



Bariatric Surgery in Prior Solid Organ Transplantation Patients: Is Race a Predictor of Adverse Outcomes?

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Abstract

Purpose Metabolic and bariatric surgery (MBS) is increasingly performed in patients with previous solid organ transplantation (PSOT). In addition, controversy remains about whether racial disparity in outcomes following MBS exists. Therefore, the aim of this analysis was to determine if race independently predicts outcomes in MBS patients with PSOT.

Materials and Methods Patients with PSOT undergoing sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB) were identified in the 2017 Metabolic and Bariatric Surgery Accreditation Quality and Improvement Project (MBSAQIP) database. Patients were stratified by race (Black and White). Propensity score matching was utilized to adjust for multiple demographic variables. Multivariable logistic regression analyses were performed for overall and bariatric-related morbidity.

Results Of 335 MBS patients with PSOT, 250 (75%) were white and 85 (25%) were black patients. Procedure-type and surgical approach ($p > 0.1$) were similarly distributed. Black patients were more likely ($p < 0.05$) to have hypertension dialysis-dependent chronic kidney disease, and be on chronic steroids). Mortality and morbidity were similar. Black patients had significantly ($p < 0.05$) higher rates of renal failure, pulmonary complications, and emergency department visits in unmatched analysis. After propensity score matching, 82 patients in each cohort were identified and were similar at baseline ($p > 0.5$). In the matched analysis, black patients had higher overall (17% vs. 10%, $p = 0.12$) and bariatric-related morbidity (14% vs. 7.2%, $p = 0.05$). In addition, black patients had significantly ($p < 0.05$) higher rates of postoperative pneumonias, progressive renal insufficiency, and emergency department visits. On multivariable regression analysis, black race did not independently predict overall or bariatric-related morbidity.

Conclusion MBS in racial cohorts with PSOT is safe, with very low rates of overall morbidity and mortality. Black race trended toward increased postoperative morbidity. Larger cohort studies are needed to validate our findings.

Keywords Bariatric surgery · Prior solid organ transplant · Outcomes · Racial disparity

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Introduction

Obesity is an increasing epidemic worldwide [1, 2] that is associated with significant morbidity. Metabolic and bariatric surgery (MBS) has been proven as a safe and effective treatment option for severe obesity that is associated with durable weight loss, improvement and resolution of comorbid conditions [3–6], reduced cancer risk, increased longevity [7, 8], and improved quality of life [9, 10].

Given the increasing safety profile of MBS, there is an increasing interest in its role in higher-risk patient cohorts, including transplant candidates and patients. This increasing practice trend is driven by data showing that 2–12% of patients awaiting solid organ transplantation meet the criteria for severe obesity (body mass index (BMI) $> 35 \text{ kg/m}^2$) [11] and weight loss prior to organ transplantation results in better

perioperative outcomes and improved graft survival [12, 13]. While limited to small case series and single-institution experience, there is growing evidence suggesting that MBS can be a safe and effective weight loss treatment option in patients with previous solid organ transplant (PSOT) [11–16].

While obesity has increased among all demographics in the USA, the prevalence and health impact disproportionately impact racial and ethnic minority patients [1–3, 17–20] who continue to be an underrepresented cohort of MBS patients. Even though MBS is overall safe and effective [3–10], there remains a controversy regarding the safety profile and effectiveness of MBS surgery in racial and ethnic cohorts, with some studies reporting no outcome differences [21–23] while others report higher rates of adverse outcomes in racial and ethnic minority patients [24, 25].

No published data exists on outcomes in racial and ethnic MBS patient cohorts with PSOT. Therefore, the goal of this study was to compare outcomes between black and white MBS patients with a history of PSOT to determine if race was an independent predictor of perioperative outcomes.

Material and Methods

Data Source

A retrospective analysis of the 2017 Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) Participant Use Files (PUF) database was performed, and outcomes between racial cohorts of MBS patients with PSOT were compared. The MBSAQIP is responsible for the accreditation of bariatric surgical facilities. Requirements for certification includes reporting bariatric surgical outcomes to the MBSAQIP Participant Use Data File (PUF), a Health Insurance Portability and Accountability Act (HIPAA)-compliant data file registry containing prospectively entered, risk-adjusted, clinically rich data using standardized definitions for preoperative, intraoperative, and postoperative variables that are specific to metabolic and bariatric surgical care. Data points are abstracted at participating institutions by certified reviewers who are audited for accuracy of performance. The 2017 file included data on a composite variable of previous solid organ transplantation (PSOT), including a history of heart, lung, liver, renal, pancreas, and bowel transplantation. This is a de-identified, nationally available, clinical database; therefore, neither institutional review board (IRB) approval nor patient consent was required for our study.

Case Selection and Inclusion Criteria

Our inclusion and exclusion criteria are detailed in Fig. 1. Patients with PSOT undergoing primary gastric bypass (RYGB) or sleeve gastrectomy (SG) cases were identified

through Current Procedural Terminology (CPT) codes 43644, 43645, and 43775. Exclusions included bariatric procedure other than a RYGB or SG, bariatric procedures designated as emergency, open cases, surgical approach other than robotic-assisted or conventional laparoscopy, and other races including American Indian or Alaska Native, Asian, Native Hawaiian, or Other Pacific Islands and Unknown. Selected cases were further stratified by race (non-Hispanic black vs. non-Hispanic white).

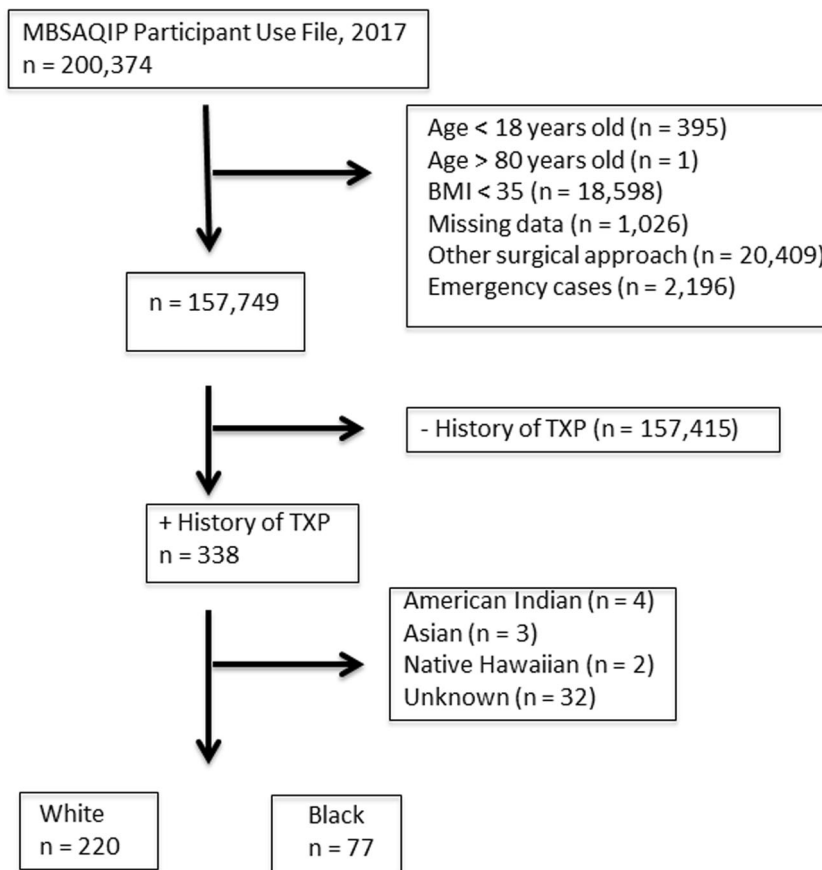
Data Collection, Matching, and Statistical Analysis

Descriptive statistics were collected and compared between groups, including demographics, health summary status, preoperative comorbidities, and operative characteristics. Primary outcome measures included 30-day mortality and morbidity. Secondary outcome measures included other 30-day adverse outcomes (reoperation, readmission, and reintervention), postoperative complication, aggregate complications (Appendix Table 7), and hospital outcomes (operative duration, conversion, and hospital length of stay). Propensity score-matched analyses were performed to adjust for intergroup biases. The matching ratio was one-to-one. A logistic regression model was generated on patient demographics and variables with a $p < 0.1$ on univariate analysis between racial cohorts with prior solid organ transplantation. Variables included in our regression model were Hispanic ethnicity, hypertension (HTN), chronic steroid use, obstructive sleep apnea (OSA), dialysis-dependent chronic kidney disease (CKD), and renal insufficiency. A propensity score from 0 to 1 was generated from this model and assigned to each subject. A nearest neighbor 1:1 variable ratio with propensity scores that fell within a caliper of 0.02 was then used to generate matched cohorts hypothesized to be balanced of potentially confounding baseline characteristics.

A backward method multivariable logistic regression was performed for overall and bariatric-related morbidity. Factors with a difference ($p < .05$) on univariate analysis between the two racial cohorts were included in the model: race (Black vs. White), Hispanic ethnicity, hypertension, chronic steroid use, and dialysis-dependent CKD in our multivariate logistic regression analyses. A procedure-specific multivariable regression analysis was performed for sleeve gastrectomy and gastric bypass cases independently. For each procedure, race and variables that were significantly ($p < .05$) on univariate analysis were included in the multivariate regression models. For SG cases, variables included in the regression algorithm were race, Hispanic ethnicity, gender, and OSA. For RYGB, variables included race, ethnicity, body mass index (BMI), and renal insufficiency.

For univariate unmatched and matched analyses, primary and secondary outcomes were compared by Pearson Chi-Square test for categorical variables and Mann-U-Whitney

Fig. 1 Inclusion and exclusion flow diagram. MBSAQIP = Metabolic and Bariatric Surgery Accreditation and Quality Improvement Project, BMI = body mass index, TXP = transplantation



for continuous variables. Continuous data is expressed as median and interquartile range (IQR) and categorical data is expressed as frequency and percentage. All statistical analyses were performed with SPSS version 26 (IBM Corporation, Armonk, NY) and SAS version 9.4 (SAS Institute, Cary, NC). A *p* value of <0.05 was considered statistically significant.

Results

Patient Demographics

Of the 200,374 cases in the 2017 MBSAQIP database, 0.3% (*n* = 614) had a PSOT. Following exclusions, 335 patients with a prior solid organ transplant were analyzed, including 250 white and 85 black patients. Thirty-four percent (*n* = 208) of the transplant cohort was excluded for CPT codes associated with procedures other than RYBG and SG. Characteristics of the unmatched racial cohorts are detailed in Table 1. Patient demographics (age, gender, and body mass index), operative characteristics (procedure type (RYGB vs. SG), surgical approach (conventional laparoscopy vs. robotic-assisted)), and most preoperative comorbidities were similar between racial cohorts. Black patients had significantly higher

rates of hypertension (77% vs. 64%, *p* = 0.03), chronic steroid use (52% vs. 38%, *p* = 0.03), and dialysis-dependent chronic kidney disease (15% vs. 6.8%, *p* = 0.02).

Outcomes Following Unmatched Analysis

Primary and secondary outcome measures were compared in the unmatched racial cohorts and are detailed in Table 2. Overall mortality and morbidity were 0.3% and 12%, respectively. All-cause mortality (0% vs. 0.4%, *p* = 1.0) and morbidity (17% vs. 10%, *p* = 0.1) were similar between black and white patients. Bariatric-related morbidity was twofold higher in black patients (14% vs. 7.2%) and trended towards significance (*p* = 0.05). In unmatched cohort analysis, black patients had higher rates of postoperative pneumonia (*p* = 0.02), acute renal failure (*p* = 0.02), aggregate pulmonary complications (*p* = 0.02), and emergency (ED) department visit (*p* = 0.03). All other outcome measures were similar (Table 2).

Outcomes Following Propensity Score Matching and Multivariate Logistic Regression Analysis

One-to-one propensity score analysis compared 82 black and 82 white MBS patients with PSOT that were statistically similar (*p* > 0.1) at baseline (Supplementary Table 1).

Table 1 Unmatched patient characteristics

	Total (<i>n</i> = 335)	White (<i>n</i> = 250)	Black (<i>n</i> = 85)	<i>p</i> Value	Effect size
Continuous variables, median					
Age, years	49 (41–58)	49 (41–59)	48 (41–57)	0.317	0.17
BMI, kg/m ²	42.1 (38.5–46.2)	41.6 (38.5–46.2)	42.9 (38.6–46.2)	0.467	0.14
Categorical variables, <i>n</i> , (%)					
Gender, female	237 (71)	173 (69)	64 (75)	0.286	1.26
Ethnicity (Hispanic)	46 (14)	45 (18)	1 (1.2)	<0.001	13
ASA class > 3	297 (89)	218 (87)	79 (93)	0.149	1.93
Operation type				0.141	1.42
Sleeve	252 (75)	183 (73)	69 (81)		
Gastric bypass	83 (25)	67 (27)	16 (19)		
Surgical approach				0.454	0.92
Laparoscopic	309 (92)	229 (92)	80 (94)		
Robotic	26 (8)	21 (8)	5 (6)		
History of myocardial infarction	9 (2.7)	8 (3.2)	1 (1.2)	0.458	2.32
History of PCI	16 (4.8)	13 (5.2)	3 (3.5)	0.533	1.37
History of Cardiac Surgery	23 (6.9)	20 (8.0)	3 (3.5)	0.159	2.02
Hypertension	225 (67)	160 (64)	65 (77)	0.034	1.83
Diabetes mellitus	117 (35)	92 (37)	25 (29)	0.217	0.92
Hyperlipidemia	135 (40)	103 (41)	32 (38)	0.564	1.12
Gastroesophageal reflux disease	143 (43)	112 (45)	31 (37)	0.180	1.30
COPD	4 (1.2)	4 (1.6)	0 (0)	0.241	0.74
Obstructive sleep apnea	118 (35)	95 (38)	23 (27)	0.068	0.89
Oxygen dependent	4 (1.2)	3 (1.2)	1 (1.2)	0.986	1.02
Smoker	11 (3.3)	8 (3.2)	3 (3.5)	0.883	1.11
Renal insufficiency	47 (14)	30 (12)	17 (20)	0.067	1.83
Dialysis	30 (9)	17 (6.8)	13 (15)	0.018	2.50
DVT	14 (4.2)	9 (3.6)	5 (5.9)	0.364	1.67
Pulmonary embolism	11 (3.3)	6 (2.4)	5 (5.9)	0.120	2.54
IVC filter	6 (1.8)	3 (1.2)	3 (3.5)	0.162	1.50
Anticoagulation	24 (7.2)	15 (6)	9 (11)	0.156	1.72
Chronic steroids	140 (42)	96 (38)	44 (52)	0.031	1.72
Limited ambulation status	9 (2.7)	5 (2.0)	4 (4.7)	0.239	2.42
Independent functional status	329 (98)	247 (99)	82 (97)	0.170	2.01
Prior bariatric/foregut surgery	23 (6.9)	19 (7.6)	4 (4.7)	0.362	1.49

IQR interquartile range, *BMI* body mass index (kg/m²), *ASA* American society of anesthesiologists, *PCI* percutaneous coronary intervention, *COPD* chronic obstructive pulmonary disease, *DVT* deep vein thrombosis, *IVC* inferior vena cava, **Bold** statistically significant, *p* < 0.05

Perioperative outcomes after propensity score matching are outlined in Table 3. There was no mortality in either cohort. Overall (17% vs. 10%, *p* = 0.2) and bariatric-related morbidity (15% vs. 8.5%, *p* = 0.2) were statistically similar between black and white patients. All other outcome measures were also similar between racial cohorts. Multivariate regression analyses were performed to identify independent predictors of overall and bariatric-related morbidity as shown in Table 4. Black race was not found to be an independent

predictor of overall morbidity (OR 1.6, *p* = 0.2) or bariatric-related morbidity (OR 1.78, *p* = 0.2). Both overall and bariatric-related morbidities were independently associated with chronic steroid use.

Procedure-Specific Analysis

Subgroup analyses of SG (*n* = 252) and RYGB (*n* = 83) cohorts were performed. Descriptive statistics of these

Table 2 Unmatched perioperative outcomes

	Total (n = 335)	White (n = 250)	Black (n = 85)	p Value
Hospital outcomes, median (IQR)				
Operative time, minutes	97 (64–136)	100 (63–135)	94 (64–138)	0.853
Length of stay, days	2 (1–2)	2 (1–2)	2 (1–3)	0.091
30-day adverse outcomes and postoperative complications, n, (%)				
Overall mortality	1 (0.3)	1 (0.4)	0 (0)	1.000
Bariatric-related mortality	1 (0.3)	1 (0.4)	0 (0)	1.000
Overall morbidity	39 (12)	25 (10)	14 (17)	0.108
Bariatric-related morbidity	30 (9)	18 (7.2)	1 (14)	0.054
Reoperation	6 (1.8)	4 (1.6)	2 (2.4)	0.651
Reoperation related	6 (1.8)	4 (1.6)	2 (2.4)	0.651
Readmission	33 (10)	21 (8.4)	12 (14)	0.126
Readmission related	27 (8.1)	16 (6.4)	11 (13)	0.056
Postoperative intervention	9 (2.7)	5 (2.0)	4 (4.7)	0.183
Postoperative intervention related	9 (2.7)	5 (2.0)	4 (4.7)	0.183
Unplanned ICU admission	10 (3.0)	5 (2.0)	5 (5.9)	0.069
Perioperative transfusions	9 (2.7)	7 (2.8)	2 (2.4)	0.826
Myocardial infarction	1 (0.3)	1 (0.4)	0 (0)	0.559
Pulmonary embolism	2 (0.6)	1 (0.4)	1 (1.2)	0.422
Pneumonia	2 (0.6)	0 (0)	2 (2.4)	0.015
Superficial SSI	4 (1.2)	4 (1.6)	0 (0)	0.598
Deep incisional SSI	1 (0.3)	1 (0.4)	0 (0)	0.559
Organ space infection	4 (1.2)	4 (1.6)	0 (0)	0.241
Sepsis	1 (0.3)	1 (0.4)	0 (0)	0.559
Progressive renal insufficiency	4 (1.2)	4 (1.6)	0 (0)	0.241
Acute renal failure	2 (0.6)	0 (0)	2 (2.4)	0.015
Urinary tract infection	1 (0.3)	1 (0.4)	0 (0)	0.559
<i>Clostridium difficile</i>	1 (0.3)	1 (0.4)	0 (0)	0.559
Emergency department visits	25 (7.5)	14 (5.6)	11 (13)	0.026
Approach converted	5 (1.5)	3 (1.2)	2 (2.4)	0.449
Aggregate complications, n (%)				
Bleeding	1 (0.3)	1 (0.4)	0 (0)	0.559
Anastomotic leak	7 (2.1)	7 (2.8)	0 (0)	0.119
Cardiovascular	2 (2.6)	2 (0.8)	0 (0)	0.408
Pulmonary	2 (2.6)	0 (0)	2 (2.4)	0.015
Renal	6 (1.8)	4 (1.6)	2 (2.4)	0.651
Venous thromboembolic	5 (1.5)	3 (1.2)	2 (2.4)	0.449
Surgical site infections	10 (3)	10 (4.0)	0 (0)	0.061

IQR interquartile range, ICU intensive care unit, SSI surgical site infection, **Bold** statistically significant, $p < 0.05$

procedure-specific analyses are detailed in Supplementary Table 2. For SG cases, female sex ($p = 0.04$) was more prevalent in black patients and preoperative obstructive sleep apnea ($p = 0.03$) was more prevalent in white patients. For RYGB cases, preoperative BMI ($p = 0.03$) and renal insufficiency (19% vs. 3%, $p = 0.05$) were higher in black patients. For both SG and RYGB, all other patient demographics and

preoperative comorbidities were similar between racial cohorts. Outcomes of these unmatched procedure-specific subgroup analyses are reported in Supplementary Table 3. Mortality was 0–0.5% ($p > 0.5$). There were no procedure-specific statistically significant racial differences in overall or bariatric-related morbidity; however, morbidity was higher in black patients for both SG and RYGB cases. For SG, there

Table 3 Propensity score–matched perioperative outcomes

	Total (<i>n</i> = 164)	White (<i>n</i> = 82)	Black (<i>n</i> = 82)	<i>p</i> Value
Hospital outcomes, median (IQR)				
Operative time, minutes	95 (63–139)	95 (57–151)	95 (65–137)	0.732
Length of stay, days	2 (1–3)	2 (1–2)	2 (1–3)	0.649
30-day adverse outcomes and postoperative complications <i>n</i> , (%)				
Overall morbidity	22 (13)	8 (10)	14 (17)	0.169
Bariatric-related morbidity	19 (12)	7 (8.5)	12 (15)	0.222
Reoperation	3 (1.8)	1 (1.2)	2 (2.4)	0.560
Reoperation related	3 (1.8)	1 (1.2)	2 (2.4)	0.560
Readmission	19 (12)	7 (8.5)	12 (15)	0.222
Readmission related	18 (11)	7 (8.5)	11 (13)	0.318
Postoperative intervention	5 (3.0)	1 (1.2)	4 (4.9)	0.173
Postoperative intervention related	5 (3.0)	1 (1.2)	4 (4.9)	0.173
ICU admission	8 (4.9)	3 (3.7)	5 (6.1)	0.468
Perioperative transfusions	6 (3.7)	4 (4.9)	2 (2.4)	0.405
Myocardial infarction	1 (0.6)	1 (1.2)	0 (0)	0.316
Pulmonary embolism	1 (0.6)	0 (0)	1 (1.2)	0.316
Pneumonia	2 (1.2)	0 (0)	2 (2.4)	0.155
Deep incisional SSI	1 (0.6)	1 (1.2)	0 (0)	0.316
Organ space infection	1 (0.6)	1 (1.2)	0 (0)	0.316
Progressive renal insufficiency	3 (1.8)	3 (3.7)	0 (0)	0.080
Acute renal failure	2 (1.2)	0 (0)	2 (2.4)	0.155
Urinary tract infection	1 (0.6)	1 (1.2)	0 (0)	0.316
<i>Clostridium difficile</i>	1 (0.6)	1 (1.2)	0 (0)	0.316
Emergency department visits	14 (8.5)	4 (4.9)	10 (12)	0.094
Approach converted	2 (1.2)	1 (1.2)	1 (1.2)	1.000
Aggregate complications, <i>n</i> (%)				
Bleeding	0 (0)	0 (0)	0 (0)	–
Anastomotic leak	4 (2.4)	4 (4.9)	0 (0)	0.120
Cardiovascular	1 (0.6)	1 (1.2)	0 (0)	0.316
Pulmonary	2 (1.2)	0 (0)	2 (2.4)	0.155
Renal	5 (3.0)	3 (3.7)	2 (2.4)	0.650
Venous thromboembolic	4 (2.4)	2 (2.4)	2 (2.4)	1.000
Surgical site infections	3 (1.8)	3 (3.7)	0 (0)	0.080

IQR interquartile range, ICU intensive care unit, SSI surgical site infection

was a higher rate of aggregate pulmonary complications (2.9% vs. 0%, $p=0.07$) and ED visits (10% s. 3.8%, $p=0.05$), though it did not reach statistical significance. For RYGB cases, there was an 8.6-fold higher likelihood of ICU admission for black patients; however, the difference was not statistically significant ($p=0.09$). Procedure-specific multivariate regression analyses were performed and results are detailed in Table 5. For SG cases, black race was associated with a higher likelihood of overall (OR 2.3, CI 0.92–5.73, $p=0.07$) and bariatric-related morbidity (OR 2.78, CI 0.98–7.89, $p=0.06$), but not significantly so. Obstructive sleep apnea

also independently correlated with bariatric-related morbidity (OR 2.95, CI 1.06–8.24, $p=0.04$). While overall (OR 2.08) and bariatric related (OR 2.52) morbidity were also higher in black patients after RYGB, the differences were not significant (Table 6).

Discussion

This is the first and largest study reporting on disparity in outcomes following metabolic and bariatric surgery in racial

Table 4 Multivariable regression for risk factors associated with overall and bariatric-related morbidity

	Odds ratio	95% CI	p Value
Overall morbidity			
Race (Black vs. White)	1.60	0.76–3.82	0.218
Preoperative steroid use	2.40	1.17–4.92	0.017
Preoperative dialysis	1.04	0.33–3.26	0.941
Hispanic	1.00	0.35–2.83	0.993
Hypertension	0.95	0.43–2.07	0.890
Bariatric-related morbidity			
Race (Black vs. White)	1.78	0.79–4.02	0.168
Preoperative steroid use	2.25	1.05–4.84	0.038
Preoperative dialysis	1.48	0.47–4.71	0.506
Hypertension	1.32	0.53–3.32	0.556
Hispanic	0.81	0.22–2.93	0.747

Bold statistically significant, $p < 0.05$

cohorts with a history of prior solid organ transplantation. In this analysis, we have reinforced the safety of MBS in transplant patients, showing a low rate of overall mortality (0.3%), overall morbidity (12%), bariatric-related mortality (0.3%), and bariatric-related morbidity (9%). This is consistent with the published literature on perioperative outcomes following MBS. The systematic review of randomized and observational studies ($n = 161,756$) by Chang et al. [3] reported mortality and morbidity rates of 0.22–0.35% and 9.8%, respectively, following metabolic and bariatric surgery. Following propensity score–matched analyses in our study, there were no statistically significant differences in hospital outcomes, 30-day adverse outcomes, and postoperative or aggregate complications between racial cohorts. Nonetheless, the rates of readmission (1.8-fold), reoperation (2-fold), reintervention (4-

Table 5 Multivariable regression for risk factors associated with overall and bariatric-related morbidity in SG patients

	Odds ratio	95% CI	p Value
Overall morbidity			
Race (Black vs. White)	2.30	0.92–5.73	0.074
Obstructive sleep apnea	2.39	0.99–5.77	0.052
Hispanic	1.16	0.31–4.36	0.825
Male (vs. Female)	1.10	0.44–2.75	0.836
Bariatric-related morbidity			
Race (Black vs. White)	2.78	0.98–7.89	0.055
Obstructive sleep apnea	2.95	1.06–8.24	0.039
Hispanic	1.11	0.23–5.44	0.898
Male (vs. Female)	0.94	0.32–2.76	0.906

SG sleeve gastrectomy, Bold statistically significant, $p < 0.05$

Table 6 Multivariable regression for risk factors associated with overall and bariatric-related morbidity in RYGB patients

	Odds ratio	95% CI	p Value
Overall morbidity			
Race (Black vs. White)	2.08	0.48–9.09	0.330
Hispanic	0.99	0.18–5.45	0.993
Preoperative renal insufficiency	0.88	0.08–9.61	0.917
BMI	0.65	0.11–3.72	0.626
Bariatric-related morbidity			
Race (Black vs. White)	2.52	0.55–11.5	0.233
Preoperative renal insufficiency	1.01	0.09–11.4	0.992
Hispanic	0.55	0.06–5.01	0.593
BMI	0.50	0.08–2.98	0.449
Race (Black vs. White)	2.52	0.55–11.5	0.233

RYGB Roux-en-Y gastric bypass, BMI body mass index, Bold statistically significant, $p < 0.05$

fold), and emergency department (ED) visits (2.4-fold) were higher in black patients. On multivariate regression analysis, black race was not found to be an independent predictor of all-cause or bariatric-related morbidity. While race was not an independent predictor of outcomes in this cohort of MBS patients with prior solid organ transplantation, chronic steroid use was.

The nonsignificant differences in outcomes noted between black and white patients in this study are consistent with prior studies reporting a lack of significant correlation between race and MBS outcomes [21–23]. However, the nonsignificantly higher rates of some adverse outcomes (reoperation, readmission, reintervention) in black patients in our study are concerning and need further exploration with larger patient cohorts. It is possible that these differences represent racial disparity in outcomes, but given the small sample sizes, the study had inadequate power to show a statistically significant difference.

Upon multivariable regression analysis of SG and RYGB cases independently, black race was associated with a high odds ratio (OR > 2) for both overall and bariatric-related morbidity, more so with SG. However, these differences did not reach statistical significance. In our study, we also notice a trend toward a higher rate of ED visits (2.6-fold) in black SG patients. The reasons for this finding remain unclear and could not be elucidated from the database used for our study. In the published literature, the most common reported reasons for ED visits including abdominal pain, nausea/vomiting, dehydration, wound concerns, and compliance issues [26–29]. In a recent prospective cohort study of patients in the Michigan Bariatric Surgery Collaborative (MBSC) database, Stevens et al. [26] found that most ED presenting symptoms following bariatric surgery were of low acuity and non-life-

threatening. Some studies have highlighted educational level as a possible contributor to poor compliance, resulting in higher readmission rates. Mahoney et al [30] evaluated grade level education (survey) and health literacy using the Rapid Estimate of Adult Literacy in Medicine-Short Form (REALM-SF) health literacy test and found that educational level less than or equal to 12th grade was associated with a threefold higher rate of ED visits and readmissions following bariatric surgery. No correlation was found between health literacy and ED visits. Others have reported patient demographics, such as younger age and female sex as potential predictors of ED visits [28]. Given the higher associated healthcare cost from ED visits and readmissions, there is increasing interest to improve this MBS quality metric. Further studies to differentiate reasons for ED visits and readmissions between racial cohorts and high-risk patient cohorts (e.g., prior transplantation) may further our understanding of this quality metric and highlight opportunities for improvement, efficiency, and cost-savings. In contrast to numerous studies showing a higher rate of adverse outcomes following RYGB compared with SG, in our procedure-specific analyses of racial bariatric surgery cohorts with prior solid organ transplantation, there were no significant differences in outcomes between RYGB and SG cases.

While our study demonstrated that outcomes in this cohort of MBS patients are not mediated by race, there are several study limitations to consider. First, this is a retrospective analysis that is subject to the inherent biases of such an analysis. Second, a significant portion of transplant cases were excluded, primarily because of CPT codes not specific to SG or RYGB. Even though this represents the largest study in this cohort of patients, generalizability is limited by the overall small sample size analyzed. In addition, several granular data points are not included in the database and therefore could not be accounted for in our analysis. Such data points include the

type of solid organ transplantation performed, timeframe from transplantation to bariatric surgery, and the immunosuppressive regimen of each patient. The timeframe between organ transplantation and metabolic and bariatric surgery may impact intraoperative findings, operative course, and ultimately perioperative outcomes. The inability to account for these confounders may have an impact on our findings.

Conclusion

Metabolic and bariatric surgery in racial cohorts of post-solid organ transplantation patients is safe, with very low rates of morbidity and mortality. While some adverse outcomes were higher in black patients, race was not found to be an independent predictor of adverse outcomes following SG or RYGB in patients with prior solid organ transplantation. However, there were trends toward higher rates of adverse outcomes, including overall and bariatric-related morbidity, in both propensity score-matched and multivariate regression analyses. Given the sample size limitation of our study, additional analyses of larger cohorts are needed to further explore the impact of race on outcomes in bariatric surgery patients with prior organ transplantation.

Compliance with Ethical Standards

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

Ethical Approval Statement This is a retrospective study of nationally available de-identified data. For this type of study formal consent is not required.

Informed Consent Statement Informed consent does not apply.

Appendix

Table 7 Composite complication methodology

Aggregate variable	Composite variables
Leak	Reoperation with suspected reason: leak Readmission with suspected reason: leak Intervention with suspected reason: leak Drain present over 30 days Complication: organ space SSI
Bleeding	Reoperation with suspected reason: bleeding Readmission with suspected reason: bleeding Intervention with suspected reason: bleeding

Table 7 (continued)

Aggregate variable	Composite variables
Cardiac/CVA	Reoperation with suspected reason: cardiac NOS, CVA, or MI Readmission with suspected reason: cardiac NOS, CVA, or MI Intervention with suspected reason: cardiac NOS, CVA, or MI Complication of CVA Complication of MI
Pulmonary	Reoperation with suspected reason: shortness of breath, pneumonia, or other respiratory failure Readmission with suspected reason: shortness of breath, pneumonia, or other respiratory failure Intervention with suspected reason: shortness of breath, pneumonia, or other respiratory failure Complication: on ventilator > 48 h Complication: unplanned intubation Complication: pneumonia
Renal	Reoperation with suspected reason: renal insufficiency Readmission with suspected reason: renal insufficiency Intervention with suspected reason: renal insufficiency Complication: progressive renal insufficiency Complication: acute renal failure
DVT or PE	Reoperation with suspected reason: vein thrombosis requiring therapy or pulmonary embolism Readmission with suspected reason: vein thrombosis requiring therapy or pulmonary embolism Intervention with suspected reason: vein thrombosis requiring therapy or pulmonary embolism Complication: vein thrombosis requiring therapy Complication: pulmonary embolism Complication: anticoagulation initiated of presumed/confirmed vein thrombosis/PE
Wound infection	Reoperation with suspected reason: wound infection or other abdominal sepsis Readmission with suspected reason: wound infection or other abdominal sepsis Intervention with suspected reason: wound infection or other abdominal sepsis Complication: post-op superficial incisional SSI occurrence Complication: post-op deep incisional SSI occurrence
Other infection	Reoperation with suspected reason: infection/fever Readmission with suspected reason: infection/fever, Intervention with suspected reason: infection/fever Complication: post-op sepsis occurrence Complication: post-op septic shock occurrence Complication: post-op pneumonia occurrence Complication: post-op urinary tract infection occurrence
Overall morbidity	Mortality within 30 days Need for intervention within 30 days Need for readmission within 30 days Need for reoperation within 30 days Unplanned ICU transfer within 30 days
Aggregate-related reoperation	Any reoperation designated as related to metabolic/bariatric by variable REOP_RELATED_BAR1. To REOP_RELATED_BAR.13
Aggregate-related readmission	Any readmission designated as related to metabolic/bariatric by variable READ_RELATED_BAR1. To READ_RELATED_BAR.11
Aggregate-related intervention	Any intervention designated as related to metabolic/bariatric by variable INVT_RELATED_BAR1. To INTV_RELATED_BAR.5
Bariatric surgery–related morbidity	Death related to bariatric surgery Aggregate reoperation related to metabolic/bariatric surgery Aggregate readmission related to metabolic/bariatric surgery Aggregate intervention related to metabolic/bariatric surgery

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