Published in final edited form as:

Obes Surg. 2019 March ; 29(3): 975–982. doi:10.1007/s11695-018-3604-2.

National Postoperative Bariatric Surgery Outcomes in Patients with Chronic Kidney Disease and End Stage Kidney Disease

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Abstract

Purpose: Obesity is a major risk factor for end stage kidney disease (ESKD) and is often a barrier to kidney transplantation. However, limited evidence exists evaluating postoperative bariatric surgery outcomes in patients with chronic kidney disease (CKD) and ESKD.

Materials and Methods: We performed a retrospective cohort study of patients who underwent bariatric surgery in 2015-2016 using the national Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program dataset. Propensity score matching was used to balance characteristics across patients with CKD and ESKD vs. those without CKD.

Results: There were 323,034 patients without CKD, 1,694 patients with CKD, and 925 patients with ESKD who underwent bariatric surgery. Patients with CKD and ESKD had a significantly increased risk of 30-day reoperation (CKD odds ratio [OR] 2.25 95% confidence interval [CI] 1.45-3.51; ESKD OR 3.10, 95% CI 1.72-5.61) and readmission (CKD OR 1.98, 95% CI 1.5-2.56; ESKD OR 2.97, 95% CI 2.05-4.31) compared to patients without CKD; mortality risk was elevated in patients with ESKD (OR 11.59, 95% CI 6.71-20.04) but not in those with CKD (OR 1.00, 95% CI 0.32-3.11). Rates of adverse outcomes were <15% across all groups. There were 12, 50, and 172 deaths per 1,000 person-years among patients without CKD, with CKD, and with ESKD, respectively.

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Conflicts of Interest

The authors declare that they have no conflicts of interest to disclose.

Compliance with Ethical Standards

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. For this type of study formal consent is not required.

Informed Consent

Does not apply.

Conclusion: Patients with CKD and ESKD experienced higher risk of post-bariatric surgery complications compared to those without kidney disease, although absolute complication rates were low across all groups. CKD and ESKD should not be perceived as contraindications to bariatric surgery.

Keywords

bariatric surgery; obesity; chronic kidney disease; end stage renal disease; weight loss surgery

INTRODUCTION

There is a robust and complex relationship between obesity and the development and progression of CKD. Obesity is strongly associated with several comorbidities that contribute to the deterioration of kidney function. For example, the elevated risk of CKD in obesity is likely mediated by a heightened incidence of diabetes and hypertension in patients with obesity [1–5]. Nonetheless, evidence suggests that even after accounting for these comorbidities, there remains a strong, independent association between obesity and development of ESKD [6].

In the general population, bariatric surgery is the treatment of choice for longstanding weight loss to reduce cardio-metabolic risk in patients with severe obesity [7]. In addition to improving glycemic control and blood pressure [7–10], bariatric surgery improves glomerular filtration rate and proteinuria [11], and reduces the risk of developing CKD and ESKD [12,13]. However, there is ongoing reticence to perform bariatric surgery in patients with CKD and ESKD [14]. This may in part be due to the presence of an “obesity paradox” in patients on dialysis; dialysis-dependent individuals with obesity have a significantly lower risk of cardiovascular morbidity and mortality compared to normal-weight patients [15,16]. Additionally, evidence suggests an elevated risk of surgical complications among patients with kidney disease who undergo bariatric surgery [17], although this has not been consistently demonstrated [18–21]. Thus, despite the highly concomitant nature of obesity and CKD, many providers are reticent to recommend bariatric surgery in patients with obesity and CKD or ESKD. This reticence may result in compounded comorbidity burden, and has been associated with reduced access to the transplant waiting list [22].

Existing studies of the perioperative risks associated with bariatric surgery in kidney disease were limited by small sample sizes of individuals with kidney disease, particularly ESKD. Additionally, while these studies highlighted stark differences in comorbidity burden between patients with vs. without CKD, they were limited by an absence of an appropriate control population. Given the significant potential cardio-metabolic benefit of bariatric surgery and the importance of removing barriers to the kidney transplant waiting list, the goal of this study was to better understand the risks of short term bariatric surgery complications in patients with CKD or ESKD compared to patients without CKD.

METHODS

Study Design and Data Source

We performed a retrospective cohort study of national registry data provided by the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) 2015 and 2016 Participant Use Data Files, which encompass over 150,000 metabolic and bariatric surgery cases performed at 796 centers in the United States and Canada annually [23]. MBSAQIP collects deidentified data on preoperative risk factors, intraoperative events, and 30-day postoperative morbidity and mortality among patients undergoing metabolic and bariatric surgery. Patients were included in the study if they were at least 18 years of age at the time of undergoing bariatric surgery [23].

Exposures, Covariates, and Outcomes

The primary exposures were pre-operative renal insufficiency (defined as a serum creatinine greater than 2 mg/dL without requiring dialysis, presumed to be CKD given that acute kidney injury is a contraindication for undergoing a non-urgent procedure [24,25]) and dialysis-dependence, i.e. ESKD [26]. Covariates were selected *a priori* for inclusion in the multivariable models and matching algorithms based on clinical relevance and previously demonstrated associations with postoperative outcomes [27–30]. The primary outcome was 30-day postoperative mortality. The secondary outcomes were 30-day reoperation, readmission, intervention, and acute kidney injury (only among patients not on dialysis at the time of surgery) [23]. *Please refer to the Supplemental Methods for additional details.*

Statistical Analyses

All statistical analyses were performed using STATA version 15.1 (Statacorp LP, College Station, TX). Demographic and medical characteristics were described medians, means, and percentiles, with Wilcoxon rank sum test or t-test for comparing continuous variables and chi-square test for comparing categorical and binary variables. Poisson regression was used to calculate event rates. Multivariable logistic regression with and without propensity score matching was used to compare patients with CKD and ESKD to patients with no CKD with regard to the risk of developing the primary and secondary 30-day outcomes.

Propensity score matching was used to balance the covariates across patients with CKD or ESKD and those with no CKD [31]. Propensity score matching is a matching technique that estimates the effect of an outcome across different exposure groups by collectively balancing risk factors across each exposure group [31,32]. To achieve this, the technique calculates a score based on the likelihood of individuals being in each exposure group, taking into account their known risk factors. *Please refer to the Supplemental Methods for additional details, including handling of missing data.*

RESULTS

Cohort Characteristics

There were 323,034 patients without CKD, 1,694 patients with CKD, and 925 patients with ESKD who underwent bariatric surgery in 2015 and 2016 who met inclusion criteria.

Compared to patients without CKD, those with CKD or ESKD were significantly older (Table 1; median age 44 vs. 56 vs. 49, respectively; $p<0.001$), had clinically and statistically significantly higher rates of hypertension (49% vs. 92% vs. 80%, $p<0.001$), diabetes mellitus (27% vs. 68% vs. 56%, $p<0.001$), hyperlipidemia (24% vs. 64% vs. 52%, $p<0.001$), and cardiac disease (3% vs. 19% vs. 13%, $p<0.001$). Patients with ESKD were more likely to have sleeve gastrectomy, as opposed to gastric bypass, compared to patients without CKD or with pre-dialysis CKD. Individuals without CKD experienced 12 deaths per 1,000 person-years, individuals with CKD experienced 50 deaths per 1,000 person-years, and individuals with ESKD experienced 172 deaths per 1,000 person-years of postoperative follow up (see Table 2 for unadjusted event rates for each of the primary and secondary outcomes).

Multivariable Logistic Regression

After adjusting for important preoperative and perioperative characteristics, patients with CKD had no significant difference in 30-day mortality compared to patients without CKD (Figure 1, Table S1; adjusted OR [aOR] 1.26, 95% CI 0.59-2.72); however, patients with ESKD had a significantly increased 30-day mortality risk (aOR 8.65, 95% CI 4.78-15.68) compared to patients without CKD. Older age, male gender, Black race, higher pre-operative BMI, diabetes, hyperlipidemia, history of myocardial infarction, history of pulmonary embolism, chronic obstructive pulmonary disease, and gastric bypass (as opposed to sleeve gastrectomy) were independently associated with mortality. Patients with both CKD and ESKD had a significantly increased risk of 30-day reoperation (CKD aOR 1.72, 95% CI 1.33-2.22; ESKD aOR 2.73, 95% CI 2.01-3.72), intervention (CKD aOR 2.49, 95% CI 2.02-3.07; ESKD aOR 2.28, 95% CI 1.67-3.10), and readmission (CKD aOR 1.78, 95% CI 1.51-2.08; ESKD aOR 2.23, 95% CI 1.82-2.74). Patients with pre-dialysis CKD also had a significantly increased odds of acute kidney injury compared to patients without CKD (aOR 7.28, 95% CI 5.46-9.69; *see Tables S2-S5 for factors independently associated with each complication*).

Effect Modification

There was significant interaction between diabetes and CKD status with regard to the 30-day intervention outcome (Table S6; $p<0.001$); unlike diabetics, non-diabetics with CKD had no significant difference in 30-day intervention risk compared to non-diabetics without CKD (Diabetic with CKD aOR 2.98, 95% CI 2.36-3.77; Non-Diabetic with CKD aOR 1.42, 95% CI 0.87-2.31). There was also significant interaction between sex and CKD status with regard to 30-day reoperation ($p=0.003$); males with CKD had a significantly increased risk of 30-day reoperation compared to males without CKD (aOR 2.10, 95% CI 1.49-2.95), while females with CKD had no significantly increased risk of 30-day reoperation compared to females without CKD (aOR 1.32, 95% CI 0.89-1.97). There was no effect modification of the association between CKD status and age ≥ 60 years, hypertension, and type of bariatric surgery ($p>0.05$). There was insufficient statistical power to assess for effect modification in ESKD.

Propensity Score Matching

3,372 patients without CKD and with pre-dialytic CKD were able to achieve 1:1 propensity score matching (1,686 from each group; see Table S7 for balance table). Similar to the

multivariable logistic regression models, there was no significant difference in mortality between patients with CKD and those without CKD (Table 3; OR 1.00, 95% CI 0.32-3.11). Compared to patients without CKD, patient with pre-dialytic CKD had significantly higher risk of 30-day reoperation (OR 2.25, 95% CI 1.45-3.51), intervention (OR 4.82, 95% CI 3.02-7.68), readmission (OR 1.98, 95% CI 1.53-2.56), and acute kidney injury (OR 7.23, 95% CI 3.59-14.59).

1,834 patients without CKD and with ESKD achieved 1:1 propensity score matching (917 from each group; see Table S8 for balance table). Patients with ESKD continued to have a significantly increased risk of 30-day mortality (Table 3; OR 11.59, 95% CI 6.71-20.04), reoperation (OR 1.72-5.61), intervention (OR 3.59, 95% CI 1.92-6.70), and readmission (OR 2.97, 95% CI 2.05-4.31) compared to patients without CKD.

DISCUSSION

Understanding that ESKD is described as a relative contraindication to bariatric surgery [14], this is the largest study to date of postoperative bariatric surgery outcomes in patients with CKD and ESKD. Using national registry data, we demonstrated that patients with CKD and ESKD were more likely to experience postoperative complications compared to individuals with normal kidney function. Nonetheless, rates of 30-day complications and readmissions across all groups were <15%. While patients with ESKD had an increased risk of 30-day mortality, there was no significant difference in mortality risk among patients with CKD compared to patients without CKD; the mortality rates were comparable to the non-bariatric surgery CKD and ESKD population [33,34]. Reflective of current national trends [35,36], the overwhelming majority of patients in the cohort underwent sleeve gastrectomy, with a minority undergoing Roux-en-y gastric bypass.

Our study was strengthened by the use of an expansive, contemporary cohort that is highly generalizable to bariatric surgery practices across the United States and Canada. In order to provide less biased evidence regarding post-bariatric surgical outcomes in patients with CKD or ESKD, we also employed matching techniques to address differences in medical morbidities and surgical risk factors across patients with vs. without CKD and ESKD. Existing studies have demonstrated mixed findings with regard to postoperative bariatric surgery outcomes in patients with kidney disease [17–21]. We suspect the discrepancy in outcomes across studies is at least somewhat attributable to small sample sizes, as several studies included <40 dialysis patients [17,20]. These studies also occurred in an era when more invasive bariatric surgery was common, whereas there has more recently been a shift to laparoscopic and minimally invasive surgeries, particularly sleeve gastrectomy [35,36]. To the best of our knowledge, previous studies have not evaluated postoperative outcomes in a nation-wide cohort. Understanding the substantial differences in comorbidity burden across patients with and without CKD, previous studies were also limited by the absence of a carefully matched control group to compare outcomes of patients with CKD and ESKD to patients without CKD.

We reported that individuals without CKD, with CKD, and with ESKD experienced 12, 50, and 172 deaths per 1,000 person-years of post-bariatric surgery follow up, respectively.

Among patients with CKD, the mortality rate we observed is markedly lower than that reported nationally in (non-bariatric surgery) Medicare patients with CKD (110 per 1,000 person-years) [33]; this difference is likely somewhat attributable to the fact that the average age of our cohort is much lower than the average age in the Medicare population. Patients with ESKD had a similar mortality rate compared to the nationally reported (non-bariatric surgery) mortality rate in dialysis patients during the same time period (166 per 1,000 person-years) [33]. Additionally, the mortality rate in our cohort was lower than 30-day postoperative mortality rates reported in dialysis patients who underwent other non-emergent surgeries (1.4% in our cohort, compared to 12.6% reported for non-emergent surgeries in the American College of Surgeons (ACS) National Surgical Quality Improvement Program database) [34].

In sensitivity analyses, our study demonstrated that non-diabetic patients with CKD had no increased risk of 30-day non-operative interventions following bariatric surgery compared to non-diabetic patients without CKD, although diabetics with CKD had markedly increased risk of interventions. These results corroborate previous evidence that diabetics have a greater risk of postoperative infection compared to non-diabetics in the one month after bariatric surgery [37]. Additionally, in non-emergent surgeries, diabetics are at a greater risk of surgical site infection [38] and cardiovascular complications [27] compared to non-diabetics. Our study also demonstrated that men with CKD had a higher risk of readmission after bariatric surgery compared to men without CKD, while women with CKD had similar rates of readmission as women without CKD. There is existing evidence of greater risk of post-bariatric surgical adverse outcomes among men compared to women [39,40], although this is not consistent across all studies [41]. The reason for worse outcomes among men is speculated to be, in part, due to larger relative body habitus at the time of bariatric surgery [39]. Given similar mortality risk and risk of other complications across men and women in our study, we conclude that the increased risk of readmission is likely not clinically significant with regard to more serious adverse events.

Our study has several important limitations to consider. While we had access to robust, comprehensive data on comorbidities, demographics, and 30-day outcomes, more granular information regarding degree of renal dysfunction was not available. The MBSAQIP dataset relies on center-level reporting of risk factors and outcomes, and does not collect creatinine or proteinuria data. As a result, patients with mild CKD (e.g. creatinine <2 mg/dL but low-grade proteinuria) may have been misclassified as not having CKD. Correspondingly, we were unable to explore the relationship between severity of pre-dialysis CKD and adverse outcomes, although existing evidence suggests that patients with CKD experience similar post-bariatric surgery outcomes across all categories of CKD severity [18]. Additionally, we were unable to validate the outcome of 30-day acute kidney injury or to apply more widely accepted definitions of acute kidney injury [42,43]. It is not surprising that CKD patients would be more prone to postoperative acute kidney injury than non-CKD patients [44–46]; however, we urge cautious interpretation of the results of this outcome. Given that the MBSAQIP dataset uses a conservative definition of acute kidney injury, patients who truly had acute kidney injury, particularly those with normal baseline kidney function, may have been misclassified as not experiencing this outcome. We did not have sufficient statistical power to assess for effect modification in ESKD. Finally, the dataset does not provide

information on key longitudinal outcomes, such as mortality beyond 30-days or sustained weight loss; these are important areas for future investigation.

CONCLUSION

Patients with CKD and ESKD experience higher relative risk of post-bariatric surgery complications compared to patients without CKD; however, the overall rates of complications are quite low across all patients. Furthermore, after matching on important comorbidities, patients with CKD have similar postoperative mortality risk compared to patients without CKD. Although patients with ESKD have higher mortality risk compared to patients without CKD, this is comparable to the expected increased mortality rates in the non-surgical ESKD population, and substantially lower than postoperative ESKD mortality rates previously reported in other non-emergent surgeries. Our results reinforce that CKD and ESKD should not be contraindications to undergoing bariatric surgery. Among patients who have not yet started dialysis, bariatric surgery can help reduce the risk of progression to ESKD [13]. In patients who are already on dialysis, bariatric surgery can be an important bridge to lifesaving transplantation [22]. Nonetheless, acknowledging the elevated risk of complications, the effect of bariatric surgery on longitudinal survival in patients with ESKD (particularly those who are not transplant candidates) remains unknown. Taking into account ongoing reticence to refer patients with CKD and ESKD for bariatric surgery, future research should focus on exploring the long-term survival impact of bariatric surgery and on ways to mitigate short-term adverse postoperative outcomes in this patient population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements:

The ACS MBSAQIP and the centers participating in the ACS MBSAQIP are the source of the data 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.

Grant Information: This research was supported in part by the National Institutes of Health grant number K23-HL133843 (NHLBI, PI: Cohen). The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as an official policy of or interpretation by the National Institutes of Health.

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Figure 1. 30-Day Postoperative Risk by Chronic Kidney Disease Status^a

Abbreviations: CKD = chronic kidney disease (pre-dialysis); ESKD = end stage kidney disease (on dialysis).

^aThe figure represents odds ratios (enclosed circles) with 95% confidence intervals (lines) using multivariable logistic regression of all patients in the cohort (No CKD N=323,034 [green]; CKD N=1,694 [red]; ESKD N=925 [blue]). Models were adjusted for age, sex, race/ethnicity, closest preoperative BMI to surgery, history of hypertension, diabetes, hyperlipidemia, coronary artery disease, pulmonary embolism or deep vein thrombosis,

chronic obstructive pulmonary disease, obstructive sleep apnea, gastroesophageal reflux disease, American Society of Anesthesiologists physical status classification, smoking status, functional dependence, and type of bariatric surgery; missing variables were addressed using multiple imputation

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Table 1.

Baseline patient demographic characteristics, pre-operative comorbidities, and surgical risk factors by chronic kidney disease status

	No CKD N=323,034	CKD N=1,694	ESKD N= 925	P-value
Median age, years (IQR)	44 (36-53)	56 (48-64)	49 (41-56)	<0.001
Female, n (%)	256,849 (80%)	942 (56%)	515 (56%)	<0.001
Race/ethnicity, n (%)				<0.001
White Non-Hispanic	192,010 (59%)	930 (55%)	314 (34%)	
White Hispanic	30,336 (9%)	94 (6%)	89 (10%)	
Black Non-Hispanic	50,120 (16%)	439 (26%)	353 (38%)	
Black Hispanic	1,364 (<1%)	6 (<1%)	6 (1%)	
American Indian or Alaskan Native	1,256 (<1%)	9 (1%)	7 (1%)	
Native Hawaiian or Other Pacific Islander	893 (<1%)	893 (<1%)	8 (1%)	
Asian	1,519 (<1%)	16 (1%)	9 (1%)	
Unknown	45,536 (14%)	194 (11%)	140 (15%)	
Median pre-operative BMI closest to bariatric surgery, kg/m ² (IQR)	43.9 (39.9-49.5)	45.3 (40.4-50.9)	44.7 (40.7-49.6)	<0.001
Hypertension, n (%)	157,488 (49%)	1,555 (92%)	740 (80%)	<0.001
Median number of antihypertensive medications, n (%)	2 (0-3)	2 (2-3)	2 (1-3)	<0.001
Diabetes mellitus, n (%)	85,625 (27%)	1,153 (68%)	514 (56%)	<0.001
Hyperlipidemia, n (%)	79,258 (24%)	1,085 (64%)	478 (52%)	<0.001
Myocardial infarction or cardiac stent, n (%)	8,571 (3%)	320 (19%)	119 (13%)	<0.001
Pulmonary embolism or deep vein thrombosis, n (%)	7,653 (2%)	142 (8%)	66 (7%)	<0.001
Chronic obstructive pulmonary disease, n (%)	5,829 (2%)	137 (8%)	30 (3%)	<0.001
Obstructive sleep apnea, n (%)	122,636 (38%)	1,025 (61%)	495 (54%)	<0.001
Gastroesophageal reflux disease, n (%)	102,182 (32%)	708 (42%)	370 (40%)	<0.001
Median serum albumin, mg/dl (IQR)	4.1 (3.8-4.3)	3.9 (3.5-4.2)	3.9 (3.6-4.2)	<0.001
American Society of Anesthesiologists Physical Status Classification 4, n (%)	12,383 (4%)	316 (19%)	389 (42%)	<0.001
Dependent functional status, n (%)	3,211 (1%)	110 (6%)	50 (5%)	<0.001
Active smoker within 1 year, n (%)	28,574 (9%)	119 (7%)	48 (5%)	<0.001
Surgery type, n (%)				<0.001
Roux-en-y gastric bypass	93,497 (29%)	548 (32%)	150 (16%)	
Sleeve gastrectomy	229,537 (71%)	1,146 (68%)	775 (84%)	

Abbreviations: CKD = chronic kidney disease (pre-dialysis); ESKD = end stage kidney disease (on dialysis); IQR interquartile range; BMI = body mass index

Table 2.

Rates of 30-day postoperative outcomes by chronic kidney disease status

	No CKD N=323,034	CKD N=1,694	ESKD N= 925	P-value
Mortality, n (%)	322 (0.1%)	7 (0.4%)	13 (1.4%)	<0.001
Reoperation, n (%)	5,389 (1.7%)	64 (3.8%)	45 (4.9%)	<0.001
Intervention, n (%)	6,266 (1.9%)	102 (6%)	45 (4.9%)	<0.001
Readmission, n (%)	15,677 (4.9%)	182 (10.7%)	113 (12.2%)	<0.001
Acute Kidney Injury, n (%)	552 (0.2%)	63 (3.7%)		<0.001

Abbreviations: CKD = chronic kidney disease (pre-dialysis); ESKD = end stage kidney disease (on dialysis)

Analyses were not performed evaluating acute kidney injury in ESKD because these patients were already on dialysis at the time of surgery

Table 3.30-day postoperative risk by kidney disease status, using 1:1 propensity score matching^a

No CKD vs. CKD (N=3,372)				No CKD vs. ESKD (N=1,834)			
	Odds ratio	95% CI	P-value		Odds ratio	95% CI	P-value
Mortality				Mortality			
No CKD	-	-	-	No CKD	-	-	-
CKD	1.00	0.32-3.11	1.000	ESKD	11.59	6.71-20.04	<0.001
Reoperation				Reoperation			
No CKD	-	-	-	No CKD	-	-	-
CKD	2.25	1.45-3.51	<0.001	ESKD	3.10	1.72-5.61	<0.001
Intervention				Intervention			
No CKD	-	-	-	No CKD	-	-	-
CKD	4.82	3.02-7.68	<0.001	ESKD	3.59	1.92-6.70	<0.001
Readmission				Readmission			
No CKD	-	-	-	No CKD	-	-	-
CKD	1.98	1.53-2.56	<0.001	ESKD	2.97	2.05-4.31	<0.001
Acute Kidney Injury							
No CKD	-	-	-				
CKD	7.23	3.59-14.59	<0.001				

Abbreviations: CKD = chronic kidney disease (pre-dialysis); ESKD = end stage kidney disease (on dialysis); CI = confidence interval.

No CKD was the reference group for all analyses. Analyses were not performed evaluating acute kidney injury in ESKD because these patients were already on dialysis at the time of surgery

^aAll individuals were matched on age, sex, race, closest preoperative BMI to surgery, history of hypertension, diabetes, hyperlipidemia, coronary artery disease, pulmonary embolism or deep vein thrombosis, chronic obstructive pulmonary disease, obstructive sleep apnea, gastroesophageal reflux disease, American Society of Anesthesiologists physical status classification, smoking status, functional dependence, and type of bariatric surgery; multiple imputation was used to address missing covariates