Postoperative Care Fragmentation Is Associated with Increased 30-Day Mortality after Bariatric Surgery

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Abstract

Background Compromised access following bariatric centers-or-excellence designations may have led to increased incidence of non-index readmissions and worsened care fragmentation. We seek to evaluate risk factors and impact of non-index readmissions on short-term mortality during readmission using a national bariatric registry data from 2015.

Methods A retrospective cohort study was performed using a national clinical database. Multivariate logistic regression models were developed to quantify association between non-index readmissions and 30-day mortality among bariatric patients with 30-day readmissions.

Results A total of 4704 patients were identified as undergoing bariatric surgery and readmitted within 30 days. Of these, 325 (6.9%) patients were readmitted to a non-index facility while the rest were hospitalized at the original hospital. Patient characteristics were largely similar between the two comparison groups, although patients with in-hospital complications and non-home disposition during the initial stay were more likely to experience non-index readmissions. Multivariate regression demonstrated that non-index readmission was associated with an adjusted odds ratio of 4.4 for 30-day mortality (95% confidence interval 2.6–9.2, $p < 0.01$). The most common reason for mortality for both index and non-index readmissions was pulmonary embolism.

Conclusions Care fragmentation may lead to increased 30-day mortality during readmissions following bariatric surgery. Heightened vigilance and longitudinal follow-up planning is recommended for patients with elevated risk for venous thromboembolism.

Keywords Bariatric surgery · Care fragmentation · Pulmonary embolism · Access disparity

Introduction

With demonstration of the volume-outcome relationship for bariatric procedures, there has been a prevalent trend towards bariatric centers-of-excellence designation. One primary concern for this regionalization model is the increased potential for

care fragmentation following discharge after surgery [1]. Patients who traveled a long distance to receive surgery may not be able to reach the original hospital when urgent complications occurred [2, 3]. Given that most hospitals do not yet share electronic medical records with each other [4], physicians managing patients who received surgery at a separate hospital were frequently not apprised of events that have transpired during the initial hospitalization. Furthermore, community physicians who are not familiar with the unique anatomy and anticipated postoperative course following bariatric surgery may find it challenging to manage this patient population [5].

While modern bariatric procedures have proven its enduring weight loss efficacy [6–8], concerns regarding its safety profile remain one of the main reasons for its poor perception among patients and referral physicians [9–11]. Acceptable 30-day mortality rates have been quoted to be as low as 0.1 to 0.3% [12–14], and studies have shown that most bariatric-related mortality occurred among patients who experienced 30-day readmissions [15, 16]. Recent literature from other surgical disciplines have demonstrated that readmission to a

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hospital different from the original hospital where surgery was performed, i.e., non-index readmissions (NRs), was associated with significantly higher readmission mortality due to care fragmentation [2, 17, 18]. Whether this association holds true in an elective procedure like bariatric surgery remains unclear.

In the current study, we seek to assess the incidence and characterize risk factors for NR after bariatric surgery. Furthermore, we hypothesize that NR following bariatric surgery is associated with increased short-term mortality.

Methods

Study Design This was a retrospective, cross-sectional review of adult patients (above 18 years old) who underwent elective bariatric surgery and experienced 30-day readmission in 2015. Patients were identified from a clinical database maintained by the Metabolic and Bariatric Surgery Accreditation And Quality Improvement Program (MBSAQIP). Current Procedural Terminology (CPT) codes used for identifying bariatric procedures included 43775 (sleeve gastrectomy), 43644, 43645 (laparoscopic Roux-en-Y gastric bypass), 43846, 43847 (open Roux-en-Y gastric bypass), and 43770 (gastric banding). Exclusion criteria included mortality during initial hospitalization and planned or irrelevant readmission.

Data Source The 2015 MBSAQIP Participant Use Data File (PUF) is the largest bariatric-specific clinical database in the USA, with over 10,000 bariatric surgery cases being assessed across the nation each year. The cases were voluntarily submitted to the MBSAQIP Data Registry by participating bariatric surgery centers. Centers with less than 80% 30-day follow-up rate or above 5% data integrity audit disagreement rate were prohibited from contributing data. The MBSAQIP PUF contains patient-level data without identifying hospitals, health care providers, or patients. It has over 200 variables with regard to preoperative risk factors, intraoperative variables, and 30-day postoperative outcomes.

The main MBSAQIP data file containing information with regard to preoperative patient characteristics, perioperative events, and procedure characteristics was merged with three secondary MBSAQIP data files containing information regarding readmission, reoperation, and intervention using patient-specific ID. If more than one readmission episode were identified for the same patient, information from only the first readmission was retained.

Exposure and Outcome Variables The primary exposure variable was NR, which was defined as any 30-day readmission that occurred at a hospital different from the original hospital where bariatric surgery was performed. On the other hand, patients readmitted back to the original hospital was classified as undergoing index readmission (IR). Primary outcome of

interest was 30-day mortality, defined as death due to any cause within 30 days of the initial surgery. Secondary outcome of interest was readmission length of stay.

Statistical Analysis Descriptive analysis was performed for each comparison group, respectively. Reasons for mortality were substituted with reasons for readmission when the prior were missing or documented as “other.” Subsequently, *t* tests were used for comparison of normally distributed continuous variables while Wilcoxon rank-sum test was used to compare non-normally distributed continuous variables. Chi-square test was used for comparison of categorical variables. All tests were two-sided, with the significance level set at $\alpha = 0.05$. In order to adjust for baseline differences between comparison groups, multivariable analyses were conducted using logistic regression modeling to assess the association between NR and 30-day mortality. Model fit was assessed using Hosmer-Lemeshow test [19]. A *p* value of greater than 0.05 was interpreted as the observed outcome matching the predicted outcome in subgroups of the model population; therefore, the model was deemed well calibrated. Statistical analyses were carried out using Stata MP, version 13 (Stata Corp).

Results

A total of 168,093 patients were documented as undergoing bariatric surgery in the 2015 MBSAQIP database, among whom 4704 were subsequently readmitted within 30 days of discharge. Demographics and baseline characteristics are tabulated in Table 1. Approximately 82.2% of these were females and 70.6% were white. Of these, 325 (6.9%) patients were readmitted to a hospital other than the one where their initial bariatric surgery was performed and categorized as undergoing NR. There were a slightly greater proportion of sleeve gastrectomy (63.1 vs 50.6%, $p < 0.01$), male patients (22.5 vs 17.5%, $p = 0.02$), American Society of Anesthesiologists (ASA) class above 3 (79.0 vs 77.9%, $p < 0.01$) among the NR group; otherwise, patient characteristics were largely similar between the two comparison groups, including age ($p = 0.19$), body mass index ($p = 0.85$), and race ($p = 0.81$). In addition, baseline functional health status and comorbidities were also similar between the two comparison groups.

A higher proportion of patients who subsequently underwent NR had experienced complications during the initial surgery than patients who had IR (24.0 vs 19.1%, $p = 0.03$), with pulmonary embolism (4 vs 2.1%, $p = 0.02$) and venous thromboembolism requiring anticoagulation (5.2 vs 11.1%, $p < 0.01$) being the most disparate. There is otherwise no significant difference in most other examined postoperative complications or length of stay. There is significantly less routine home discharge (94.5 vs 98.8%) and more discharge to a separate acute care facility (4.0 vs 0.1%, $p < 0.01$) among NR patients.

Table 1 Characteristics during initial hospitalization and 30-day readmission (reported in *n*(%) unless noted otherwise)

	Index readmission <i>n</i> = 4379 (93.1%)	Non-index readmission <i>n</i> = 325 (6.9%)	<i>P</i> value
Operations			
Sleeve gastrectomy	2215 (50.6%)	205 (63.1%)	< .01
Laparoscopic Roux-en-Y gastric bypass	2038 (46.5%)	114 (35.1%)	
Open Roux-en-Y gastric bypass	62 (1.4%)	4 (1.2%)	
Gastric banding	64 (1.5%)	2 (0.6%)	
Patient characteristics			
Mean age ± standard deviation (years)	44.1 ± 10.9	45.6 ± 11.9	0.19
Female gender	3614 (82.5%)	252 (77.5%)	0.02
Median body mass index ± interquartile range (kg/m ²)	44.1 ± 10.9	43.8 ± 9.9	0.85
Race			
White	3088 (70.5%)	231 (71.1%)	0.81
Black or African American	971 (22.2%)	73 (22.5%)	
Asian	19 (0.4%)	1 (0.3%)	
Others	301 (6.9%)	20 (6.2%)	
American Society of Anesthesiologists (ASA) Class			
Class I—no disturbance	25 (0.6%)	2 (0.6%)	< 0.01
Class II—mild disturbance	940 (21.5%)	66 (20.4%)	
Class III or above	3398 (77.9%)	256 (79.0%)	
Functional health status			
Independent	4306 (98.3%)	319 (98.2%)	0.11
Partially dependent	43 (1.0%)	6 (2.0%)	
Totally dependent	30 (0.7%)	0 (0.0%)	
Limited ambulation	138 (3.2%)	12 (3.7%)	0.59
Hypertension	2315 (52.9%)	171 (52.6%)	0.93
Diabetes	1314 (30.0%)	91 (28.0%)	0.21
Dyslipidemia	1172 (26.8%)	88 (27.1%)	0.90
Active smoker	437 (10.0%)	26 (8.0%)	0.25
chronic obstructive pulmonary disease	132 (3.0%)	7 (2.2%)	0.38
Oxygen dependence	61 (1.4%)	5 (1.5%)	0.83
Dialysis	24 (0.5%)	2 (0.6%)	0.69
History of deep venous thrombosis	149 (3.4%)	7 (2.2%)	0.23
History of pulmonary embolism	116 (2.7%)	9 (2.8%)	0.90
Therapeutic anticoagulation	194 (4.4%)	11 (3.4%)	0.37
Presence of inferior vena cava filter	92 (2.1%)	5 (1.5%)	0.49
Previous foregut/bariatric surgery	452 (10.3%)	34 (10.5%)	0.94
Initial hospitalization characteristics			
Surgical approach conversion	45 (1.0%)	3 (1.0%)	0.86
Length of stay (median ± Interquartile range), days	2 ± 2	2 ± 1	< 0.01
Any complications	838 (19.1%)	78 (24.0%)	0.03
Acute renal failure	45 (1.0%)	4 (1.2%)	0.73
Superficial incisional site infection	116 (2.7%)	6 (1.9%)	0.67
Deep incisional site infection	47 (1.1%)	1 (0.3%)	0.19
Organ space infection	265 (6.0%)	14 (4.3%)	0.40
Unplanned intubation	43 (1.0%)	6 (1.9%)	0.14
Ventilator use > 48 h	43 (1.0%)	1 (0.3%)	0.47
Myocardial infarction	14 (0.3%)	2 (0.6%)	0.38
Pneumonia	96 (2.2%)	10 (3.1%)	0.30
Sepsis	110 (2.5%)	5 (1.5%)	0.54

Table 1 (continued)

	Index readmission <i>n</i> = 4379 (93.1%)	Non-index readmission <i>n</i> = 325 (6.9%)	<i>P</i> value
Pulmonary embolism	91 (2.1%)	13 (4.0%)	0.02
Venous thromboembolism requiring anticoagulation	130 (3.0%)	13 (4.0%)	0.30
Urinary tract infection	70 (1.6%)	9 (2.8%)	0.23
Transfusion needed	140 (3.2%)	9 (2.8%)	0.67
Unplanned intensive care unit admission	297 (6.8%)	20 (6.2%)	0.66
Wound disruption	14 (0.3%)	3 (0.9%)	0.08
Anticoagulation initiated	227 (5.2%)	36 (11.1%)	< 0.01
Discharge destination			
Home	4326 (98.8%)	307 (94.5%)	< 0.01
Skilled care	21 (0.5%)	3 (0.9%)	
Rehab	11 (0.3%)	1 (0.3%)	
Separate acute care	5 (0.1%)	13 (4.0%)	
Readmission outcomes			
Readmission information source			
Medical record	4340 (99.3%)	241 (74.2%)	< 0.01
Patient/family report	13 (0.3%)	56 (17.2%)	
Others	20 (0.5%)	28 (8.6%)	
Reoperation performed	939 (21.4%)	64 (19.7%)	0.46
Readmission day from discharge (median ± interquartile range), days	8 ± 12	9 ± 15	0.28
Readmission length of stay (median ± interquartile range), days	3 ± 3	3 ± 2	0.51
Mortality	27 (0.6%)	10 (3.1%)	< 0.01
Mean time from operation to mortality ± standard deviation (days)	14.8 ± 7.5	14.3 ± 6.8	0.85

The majority of readmission encounter information was derived from medical records (99.3%) for patients readmitted to the index facility, while up to 17.2% was derived from patient/family report for patients readmitted to a non-index facility. Readmission occurred at similar interval from the time of discharge between IR and NR ($p = 0.28$). Documented reasons for readmission are tabulated in Table 2. Furthermore, similar proportion of patients (21.4 vs 19.7%, $p = 0.46$) received reoperation during their readmission.

Without adjustment, significantly higher mortality was observed in the NR group (3.1 vs 0.6%, $p < 0.01$). Reasons for mortality are tabulated in Table 3, with venous thromboembolism-related complications being the most common reason for both IR and NR. Previously established risk factors for pulmonary embolism, such as history of pulmonary embolism (2.7 vs 2.8%, $p = 0.90$), venous stasis (1.2 vs 0.6%, $p = 0.33$), sleep apnea (39.2 vs 44.3%, $p = 0.07$), and BMI above 60 kg/m² (8.3 vs 6.2%, $p = 0.17$) have not been found to be significantly different between the IR and NR group. Variables found to be significantly different between the comparison groups from the

Table 2 Reasons for readmission, *n* (%)

Index readmission (<i>n</i> = 4379)		Non-index readmission (<i>n</i> = 325)	
1. Nausea and vomiting, fluid, electrolyte imbalance	1592 (36.4%)	1. Nausea and vomiting, fluid, electrolyte imbalance	93 (28.6%)
2. Abdominal pain, not otherwise specified	631 (14.4%)	2. Other	43 (13.2%)
3. Other	455 (10.4%)	3. Abdominal pain, not otherwise specified	34 (10.5%)
4. Anastomotic/staple line leak	265 (6.1%)	4. Pulmonary embolism	24 (7.4%)
5. Bleeding	210 (4.8%)	5. Venous thrombosis requiring therapy	23 (7.1%)
6. Intestinal obstruction	209 (4.8%)	6. Anastomotic/staple line leak	21 (6.5%)
7. Venous thrombosis requiring therapy	165 (3.8%)	7. Bleeding	18 (5.5%)
8. Infection/fever	137 (3.1%)	8. Pneumonia	14 (4.3%)
9. Wound infection/evisceration	127 (2.9%)	9. Intestinal obstruction	13 (4.0%)
10. Stricture/stomal obstruction	117 (2.7%)	10. Wound infection/evisceration	9 (2.8%)

univariate analyses tabulated in Table 1 (operation type, gender, ASA class, anticoagulation initiation, and pulmonary embolism) were used to construct a multivariate logistic regression model in order to adjust for differences in mortality risk between the two groups. After adjustment, NR was still found to be associated with an adjusted odds ratio [OR] of 4.4 (95% confidence interval [CI] 2.6–9.2, $p < 0.01$) while pulmonary embolism during initial hospitalization was associated with an adjusted OR of 5.4 (95% CI 2.4–11.3, $p < 0.01$). Male gender (OR 0.94, 95% CI 0.42–2.12, $p = 0.89$), ASA class above III (OR 0.58, 95% CI 0.19–1.80, $p = 0.31$), having been initiated on anticoagulation (OR 0.38, 95% CI 0.39–3.48, $p = 0.78$) and discharge to a separate acute care facility (OR 0.89, 95% CI 0.45–1.79, $p = 0.61$) were not significantly associated with increased odds of 30-day mortality. As a sensitivity analysis, additional variables representing known risk factors for pulmonary embolism, such as sleep apnea, venous stasis, BMI above 60 kg/m², and history of pulmonary embolism were added to the model as additional confounding factors. The second model demonstrated a similar association between NR and 30-day mortality, with an adjusted odds ratio of 4.90 (95% CI 2.22–10.84, $p < 0.01$). A subgroup analysis was carried out whereby patients who were readmitted for or died from pulmonary embolism were excluded. The association between NR and 30-day mortality has

persisted but the strength of the association has diminished (odds ratio 3.67, 95% CI 1.32–10.22, $p = 0.01$).

Discussion

In our study of a national bariatric database, we have found a much lower proportion (6.9%) of readmitted patients being hospitalized at non-index facilities than previously reported figures for other procedure types. There was no significant difference in most baseline characteristic between patients undergoing IR and NR. However, NR was found to be associated with a 30-day mortality odds ratio of 4.4 after adjusting for other factors. Furthermore, most common reasons for mortality, for both IR and NR patients, were related to venous thromboembolism. Postoperative follow-up is emphasized as one of the key aspects to achieving excellent outcomes after bariatric surgery. However, this discussion is frequently limited to outpatient long-term follow-up for optimizing weight loss rather than readmissions when short-term postoperative complications occurred. Our study has provided an extension to the current narrative on the importance of continuity of care after bariatric surgery.

Table 3 Reasons for death within 30 days of operation, *n* (%)

Index readmission (<i>n</i> = 27)		Non-index readmission (<i>n</i> = 10)	
1. Pulmonary embolism	5 (18.5%)	1. Pulmonary embolism	5 (50.0%)
2. Venous thrombosis requiring therapy	5 (18.5%)	2. GI perforation	2 (30.0%)
3. Unspecified	5 (18.5%)	3. Intestinal obstruction	1 (10.0%)
4. Other respiratory failure	3 (11.1%)	4. Anastomotic/staple line leak	1 (10.0%)
5. Anastomotic/staple line leak	3 (11.1%)	5. Other	1 (10.0%)
6. Other abdominal sepsis	2 (7.4%)		
7. Intestinal obstruction	2 (7.4%)		
8. GI perforation	1 (3.7%)		
9. Infection, not specified	1 (3.7%)		

Overall, the incidence of NR appeared to be much lower among bariatric surgery patients than those reported for other surgical disciplines [1, 20, 21], likely as a result of improved preoperative education regarding the importance of continuity-of-care among bariatric patients. Previous literature has reported non-index rates ranging from 10 to 47% among readmitted patients receiving a variety of emergency general surgery procedures, and most studies demonstrated a significant association between short-term mortality and NR [2, 22, 23]. With advances in postoperative care and the use of minimally invasive approach, incidences of short-term complications and 30-day mortality after bariatric surgery were also substantially lower than most other surgical procedures [24]. Despite this, we have observed higher 30-day mortality among NR than IR patients, which raised the question of whether the observed association represented a residual confounding effect or a manifestation of care fragmentation.

Previous literature cited geographic access and work- and family-related problems as the most common reasons [25] for non-adherence to outpatient follow-up after bariatric surgery. Besides slight incongruities in gender and ASA class distribution, we have observed very little differences in mortality risk factors between IR and NR patients. This may either indicate that patients undergoing IR and NR are truly similar in baseline risk profile or perhaps the socioeconomic risk factors for non-adherence, such as earnings, residential area, and insurance coverage, were simply not accounted for in the current MBSAQIP database, limiting our capability to fully account for baseline differences between the two comparison groups during our regression analyses.

For both IR and NR, the most common reasons of death are related to venous thromboembolisms. Pulmonary embolism has been and remains the leading cause of death following bariatric surgery since the initial report by International Bariatric Surgery Registry in 1986 [26]. According to this report, risk factors for pulmonary embolism include a BMI of 60 kg/m² or higher, chronic lower extremity edema, obstructive sleep apnea, and previous pulmonary embolism [27]. Success of pulmonary embolism may be more dependent on the availability of an experienced disciplinary team, including thoracic surgeons, hematologists, and interventional radiologists [28], than the bariatric surgeon who is familiar with the upper gastrointestinal tract anatomy. Due to the lack of hospital-level variable in MBSAQIP, it is difficult to discern whether the observed survival benefit among IR stems from the bariatric center's multidisciplinary back-up capacity to manage pulmonary embolism or truly related to some advantages associated with preserved continuity of care. However, our sensitivity analyses excluding patients who had pulmonary embolism showed that the association between NR and elevated 30-day mortality has diminished but persisted, suggesting that some degree of care fragmentation may still be present.

Several factors must be taken into consideration when evaluating the data presented in the current study. The most considerable concern pertains to the retrospective nature of the MBSAQIP database, making it impossible to infer causal relationship from the observed association between NR and worsened outcome. It is unclear if bariatric patients suffered subpar care due to care fragmentation during NR or if higher acuity patients were brought to non-index facilities due to the urgency of their conditions and therefore experienced worse outcomes. Furthermore, a high proportion of missing data exists for reason of death among the readmitted patients. Due to the lack of medical information sharing between hospitals, data sources of NR frequently derived from telephone follow-up of patients and family and may be less reliable than chart extraction by trained clinical personnel, as performed for the majority of patients undergoing IR. This may have led to differential categorization bias between the two comparison groups. In other words, the reported readmission rates for NR patients in the current study may be underestimated in comparison with those reported for IR patients. Furthermore, the MBSAQIP data was submitted by voluntarily participating centers only, causing concern for the lack of generalizability to other centers. Finally, the low incidence of mortality following bariatric surgery may have compromised the statistical power in some of our univariate analyses and predisposed the results to type II error. Adverse outcomes such as mortality and reasons for mortality may be less reliable for admissions to non-MBSAQIP-participating facilities than MBSAQIP-participating facilities, leading to additional risk of bias between the two comparison groups during analysis.

In summary, we found that NR incidence in bariatric surgery may be substantially lower than previously reported figures among other surgical procedures. Patients readmitted to hospitals other than the one where initial bariatric surgery was performed may have experienced higher 30-day mortality, with pulmonary embolism being the most common reason for mortality. Future efforts at enhancing information continuity via medical record sharing could be a viable solution to mitigate the adverse consequences of care fragmentation among the bariatric population.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest.

Ethical Statement This article does not contain any studies with human participants or animals performed by any of the authors.

Consent Statement The study was deemed exempt from institutional review board approval based on the use of de-identified records.

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