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ORIGINAL CONTRIBUTIONS

Readmissions Following Gastric Bypass Surgery

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Abstract
Background Interest is growing in preventing readmissions as payers start to link reimbursement to readmission rates. The purpose of this study was to assess factors contributing to 30-day readmission for patients undergoing gastric bypass (GB) and determine whether these readmissions may be preventable.
Methods Data were from the Pennsylvania Health Care Cost Containment Council (PHC4) and included all patients undergoing elective GB for obesity in 2011 (n=4427). The outcomes measured were length of stay (LOS) and 30-day readmission. Univariate comparisons between characteristics of readmitted (n=298) and non-readmitted (n=4133) patients were performed. Readmission was modeled using multivariate logistic regression; LOS was modeled using linear regression.
Results Of the 298 (6.6 %) patients who were readmitted, the most common causes for readmission were bleeding (11.84 %), infection (8.88 %), and abdominal pain (7.89 %). In multivariate analyses, black race, open GB, and history of myocardial infarction or rheumatoid arthritis were associated with increased odds of readmission. Longer LOS was also predictive of readmission (OR 1.10, p=<0.0001). Patients who were >50 years old and those with history of congestive heart failure, peripheral vascular, and kidney diseases were more likely to have longer LOS. Black race, open surgery, and discharge to an extended care facility were also predictive of prolonged LOS.
Conclusions The most common causes of readmission following elective GB were bleeding, infection, and abdominal pain. Since several patient-specific factors were associated with higher odds of readmission and longer LOS, there are opportunities to design interventions to prevent readmissions and decrease LOS in this patient population.

Keywords Gastric bypass · Readmission · Length of stay · Obesity surgery · Metabolic surgery

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Introduction

Gastric bypass is a commonly performed surgical weight loss operation in the USA and is one of the most effective and lasting treatments for morbid obesity [1]. While combination therapies of dietary changes, exercise programs, and medication therapy usually achieve some degree of weight loss, results are often transient [2]. Studies have shown that patients undergoing gastric bypass surgery are more likely to experience significant long-term weight loss when compared with those treated non-surgically [3, 4]. The Swedish Obese Subjects study showed that bariatric surgery is associated not only with durable weight loss but the amelioration of chronic conditions including type 2 diabetes, heart disease, hypertension, and dyslipidemia [3]. For these reasons, laparoscopic Roux-en-Y gastric bypass (RYGBP) has become a commonly chosen procedure for the treatment of morbid obesity.

With increased pressures to lower healthcare expenditures, initiatives have been implemented to decrease length of stay. From 1998 to 2004, the cost per bariatric surgery decreased by 5.2 %. This was attributed to the 38 % decrease in length of stay during that time [5]. With the implementation of the Affordable Care Act, the Centers for Medicare and Medicaid Services (CMS) are beginning to deny reimbursement for readmissions for certain diseases [6]. Thus, readmissions have become an important measure of quality and an outcome of clinical interest. In order to improve quality of care and limit healthcare costs, institutions have developed clinical pathways to reduce length of stay and readmissions post bariatric surgery [7].

The purpose of our study was to evaluate predictors for readmission and extended length of index hospitalization, as these are associated with quality of care and cost. We attempted to identify the reasons for readmission following bypass surgery in order to inform protocols that decrease readmissions due to avoidable causes.

Methods

Data

The data set used in this study was discharge data from the Pennsylvania Health Care Cost Containment Council (PHC4). The PHC4 database contains inpatient hospital discharge data for admissions to all hospitals and surgical facilities in Pennsylvania and includes patient demographics, diagnosis codes, procedure codes, and hospital information.

Patient Selection

Patients over age 18 who underwent elective gastric bypass for severe obesity in 2011 were included. Gastric bypass was identified using the International Classification of Disease, 9th Revision, Clinical Modification (ICD-9) procedure codes 44.38, 44.31, and 44.39. Those who underwent laparoscopic gastric bypass were indicated if an additional code for laparoscopy was present (54.21). Conversion from laparoscopic to open surgery was defined by ICD-9 diagnosis codes V64.4 and V64.41. In addition to a procedure code, patients were required to have an ICD-9 diagnosis code for obesity (277.7, 278.00, or 278.01). Complications from gastric banding were identified with codes 539.09 and 996.59.

Outcomes

The primary outcome assessed was readmission within 30 days of discharge from the initial hospital stay. Length of stay (LOS) was assessed as a secondary outcome.

Covariates

Demographic data included in the study were age (≤30, 31–40, 41–50, 51–60, >60), sex, race (white, black, other), payer type (self-pay, HMO, commercial, Medicare), laparoscopic surgery, discharge destination, and history of complication from gastric band. Hospital volume was stratified into high (>240), medium (26–240), and low (≤25). Low-volume centers were those with fewer than 25 bypasses per year based on the criteria for accreditation in bariatric surgery. High-volume

Table 1 Patient characteristics based on readmission status

Variable	Not readmitted (n=4133)	Readmitted (n=294)	p value
Age	44.1	43.7	0.5559
≤30	14.0 %	14.6 %	
31–40	26.3 %	26.9 %	
41–50	28.1 %	27.6 %	
51–60	23.2 %	24.1 %	
>60	8.4 %	6.8 %	
Sex			0.5390
Female	78.8 %	80.3 %	
Male	21.2 %	19.7 %	
Race			<0.0001
White	78.5 %	67.0 %	
Black	14.3 %	24.8 %	
Other	7.2 %	8.2 %	
Payer type			0.0100
Medicare	14.2 %	18.4 %	
Commercial	66.4 %	51.4 %	
Self-pay	0.5 %	0.0 %	
HMO	33.8 %	40.1 %	
Surgeon volume	87.4	82.7	0.0817
Low (≤10)	1.8 %	3.4 %	
Medium (11–100)	66.5 %	67.7 %	
High (>100)	31.7 %	28.9 %	
Hospital volume	204.4	184.9	0.0120
Low (≤25)	3.7 %	3.1 %	
Medium (26–240)	66.6 %	73.1 %	
High (>240)	29.7 %	23.8 %	
Laparoscopic			0.0070
Yes	94.8 %	91.2 %	
No	5.2 %	8.8 %	
Discharge			0.0090
Home	89.7 %	85.0 %	0.0120
SNF	0.3 %	1.4 %	0.0080
Home with home health	9.9 %	13.6 %	0.0430
Other	0.0 %	0.0 %	0.7900
Complication from gastric band	0.2 %	0.3 %	0.7440
LOS (days)	2.2	2.7	<0.0001

centers were identified based on the upper 75th percentile of gastric bypasses performed per year. Surgeons who performed ≤10 bypasses per year (lower 5th percentile) were considered low volume, those who performed 11–100 were considered medium volume, and those with >100 bypasses per year (upper 75th percentile) were high volume surgeons. Comorbidities were assessed using the Charlson comorbidity index, which consisted of 17 comorbid conditions. These included acute myocardial infarction, congestive heart failure, peripheral vascular disease, cerebral vascular disease, dementia, COPD, rheumatoid arthritis, peptic ulcer disease, liver disease, diabetes mellitus, hemiplegia, paraplegia, renal disease, cancer, and AIDS.

Statistical Analysis

The statistical analysis was designed to determine variables that had a significant association with readmission within 30 days. We also studied factors that may affect length of stay (LOS) of the index hospitalization.

Patient demographics were compared between those readmitted and not readmitted using Student's *t* tests for continuous variables and chi-square tests for binary and categorical variables. Logistic regression was used to model 30-day readmission as a function of other covariates. Goodness of fit of the logistic regression model was measured as the area under the Receiver Operating Characteristic (ROC) Curve. We also modeled length of hospitalization using linear regression and controlled for potential confounders. All statistical analyses were performed using STATA software (version 10.1, StataCorp, College Station, TX, USA). Statistical significance was defined by p value <0.05.

Table 2 Preoperative patient comorbidities

Variable	Not readmitted (n=4133)	Readmitted (n=294)	p value
Comorbidities			
AMI	1.3 %	3.1 %	0.0140
CHF	1.4 %	3.1 %	0.0210
PVD	0.5 %	1.7 %	0.0050
COPD	23.1 %	25.5 %	0.3410
RA	1.2 %	4.8 %	<0.0001
PUD	0.4 %	0.3 %	0.8090
Diabetes	34.3 %	37.8 %	0.2270
Liver disease	0.5 %	1.4 %	0.0480
Renal disease	2.0 %	2.0 %	0.9460
Number of comorbidities	0.65	0.80	0.0012
Charlson index	0.68	0.84	0.0012

AMI acute myocardial infarction, *CHF* congestive heart failure, *PVD* peripheral vascular disease, *COPD* chronic obstructive pulmonary disease, *RA* rheumatoid arthritis, *PUD* peptic ulcer disease

Table 3 Multivariate odds ratio of risk factors for 30-day readmission

Variable	95 % Confidence			
	OR	Lower	Upper	p value
Age				
≤30	Reference			
31–40	1.01	0.68	1.49	0.9760
41–50	0.92	0.62	1.37	0.6860
51–60	0.92	0.60	1.40	0.6880
>60	0.60	0.32	1.10	0.1000
Sex				
Female	Reference			
Male	0.94	0.68	1.28	0.6750
Race				
White	Reference			
Black	1.73	1.27	2.36	<0.0001
Other	1.21	0.76	1.91	0.4230
Payer type				
Commercial	Reference			
Medicare	1.29	0.91	1.83	0.1460
HMO	1.14	0.88	1.48	0.3280
Surgeon volume				
Low (≤10)	1.95	0.92	4.13	0.0810
Medium (11–100)	1.01	0.77	1.34	0.9210
High (>100)	Reference			
Hospital volume				
Low (≤25)	0.87	0.41	1.87	0.7270
Medium (26–240)	1.28	0.95	1.73	0.1090
High (>240)	Reference			
Laparoscopic				
Yes	Reference			
No	1.63	1.03	2.57	0.0370
Discharge to home				
Yes	Reference			
No	1.06	0.73	1.54	0.7540
Complication from gastric band				
Yes	0.98	0.10	9.51	0.9860
No	Reference			
LOS	1.09	1.03	1.14	<0.0001
Comorbidities				
AMI	2.28	1.07	4.85	0.0320
CHF	1.53	0.71	3.33	0.2800
PVD	2.79	0.99	7.89	0.0530
COPD	1.03	0.78	1.36	0.8400
RA	3.98	2.12	7.48	<0.0001
PUD	0.91	0.12	6.95	0.9260
Diabetes	1.15	0.88	1.49	0.3160
Liver disease	2.21	0.70	7.02	0.1780
Renal disease	0.79	0.33	1.93	0.6100

Area under the ROC curve=0.6547

Results

Descriptive Statistics

A total of 4427 patients who underwent elective gastric bypass for obesity were included in this study. Patient characteristics stratified by readmission status are reported in Table 1. There were statistically significant differences in race ($p<0.0001$), payer type ($p=0.01$), and discharge destination ($p=0.009$) between readmitted and not readmitted patients. Patients who were not readmitted more frequently underwent surgery at hospitals with a higher average volume of gastric bypass cases (204 versus 184.9, $p=0.0120$). More readmitted patients underwent open gastric bypass (8.8 versus 5.2 %, $p=0.007$). There were also statistically significant differences in discharge destinations between the readmitted and not readmitted cohorts; more readmitted patients were discharged to skilled nursing facilities (1.4 versus 0.3 %; $p=0.008$) or home with home healthcare (13.6 versus 9.9 %, $p=0.043$), and a smaller proportion of patients who were discharged home independently were readmitted (85 versus 89.7 %, $p=0.012$). The mean postoperative length of stay for the readmitted group was 2.7 versus 2.2 days for the non-readmitted group ($p<0.0001$).

Patient comorbidities stratified by readmission are reported in Table 2. When compared to the non-readmitted cohort, readmitted patients were more likely to have had higher total number of preoperative comorbidities (0.80 versus 0.65, $p=0.0012$). The readmitted cohort was also more likely to have had a number of specific comorbidities, including myocardial infarction (3.1 versus 1.3 %, $p=0.014$), congestive heart failure (3.1 versus 1.4 %, $p=0.021$), peripheral vascular disease (1.7 versus 0.5 %, $p=0.005$), rheumatoid arthritis (4.8 versus 1.2 %, $p<0.0001$), and liver disease (1.4 versus 0.5 %, $p=0.048$).

Readmission

Results from the logistic regression model of 30-day readmission are presented in Table 3. This model suggests that African American patients are more likely to be readmitted than white patients (OR 1.73, $p<0.0001$). Patients who underwent open surgery were 1.63 times more likely to be readmitted than those who had laparoscopic gastric bypass ($p=0.037$). Each additional day in hospital stay was associated with a 9 % greater odds of readmission (OR 1.09, $p=<0.0001$). Additionally, a history of AMI (OR 2.28, $p=0.032$) or RA (OR 3.98, $p<0.0001$) was predictive of 30-day readmission. Other variables did not have statistically significant effects on risk of readmission.

Causes for Readmission

The causes of readmission are presented in Fig. 1. Of the 294 readmitted patients, 11.8 % were secondary to bleeding. The second most common reason for readmission was infection

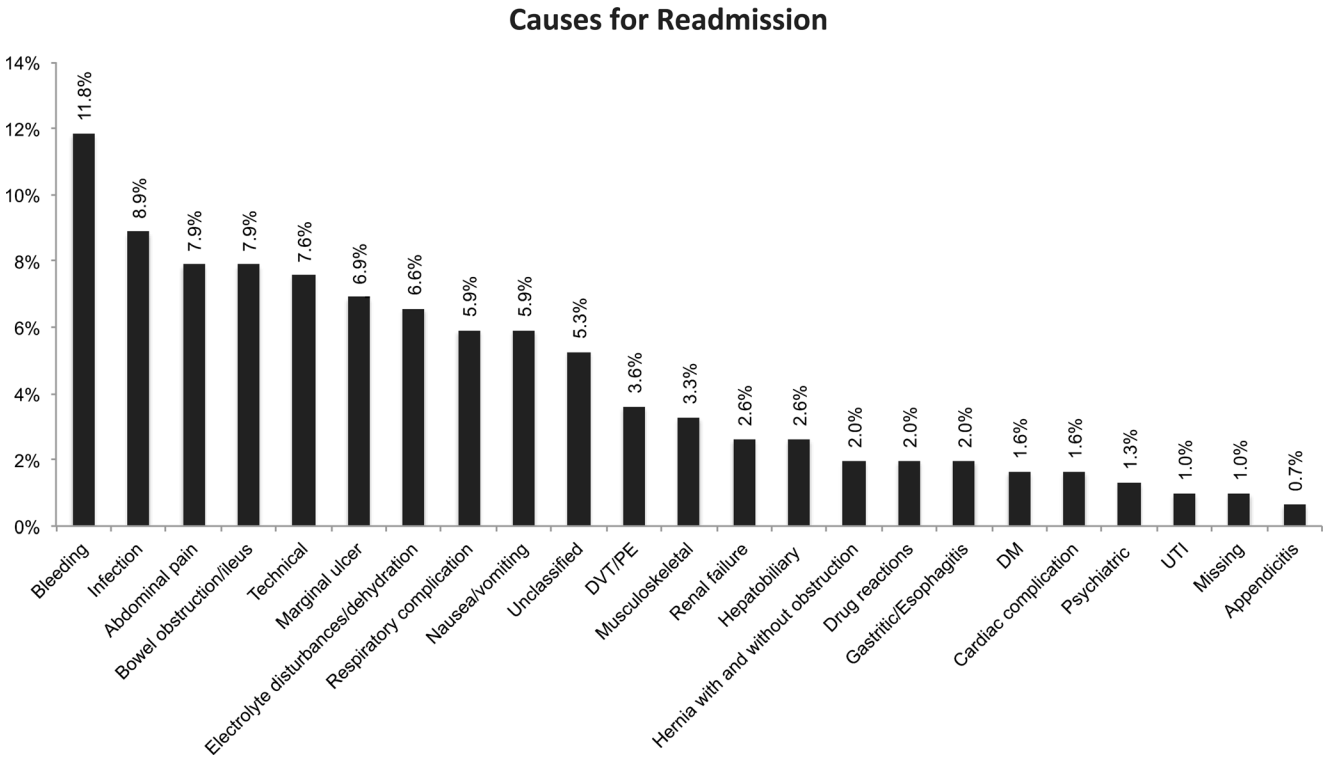

Fig. 1 Causes for readmission following gastric bypass

(8.9 %), followed by abdominal pain (7.9 %), bowel obstruction/ileus (7.9 %), technical (7.6 %), and marginal ulcers (6.9 %).

Length of Hospital Stay

Next, we evaluated factors associated with hospital stay. Table 4 presents the results of the multivariate linear regression model for factors affecting length of hospital stay. Age >50, black race (p=0.001), low or medium surgeon volumes (p<0.0001), and open surgery (p<0.0001) were associated with longer LOS. Patient whose discharge destination was not home had a length of stay that was on average 0.92 days longer than those who were discharged home (p<0.0001). Comorbidities such as congestive heart failure (p<0.0001), peripheral vascular disease (p=0.013), and renal disease (p=<0.0001) were predictive of longer lengths of stay.

Discussion

Public reporting of hospitals' 30-day readmission rates was initiated by CMS in 2009, making this a highly scrutinized outcome [8]. Subsequently, CMS instituted penalties for potentially avoidable readmissions in 2013 [9]. Desire on the part of physicians and hospitals to improve quality and safety, as well as significant concern regarding withheld payments and penalties, has all driven the charge to study early hospital readmission and look for areas of potential practice change. Thirty-day readmission rates after RYGB have been reported to be as high as 15 % [8].

Initial LOS has been a strong predictor of readmission in multiple studies, including our own [10–12]. Clearly, a longer LOS may be associated with open surgery, as well as with intraoperative and in-hospital complications. We and others have found open surgery alone to be an independent predictor of readmission [13]. Additional factors found to be predictors of readmission include higher BMI and higher ASA class [8, 13]. In our study, African American race was also associated with increased LOS and independently associated with early readmission, a finding confirmed in other studies [11]. We also found a prior history of MI and history of RA to be independent factors associated with early readmission; these findings are novel according to our review of the literature. Awareness of any factors potentially associated with readmission may lead to differentiated care pathways for higher-risk patients.

Previous research has identified government-subsidized insurance and discharge with visiting nurse service (VNS) or to a skilled nursing facility as being significantly associated with 30-day readmission [8, 14]. While insurance status is not generally a variable that can be modified, it likely indicates lower socioeconomic status, advanced age, or disability. A separate

Table 4 Multivariate model of factors affecting length of stay

Variable	95 % Confidence			
	Coefficient	Lower	Upper	p value
Age				
≤30	Reference			
31–40	0.06	−0.09	0.21	0.4500
41–50	0.11	−0.04	0.26	0.1480
51–60	0.20	0.04	0.36	0.0170
>60	0.37	0.16	0.59	0.0010
Sex				
Female	Reference			
Male	−0.06	−0.17	0.06	0.3270
Race				
White	Reference			
Black	0.23	0.09	0.36	0.0010
Other	−0.18	−0.36	0.01	0.0570
Payer type				
Commercial	Reference			
Medicare	0.08	−0.06	0.22	0.2620
HMO	0.02	−0.09	0.12	0.7690
Surgeon volume				
Low (≤10)	0.76	0.41	1.12	<0.0001
Medium (11–100)	0.49	0.38	0.59	<0.0001
High (>100)	Reference			
Hospital volume				
Low (≤25)	−0.22	−0.48	0.05	0.1050
Medium (26–240)	−0.28	−0.39	−0.17	<0.0001
High (>240)	Reference			
Laparoscopic				
Yes	Reference			
No	0.68	0.47	0.88	<0.0001
Discharge to home				
Yes	Reference			
No	0.92	0.76	1.07	<0.0001
Complication from gastric band				
Yes	0.26	−0.65	1.18	0.5710
No	Reference			
Comorbidities				
AMI	0.33	−0.05	0.72	0.0890
CHF	1.51	1.13	1.89	<0.0001
PVD	0.78	0.16	1.41	0.0130
COPD	0.02	−0.09	0.13	0.6880
RA	0.24	−0.15	0.62	0.2260
PUD	−0.19	−0.88	0.51	0.6020
Diabetes	0.00	−0.10	0.10	0.9990
Liver disease	0.26	−0.37	0.88	0.4200
Renal disease	0.70	0.36	1.03	<0.0001
Intercept	1.76	1.60	1.91	<0.0001

series found unemployed, disabled, or retired status to similarly increase readmission rate [13]. Need for skilled nursing or VNS suggest multiple potentially associated complicating factors such as frailty, increased complexity of the index hospital stay, and inadequate home support.

The three leading causes of readmission in our study were bleeding, infection, and abdominal pain. Other studies have had various orders and combinations of causes but generally include technical issues, nausea and vomiting, gastrointestinal issues, wound infection, bleeding, and abdominal pain. We found "technical" to be in the top five more common reasons for readmission, and in fact, it was the leading cause in three similar reports [10, 14, 15]. While "technical" is a nebulous indicator, it is generally felt to include strictures, bleeding, leaks, and intraabdominal infections. To definitively claim that any of these complications is a technical "error" as opposed to a technical "issue" may be an overstatement. However, the use of hospital or surgeon volume as a proxy for operative experience may tease out the likelihood of experiencing technical problems. To this end, a large study of University Health System Consortium Clinical Data found that 30-day readmission rate after bariatric surgery was twice as high in low-volume compared to medium- and high-volume centers [16]. This topic clearly requires further study and analysis.

Nausea and vomiting have been implicated as among the most frequent causes of readmission after RYGB [11, 13]. Other common causes include dehydration, pain, and wound complications [8], all of which were in the upper range of causes for readmission in our cohort. Nonetheless, some of our series' more prominent causes, including "abdominal pain," "bowel," and "technical," most likely included nausea and vomiting in their constellation of symptoms. It has been suggested that early readmission for nausea and vomiting may be associated with pressure from hospitals and payers for earlier hospital discharge [17]. Nonetheless, increased LOS is generally associated with increased readmissions, [10–12] as we also found. Care pathways and discharge protocols may help assure that patients are ready to safely leave at the optimal time [18].

The bariatric program at Stanford University Medical Center has initiated the first national quality improvement project for Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP), called Decreasing Readmissions through Opportunities Provided (DROP) [19]. This initiative looks at multiple pre- and postoperative measures and standardized care protocols that may decrease the likelihood of readmissions. This includes such measures as tightened preoperative glucose control, weight-based antibiotic dosing, a post-discharge day one nurse phone call, same day clinic appointments on an as-needed basis, and an outpatient unit for treatment of dehydration. Such outpatient units are coming into more frequent use as hospitals contend with the issue of how readmission is currently defined by payers.

The major limitation to our study was the inability to assess for complications, which undoubtedly were associated with LOS and readmissions. Secondly, because the PHC4 is limited to the state of Pennsylvania, we were unable to control for readmissions to neighboring states. We suspect that the overall rate of out of state readmissions is low; however, it may be higher among hospitals located around the state border. Third, only readmissions within 30 days were captured; thus, delayed readmissions were not included in our analysis. Lastly, since our data were derived from an administrative database, we were limited by the variables included and subject to potential coding errors in the database.

Our study, like many others, identifies a number of factors that predispose gastric bypass patients to postoperative readmission. Having such data can help programs plan in advance to initiate measures that may decrease the likelihood of this happening. Simply informing patients, for example, that their history of RA places them in a higher-risk group is a first step. Such patients might then arrange for more help at home during the postoperative period. We also identified the more common causes for readmission in our cohort, and awareness of these causes will give programs a point of focus for planning care pathways and discharge protocols.

Conflict of Interest The authors declare that they have no competing interests.

Ethics Approval and Consent to Participate For this type of retrospective study, ethical or review board approval and informed formal consent are not required.

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