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ORIGINAL CONTRIBUTIONS

Attending Specialization and 30-Day Outcomes Following Laparoscopic Bariatric Surgery: an Analysis of the ACS-MBSAQIP Database

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Abstract

Background Surgeon and hospital volume are factors that have been shown to impact outcomes following bariatric surgery. Nevertheless, there is a paucity of literature investigating surgeon training on bariatric surgery outcomes. The purpose of our study was to determine if bariatric specialty training leads to improved short-term outcomes following laparoscopic bariatric surgery using the American College of Surgeons Metabolic and Bariatric Surgery Accreditation Quality Improvement Program (ACS-MBSAQIP) database.

Methods All patients undergoing first-time, elective, laparoscopic bariatric surgery from 2015 to 2016 were identified within the ACS-MBSAQIP database. Patients were divided into two groups based on the type of bariatric procedure performed and the surgeon performing the procedure. Thirty-day outcomes were compared between the groups using multivariable logistic regression analysis.

Results A total of 140,340 patients met inclusion criteria. Higher risk patients with more associated comorbidities underwent bariatric surgery by a metabolic and bariatric surgeon. After controlling for these differences, patients who underwent Roux-en-Y gastric bypass (RYGB) had similar 30-day irrespective of the surgeon performing the procedure while patients who underwent sleeve gastrectomy (SG) by a metabolic and bariatric surgeon (MBS) had improved 30-day outcomes.

Conclusion Surgeon type is associated with 30-day morbidity and mortality outcomes for SG but not for RYGB. These differences in 30-day morbidity and mortality outcomes may be facilitated by institutional factors, surgeon experience, and participation in bariatric surgery accredited centers. Standardization of the perioperative process for both surgeons and institutions may improve 30-day morbidity and mortality outcomes for all patients who undergo laparoscopic bariatric surgery.

Keywords Bariatric surgery · Accredited centers · Gastric bypass · Morbidity · Mortality · Sleeve gastrectomy · Surgeon subspecialty · Surgeon training

Introduction

Obesity is endemic in the USA. Currently, the only effective and durable treatment for obesity is bariatric surgery [1–4]. In 2017, 39.8% of Americans were obese and an estimated 228,000 bariatric procedures were performed in the USA [5–7]. In response to the initial higher risk of perioperative morbidity and mortality following bariatric surgery, strategies were proposed to improve the safety of these procedures [7].

One such strategy for improving the safety of bariatric surgery was the development of criteria for bariatric surgery accredited centers [7]. The criteria for bariatric accredited centers include facility-related factors, such as appropriate surgical and hospital equipment, as well as a multidisciplinary team that helps bariatric patients navigate through the perioperative bariatric surgery process [8]. While it was assumed that such facility-related factors may lead to improved patient outcomes following bariatric surgery, no requirement was made for formal surgeon subspecialty training despite endorsement from the American College of Surgeons and the American Society

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for Metabolic and Bariatric Surgery for such subspecialty training. Currently, there is a paucity of data investigating the association of surgeon subspecialty training on bariatric surgery outcomes. Therefore, the purpose of our study was to determine if bariatric surgery specialty training leads to improved short-term outcomes following laparoscopic bariatric surgery using the American College of Surgeons Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (ACS-MBSAQIP) database.

Methods

Following Internal Review Board Exemption, all adult (≥ 18 years of age) patients undergoing first-time, elective, laparoscopic Roux-en-Y gastric bypass (RYGB) or laparoscopic sleeve gastrectomy (SG) in 2015 and 2016 were identified within the ACS-MBSAQIP database using Current Procedural Terminology (CPT) codes. The ACS-MBSAQIP database is a joint database sponsored by the American College of Surgeons and the American Society for Metabolic and Bariatric Surgery that tracks 30-day outcomes following bariatric surgery at designated bariatric surgery accredited centers in the USA [7–9]. Specifically, patients undergoing RYGB were identified by the CPT code 43644 and patients undergoing SG were identified by the CPT code 43775. Patients undergoing emergency surgery, open RYGB, open SG, revisional bariatric surgery, pediatric (< 18 years of age) cases, and those patients without 30-day follow-up data available were excluded from our analysis.

Preoperative patient variables, intraoperative variables, and 30-day morbidity and mortality outcomes, as available within the ACS-MBSAQIP database, were compared between those patients who underwent bariatric surgery by a general surgeon (GS) and those patients who underwent bariatric surgery by a metabolic and bariatric surgeon (MBS). The specialty of the surgeon performing the bariatric surgery can be determined within the ACS-MBSAQIP database by the variable "SURGSPECIALTY_BAR," which includes options for GS, MBS, gastroenterologist, interventional radiologist, and other medical subspecialty [9]. Patients with missing surgeon specialty information or those identified as having their index bariatric procedure performed by a gastroenterologist, interventional radiologist, or other medical professional were excluded from this analysis.

To determine if differences existed in 30-day morbidity and mortality outcomes for patients undergoing laparoscopic bariatric surgery, we performed two different analyses. Because we know that there are inherent 30-day morbidity and mortality differences between the RYGB and the SG procedures, we divided patients by the type of bariatric procedure performed [10]. For each analysis, two-tailed between groups *t* test, nonparametric Kruskal-Wallis test, chi-square analysis, and Fisher's exact tests were used to compare preoperative patient variables and intraoperative variables between those patients who underwent SG or RYGB by a GS and those patients who underwent SG or RYGB by a MBS. In order to determine if surgeon specialty type was associated with the 30-day morbidity and mortality outcomes, multivariable logistic regression analysis was performed. All relevant covariates that had a univariable $p < 0.20$ association with surgeon specialty type for each of the three analyses were controlled for using a backwards-elimination approach. The resulting adjusted odds ratios, 95% confidence intervals, and *p* values for the 30-day morbidity and mortality outcomes that were statistically different between surgeon specialty type are presented below. All statistical analysis was performed using SAS (Cary, NC) version 9.3 and $p < 0.05$ was considered statistically significant.

Results

A total of 140,340 patients met inclusion criteria; 4598 (3.3%) patients underwent bariatric surgery by a GS while 135,472 (96.7%) underwent bariatric surgery by a MBS. With respect to those patients who underwent bariatric surgery by a GS, 3049 (66.3%) underwent SG while 1549 (33.7%) underwent RYGB. With respect to those patients who underwent bariatric surgery by a MBS, 99,435 (73.4%) underwent SG while 36,037 (26.6%) underwent RYGB.

Table 1 details the patient demographics of those patients who underwent sleeve gastrectomy. Among SG patients, there were several statistically significant differences in the patient demographic variables between those patients who underwent SG by a MBS and those patients who underwent SG by a GS. Table 2 details the surgical and intraoperative variables for those patients who underwent SG. Metabolic and bariatric surgeons and GSs varied significantly on all measurable surgical and intraoperative variables. Tables 3 and 4 detail the differences in 30-day morbidity and mortality outcomes between those patients who underwent SG by a MBS and those patients who underwent SG by a GS. Table 3 details the differences in 30-day morbidity and mortality outcomes following univariable analysis. Table 4 details the differences in 30-day morbidity and mortality outcomes for those patients who underwent SG following multivariable logistic regression analysis. Following multivariable logistic regression analysis, patients who underwent SG by a MBS were less likely to experience bleeding requiring a blood transfusion (OR 0.60, CI 0.39–0.92, $p = 0.02$) or to develop a urinary tract infection (OR 0.52, CI 0.32–0.87, $p = 0.01$) and they were less likely to have a length of stay greater than 2 days (OR 0.79, CI 0.70–0.89, $p < 0.01$).

Table 5 details the patient demographics of those patients who underwent RYGB. There were several statistically significant differences in the patient demographic variables between those patients who underwent RYGB by a MBS and those

Table 1 Sleeve gastrectomy patient demographic variables, stratified by surgeon specialty type

Variable	General surgeon $N = 3049$	Metabolic and bariatric surgeon $N = 99{,}453$	*p* value
Age (mean, SD)	44.9 ± 12.7	44.5 ± 12.0	0.14
Female gender (*N*, %)	2418 (79.3%)	78,763 (79.2%)	0.90
Race (*N*, %)			
Caucasian	2429 (79.7%)	72,095 (72.5%)	< 0.0001
African-American	409 (13.4%)	18,800 (18.9%)	
Other	211 (6.9%)	8558 (8.6%)	
BMI, kg/m^2 (mean, SD)	44.9 ± 7.7	45.0 ± 7.6	0.19
Non-independent functional status (*N*, %)	32 (1.1%)	1023 (1.0%)	0.91
ASA class (*N*, %)			
1	7 (0.2%)	293 (0.3%)	< 0.0001
2	937 (30.7%)	24,378 (24.5%)	
3	2042 (67.0%)	70,756 (71.2%)	
4	59 (1.9%)	3152 (3.2%)	
Unknown	4 (0.2%)	856 (0.8%)	
Current smoker (*N*, %)	310 (10.2%)	8563 (8.6%)	0.003
Chronic steroid use (*N*, %)	66 (2.2%)	1764 (1.8%)	0.11
Preoperative albumin level, g/dL (mean, SD)	4.0 ± 0.4	4.1 ± 0.3	< 0.0001
OSA (*N*, %)	1040 (34.1%)	36,273 (36.5%)	0.01
HTN (*N*, %)	1383 (45.4%)	46,601 (46.9%)	0.10
HLD (*N*, %)	672 (22.0%)	22,417 (22.5%)	0.51
Previous MI (*N*, %)	36 (1.2%)	1221 (1.2%)	0.82
Previous PCI (*N*, %)	56 (1.8%)	2056 (2.1%)	0.38
COPD (*N*, %)	54 (1.8%)	1693 (1.7%)	0.77
GERD (*N*, %)	924 (30.3%)	28,440 (28.6%)	0.04
ESRD requiring dialysis (*N*, %)	11 (0.4%)	339 (0.3%)	0.85
DM (*N*, %)	716 (23.5%)	23,060 (23.2%)	0.71
History of PE (*N*, %)	32 (1.1%)	1113 (1.1%)	0.72
History of DVT (*N*, %)	41 (1.3%)	1487 (1.5%)	0.50
Venous stasis (*N*, %)	25 (0.8%)	974 (1.0%)	0.38

N, number; *SD*, standard deviation; *BMI*, body mass index, *ASA*, American Society of Anesthesiologists; *OSA*, obstructive sleep apnea; *HTN*, hypertension; *HLD*, hyperlipidemia; *MI*, myocardial infarction; *PCI*, percutaneous coronary artery intervention; *COPD*, chronic obstructive pulmonary disease; *GERD*, gastroesophageal reflux disease; *ESRD*, end-stage renal disease; *DM*, diabetes mellitus; *PE*, pulmonary embolism; *DVT*, deep venous thrombosis

patients who underwent RYGB by a GS. Table 6 details the surgical and intraoperative variables for those patients who underwent RYGB. Again, MBSs and GSs varied significantly on all measurable surgical and intraoperative variables. Metabolic and bariatric surgeons were less likely to test their anastomoses ($p < 0.0001$) and they had a longer average operating room time ($p < 0.0001$). Tables 7 and 8 detail the differences in 30-day morbidity and mortality outcomes between those patients who underwent RYGB by a MBS and those patients who underwent RYGB by a GS. Table 7 details the differences in 30-day morbidity and mortality outcomes following univariable analysis while Table 8 details the differences in 30-day morbidity and mortality outcomes for those patients who underwent RYGB following multivariable logistic regression analysis. Following multivariable logistic regression analysis, patients who underwent RYGB by a MBS were more likely to develop a superficial surgical site infection (OR 2.19, CI 1.02–4.70, $p = 0.04$) and to have a length of stay greater than 2 days postoperatively (OR 1.43, CI 1.21–1.68, $p < 0.01$).

Discussion

Bariatric surgery has an inherently higher risk of perioperative morbidity and mortality compared with other general surgery procedures due to both patient and technical factors [11, 12]. Prior to the establishment of bariatric surgery accredited

Table 2 Sleeve gastrectomy intraoperative variables, stratified by surgeon specialty type

Variable	General surgeon $N = 3049$	Metabolic and bariatric surgeon $N = 99,453$	*p* value
Staple line tested (*N*, %)			
Yes	1764 (57.9%)	73,033 (73.5%)	< 0.0001
No	1285 (42.1%)	26,420 (26.5%)	
Staple line reinforced (*N*, %)			
Yes	1874 (61.5%)	67,913 (68.3%)	< 0.0001
No	1175 (38.5%)	31,522 (31.7%)	
Distance from pylorus sleeve started, cm (mean, SD)	5.3 ± 2.1	4.9 ± 1.9	< 0.0001
Bougie size used, Fr (mean, SD)	37.5 ± 2.5	37.0 ± 2.9	< 0.0001
Operative time, min (mean, SD)	75.5 ± 35.6	72.9 ± 37.2	0.0002

N, number; *cm*, centimeter; *SD*, standard deviation; *Fr*, French; *min*, minutes

centers, 30-day mortality following bariatric surgery was estimated to be as high as 9% [7]. In response to this prohibitively high rate of perioperative mortality, the American College of Surgeons and the American Society for Metabolic and Bariatric Surgeons established criteria for bariatric surgery accredited centers [7]. One of the tenants of hospital bariatric surgery accreditation is continuous quality improvement through data input into the ACS-MBSAQIP database as well as uniform data definitions to help facilitate aggregate data integrity [7–9, 13]. Using the ACS-MBSAQIP database, we found significant differences in patient selection and operative variables, with somewhat better 30-day morbidity and mortality outcomes for patients undergoing SG by MBSs and similar 30-day morbidity and mortality outcomes for patients undergoing RYGB irrespective of surgeon type. Specifically, MBSs performed a majority (96.7%) of both SGs and RYGBs. In general, patients who underwent RYGB were higher risk patients with more associated medical comorbidities. These

Table 3 Sleeve gastrectomy 30-day morbidity and mortality outcomes, stratified by surgeon specialty type

Outcome	General surgeon $N = 3049$	Metabolic and bariatric surgeon $N = 99,453$	*p* value
Superficial SSI (*N*, %)	10 (0.33%)	230 (0.23%)	0.28
Deep SSI (*N*, %)	2 (0.07%)	24 (0.02%)	0.18
Organ space SSI (*N*, %)	7 (0.23%)	143 (0.14%)	0.22
Wound dehiscence (*N*, %)	2 (0.07%)	38 (0.04%)	0.33
Myocardial infarction (*N*, %)	0	26 (0.03%)	0.99
Cardiac arrest requiring CPR (*N*, %)	0	28 (0.03%)	0.99
PNA (*N*, %)	6 (0.20%)	132 (0.13%)	0.31
Unplanned re-intubation (*N*, %)	0	108 (0.11%)	0.08
Prolonged intubation (*N*, %)	0	38 (0.04%)	0.63
Bleeding requiring blood transfusion (*N*, %)	22 (0.72%)	447 (0.45%)	0.03
Sepsis (*N*, %)	4 (0.13%)	71 (0.07%)	0.29
Septic shock (*N*, %)	0	27 (0.03%)	0.99
Urinary tract infection (*N*, %)	16 (0.52%)	282 (0.28%)	0.02
PE (*N*, %)	2 (0.07%)	88 (0.09%)	0.99
DVT (*N*, %)	1 (0.03%)	183 (0.18%)	0.05
30-day related unplanned readmission to the hospital (*N*, %)	97 (3.2%)	2263 (2.3%)	< 0.01
30-day related unplanned reintervention (*N*, %)	30 (0.98%)	752 (0.76%)	0.15
30-day related unplanned return to the OR (*N*, %)	16 (0.52%)	575 (0.58%)	0.70
30-day related mortality (*N*, %)	0	31 (0.03%)	0.99
Length of stay > 2 days (*N*, %)	302 (9.90%)	8336 (8.38%)	< 0.01
Discharge destination other than home (*N*, %)	10 (0.33%)	282 (0.28%)	0.64

N, number; *SSI*, surgical site infection; *CPR*, cardiopulmonary arrest; *PNA*, pneumonia; *PE*, pulmonary embolism; *DVT*, deep venous thrombosis; *OR*, operating room; *N/A*, unable to calculate due to low event rate

Table 4 Sleeve gastrectomy adjusted odds ratios for 30-day morbidity and mortality outcomes, metabolic and bariatric surgeon vs. general surgeon

Outcome	Adjusted odds ratio (95% CI)	*p* value
Superficial SSI (*N*, %)	0.68 (0.36–1.28)	0.23
Deep SSI (*N*, %)	0.36 (0.08–1.53)	0.17
Organ space SSI (*N*, %)	0.64 (0.30–1.38)	0.26
Wound dehiscence (*N*, %)	0.60 (0.14–2.50)	0.48
Myocardial infarction (*N*, %)	N/A	N/A
Cardiac arrest requiring CPR (*N*, %)	N/A	N/A
PNA (*N*, %)	0.68 (0.30–1.55)	0.36
Unplanned re-intubation (*N*, %)	N/A	N/A
Prolonged intubation (*N*, %)	N/A	N/A
Bleeding requiring blood transfusion (*N*, %)	0.60 (0.39–0.92)	0.02
Sepsis (*N*, %)	0.53 (0.19–1.44)	0.21
Septic shock (*N*, %)	N/A	N/A
Urinary tract infection (*N*, %)	0.52 (0.32–0.87)	0.01
PE (*N*, %)	1.02 (0.31–3.37)	0.97
DVT (*N*, %)	3.75 (0.78–17.92)	0.10
30-day related unplanned readmission to the hospital (*N*, %)	0.67 (0.54–0.82)	< 0.01
30-day related unplanned reintervention (*N*, %)	0.72 (0.50–1.03)	0.07
30-day related unplanned return to the OR (*N*, %)	1.07 (0.65–1.76)	0.79
30-day related mortality (*N*, %)	N/A	N/A
Length of stay > 2 days (*N*, %)	0.79 (0.70–0.89)	<0.01
Discharge destination other than home (*N*, %)	0.81 (0.43–1.52)	0.51

N, number; *SSI*, surgical site infection; *CPR*, cardiopulmonary arrest; *PNA*, pneumonia; *PE*, pulmonary embolism; *DVT*, deep venous thrombosis; *OR*, operating room; *N/A*, unable to calculate due to low event rate

patients, not surprisingly, experienced a greater proportion of the overall 30-day morbidity and mortality, which is consistent with them being higher risk surgical candidates [10]. Importantly, this is the first study to investigate the effect of bariatric surgery specialty training on 30-day outcomes following laparoscopic bariatric surgery. Nevertheless, it is important to note that the definition of MBS and GS as well as the number of cases performed by a specific surgeon within either of these groups requires further clarification within the ACS-MBSAQIP database.

Our study shows that patients who undergo SG by a MBS were less likely to experience bleeding requiring a blood transfusion or a urinary tract infection and that they were more likely to have a length of hospital stay greater than 2 days, while patients who underwent RYGB by a MBS were more likely to experience a superficial surgical site infection and to have a length of hospital stay greater than 2 days compared with patients who underwent RYGB by a GS. There are several explanations for these findings. First, within our study, MBSs were more likely to reinforce their SG staple lines. There is literature to support that staple line reinforcement is associated with a decreased risk for postoperative bleeding, which was also observed in our study [14–17]. With respect to the increased rate of urinary tract infections following SG by GSs, this group of surgeons may be routinely placing Foley catheters in their patients while MBSs are no longer or selectively placing Foley catheters in their patients. Unfortunately, however, information regarding the use of Foley catheters is not available within the ACS-MBSAQIP database. Therefore, any difference in the routine use of Foley catheters by either MBSs or GSs and their association with postoperative urinary tract infections in this patient population requires further investigation. Third, while high-risk patients for bariatric surgery are not well-defined within the literature, it has been our experience that male patients, patients with a body mass index ≥ 55 kg/m [2], patients with a non-independent functional status, patients with significant coronary artery disease (previous myocardial infarction or percutaneous coronary artery intervention), chronic obstructive pulmonary disease, history of pulmonary embolism, history of deep venous thrombosis, and/or venous stasis are higher risk [18, 19]. Based on these patient risk factors, patients who underwent either SG or RYGB by a MBS were higher risk patients in our study. In addition to performing the reported multivariable logistic regression analysis, we attempted to perform a subgroup analysis to look at the difference in outcomes between MBSs and GSs based on the number of higher risk patient factors. Unfortunately, as the number of higher risk patient factors increased, the proportion of patients in the GS cohort decreased, limiting the power of these results.

There are some factors that may account for the increased rate of superficial surgical site infections and longer length of

Table 5 Roux-en-Y gastric bypass patient demographic variables, stratified by surgeon specialty type

Variable	General surgeon $N = 1549$	Metabolic and bariatric surgeon $N = 36{,}307$	*p* value
Age (mean, SD)	45.8 ± 11.5	45.5 ± 11.8	0.36
Female gender (*N*, %)	1262 (81.5%)	29,126 (80.2%)	0.23
Race (*N*, %)			
Caucasian	804 (51.9%)	27,684 (76.3%)	< 0.0001
African-American	109 (7.0%)	5109 (14.1%)	
Other	636 (41.1%)	3514 (9.3%)	
BMI, kg/m^2 (mean, SD)	45.6 ± 7.5	46.1 ± 7.9	0.03
Non-independent functional status (*N*, %)	8 (0.5%)	358 (1.0%)	0.06
ASA class (*N*, %)			
1	0	76 (0.2%)	< 0.0001
2	254 (16.4%)	6128 (16.9%)	
3	1127 (72.8%)	28,562 (78.7%)	
4	166 (10.7%)	1482 (4.1%)	
Unknown	2 (0.1%)	59 (0.1%)	
Current smoker (*N*, %)	128 (8.3%)	2986 (8.2%)	0.96
Chronic steroid use (*N*, %)	25 (1.6%)	556 (1.5%)	0.80
Preoperative albumin level, g/dL (mean, SD)	4.0 ± 0.3	4.0 ± 0.3	0.06
OSA (*N*, %)	654 (42.25)	15,954 (43.9%)	0.18
HTN (*N*, %)	739 (47.7%)	19,306 (53.2%)	< 0.0001
HLD (*N*, %)	433 (28.0%)	10,693 (29.5%)	0.21
Previous MI (*N*, %)	14 (0.9%)	638 (1.8%)	0.02
Previous PCI (*N*, %)	23 (1.5%)	944 (2.6%)	0.01
COPD (*N*, %)	25 (1.6%)	715 (2.0%)	0.32
GERD (*N*, %)	558 (36.0%)	14,177 (39.1%)	0.02
ESRD requiring dialysis (*N*, %)	3 (0.2%)	59 (0.2%)	0.74
DM (*N*, %)	482 (31.1%)	12,981 (35.8%)	0.0002
History of PE (*N*, %)	15 (1.0%)	509 (1.4%)	0.15
History of DVT (*N*, %)	24 (1.6%)	726 (2.0%)	0.21
Venous stasis (*N*, %)	5 (0.3%)	491 (1.4%)	0.0005

N, number; *SD*, standard deviation; *BMI*, body mass index, *ASA*, American Society of Anesthesiologists; *OSA*, obstructive sleep apnea; *HTN*, hypertension; *HLD*, hyperlipidemia; *MI*, myocardial infarction; *PCI*, percutaneous coronary artery intervention; *COPD*, chronic obstructive pulmonary disease; *GERD*, gastroesophageal reflux disease; *ESRD*, end-stage renal disease; *DM*, diabetes mellitus; *PE*, pulmonary embolism; *DVT*, deep venous thrombosis

hospital stay seen in patients who underwent RYGB by MBSs. Previous studies have shown that there is an increased risk for postoperative wound events when a circular stapler is used to perform the gastrojejunostomy anastomosis due to the fact that the circular stapler is most often passed through the abdominal wall after removal of the left lateral trocar without the use of a wound protector device [20, 21]. It is possible that more MBSs performed their gastrojejunostomy anastomosis

Table 6 Roux-en-Y gastric bypass intraoperative variables, stratified by surgeon specialty type

Variable	General surgeon $N = 1549$	Metabolic and bariatric surgeon $N = 36{,}307$	*p* value
Anastomosis tested (*N*, %)			
Yes	1510 (97.5%)	33,557 (92.4%)	<0.0001
No	39 (2.5%)	2750 (7.6%)	
Operative time, min (mean, SD)	112.8 ± 48.9	120.4 ± 54.8	< 0.0001

N, number; *min*, minutes

Table 7 Roux-en-Y gastric bypass 30-day morbidity and mortality outcomes, stratified by surgeon specialty type

Outcome	General surgeon $N = 1549$	Metabolic and bariatric surgeon $N = 36{,}307$	*p* value
Superficial SSI (*N*, %)	7 (0.45%)	358 (0.99%)	0.03
Deep SSI (*N*, %)	2 (0.13%)	54 (0.15%)	0.99
Organ space SSI (*N*, %)	3 (0.19%)	113 (0.31%)	0.64
Wound dehiscence (*N*, %)	2 (0.13%)	38 (0.10%)	0.68
Myocardial infarction (*N*, %)	0	17 (0.05%)	0.99
Cardiac arrest requiring CPR (*N*, %)	0	15 (0.04%)	0.99
PNA (*N*, %)	7 (0.45%)	147 (0.40%)	0.78
Unplanned re-intubation (*N*, %)	2 (0.13%)	89 (0.25%)	0.59
Prolonged intubation (*N*, %)	0	51 (0.14%)	0.27
Bleeding requiring blood transfusion (*N*, %)	11 (0.71%)	396 (1.09%)	0.15
Sepsis (*N*, %)	1 (0.06%)	61 (0.17%)	0.52
Septic shock (*N*, %)	1 (0.06%)	37 (0.10%)	0.99
Urinary tract infection (*N*, %)	8 (0.52%)	200 (0.55%)	0.86
PE (*N*, %)	0	63 (0.17%)	0.19
DVT (*N*, %)	2 (0.13%)	65 (0.18%)	0.99
30-day related unplanned readmission to the hospital (*N*, %)	74 (4.78%)	1772 (4.88%)	0.85
30-day related unplanned re-intervention (*N*, %)	30 (1.94%)	837 (2.31%)	0.34
30-day related unplanned return to the OR (*N*, %)	33 (2.13%)	674 (1.86%)	0.44
30-day related mortality (*N*, %)	0	27 (0.07%)	0.63
Length of stay > 2 days (*N*, %)	184 (11.88%)	6263 (17.25%)	< 0.01
Discharge destination other than home (*N*, %)	4 (0.26%)	134 (0.37%)	0.49

N, number; *SSI*, surgical site infection; *CPR*, cardiopulmonary arrest; *PNA*, pneumonia; *PE*, pulmonary embolism; *DVT*, deep venous thrombosis; *OR*, operating room; *N/A*, unable to calculate due to low event rate

with a circular stapler compared with GSs, which may have contributed to the difference in the rate of superficial surgical site infections seen between the two groups. Nevertheless, information regarding how the RYGB anastomoses are performed is not included within the ACS-MBSAQIP and, therefore, we are unable to definitively explain the differences in the rate of superficial surgical site infections within the RYGB cohort. With respect to hospital length of stay, the median length of hospital stay for patients in both the SG and the RYGB groups was 2 days irrespective of if they underwent surgery by a MBS or a GS. Within the ACS-MBSAQIP database, length of hospital stay is measured in days and not hours and it is unclear when postoperative day number one becomes postoperative day number two [9]. While patients who underwent SG by a GS or RYGB by a MBS were more likely to have a length of hospital stay greater than 2 days, we do not know if this difference would persist if length of hospital stay was measured in hours. Given the larger number of higher risk patients in the MBS cohort, further investigation into the relationship between the number of higher risk patient factors and 30-day outcomes for both patients who underwent SG and RYGB may help elucidate the reasons for these outcome differences. Nevertheless, we conclude that patients in the RYGB cohort had similar 30-day morbidity and mortality outcomes irrespective of surgeon type because the increased incidence of superficial surgical site infections in the MBS cohort did not lead to an increase rate of 30-day unplanned readmission, reintervention, or return to the operating room. Furthermore, there was a statistically significant difference in the number of patients who were in the hospital for greater than 2 days but no overall difference in the median length of hospital stay between the MBS and GS cohorts.

Currently, almost 90% of all bariatric procedures performed in the USA are performed at bariatric surgery accredited centers [7]. While the requirements for bariatric surgery accredited centers help to address the previously high rate of 30-day morbidity and mortality following bariatric surgery, there remains room for quality improvement among surgeons performing bariatric surgery at bariatric surgery accredited centers. Specifically, in a study by Ibrahim et al., they found that there was significant variation in the rate of serious complications following bariatric surgery among bariatric surgery accredited centers nationwide, state-wide, and among hospitals performing a similar number of bariatric surgeries annually [7]. In their study, serious complications were defined as any 30-day morbidity event that led to an increased length of stay following bariatric surgery [7]. Our findings further support the conclusions drawn by Ibrahim et al. as

Table 8 Roux-en-Y gastric bypass adjusted odds ratios for 30-day morbidity and mortality outcomes, metabolic and bariatric surgeon vs. general surgeon

Outcome	Adjusted odds ratio (95% CI)	*p* value
Superficial SSI (*N*, %)	2.19 (1.02–4.70)	0.04
Deep SSI (*N*, %)	1.07 (0.25–4.56)	0.93
Organ space SSI (*N*, %)	1.23 (0.38–3.96)	0.74
Wound Dehiscence (*N*, %)	0.67 (0.15–2.95)	0.60
Myocardial infarction (*N*, %)	N/A	N/A
Cardiac arrest requiring CPR (*N*, %)	N/A	N/A
PNA (*N*, %)	0.70 (0.32–1.53)	0.37
Unplanned re-intubation (*N*, %)	1.31 (0.32–5.44)	0.71
Prolonged intubation (*N*, %)	N/A	N/A
Bleeding requiring blood transfusion (*N*, %)	1.62 (0.88–3.00)	0.12
Sepsis (*N*, %)	2.08 (0.28–15.43)	0.48
Septic shock (*N*, %)	0.91 (0.12–6.67)	0.92
Urinary tract infection (*N*, %)	0.84 (0.41–1.74)	0.63
PE (*N*, %)	N/A	N/A
DVT (*N*, %)	1.39 (0.33–5.95)	0.65
30-day related unplanned readmission to the hospital (*N*, %)	0.93 (0.73–1.19)	0.57
30-day related unplanned re-intervention (*N*, %)	0.94 (0.64–1.37)	0.74
30-day related unplanned return to the OR (*N*, %)	0.81 (0.56–1.18)	0.27
30-day related mortality (*N*, %)	N/A	N/A
Length of stay > 2 days (*N*, %)	1.43 (1.21–1.68)	< 0.01
Discharge destination other than home (*N*, %)	1.36 (0.48–3.83)	0.56

N, number; *SSI*, surgical site infection; *CPR*, cardiopulmonary arrest; *PNA*, pneumonia; *PE*, pulmonary embolism; *DVT*, deep venous thrombosis; *OR*, operating room; *N/A*, unable to calculate due to low event rate

our study demonstrates that there are statistically significant differences in patient selection, operative variables, and some of the 30-day morbidity and mortality outcomes among bariatric surgery accredited centers based on the type of bariatric surgery performed and the surgeon performing the bariatric procedure. We suspect that with additional standardization of the perioperative process among surgeons performing bariatric surgery within bariatric surgery accredited centers, including factors such as preoperative patient optimization requirements, the use of Foley catheters, the technique used for gastric sleeve and gastrojejunostomy creation, and postoperative enhanced recovery pathways, 30-day morbidity and mortality outcomes will continue to improve regardless of the surgeon performing the bariatric procedure. Furthermore, it may be worthwhile to consider the ability to be able to compare the outcomes of bariatric accredited centers based on geographic location and operative volume within the ACS-MBSAQIP. While currently we can only investigate 30-day outcomes on a nationwide scale, the comparison of 30-day outcomes based on surgeon and hospital volume as well as geographic location may provide further clarity with respect to the differences seen in terms of patient and surgery selection.

In addition to perioperative standardization within bariatric surgery accredited centers, 30-day morbidity and mortality outcomes may be further improved following evaluation of the subspecialty training requirements for the surgeons identified as members of bariatric surgery accredited centers. Currently, a general surgeon in the USA can obtain metabolic and bariatric surgery accreditation in one of two ways: (1) the successful completion of a bariatric surgery fellowship or (2) the successful completion of a structured training curriculum developed by their institution's Bariatric Surgery Medical Director and initial performance of bariatric procedures with a trained MBS [22, 23]. Bariatric surgery fellowship training and institutional-specific training curriculums for Metabolic and Bariatric Surgery accreditation, however, are highly variable [23]. This lack of standardization in the requirements for Metabolic and Bariatric Surgery accreditation creates the potential for increased variation in the skill sets of the surgeons identified as MBSs, which may have contributed to the findings in our study. This is in contrast to the smaller sub-set of GSs in our study who are likely self-selected with significant bariatric surgery experience, which may have also contributed to the similar outcomes observed in our study, at least for those patients who underwent RYGB.

In a study by Kim et al., they found that patients who underwent bariatric surgery at hospitals with a Fellowship Council-Accredited Bariatric Fellowship Program were significantly less likely to experience 30-day major morbidity events [24]. The conclusions drawn by Kim et al. was that the multidisciplinary approach within teaching institutions provides for additional checks and balances of patients and their perioperative management, ultimately leading to improved outcomes [24]. We anticipate that similar improvements in patient outcomes following bariatric surgery may be facilitated by standardization of training requirements for both MBSs and GSs performing these procedures. Furthermore, not all MBSs or GSs performing bariatric surgery operations are at accredited bariatric surgery centers. Additional standardization of the perioperative process, including hospital processes and protocols used by both surgeon groups irrespective of the site at which these procedures are being performed, may lead to further improvement in 30-day outcomes following laparoscopic bariatric surgery. For example, implementation of selective Foley catheter placement may decrease the risk of urinary tract infections and the development of enhanced recovery after surgery protocols may decrease overall length of hospital stay. Similarly, an in-depth review of patients who experience postoperative wound events and identification of risk factors associated with developing a postoperative wound event may lead to identification of patients that would benefit from additional antibiotic prophylaxis.

Despite our results, our study does have limitations. First, this is a retrospective study using the ACS-MBSAQIP database that relies on clinical nurse abstractors for data collection and input [9]. Furthermore, as previously mentioned, length of stay within the ACS-MBSAQIP database is in days and not hours [9]. In order to determine if there was truly a difference in length of hospital between those patients who underwent bariatric surgery by a MBS versus a GS, we chose a length of stay greater than 2 days, knowing that many patients are now discharged on postoperative day number one following bariatric surgery [25]. Nevertheless, we are unable to determine at which point patients are "rounded" to the next postoperative day based on the description of length of stay currently available within the ACS-MBSAQIP database [9]. Another limitation is that there remains a significant body of literature that emphasizes the association of higher surgeon volume with improved clinical outcomes [7, 8, 24]. Unfortunately, we are unable to determine the total volume of cases contributed by each surgeon within the ACS-MBSAQIP database or the duration for which each surgeon included in our analysis has been in practice. Furthermore, we cannot tell from the ACS-MBSAQIP database how surgeons are designated as a MBS versus GS. As discussed earlier, all surgeons at bariatric surgery accredited centers are expected to have either completed a bariatric surgery fellowship or institutional-specific subspecialty training [22, 23]. This would lead us to believe that the bariatric procedures performed by GS may be by those undergoing facility-specific training or that they were performed at non-accredited bariatric surgery centers that enter data into the ACS-MBSAQIP. Finally, while it is encouraging that all bariatric surgery accredited centers input data into the ACS-MBSAQIP, they may alternatively contribute to an equivalent regional or national quality improvement program [23]. Furthermore, of the available patients within the ACS-MBSAQIP database at the time of our study, 168,904 (55%) had data missing under the "SURGSPECIALTY_BAR" variable. This creates the potential for under-representation of 30-day morbidity and mortality outcomes in both the MBS and GS patient groups.

Conclusion

Patients who undergo RYGB by either a MBS or GS have similar 30-day morbidity and mortality outcomes while patients who undergo SG by a MBS have improved 30-day morbidity and mortality compared with patients who undergo SG by a GS. It is possible that 30-day morbidity and mortality outcomes may be improved for all patients undergoing laparoscopic bariatric surgery with standardization of the perioperative processes at all institutions performing bariatric surgery. Additional studies are needed to determine the effect of such standardization on the long-term outcomes following laparoscopic bariatric surgery.

Compliance with Ethical Standards

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

MBSAQIP Disclaimer Statement The American College of Surgeons Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (ACS-MBSAQIP) and the hospitals participating in the ACS-MBSAQIP are the source of the date used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

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