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Weight Recidivism after Roux-en-Y Gastric Bypass Surgery: an 11-year Experience in a Multi-Ethnic Medical Center

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Abstract

Objective: Weight recidivism following Roux-en-Y gastric bypass (RYGB) is common and is associated with recurrence of comorbidities. Studies with long-term follow-up of recidivism quantified by weight regain (WR) are lacking. We performed a retrospective review of all RYGB at our center from 2004 – 2015 to examine the effects of race and type 2 diabetes (T2D) on WR following RYGB.

Methods: Multivariable linear mixed model for the effects of time and race on weight, WR relative to nadir weight (WR/nadir), WR relative to weight loss (WR/WL), and Cox regressions for low, moderate, and high WR/nadir.

Results: 1395 participants were identified. The sample was limited to African Americans (AA), Caucasians (CA), and Hispanics (HA). The effects of time ($p < 0.0001$), race ($p < 0.0001$), and race $\times$ time interaction ($p = 0.0008$) on weight trajectory were significant. AA had significantly more WR than CA ($p < 0.01$). AA and HA had a higher hazard ratio for having low, moderate, and rapid WR/nadir.

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Conclusions: Racial disparities after RYGB include WR and particularly affect AA.

Understanding the etiologic factors that contribute to these disparities is important to optimize the long-term clinical outcomes of bariatric surgery.

Keywords

weight recidivism; race; bariatric surgery; diabetes

Introduction

Obesity is a worldwide epidemic that affects one-third of the U.S. population and globally affects 107 million children and 603 million adults.(1) All cause-mortality increases by 30% for every five-point increase in body mass index (BMI) over 25 kg/m².(2) Of those affected, 8% have class III obesity, defined as a BMI greater than or equal to 40 kg/m².(3) Bariatric surgery is considered the gold standard and most cost-effective management of severe obesity (BMI ≥ 35 kg/m² with associated chronic disease or BMI ≥ 40 kg/m²), especially for those with metabolic comorbidities such as type 2 diabetes (T2D).(4) The Roux-en-Y gastric bypass (RYGB) has become the second most common type of bariatric surgery performed after the sleeve gastrectomy in the United States since 2013(5) and worldwide since 2014.(6) Median excess weight loss of 66.5%(7) and total body weight loss of 33%(8) have been reported one year after RYGB in large cohort studies. RYGB leads to improvement and/or remission of comorbidities such as T2D, hypertension (HTN), dyslipidemia (DLD), and obstructive sleep apnea (OSA) in proportion to the degree of weight loss.(9) Weight recidivism (WR) (also referred to as weight regain) following RYGB could reduce the long-term clinical benefits of RYGB.

Studies of long-term weight changes after RYGB are lacking but significant WR of ≥ 25% of the total weight loss after RYGB has been reported.(10) There is no consensus on how to best quantify and track WR. Variations in how WR is reported and in how long patients are followed after surgery contribute to variability in reports of WR after RYGB. In addition to the absolute and relative WR, the rate of WR has clinical relevance. Rapid WR is due to a greater energy surplus and may be more clinically detrimental than slower WR. The rate of WR after bariatric surgery has not been studied.

We previously found that race is an important determinant of weight loss after RYGB, with African Americans (AA) losing less weight than Caucasian Americans (CA)(11). To date, no study has addressed the effect of race on WR. The primary purpose of this study was to determine the long-term degree of WR in CA, HA, and AA patients from our diverse patient population with up to 11 years follow-up after RYGB. We tested the hypothesis that AA will have greater absolute WR than CA due to periods of rapid WR. Identifying the risk factors for WR is an important first step in improving the long-term clinical outcomes of bariatric surgery.

Methods

Patients

This retrospective study used the electronic medical record (EMR) data of adult patients who had undergone bariatric surgery at our institution between 2004 and 2015. This study was approved by our Institutional Review Board.

Clinical Data

Race and ethnicity were self-identified as white, black/African-American, Hispanic, Asian, American Indian/Native American, Native Hawaiian/Pacific Islander, or not available/declined information. Data were extracted by a Clinical Data Warehouse analyst and included date of birth, date of enrollment in the bariatric surgery program, date of the surgery, and weight, height, and BMI.

We identified 1395 adult bariatric surgery patients during this period (Table 1). We limited our study to patients from the three most common racial and ethnic groups in our population: AA, HA, and CA who had RYGB (n=1232). Patients who became pregnant after surgery or underwent surgical revisions were excluded.

Pre-surgical medical ICD-9 codes were used to identify comorbid conditions including T2D (250 and 790.29), osteoarthritis (OA) (715.9 and 716.9), (HTN) (401.1, 401.9 and 796.2), DLD (272), OSA (780.57, 780.53, 327.23).

The zip code for each patient was used to estimate the socioeconomic status (SES) based on the zip code median income. Data on the median income by zip code in 2014 were obtained from the United States Census Bureau.(12) Patients were classified into SES quartiles based on the zip code median income.

Statistical analyses

The primary objective for this study was to determine the effect of race on long-term weight recidivism which is quantified by weight regain. A linear mixed model (treating subjects as a random effect) was used to examine race, sex, time, and presence of comorbid conditions as fixed effects on weight. Age and pre-surgery BMI were included as covariates. Seven time-intervals were used in these analyses: pre-surgery, 1–2 years, 2–3 years, 3–4 years, 4–5 years, and 5–6 years, and beyond 6 years post-surgery. The number of subjects included at each time point is shown in Figure 1.

Patients who had not yet achieved nadir weight (n=606) were excluded from the following calculations. We calculated weight loss (WL) as the difference between the pre-surgical weight and the nadir weight for each subject (n=626). We defined WR as the difference between the weight at each clinic visit following the nadir date and the nadir weight in kilograms. WR was evaluated relative to amount of weight lost (WR/WL, expressed as %) and relative to nadir (WR/nadir, expressed as %) for each patient based on the recorded weights at each clinic visit after nadir. Hence, WR/WL and WR/nadir are both repeated measures for each subject.

The rate of weight regain was calculated based on both WR/WL and WR/nadir at each subsequent weight measurement relative to the time elapsed since nadir (reported as % per 30-day interval). Differences in continuous variables between categorical groups were assessed by ANOVA. Categorical outcomes were assessed by cross tabulation and chi-squared distribution analysis. Multinomial logistic regressions were used to compare groups with more than two categorical outcomes across groups.

The 25%, 50% and 75% of the WR/nadir weight distribution based upon the last observed weight were used to define thresholds and group patients into quartiles of low, moderate, and high rates of WR. We performed a Cox regression model to determine the proportional hazard ratio (HR) of WR at each of these three thresholds. Hence, event occurrence was defined as the time to first occurrence for a patient that WR/nadir exceeded each specific cut-off threshold corresponding to 25th, 50th, and 75th WR/nadir distribution (corresponding to WR/nadir of 1.49%, 6.25%, and 14.29%, respectively). Race, sex, SES, and each comorbid condition were entered individually into the Cox regression as categorical predictors; age and MWL were entered as continuous predictors. The final multivariable Cox regression included all the factors with p values <0.05. All statistical analyses were performed using the SAS studio 3.71.

Results

Patient Demographics

In our final cohort, the mean age of subjects was 46.0 years. CA were significantly older than AA and HA. Comorbid conditions varied significantly between racial groups: AA had a greater prevalence of T2D than did CA; CA had higher prevalence of DLD than AA and HA. AA and HA were more likely to live in zip code areas with lower median income than CA (Table 1).

Eleven-year Weight Trajectory

The 95% confidence interval for the 11-year weight trajectory of all patients and for each racial group is shown in Figure 1. Nadir weight was achieved between 12–16 months post-surgery, followed by WR in the following 1–5 years for most patients. Loss to follow-up with increasing time from surgery led to larger 95% confidence intervals. The mean weight appears to be stable from 5 to 11 years post-RYGB, consistent with previous literature.(13) However, the mean weight trajectory of AA was consistently higher throughout the 11-year period (including at nadir) compared to CA.

Results from linear mixed model analyses showed significant effects of time ($p<0.0001$), race ($p<0.0001$), and race $\times$ time interaction ($p=0.0008$) on weight as a percent of baseline weight (Figure 1). Fixed factors and covariates entered individually into the mixed model showed significant effects of pre-surgical BMI ($p<0.0001$) and DLD ($p=0.029$). There was no statistically significant effect on weight for T2D ($p=0.12$), HTN ($p=0.11$), sex ($p=0.054$), age ($p=0.37$), OSA ($p=0.29$), SES ($p=0.22$) and degenerative osteoarthritis ($p=0.39$).

Weight Regain

WR was quantified in patients who had achieved nadir weight at the time of data collection and had one or more weights at least 90 days after the nadir date ($n = 626$). The mean time between surgery and the last available visit was 1572 ± 34.5 days (range 420 – 4020 days) with no significant differences by race. WR/WL at last available observation was $17.0 \pm 1.1\%$. AA had the highest mean WR/MWL ($22.4 \pm 1.9\%$) followed by HA ($17.2\% \pm 2.6$) and CA ($13.5\% \pm 1.5$). These differences in WR/WL between AA and the other two racial groups were statistically significant (global ANOVA model $p=0.001$; AA vs. HA $p=0.11$; AA vs. CA $p=0.0003$). WR/nadir at the last available observation for the total patient population was $8.5 \pm 0.5\%$. AA also had the largest mean WR/nadir at $10.7 \pm 0.9\%$ compared with $8.3 \pm 1.3\%$ among HA and $7.2 \pm 0.7\%$ among CA (global ANOVA model $p=0.0086$, AA vs. HA $p=0.11$, AA vs. CA $p=0.0021$).

Table 2 summarizes the differences in maximal WL and WR between AA, CA, and HA. AA had the lowest mean WL of 30.3% while CA had the highest mean WL of 32.0% of baseline weight (AA vs. CA $p=0.0035$). AA had significantly greater mean maximal WR of 12.7 kg compared with 8.6 kg in HA and 8.7 kg in CA (AA vs. CA $p<0.0001$, AA vs. HA $p=0.0009$).

Monthly WR/WL ranged between -4.19 and 5.51% per 30 days with negative rates corresponding to either continual weight loss beyond the expected nadir date window of 180 and 730 days after surgery or due to another period of weight loss (possibly due to initiation of an obesity medication) leading to weights below the surgical nadir weight. AA had the highest mean monthly WR/WL at last observation of $0.79 \pm 0.07\%$; while CA had the lowest mean monthly WR/WL of $0.57 \pm 0.06\%$ ($p=0.016$ vs AA). HA had a monthly WR/WL at last observation of $0.67 \pm 0.10\%$ ($p=0.31$ vs AA and $p=0.39$ vs CA). The difference in mean monthly WR/MWL in AA compared to CA remained statistically significant after adjusting for age, sex, and comorbidities.

Mixed models of WR (summarized in Figure 2) showed a significant time-dependent increase in WR (Figure 2a), WR/WL (Figure 2b), and WR/nadir (Figure 2c) following surgery. On the other hand, mixed model analyses showed a significant time-dependent decrease in monthly WR/WL (Figure 2d) following surgery with a significant effect of race ($p = 0.0005$). AA had significantly greater WR than CA (mean difference 1.81 kg, $p = 0.014$) and HA (mean difference 1.8 kg, $p = 0.047$). This same pattern is observed in the WR/WL for AA compared with CA and HA and is also reflected by a higher monthly WR/WL in AA compared with CA and HA (all $p < 0.05$).

Table 3 summarizes the general characteristics between each quartile of WR/nadir. There were no significant differences in age, sex, or SES between the WR/nadir quartiles. The quartiles with higher WR/nadir were significantly more likely to include AA (3rd quartile likelihood ratio 1.778; 95% CI, 1.070–2.953; $p=0.0263$, 4th quartile likelihood ratio 2.032; 95% CI, 1.234 – 3.346; $p=0.0054$).

Cox regression (Figure 3 and Table 4) showed that compared with CA, AA had hazard ratios (HR) of 1.323 [95% CI, 1.062–1.649], 1.398 [95% CI, 1.080–1.810], and 1.551 [95% CI,

1.096–2.195] for having at any follow up visit a low, moderate, or high WR/nadir weight, respectively (Table 4). Older age was associated with significantly higher HR at the lower two thresholds. A 1 kg increase in WL was associated with HR of 1.008 [95% CI, 1.000–1.015] for low WR/nadir, 1.015 [95% CI, 1.007–1.023] for moderate WR/nadir, and 1.025 [95% CI, 1.014–1.036] for high WR/nadir. On the other hand, a higher BMI prior to surgery was associated with slightly reduced HR at each of the WR/nadir thresholds.

Discussion

Bariatric surgery is the recommended treatment for patients with severe obesity with comorbid conditions. Wider awareness of obesity as a disease with associated cardio-metabolic dysfunction has increased acceptance for surgical interventions. The beneficial effects of RYGB on T2D are clear and studies with only 1–2 years of follow-up have suggested that RYGB is associated with long-term weight stability. However, recent reports of weight recidivism after RYGB have undermined confidence that RYGB is a durable therapy. Estimates of the proportion of patients who have “significant” WR have varied from 17–30% 2 years from RYGB (14, 15, 16, 17), to 59% with greater than 20% PWR at least 1 year from RYGB (18) to 79% by self-report.(19) These estimates depend upon the definition of “significant” WR and the study duration.(20, 21, 22, 23, 24) Without a standard definition, it is difficult to compare data from different studies. We quantified WR here by WR/WL, WR/nadir, and monthly rate of WR relative to WL and nadir. While these parameters are related, they each add a distinct perspective. WR/WL provides a long-term “success” measure of the weight loss outcome achieved after RYGB. On the hand, expressing WR relative to nadir weight, and as a monthly rate in particular, correlates with the individual’s relative state of positive energy balance that underlies the process of weight regain.

This study extends our previous observations of weight trajectories following RYGB in our diverse patient population.(11) We confirmed that on average AA at our institution lose less weight after RYGB than CA or HA despite adjusting for covariates including SES. These racial differences are modest at nadir but may increase over time due to differences in WR. The weight trajectories (Figure 1) suggest that the “average patient” after reaching nadir has a period of WR in the subsequent 1–4 years followed by a “relatively stable” weight thereafter, consistent with previous literature.(13) However, when WR is included in trajectory analyses (Figure 2), racial differences become discernable. The fact that AA are at a higher risk of low, moderate, and high WR/nadir following RYGB compared with CA is confirmed in our Cox regression analyses. None of these differences could be attributed to age, SES, baseline BMI, sex, and presence of co-morbid conditions in the current cohort. The consistency of these results, derived from two different statistical models, further increase the confidence in the conclusions of our study.

The mechanisms for these racial differences in weight recidivism after RYGB remain unclear. There is marked caloric restriction in the first 3 months after RYGB followed by a gradual increase in energy intake.(25) WR following weight nadir could be related to an increase in caloric intake, a decrease in energy expenditure, or a combination of both. Few studies have examined dietary intake beyond 2 years after RYGB. In one study, significant

predictors of WR were time since surgery and suboptimal eating habits assessed by the Healthy Eating Index.(15) Disordered eating behaviors are prevalent after bariatric surgery. For example, 51% of subjects assessed 8 years after RYGB reported episodes of binge eating or night eating;(26) grazing or nibbling behavior is common.(27) Suboptimal dietary and eating behaviors are associated with WR and could be better identified by specialized screening and behavioral interventions.(28)

Weight recidivism may also be mediated by metabolic factors such as changes in thermogenesis after weight loss.(29) Weight loss is associated with a proportional reduction in non-resting energy expenditure that may contribute to WR.(30) However, RYGB is associated with “paradoxical” increases in weight-adjusted resting energy expenditure (REE) despite large weight loss.(31, 32, 33) Blunted adaptive thermogenesis (the difference between measured and expected REE) may also help maintain weight stability after RYGB. (34) Consistent with this, another study showed that subjects who maintained weight loss had larger diet-induced thermogenesis than subjects who regained weight after RYGB.(35) Whether these factors contribute to the differences in this study warrants further investigation.

Racial/ethnic differences in food choices and eating behaviors have long been linked to obesity and cardiovascular disease.(36, 37, 38) It is unclear whether there are racial differences in RYGB-mediated changes in appetite hormonal signals,(39) mental health, and eating behaviors. According to the Center for Disease Control and Prevention, AA experience greater rates of depression compared to HA and CA.(40) This is further supported by a study that tracked changes in psychosocial factors and patients’ behavioral and mental health after RYGB, and found more WR among those who experienced more depression after surgery.(10) Differences in energy metabolism between AA and other racial groups have also been documented in relationship to obesity,(41) weight loss,(42) and body composition.(41, 43) Whether these racial metabolic differences contribute to disparities post-RYGB remains unclear.

While previous studies have shown that patients with obesity and T2D lose less weight with medical weight management interventions,(44) our study is the first to identify race as a risk factor for WR after RYGB. This finding emphasizes the need for future research in diverse populations.

Our study has numerous strengths that made it possible to assess the impact of race on WR following RYGB, including the racial diversity of our population, the large sample size, and the long duration of follow-up over 11 years. Several measures of WR and statistical models gave concordant results, which strengthens our conclusions.

Limitations

Our retrospective analysis of EMR data has limitations including potential errors in data collection, and use of zip code median income as a surrogate for SES. Statistical power was limited due to small sample sizes in subgroup analyses and gradual loss to follow up over time. With 78% of the population being female, our findings may not be generalizable to

men. We cannot exclude the possibility of residual confounding by unmeasured factors. These findings are preliminary and need to be confirmed in other populations.

Conclusion

There are important racial differences in WR following RYGB. A greater degree of vigilance is warranted for AA and HA patients who are at higher risk for WR. Patients with T2D are at higher risk of WR compared to those without T2D. More frequent follow-up visits, education, and behavioral interventions may be warranted after RYGB in AA and HA patients as well as those with T2D to avert the consequences of WR. Further research is needed to understand the underlying causes of racial differences in weight loss and recidivism following bariatric surgery.

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What is already known about the subject?

- Racial/ethnic differences in the prevalence of obesity are well known
- Bariatric surgery is the gold standard for treatment of severe obesity but weight regain in the following years is common
- Weight recidivism is associated with relapse of type 2 diabetes and other comorbid conditions

What does your study add?

- Our retrospective review assessed the prevalence and rate of weight recidivism in all 1395 Roux-en-Y bariatric surgeries performed at our center over an 11-year period.
- Mean weight regain was 17% of the maximal weight loss at a mean follow-up period of 4.0 years from surgery. Regain was greater in African Americans and Hispanics compared with Caucasians and more frequently occurred at a rapid rate.

Figure 1.A.

Figure 1.B.

Figure 1:

Weight trajectory after RYGB in a racially mixed patient population. Weights shown as a percent of the immediate pre-operative weight. A) mean $\pm$ SE for all subjects; B) means $\pm$ SE by race.

AA: African American; HA: Hispanic American; CA: Caucasian American.

Number of subjects at baseline, 1–2 years, 2–3 years, 3–4 years, 4–5 years, 5–6 years, beyond 6 years:

Overall: 603, 576, 465, 327, 214, 157, 147

AA: 195, 187, 163, 119, 73, 52, 57

HA: 100, 98, 74, 61, 35, 22, 17

CA: 308, 291, 228, 147, 106, 83, 73

Figure 2.A.

Figure 2.B.

Figure 2.C.

Figure 2.D.

Figure 2:

A. Weight regain over time by race. B. Weight regain / maximum weight loss over time by race. C. Weight regain / nadir weight over time by race. D. Monthly weight regain / maximal weight loss over time by race.

Figure 3.A.

Figure 3.B.

Figure 3.C.

Figure 3:

Cox regression for weight regain / nadir greater than the thresholds of 1.49%, 6.25%, and 14.29% by race

A. Weight regain/nadir weight >1.49%. B. Weight regain/nadir weight >6.25%. C. Weight regain/nadir weight >14.29%.

Table 1:

Characteristics of all patients by race.

		African-Americans	Hispanic-Americans	Caucasian-Americans	Total	Significance
		n=202 (32.3%)	n=103 (16.5%)	n=321 (51.3%)	n=626	
Age (years)		45.3±0.8 ^{b,c}	41.9±1.0 ^{a,c}	47.8±0.7 ^{a,b}	46.0±0.5	<0.0001
Sex (%)	Female	87.6 ^c	89.3 ^c	75.7 ^{a,b}	81.8	0.0004
	Male	12.4	10.7	24.3	18.2	
Initial weight (kg)		128.0±2.1 ^b	117.5±2.6 ^{a,c}	128.6±1.5 ^b	126.6±1.1	0.0014
Initial BMI (kg/m ²)		47.5±0.7 ^b	45.0±0.8 ^a	46.7±0.5	46.7±0.4	0.0548
T2D (%)		67.3 ^c	60.2	55.1 ^a	59.9	0.022
Dyslipidemia (%)		34.2 ^c	36.9 ^c	48.6 ^{a,b}	42.0	0.0027
OSA (%)		34.2	36.9	36.1	35.6	0.381
Hypertension (%)		71.3	60.2	68.5	68.1	0.142
Osteoarthritis (%)		11.9	10.7	10.6	11.0	0.330
SES (%)	1	40.0 ^c	44.1 ^c	16.2 ^{a,b}	30.3	<0.0001
	2	28.5 ^c	28.4 ^c	28.9 ^{a,b}	28.7	
	3	17.0 ^c	16.7 ^c	21.8 ^{a,b}	19.3	
	4	9.5 ^c	10.8 ^c	33.1 ^{a,b}	21.6	

BMI=body mass index; T2D=type 2 diabetes; OSA=obstructive sleep apnea; Data are mean values ± standard error.

SES: 1, <\$47,297; 2, \$47,297–60,774; 3, \$60,775–76,924; 4, >\$76,924

^a, Significant versus African-Americans

^b, Significant versus Hispanic-Americans

^c, Significant versus Caucasian-Americans

Table 2:

Characteristics of weight loss and regain by race.

	African-Americans	Hispanic-Americans	Caucasian-Americans	Total	Significance
MWL (kg)	39.3±1.2 ^a	39.1±1.6	42.3±0.9 ^c	40.8±0.65	0.0595
MWL (% of baseline)	30.3±0.7 ^{b,c}	32.5±0.9 ^a	32.9±0.5 ^a	32.0±0.4	0.011
Time to nadir (days)	439.4±10.2	435.0±14.3	438.6±8.1	428.3±5.8	0.97
Nadir weight	88.5±1.5 ^b	78.2±2.1 ^{a,c}	85.6±1.2 ^b	85.3±0.9	0.0003
Maximal regain	12.7±0.7 ^{b,c}	8.6±1.0 ^a	8.7±0.6 ^a	10.0±0.4	<0.0001
Time to maximal regain (days)	916.6±50.2	795.5±70.2	843.2±39.9	859.0±28.5	0.32

Data are mean ±SE

^a, Significant versus African-Americans

^b, Significant versus Hispanic-Americans

^c, Significant versus Caucasian-Americans

Table 3:

Patient characteristics by quartile of WR/nadir at last visit

	<1.49%	1.50–6.25%	6.26–14.29%	>14.30%	P
N	156	158	155	157	
Age	46.7±0.9	46.8±0.9	46.4±0.9	44.2±0.9	0.11
Sex (% female)	80.8	75.9	86.5	84.1	0.088
Pre-BMI	48.0±0.8	44.7±0.5	46.0±0.8	48.2±0.7	0.0008
MWL (kg)	40.0±1.5	37.2±1.1	39.5±1.3	46.7±1.3	<0.0001
WR/MWL (%)	-12.2±1.8	10.1±0.5	24.2±0.9	45.7±1.8	<0.0001
WR/nadir (%)	-4.6±0.5	3.9±0.1	10.0±0.2	24.6±1.0	<0.0001
Interval (days)	1569±69	1145±53	1570±69	2007±68	<0.0001
WR/MWL per month (%)	-0.36±0.05	0.72±0.05	1.03±0.07	1.22±0.08	<0.0001
Race (%)AA	26.9	25.3	36.1	40.8	0.017
	HA	14.1	17.1	19.4	15.3
	CA	59.0	57.6	44.5	43.9
T2D (%)	59.6	63.3	61.3	55.4	0.53
OSA (%)	34.0	29.7	40.6	38.2	0.19
HTN (%)	69.9	68.4	65.8	68.2	0.89
Osteoarthritis (%)	14.1	8.9	12.9	8.3	0.26
DLD (%)	41.7	47.5	38.1	40.8	0.39
SES (%)	1	32.5	30.1	31.1	27.9
	2	27.8	28.9	27.0	31.2
	3	15.9	17.3	23.0	21.4
	4	23.8	23.7	19.0	19.5

Data are mean ±SE; WR: weight regain from nadir; Pre-BMI: BMI prior to RYGB; MWL: maximal weight loss; interval: days from date of RYGB to last available weight; AA: African American; HA: Hispanic American; CA: Caucasian American; Pre-op comorbidities: T2D: type 2 diabetes; OSA: obstructive sleep apnea; HTN: hypertension; DLD: dyslipidemia; SES: Socioeconomic status quartile based on zip code median income

Table 4:

Summary of multivariate cox regression analysis

Factor	HR	WR/nadir 1.49%			WR/nadir >6.25%			WR/nadir>14.29%					
		Lower	Upper	P	HR	Lower	Upper	P	HR	Lower	Upper	P	
Race													
AA	1.323	1.062	1.649	0.0126	1.398	1.080	1.810	0.0396	1.551	1.096	2.195	0.0349	
HA	1.208	0.925	1.577	0.166	1.212	0.880	1.669	0.2399	1.087	0.699	1.690	0.7114	
CA	(reference)	-	-	-	(reference)	-	-	-	(reference)	-	-	-	
MWL	1.008	1.000	1.015	0.045	1.015	1.007	1.023	0.0001	1.025	1.014	1.036	<0.0001	
DM	1.049	0.866	1.271	0.624	0.939	0.750	1.175	0.5834	1.027	0.755	1.399	0.8633	
No DM	(reference)	-	-	-	(reference)	-	-	-	(reference)	-	-	-	
Age													
Age	1.014	1.005	1.024	0.0019	1.012	1.001	1.022	0.0272	0.989	0.976	1.003	0.1131	
Pre-BMI													
Pre-BMI	0.981	0.967	0.995	0.0077	0.979	0.963	0.994	0.0082	0.963	0.942	0.985	0.0011	
SES													
SES	0.923	0.847	1.006	0.0687	1.005	0.907	1.114	0.9216	1.054	0.916	1.213	0.4596	
Female													
Female	0.986	0.778	1.250	0.910	1.305	0.964	1.766	0.0844	1.098	0.731	1.649	0.6538	
Male													
Male	(reference)	-	-	-	(reference)	-	-	-	(reference)	-	-	-	

WR/nadir: weight regain as percent of nadir weight; AA: African American; HA: Hispanic American; CA: Caucasian American; Pre-BMI: pre-operative body mass index; SES: socioeconomic status based on zip code median income; DM: diabetes mellitus; MWL: maximum weight loss (at nadir); HR: hazard ratio