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Hospital Readmissions after Colectomy: A Population-Based Study

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Abstract

Background: Surgical readmissions will be targeted for reimbursement cuts in the near future. We sought to understand differences between hospitals with high and low readmission rates in a statewide surgical collaborative to identify potential quality improvement targets.

Study Design: We studied 5,181 patients undergoing laparoscopic or open colectomy at 24 hospitals participating in the Michigan Surgical Quality Collaborative between May 2007 and Jan 2011. We first calculated hospital risk-adjusted 30-day readmission rates. We then compared reasons for readmission, risk-adjusted complication rates, risk-adjusted inpatient length of stay and composite process compliance across readmission rate quartiles.

Results: Hospitals with the lowest 30-day readmission rates averaged 5.1%, compared to 10.3% in hospitals with the highest rates ($p < 0.01$). Despite wide variability in readmission rates, reasons for readmission were similar between hospitals. Compared to hospitals with low readmission rates, hospitals with high readmission rates had higher risk-adjusted complication rates (29% vs. 22%, $p = 0.03$), but similar median length of stay (5.5 days vs. 5.6, $p = 0.61$). While measures to reduce complications were associated with lower surgical site infection rates, they were not associated with reduced overall complication or readmission rates. There was wide variation in complication rates among hospitals with similar readmission rates.

Conclusions: There is wide variation in hospital readmission rates after colectomy that correlates with overall complication rates. However, the wide variation in complication rates among hospitals with similar readmission rates suggests that hospital complication rates explain little of their readmission rates. Preventing readmissions after colectomy in hospitals with high readmission rates will require more attention to different care processes currently unmeasured in many clinical registries as well as complication prevention.

Keywords

patient readmission; postoperative complications; length of stay

INTRODUCTION

The Centers for Medicare and Medicaid Services (CMS) began a program of decreasing hospital reimbursements for excessive risk-adjusted readmission rates in an effort to improve quality and efficiency of medical care. In the near future CMS will apply this policy to several surgical procedures. (1,2) These measures are part of national efforts to

improve the quality of post-discharge medical and surgical care. (3) Providers have redoubled efforts to better understand and reduce unnecessary readmissions.

However, the optimal strategy to reduce readmission rates following general surgical procedures remains unclear. A growing body of literature in this field suggests that surgical readmissions are influenced heavily by the development of postsurgical complications. (4-8) As such, it is possible that readmissions following surgery may best be prevented through minimization and management of complications. However, readmissions also depend upon care coordination and discharge processes, and it may be that the optimal strategy to reduce readmissions is through improvement in care coordination. (9-12) Therefore, characterizing differences in hospital postsurgical readmissions would lead to a clearer understanding of the processes that contribute to low readmission rates and identify targets for process improvement and “best practices” to reduce unnecessary readmissions.

In this context, we analyzed data from the 52-hospital Michigan Surgical Quality Collaborative (MSQC) to better understand general surgical readmissions and identify potentially preventable readmissions. We assessed the variation in readmission rates across hospitals and compared reasons for readmission between hospitals with high and low risk-adjusted readmission rates. Finally, to better understand differences between hospitals with high and low readmission rates, we examined the relationship between readmission rates, complications, and process compliance.

METHODS

Data source and study population

The Michigan Surgical Quality Collaborative (MSQC) is a 52-hospital consortium representing diverse practice settings. MSQC data abstraction and data quality assurance details have been described elsewhere. (13, 14) In brief, specially trained personnel conduct chart reviews to record patient demographics, preoperative comorbidity data, lab values, perioperative process data and 30-day outcomes for all patients utilizing an algorithm that minimizes selection bias. Regular data audits ensure registry data validity. Between 2007 and 2011, 24 hospitals participated in a project targeting colectomy process improvement. In addition to regularly collected variables, personnel recorded procedure-specific variables for patients undergoing laparoscopic or open partial colon resections (CPT codes 44140, 44160, 44204, and 44205). Such processes collected for the special project included receipt of a mechanical bowel preparation with oral antibiotics, preoperative prophylactic antibiotic agent, temperature upon arrival to the post anesthesia care unit, epidural anesthetic use, and postoperative serum glucose. The patients from the colectomy project formed the cohort for this study. Data collection for MSQC is Institutional Review Board (IRB)-exempt and this study was reviewed and deemed “not regulated” by the University of Michigan IRB.

Outcomes

The primary outcome was readmission to any hospital within 30 days of operation. The duration from hospital discharge to readmission was recorded, as well as the ICD-9 code for the primary readmission diagnosis. We categorized readmission diagnoses as surgical site complications (wound complications, surgical site infection and anastomotic leak), bleeding complications, other infections and septicemia, dehydration and other fluid/electrolyte imbalances, cardiac complications (myocardial infarction, dysrhythmias), venous thromboembolism, gastrointestinal symptomatology (nausea, vomiting, ileus), bowel obstruction, pain/failure to thrive, renal failure, and “other/miscellaneous” by relevant ICD-9 codes. Secondary outcomes included risk-adjusted overall complication rates and risk-adjusted inpatient length of stay.

Explanatory Variables

Demographic data collected included age, race, sex, indication for operation (from postoperative diagnosis ICD-9 codes), and patient insurer. Comorbidities included preoperative cardiac, pulmonary, gastrointestinal, renal, nervous system, hematologic, infectious and endocrine diagnoses. Preoperative lab values included blood count results, as well as serum chemistry values and coagulation parameters. Procedure type (laparoscopic or open), emergent case status, and prophylactic antibiotic agent were recorded as well.

Analysis

We compared demographic data, comorbidities and operative details (emergent case, procedure type) as well as postoperative outcomes between patients who were readmitted and those not readmitted. We compared continuous variables with unpaired t-tests or rank-sum tests as appropriate and categorical variables with Pearson's chi-squared test or Fisher's exact test as appropriate.

Next, we entered demographics and preoperative risk factors with p-value less than 0.3 in univariate analysis along with procedural data (emergency or laparoscopic case) into a forward stepwise logistic regression model with 30-day readmission as the dependent variable. We used variables with regression coefficient p value <0.05 , as well as patient age, sex, race, primary insurer, emergency case status and procedure type in a second logistic regression model with readmission as the dependent variable to create each patient's predicted probability of readmission. We assessed model calibration with the Hosmer-Lemeshow goodness of fit test. We then calculated hospital risk-adjusted readmission rates using the ratio of observed to expected readmissions over the study period. This is similar to established methods in national quality databases, and forms the basis for the CMS readmission policy. (15, 16) To further account for random variation in hospital readmission rates, we also adjusted for statistical reliability using hierarchical modeling and empirical Bayes techniques. (17)

To assess the relationship of readmissions to complications, we created hospital risk and reliability adjusted complication and post-discharge complication rates. We first identified all 30-day complications and classified them as occurring either inpatient or post-discharge. We then used the same analytic method to calculate hospital risk-adjusted complication rates using any complication and then any post-discharge complication as the dependent variables. To calculate risk-adjusted length of stay, we used forward stepwise linear regression with log-transformed length of stay as the outcome variable to create patients' predicted lengths of stay. We then used hierarchical linear modeling techniques to create hospital risk and reliability-adjusted length of stay.

To compare differences between hospitals with high and low risk-adjusted readmission rates, we first grouped hospitals into quartiles according to their risk-adjusted readmission rates. Then, we compared reasons for readmission (based on diagnosis at readmission) between the quartiles with the lowest and highest readmission rates using Fisher's exact test. Next, we examined risk-adjusted overall complication rates, post-discharge complication rates, risk-adjusted inpatient length of stay and hospital median time from discharge to readmission across readmission rate quartiles.

To assess whether hospital compliance with recommend care processes might be associated with both complication risk and readmission risk, we performed analyses to test these associations. We focused our assessment on processes recorded in the dataset that may reduce certain complications such as surgical site infection. Those processes included receipt of a mechanical bowel preparation with oral antibiotics, receipt of appropriate preoperative prophylactic antibiotics as defined by Surgical Care Improvement Project

guidelines (18), laparoscopic approach, post-anesthesia care unit temperature greater than 36 degrees Celsius, and adequate postoperative glucose control defined as postoperative day 1 glucose less than 140 mg/dL. We categorized each process measure as a binary variable (yes/no) and assigned patients a composite score equal to the number of process measures met. We defined hospital compliance as the hospital proportion of patients meeting all 5 compliance measures among their patients undergoing elective surgery. To assess the relationship between process compliance, complications and readmission, we first grouped hospitals into quartiles by their overall compliance rates. We then compared unadjusted surgical site complication (superficial, deep, or organ/space surgical site infection, wound disruption, or anastomotic leak) rates, overall risk-adjusted complication rates, and risk-adjusted readmission rates across hospital quartiles based on compliance.

We performed all statistical analyses using STATA release 12 (StataCorp, College Station, TX).

RESULTS

We identified 5181 patients in 24 hospitals who underwent laparoscopic or open partial colectomy between 2007 and 2011. Demographic and procedural data as well as postoperative outcomes between groups are shown in Tables 1 and 2. Patients who were readmitted were less independent functionally, were more likely to have inflammatory bowel disease and had more comorbidities than those who were not readmitted. The proportion of emergent cases and procedure mix were similar between groups (Table 1). Patients who were readmitted experienced more 30-day complications (63.6% vs. 20.2%, $p<0.01$) than those who were not (Table 2). There were higher anastomotic leak rates (12.7% vs. 2.2%, $p<0.01$), higher postoperative bowel obstruction rates (5.7% vs. 0.7%, $p<0.01$) and higher reoperation rates (23.0% vs. 4.7%, $p<0.01$) among patients who were readmitted. Mortality was similar between groups.

In our stepwise logistic regression model for readmission, the following variables had coefficient p -values less than 0.05: functional status less than independent, long-term steroid use, esophageal varices, vascular disease, inflammatory bowel disease (Crohn's Disease or ulcerative colitis), and hypertension requiring medications. We also included patient age, race, gender and primary insurer as well as procedure type (laparoscopic) and emergent case status as risk-adjustment covariates. Model calibration was good with Hosmer-Lemeshow p -value 0.91, comparable to other readmission risk models. (19)

Unadjusted and risk-adjusted hospital readmission rates are presented in Figure 1. The overall unadjusted 30-day readmission rate across hospitals was 7.5%. Unadjusted 30-day readmission rates ranged from 1.2% to 12.9% and risk-adjusted readmission rates ranged from 3.7% to 12.1% (Figures 1A and 1B). The average risk-adjusted readmission rate among the highest performing hospitals was 5.1%, compared to 10.3% among the worst performing hospitals ($p<0.01$).

Figure 2 demonstrates differences in readmission diagnoses between hospitals in the quartiles with the lowest and highest risk-adjusted readmission rates. Surgical site complications, including anastomotic leak, accounted for 20.5% compared to 22.9% of readmissions between the first and fourth quartiles ($p=0.45$). Bowel obstruction accounted for 9.1% compared to 5.3% of readmissions between quartiles ($p=0.26$). Dehydration and electrolyte imbalances accounted for 4.6% compared to 9.0% of readmissions between quartiles ($p=0.26$). Other medical complications (cardiac complications, renal insufficiency, venous thromboembolism) accounted for 13.6% of compared to 10.1% of readmissions between quartiles ($p=0.33$).

Figures 3 shows the relationships between hospital risk-adjusted readmission rates with complication rates, index length of stay and time from discharge to readmission. Complication rates were higher in hospitals with high readmission rates (28.5% vs. 21.9% in low readmission rate hospitals, $p=0.03$). We saw a similar relationship with post-discharge complication rates (10.6% vs. 7.3%, $p=0.01$) (Figures 3A and 3B). There was a positive and statistically significant correlation between hospital readmission rates and complication rates (Spearman correlation coefficient 0.56, $p<0.01$). The relationship was similar with post-discharge complications. Both risk-adjusted index length of stay (5.6 days vs. 5.5 days, $p=0.62$) and median time from discharge to readmission (4.5 days vs. 5.5 days, $p=0.58$) were similar between hospitals with the lowest and highest risk-adjusted readmission rates (Figure 3C and 3D).

Figure 4 demonstrates the relationship between hospital process compliance and surgical site complications, overall complications and readmission rates. Compliance with all 5 process measures (receipt of a mechanical bowel preparation with oral antibiotics, receipt of appropriate preoperative prophylactic antibiotics as defined by Surgical Care Improvement Project guidelines, laparoscopic approach, post-anesthesia care unit temperature greater than 36 degrees Celsius, and postoperative day 1 glucose less than 140 mg/dL) among patients undergoing elective surgery ranged from 0% to 27.5% across all hospitals. Hospitals that had higher proportions of patients meeting all 5 measures had lower surgical site complication rates (8.4% vs. 14.6%, $p=0.02$). This association was not present when examining overall complication rates (23.0% in high-compliance hospitals vs. 27.3% in low-compliance hospitals, $p=0.33$) or readmission rates (7.6% in high-compliance hospitals vs. 8.3% in low-compliance hospitals, $p=0.88$).

Figure 5 demonstrates the variability in hospital complication rates and post-discharge complication rates across readmission rate quartiles. While complication rates and post-discharge complication rates were generally higher for hospitals with higher readmission rates, there was wide variation in both complication and post-discharge complication rates for hospitals in the same quartile of readmissions. For example, complication rates among hospitals with the lowest readmission rates ranged from 19.9% to 23.9%, while hospitals with the highest readmission rates had complication rates ranging from 23.5% to 40.2% (Figure 5A). We saw a similar phenomenon for post-discharge complication rates (Figure 5B).

DISCUSSION

With recent policy efforts aimed at adjusting reimbursements for readmissions, much attention has been directed at understanding and identifying those readmissions that are 'preventable.' (2, 20) Lack of a clear understanding of what defines 'preventable' readmissions has hampered this process. (21) This is especially true for surgical patients. Using a statewide clinical registry, we were unable to find differences in the reasons for readmission between hospitals with the highest and lowest readmission rates, despite a 2-fold difference in readmission rates across hospitals. While risk-adjusted complication rates correlated with readmission rates, risk-adjusted length of stay was similar across hospitals. Compliance with measures to reduce surgical site complications was associated with lower surgical site complication rates, but not with lower overall complication rates or lower readmission rates. The variability in complication rates across hospitals with similar readmission rates suggests that hospital complication rates provide an incomplete explanation for the variation in their readmission rates.

Studies across surgical specialties have consistently shown a strong association between complications and readmissions. (6, 7, 22) Several investigators have found that surgical

complications are the strongest overall predictors for readmissions following surgery. (5, 23) We also found an association between surgical complications and readmissions following colectomy; the three leading causes of readmission for our cohort were surgical site complications, other infections/sepsis and ileus. We were interested in investigating the relationship between post-discharge complications and readmissions as a possible surrogate for care coordination. Theoretically at least, hospitals with better care coordination and more robust outpatient care capabilities would be able to prevent readmissions for certain complications (e.g. wound infection). However the relationship between morbidity and readmissions persisted when examining post-discharge morbidity alone. Despite showing a relationship between improved process compliance in reducing surgical site complications, there was no association between better process compliance and overall complication rates, nor was process compliance as measured associated with readmission rates. This may be due to low overall compliance among hospitals and low number of readmissions leading to a lack of statistical power to determine real differences between high and low performing hospitals. Alternatively, it may demonstrate how process compliance by itself does not translate into high-quality care.

Both inpatient length of stay and time from discharge to readmission were similar between hospitals with high and low readmission rates. This could be interpreted as hospitals with lower readmission rates keeping patients admitted the appropriate amount of time. The converse, that hospitals may safely discharge patients earlier, may be just as likely, since hospitals with lower risk-adjusted length of stay had similar readmission rates and their patients returned to the hospital in a similar timeframe as those discharged from high-readmission rate hospitals. What are likely more relevant to readmissions are the patient and hospital factors that trigger readmission. Other studies have shown patient factors such as rurality, health literacy and care satisfaction as well as hospital resources such as discharge planners influence readmission rates. (24-27) This has spurred increased interest in studying discharge planning and care coordination. (1, 28, 29). However, this existing literature is dominated by studies of patients hospitalized (and re-hospitalized) for acute and chronic medical diagnoses, with relatively few studies that focus on surgical patients.

There are important limitations to this study. As with any clinical registry study, our study is limited by its retrospective nature and by the constraints of data abstraction from clinical chart review. While there is a possibility of missed or undocumented complications, the strength of our registry data is that it includes 30-day follow-up, and captures both in-hospital and post-discharge complications. In fact, quality improvement platforms like the MSQC are considered to be among the most accurate data sources for risk-adjusted complication rates. However, because the MSQC registry is tailored for complication analysis and reduction, our data do not include some factors that might be associated with readmission risk, such as hospital rural versus urban status, patient distance to the index and readmitting hospitals, hospital 24-hour physician coverage, discharge practices, institutional culture and patient care satisfaction. We examined a narrow subset of patients undergoing colon resections and as such our results may not apply to patients undergoing different gastrointestinal procedures. Other investigators have found that dehydration is a leading cause of readmissions following ostomy creation and that improved care coordination could limit readmissions for dehydration. (30) In our cohort there was a nearly 2-fold difference in readmissions for dehydration between hospitals with the highest and lowest readmission rates despite excluding ostomy procedures. Had there been more patients in our cohort, the difference may have reached statistical significance. Larger clinical registries that document readmissions may be able to generate enough statistical power to answer that question. Another limitation is that the 24 hospitals participating in the colectomy project were generally larger (more than 300 beds) hospitals, two-thirds were teaching hospitals, and as a

group they represent a generally strong commitment to quality improvement. As such, our results may not be fully generalizable.

What perhaps is the most important unanswered question is whether improving readmission rates affects the overall quality of care. Not all readmissions are unnecessary and policies to reduce readmissions could have unintended negative consequences such as missed severe complications that might lead to increased mortality. Our data did not demonstrate a pattern of decreased readmissions over the timeframe of this cohort (data not shown); however, future trends remain to be seen. Future studies should address the relationship between changing readmission rates and changes in the overall quality and safety of care.

In conclusion, there is wide variation in hospital readmission rates after colectomy that correlates with overall complication rates. However, complication rates among hospitals with similar readmission rates also vary, suggesting that hospital complication rates incompletely explain readmissions. Understanding and preventing readmissions after colectomy in hospitals with high readmission rates will require more attention to different care processes currently unmeasured in many clinical registries, in addition to efforts to prevent complications.

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A **B****Figure 1.**

Unadjusted and risk-adjusted hospital readmission rates in 24 hospitals participating in the Michigan Surgical Quality Collaborative special colectomy project, 2007-2011. (A) Unadjusted 30-day readmission rates; (B) risk-adjusted readmission rates. Variables used for risk adjustment: patient age, gender, race, primary insurer, functional status, long-term steroid use, esophageal varices, vascular disease, inflammatory bowel disease, hypertension requiring medications, procedure type, and emergent case status.

Figure 2. Reasons for readmission between hospitals in the lowest readmission rate quartile compared to hospitals in the highest readmission rate quartile. Dark bars, lowest readmission rate hospitals; light bars, highest readmission rate hospitals.

Figure 3.

Risk-adjusted complication rates, length of stay and median days from discharge to readmission across hospital risk-adjusted readmission quartiles. (A) Risk-adjusted 30-day complication rates. (B) Risk-adjusted post-discharge complication rates. (C) Risk-adjusted median length of stay. (D) Median time from discharge to readmission. * $p < 0.05$ Compared to low readmission rate hospitals.

Figure 4.

Surgical site complication rates, overall complication rates and 30-day readmission rates by hospital compliance (proportion of patients undergoing elective surgery meeting all 5 process measures). (A) Surgical site complication rates; (B) overall complication rates; (C) 30-day readmission rates. * $p < 0.05$ Compared to low overall compliance hospitals. Process measures: receipt of a mechanical bowel preparation with oral antibiotics, receipt of appropriate preoperative prophylactic antibiotics as defined by Surgical Care Improvement Project guidelines, laparoscopic approach, post-anesthesia care unit temperature greater than 36 degrees Celsius, and postoperative day 1 glucose <140 mg/dL.

Figure 5.
Variation in risk-adjusted complication rates across risk-adjusted readmission rate quartiles.
(A) Risk-adjusted complication rates. (B) Risk-adjusted post-discharge complication rates.

Table 1

Characteristics of 5,181 Patients Undergoing Colorectal Resections in 24 Hospitals Participating in the Michigan Surgical Quality Collaborative Special Colectomy Project, 2007–2011

	No readmission, n=4,794	Readmission, n=387	p Value
Mean age, y	64.3	64.7	0.51
Male, %	46.9	49.6	0.30
Race, %			0.30
White	77.8	80.1	
Black	11.1	11.4	
Other	11.1	8.5	
Private insurance, %	54.5	52.5	0.45
Independent functional status, %	93.2	86.3	<0.01
ASA class 3, %	50.2	54.5	0.10
Diagnosis, %			0.02
Colorectal cancer	39.3	38.8	
Diverticular disease/inflammation	26.2	23.5	
Obstruction/hernia/volvulus	6.0	8.8	
IBD (Crohn's, UC)	3.6	6.7	
Presentation, %			0.94
Obstructed	11.3	11.6	
Perforated	5.6	6.2	
Both	0.7	0.8	
Coronary artery disease, %	13.4	17.1	0.04
Vascular disease, %	1.7	3.9	0.01
Diabetes, %	17.2	19.6	0.23
Dyspnea, %	15.6	20.4	0.01
Renal failure or dialysis, %	1.4	1.0	0.55
TIA/Stroke history, %	8.7	12.1	0.02
Long-term steroid use, %	3.8	7.8	<0.01
Bleeding disorder, %	5.3	9.0	<0.01
Prior operation within 30 d, %	1.4	0.5	0.24
Emergency case, %	10.4	12.7	0.16
Procedure, %			0.15
Laparoscopic partial colectomy	29.2	24.8	
Laparoscopic ileocectomy	11.9	10.3	
Open partial colectomy	36.6	40.1	
Open ileocectomy	22.4	24.8	

Table 2

Postoperative Outcomes for 5,181 Patients in the Michigan Surgical Quality Collaborative Special Colectomy Project According to Readmission Status

	No readmission, n=4,794	Readmission, n=387	p Value
Length of stay, d, median (IQR)	5 (4–7)	6 (4–9)	<0.01
Any complication, %	20.2	63.6	<0.01
Severe complication, %	11.1	41.6	<0.01
Anastomotic leak, %	2.2	12.7	<0.01
<i>C. difficile</i> colitis, %	1.4	5.4	<0.01
Prolonged ileus, %	6.8	20.7	<0.01
Postoperative bowel obstruction, %	0.7	5.7	<0.01
Reoperation, %	4.7	23.0	<0.01
Mortality, %	3.0	2.1	0.35