). The only other significant variable affecting the odds of readmission was pancreatectomy (OR = 1.7; 95% CI, 1.09–2.66). No interactions between complications and other variables were found to be significant.

Figure 2 demonstrates that the risk of readmission increases based on the number of complications that a patient experienced. Patients with the highest rate of readmission are those that had 2 postoperative complications. Although there is a small decrease in the readmission rate for patients with ≥3 complications, calculation of this relationship with the Cochran-Armitage trend test demonstrates a significant trend of increasing readmission rate with the number of complications that occur ($p < 0.0001$). In addition, the median hospital length of stay was 5 days for patients with no complications, 9 days for patients with 1 complication, 12 days for patients with 2 complications, and 24 days for ≥3 complications.

The specific complications that occurred in patients who were readmitted are listed in Table 1. Wound complications were the most common complication within the readmission cohort (28.8%). The second most frequent postoperative occurrence associated with readmission was blood transfusion within 72 hours of a surgical procedure (26.4%). The next most common occurrences were sepsis/shock (21.5%), postoperative pulmonary complications

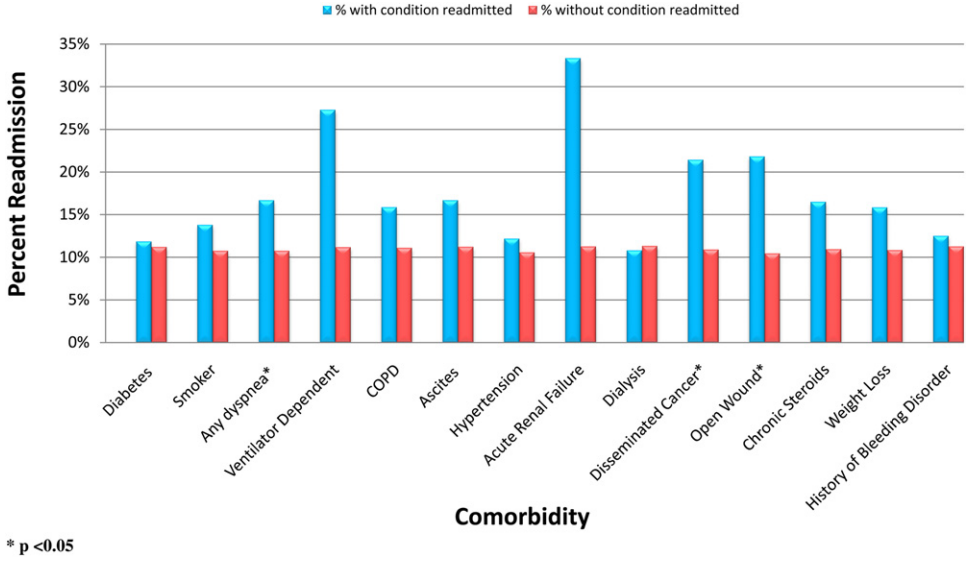

Figure 1. Comorbidity profile of readmitted patients. *$p < 0.05$.

Table 3. Readmission by Procedure

		No readmission (n = 1,279)		Readmission cohort (n = 163)	
Procedure	**n**	**n**	**%**	**n**	**%**
Pancreatectomy	190	156	82.11	34	17.89
Colectomy ± colostomy	230	201	87.39	29	12.61
Small bowel resection	93	82	88.17	11	11.83
Gastrectomy	44	39	88.64	5	11.36
Ventral hernia repair	100	89	89.00	11	11.00
Liver resection	124	112	90.32	12	9.68
Cholecystectomy	74	67	90.54	7	9.46
Parathyroidectomy	39	36	92.31	3	7.69
Thyroidectomy	35	34	97.14	1	2.86
Mastectomy	101	99	98.02	2	1.98
Other*	412	364	88.35	48	11.65

*Remaining general surgery and vascular procedures, including bariatric/foregut surgery, exploratory laparotomy, aneurysm repair, and soft tissue excision/reconstruction.

(14.7%), and UTI (9.2%). Patients who experienced a complication after discharge had 2 times the readmission rate compared with those whose complication occurred during the index admission (37.8% vs 17.9%; $p \leq 0.0001$).

Although wound complications were the most common occurrence seen in patients who were readmitted, analysis demonstrates that these patients were 3½ times more likely to be readmitted (OR = 3.52; 95% CI, 2.40–5.17). In contrast, however, postoperative UTI was a relatively uncommon occurrence in patients who were readmitted, yet it was associated with the highest risk for readmission (OR = 5.08; 95% CI, 2.62–9.86).

DISCUSSION

In April 2012, the CMS proposed a new methodology for adjusting hospital reimbursements based on the number of readmissions, with excessive readmissions leading to decreased payments.[16] In addition, the Agency for Healthcare Research and Quality has recently funded a program entitled Project RED (Re-Engineered Discharge), which focuses on patient education that facilitates successful hospital discharge.[17] With the increased attention placed on readmissions in our current health care climate, it is essential to understand risk factors and how readmissions might be prevented.

The reasons for readmission after a general surgery procedure are multifactorial. However, the common denominator that appears in our data, as well as other studies in the literature, is postoperative complications. Studies examining patients who were readmitted after colon resection cite postoperative blood transfusion, dehydration, and infection as being the complications leading to higher rates of readmission.[9,11,12,18] Similarly, among patients undergoing pancreatic resections, postoperative wound infections, pancreatic fistulas, and de-

Table 4. Multivariable Model

Variable	**Adjusted odds ratio for readmission**	**95% CI**
Preoperative sepsis	1.18	0.70–1.99
Preoperative open wound	1.28	0.71–2.29
ASA class		
1	1.00	—
2	2.75	0.36–20.91
3	3.25	0.43–24.30
4	3.78	0.47–30.43
5	5.07	0.21–119.96
Procedure: pancreatectomy	1.70*	1.09–2.66
Postoperative complication	4.20*	2.89–6.13

ASA, American Society of Anesthesiologists.

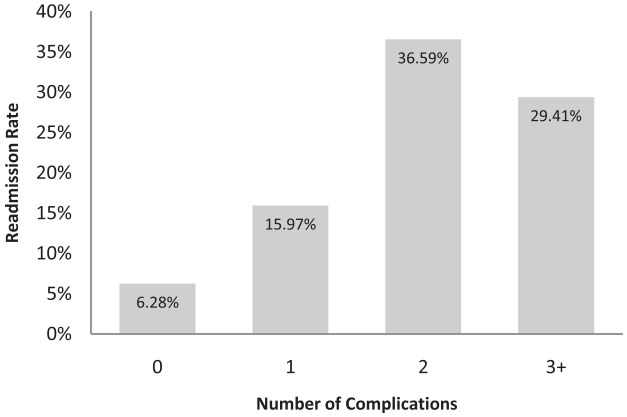

Figure 2. Rate of readmissions by number of complications. Cochran-Armitage trend test demonstrates a significant increasing trend in rate of readmission as more complications occur ($p < 0.0001$).

layed gastric emptying have been reported to be associated with increased risk of readmission.[4,8,19,20]

Our study provides additional evidence that postoperative complications are the most significant independent risk factor leading to hospital readmissions. Our analysis shows that any postoperative complication, independent of patient- and procedure-specific risk factors, increases risk of readmission by a factor of 4. In addition, patients with postoperative sepsis or UTI were approximately 5 times more likely to be readmitted than those patients without, and postoperative wound infections and postoperative pulmonary complications both carried an approximate 3½-fold increase in readmission rates.

Results of our analysis also demonstrate that certain complications represent a disproportionately large portion of readmissions. For example, postoperative blood transfusions doubled a patient's risk for readmission and represented >25% of our readmitted patient population. On the other hand, postoperative UTIs accounted only for 9.2% of readmissions, but they actually carried the highest risk for readmission of all complications studied (OR = 5.08). Understanding which postoperative complications carry larger risks will be helpful in determining how to allocate resources to prevent the complications and readmission after surgery.

We also show that the number of complications, along with their timing, influence the risk of readmission. Patients with 1 complication were more than 2 times more likely to be readmitted than those without any postoperative complications. Patients with 2 complications were more than twice as likely to be readmitted as patients with only 1 complication, and >5 times as likely when compared with patients without complications. Our data reveal, however, that patients who have ≥3 complications have a slightly lower risk of readmission than those who only have 2 complications. There could be several ways to interpret this finding. First, we demonstrate that patients with a ≥3 complications have substantially longer lengths of stay (24 days compared with 12 days or less for 2 or fewer complications), and are less likely to be discharged prematurely before the complications are completely treated and/or appropriate transition of care has been arranged. This reasoning is further supported by the fact that patients whose complications occur during, not after, their index admission are more than half as likely to be readmitted. Finally, it could be that the severity of the complications, not the actual number, is driving the rate of readmission. Future prospective analysis will be needed to clarify this result.

In addition to postoperative complications, certain risk factors, such as procedure type and preoperative length of stay, were associated with readmission risk. Although these variables cannot be changed in and of themselves, we do have an opportunity to intervene pre- and postoperatively if we know ahead of time that specific patients are at increased risk for readmission. Hendren and colleagues report that patients at risk for readmission after colectomy for colon cancer are more likely to be elderly, male, African American, and from a lower socioeconomic status.[9] Although our study did not find any substantial association among age, race, sex, and readmission, we do reveal that patients who undergo complex gastrointestinal surgery (eg, pancreatectomy, hepatectomy, and colectomy), and have a preoperative length of stay >24 hours are more likely to be readmitted than other patients.

Intra-abdominal general surgery procedures are much more likely to be associated with postoperative complications than those outside the abdomen all together (eg, mastectomy, parathyroidectomy, and thyroidectomy), and our study results support this notion.[21] Additionally, patients who are in the hospital for at least 24 hours before their surgery are likely to have greater exposure to nosocomial bacteria, further increasing the risk of an infectious complication after surgery. Multidisciplinary efforts by physicians, nurses, therapists, and social workers, should be focused on these specific patient populations during preoperative clinic visits and throughout their hospital stay to minimize the risk of postoperative complications and readmission.

There are a few comorbidities that substantially affect the risk of readmission. Patients with disseminated cancer and open wounds are at nearly double the risk of readmission than those without. Patients with dyspnea are at additional risk for readmission. When you compare preoperative comorbidities with the postoperative complications associated with readmission, they are undoubtedly related. Patients who are immunosuppressed, poor wound healers, and who have baseline pulmonary disease are vulnerable to complications that will increase the likelihood of postoperative readmission. There is an abundance of evidence within the literature to support that comorbidities such as diabetes, smoking, and immunosuppresion increase the risk of surgical site infections and postoperative pulmonary complications.[22,23] However, our analysis underscores the notion that postoperative complications, independent of patient comorbidity, are associated with a 4-fold increase in risk of readmission. Multiple comorbidities, such as acute renal failure, ventilator dependence, and ascites, although associated with a high rate of readmission, were not statistically significant risk factors within our study. This is likely due to the small number of patients with these comorbidities within our cohort. Only 3 patients had preoperative renal failure, 11 were ventilator dependent, and 26 had ascites.

In early 2011, Atul Gawande introduced the idea of "hot spots" within the American healthcare system.[24] Based on health care use research, Gawande suggests that the sickest, most "difficult" patients account for the largest expenditure of health care dollars. If resources can be focused on certain high-risk patient populations undergoing complex inpatient procedures, the number of postoperative complications could be considerably reduced and incidence of hospital readmission could be less frequent. As a result, the potential for health care savings could be quite substantial.

Our data demonstrate that postoperative complications, in particular, drive readmission rates at our institution. Consequently, focusing our efforts on effectively preventing and appropriately managing postoperative complications in high-risk patients could greatly impact the number of readmissions after surgical procedures. Patients who experience postoperative complications are likely to have a more complex discharge plan involving wound care instructions, antibiotic regimens, and/or rehabilitation therapy, each of which could lead to a readmission if not properly executed after discharge from the hospital.[25]

There are at least 3 weaknesses to our study. First, the data were collected locally for a single institution, and the small study size leads to deficiencies in gaining statistical power. Although large multi-institutional databases such as the NSQIP Participant User Files are extremely valuable, the data are de-identified, limiting the ability to capture patient readmissions. What is important to appreciate, however, is the impact that local data can have on quality improvement within single medical centers. It can be difficult to determine an institution's quality risks using large-powered, multi-institutional studies, and here we show the value of local data.

Second, we used encounter-specific NSQIP variable to analyze the risk of readmission. It is possible that other factors that are not captured by the NSQIP database could be contributing to hospital readmissions. We should also note that our method of detecting readmissions by linking our NSQIP data to our clinical data warehouse leaves the study vulnerable to underestimating readmissions. It is plausible that a patient might seek treatment for follow-up care at an outside institution. However, due to the fact that we are a regional tertiary care referral center, the majority of patients treated at our institution for their index admission are directed back here for care if a subsequent complication arises. In future studies, it might be possible to link multiple datasets, which could capture patient readmissions at multiple institutions.

Finally, this study is exploratory with the aim of identifying factors associated with readmission after a general surgical procedure. Future studies with larger sample sizes should be used to build and validate predictive models for the risk of 30-day readmission. The results we have presented, however, offer a framework for institutions to think about when trying to address and prevent unplanned patient readmissions to the hospital.

CONCLUSIONS

Better understanding the predictors of readmission for general surgery patients will allow hospitals to develop programs to decrease readmission rates. We demonstrate that patients with multiple medical comorbidities who undergo inpatient abdominal procedures, especially those admitted 24 hours or more before surgery, are at risk for readmission. This increased risk, however, is manifested through the development of postoperative complications. Future studies should focus on specifically targeting these high-risk patients to decrease the rate of 30-day readmission.

There is certainly an acceptable baseline readmission rate for each surgical procedure that needs to be defined. However, given the current health care environment, reducing readmissions by just a small amount will have a large impact on hospital budgets and operations. With the use of local data, individual institutions have the ability to analyze areas of weakness and refocus their efforts on reducing readmissions and cutting costs. And most importantly, there is the patient. Each complication averted or readmission prevented is one less burden for our patients to bear during an already trying and difficult time.

Author Contributions

Study conception and design: Kassin, Owen, Perez, Leeds, Cox, Schnier, Sadiraj, Sweeney
Acquisition of data: Kassin, Perez, Sweeney
Analysis and interpretation of data: Kassin, Owen, Perez, Leeds, Cox, Schnier, Sadiraj, Sweeney
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REFERENCES

1. The Patient Protection and Affordable Care Act. 111th United States Congress. March 23, 2010.
2. Adeyemo D, Radley S. Unplanned general surgical readmissions—how many, which patients and why? Ann R Coll Surg Engl 2007;89:363–367.
3. Friedman B, Basu J. The rate and cost of hospital readmissions for preventable conditions. Med Care Res Rev 2004;61:225–240.
4. Kent TS, Sachs TE, Callery MP, Vollmer CM Jr. Readmission after major pancreatic resection: a necessary evil? J Am Coll Surg 2011;213:515–523.

5. Khuri SF, Henderson WG, DePalma RG, et al. Determinants of long-term survival after major surgery and the adverse effect of postoperative complications. Ann Surg 2005;242:326–341; discussion 341–343.
6. Anderson GF, Steinberg EP. Hospital readmissions in the Medicare population. N Engl J Med 1984;311:1349–1353.
7. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. N Engl J Med 2009;360:1418–1428.
8. Emick DM, Riall TS, Cameron JL, et al. Hospital readmission after pancreaticoduodenectomy. J Gastrointest Surg 2006;10:1243–1252; discussion 1252–1253.
9. Hendren S, Morris AM, Zhang W, Dimick J. Early discharge and hospital readmission after colectomy for cancer. Dis Colon Rectum 2011;54:1362–1367.
10. Kellogg TA, Swan T, Leslie DA, et al. Patterns of readmission and reoperation within 90 days after Roux-en-Y gastric bypass. Surg Obes Relat Dis 2009;5:416–423.
11. Schneider EB, Hyder O, Brooke BS, et al. Patient readmission and mortality after colorectal surgery for colon cancer: impact of length of stay relative to other clinical factors. J Am Coll Surg 2012;214:390–398; discussion 398–399.
12. Wick EC, Shore AD, Hirose K, et al. Readmission rates and cost following colorectal surgery. Dis Colon Rectum 2011;54:1475–1479.
13. Hannan EL, Zhong Y, Lahey SJ, et al. 30-day readmissions after coronary artery bypass graft surgery in New York State. JACC Cardiovasc Interv 2011;4:569–576.
14. American College of Surgeons National Surgical Quality Improvement Program. Available at: www.acsnsqip.org. Accessed January 10, 2012.
15. Schilling PL, Dimick JB, Birkmeyer JD. Prioritizing quality improvement in general surgery. J Am Coll Surg 2008;207:698–704.
16. Centers for Medicare and Medicaid Services. FY 2013 Hospital Readmissions Reduction Program Supplemental Data File. Inpatient Prospective Payment System. Available at: http://www.cms.gov. Accessed May 16, 2012.
17. Agency for Healthcare Research and Quality. Re-Engineered Discharge Project Dramatically Reduces Return Trips to the Hospital. Available at: http://www.ahrq.gov/research/mar11/0311RA1.htm. Accessed May 16, 2012.
18. Guinier D, Mantion GA, Alves A, et al. Risk factors of unplanned readmission after colorectal surgery: a prospective, multicenter study. Dis Colon Rectum 2007;50:1316–1323.
19. Halloran CM, Ghaneh P, Bosonnet L, et al. Complications of pancreatic cancer resection. Dig Surg 2002;19:138–146.
20. McPhee JT, Hill JS, Whalen GF, et al. Perioperative mortality for pancreatectomy: a national perspective. Ann Surg 2007;246:246–253.
21. Aust JB, Henderson W, Khuri S, Page CP. The impact of operative complexity on patient risk factors. Ann Surg 2005;241:1024–1027; discussion 1027–1028.
22. Cheadle WG. Risk factors for surgical site infection. Surg Infect (Larchmt) 2006;7[Suppl 1]:S7–S11.
23. Sachdev G, Napolitano LM. Postoperative pulmonary complications: pneumonia and acute respiratory failure. Surg Clin North Am 2012;92:321–344.
24. Gawande A. The hot spotters: can we lower medical costs by giving the neediest patients better care? New Yorker 2011:40–51.
25. Jack BW, Chetty VK, Anthony D, et al. A reengineered hospital discharge program to decrease rehospitalization: a randomized trial. Ann Intern Med 2009;150:178–187.