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Preoperative weight gain might increase risk of gastric bypass surgery

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Abstract

Background—Weight loss improves the cardiovascular and metabolic risk associated with obesity. However, insufficient data are available about the health effects of weight gain, separate from the obesity itself. We sought to determine whether the changes in body weight before open gastric bypass surgery (OGB) would have a significant effect on the immediate perioperative hospital course.

Methods—A retrospective chart review of 100 consecutive patients was performed to examine the effects of co-morbidities and body weight changes in the immediate preoperative period on the hospital length of stay and the rate of admission to the surgical intensive care unit (SICU).

Results—Of our class III obese patients undergoing OGB, 95% had 1 co-morbid condition and an overall SICU admission rate of 18%. Compared with the patients with no perioperative SICU admission, the patients admitted to the SICU had a greater degree of insulin resistance (homeostatic model analysis—insulin resistance 10.8 ± 1.3 versus 5.9 ± 0.5 , $P = .001$), greater serum triglyceride levels (225 ± 47 versus 143 ± 8 mg/dL, $P = .003$), and had gained more weight preoperatively ($.52 \pm .13$ versus $.06 \pm .06$ lb/wk, $P = .003$). The multivariate analyses showed that preoperative weight gain was a risk factor for a longer length of stay and more SICU admissions lasting 3 days, as were a diagnosis of sleep apnea and an elevated serum triglyceride concentration.

Conclusion—The results of the present retrospective study suggest that weight gain increases the risk of perioperative SICU admission associated with OGB, independent of the body mass index. Sleep apnea and elevated serum triglyceride levels were also important determinants of perioperative morbidity. In view of the increasing epidemic of obesity and the popularity of bariatric surgical procedures, we propose that additional clinical and metabolic research focusing on the understanding of the complex relationship among obesity, positive energy balance, weight gain, and perioperative morbidity is needed.

Keywords

Morbid obesity; surgical risk; positive energy balance; hospital length of stay; perioperative morbidity

Disclosures

The authors have no commercial associations that might be a conflict of interest in relation to this article.

Gastric bypass surgery (GB) has been increasingly considered for the treatment of morbidly obese patients with a body mass index (BMI) of $\geq 40 \text{ kg/m}^2$. According to the current prevalence rates of obesity, approximately 15 million obese individuals in the United States qualify for surgical treatment [1]. The technical and surgical advances, as well as the long-term efficacy, have been responsible for the increasing popularity of open GB (OGB) [2]. However, obesity surgery remains a complex treatment modality, with a high potential for complications, especially in patients with multiple medical co-morbidities. The average operative mortality rate of OGB has been estimated at .2–.3%, increasing to .7% in the first 30 days after surgery. Morbidity rates as great as 20–30% have been reported during the same period [3]. Several risk factors have been identified, including surgeon experience and the presence of pre-existing co-morbid conditions such as hypertension and sleep apnea [4–9]. The degree of obesity is often considered a risk factor in OGB [10], thus necessitating that extremely obese patients lose weight preoperatively [6,11,12]. Although sufficient evidence has clearly documented the cardiovascular and metabolic benefits of modest weight loss [13–17], it has been unclear whether preoperative weight loss can actually reduce the surgical risks associated with GB in morbidly obese patients. A recent meta-analysis of 19 studies revealed a significant increase in the 1-year postoperative weight loss and a decreased operative time for patients who had lost weight preoperatively [18].

In the present study, we considered whether the preoperative body weight changes could influence the immediate perioperative morbidity associated with OGB. We reviewed the data from 100 consecutive morbidly obese patients undergoing OGB in an ethnically diverse urban referral center. Our findings suggest that preoperative weight gain increases the risk of admission to the surgical intensive care unit (SICU) and is associated with longer hospitalization (length of stay [LOS]) during the immediate perioperative period. The effect of weight gain was independent of obesity as measured by the BMI. Other risk factors included sleep apnea and elevated serum triglyceride levels. These data will help in planning future research designed to reduce the risk of bariatric surgical procedures in morbidly obese patients.

Methods

We conducted a retrospective chart review of 100 consecutive morbidly obese patients who underwent open gastric bypass surgery (OGB) at Boston Medical Center from January 1, 2001 to November 30, 2002. The patients were entered into the surgical program after initial screening and diagnostic workup according to the established criteria [19–21]. Each patient was individually screened and counseled on the basic principles of weight management by the bariatric dietitian to help promote 5–10% weight loss by the time of surgery; however, weight loss was not strictly mandated.

Surgical procedure

The surgical procedure was performed approximately 9–12 months after the initial presentation. All patients included in the present study underwent open Roux-en-Y gastric bypass with a gastric pouch 30–60 cm³ in capacity and a limb length of either 60 or 120 cm, determined by a BMI of <50 or $>50 \text{ kg/m}^2$, respectively. A gastrostomy tube was placed in the stomach remnant to provide additional fluids and medications, if needed. All procedures were performed by the same surgeons.

Hospital course and discharge

After surgery, all patients followed our standard postoperative protocol for OGB. In brief, after a 24–48-hour period of nothing by mouth, the patients were allowed 30 mL/hr of water for 24 hours (stage 1). If tolerated, the patients were advanced to stage 2, which consisted of

no-added sugar clear liquids for another 24 hours, followed by stage 3 (no-added sugar full liquids for another 24 hours). The patients were considered for discharge after 24 hours at the stage 3 diet. Thus, in the absence of complications, the expected hospital length of stay was 4–5 days.

The patients were admitted to the SICU for management of complications, as determined by the surgeon, in conjunction with the surgical service. In the immediate postoperative period, the reasons for admission included acute respiratory failure and hemodynamic instability (requirements for the treatment of hypotension and fluid resuscitation and/or the need for administration of vasoactive pressor agents). Subsequent complications resulting in SICU admission included predominately respiratory failure with severe atelectasis requiring aggressive pulmonary therapy such as continuous positive airway pressure or intubation, respiratory failure secondary to pulmonary embolism, bleeding requiring resuscitation, and sepsis with a primary infection such as pneumonia or peritonitis secondary to a leak.

Statistical analysis

After approval by the institutional review board at the Boston Medical Center, the following information was extracted from the outpatient charts: date of birth, gender, ethnicity, height, initial weight, and the dates of presentation, surgical procedure, admission to and discharge from the SICU, if applicable, and discharge from the hospital. The presence or absence of the following diagnoses was noted from each patient's medical record: hypertension, diabetes, sleep apnea, and blood lipid disorders. Systolic and diastolic blood pressure readings and the fasting insulin and glucose concentrations were also extracted from the charts. The total body weight changes before surgery were calculated from the weight difference between that at the initial presentation and the weight at surgery. Additionally, the changes in body weight are expressed as the average weekly rate (pounds per week) derived from the difference between the weight at surgery and at the patients' last visit, which usually occurred 3–4 weeks before surgery. The assessment of insulin resistance was done using the homeostatic model analysis–insulin resistance (HOMA-IR) [22], calculated as $[\text{fasting insulin } (\mu\text{U/mL}) \times \text{fasting glucose (mM)}] / 22.5$.

The descriptive statistics were calculated first. The patients were grouped by gender and ethnicity for evaluation of the basic clinical characteristics. Differences between the groups were evaluated using univariate analysis of variance (ANOVA). When necessary, pairwise comparisons were made using Tukey's honestly significant difference test. Correlations between continuous variables were made using Pearson's and partial correlation coefficients, as indicated in the "Results" section.

Factors influencing the LOS were initially evaluated using univariate statistical models. The following potential factors were included in the initial analyses: age, gender, race, systolic blood pressure, diastolic blood pressure, initial BMI, rate of preoperative body weight change, HOMA-IR, and a diagnosis of hypertension, diabetes, sleep apnea, and dyslipidemia. As shown in the "Results" section, admission to the SICU was a significant determinant of the LOS. Thus, an additional analysis of the risk factors leading to an SICU admission was undertaken. To ensure that the SICU admission rate was indicative of clinical complications, only data from SICU admissions lasting ≥ 3 days were used in the subsequent analysis. Differences in patient characteristics between the SICU and non-SICU groups were determined using ANOVA. Associations between SICU admission and categorical variables were determined using Pearson's chi-square and likelihood ratio statistical tests. From the analyses, variables showing a possible association with prolonged SICU admission were selected and evaluated further using multivariate statistical models. Multivariate stepwise logistic regression analysis was used to determine the odds ratios for specific variables significantly associated with SICU admission on the univariate analyses as independent risk

factors. In these analyses, the rate of preoperative body weight change was used as a covariate. Additionally, the patients were stratified by quintiles of the preoperative body weight change with the top quintile (weight gain) and lowest quintile (weight loss) included as categorical variables.

Of the 100 consecutive patients studied, only 1 was an Hispanic man. Therefore, the data from that subject were excluded from the statistical analyses. The data are reported as the mean $\pm$ standard error. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS, Chicago, IL). Two-sided *P* values $\leq .05$ were considered significant.

Results

Patient population

The anthropometric and demographic characteristics are summarized in Table 1. The average patient seeking bariatric surgery was 41 years old, with a BMI of 54.5 kg/m². Middle-age white women were the largest group, followed by black women. Minorities were also well represented, with 25% blacks and 14% Hispanics. Of the 100 patients, 95% had ≥ 1 co-morbid conditions, including hypertension, diabetes, sleep apnea, dyslipidemia, pulmonary disease, and degenerative joint disease. The percentage of patients with an increasing number of co-morbidities was 79% for 2 co-morbid conditions, 61% for 3, 26% for 4, 15% for 5, and 8% for 6 co-morbid conditions. Two patients (2%) had all 7 co-morbidities. With the exception of hypertension (a less frequent diagnosis among Hispanic women, *P* < .05, Kruskal-Wallis test), no significant differences were found in the prevalence of co-morbidities among the 5 ethnic/gender groups in Table 1.

On average, patients underwent OGB about 8 months (mean 31.2 $\pm$ 1.5 weeks, range 8.7–97.3) after their initial enrollment. During this interval, 39 patients had lost weight, 60 patients had gained weight, and 1 patient had no net weight change between their initial presentation and OGB. The mean weight loss was 9.4 $\pm$ 2.6 (range 72.4–0.2). Patients who gained weight preoperatively had a mean weight gain of 13.8 $\pm$ 1.7 lb, equivalent to 4.0% $\pm$.4% of the initial body weight.

Hospital LOS

The mean length of the perioperative hospital stay for the total patient population was 6.7 $\pm$ 0.6 days (range 4–48). Despite this large range, most patients (82%) were hospitalized for <1 week after OGB (mode 5 days, *n* = 56). Approximately 8% were hospitalized for ≥ 10 days. As a group, the morbidly obese black men tended to stay longer in the hospital after OGB (overall *P* = .006, ANOVA; post hoc comparisons listed in Table 1). All 6 black men included in the present study had a formal diagnosis of sleep apnea and also had had larger preoperative weight gains. Although most patients were hospitalized for 4–5 days, a significant positive linear correlation was found with the total weight change (*r* = .219, *P* = .032). When expressed as the rate of body weight change (pounds per week), the correlation with the hospital LOS was stronger (*r* = .267, *P* = .009). Also, significant correlations were found between the LOS and the initial BMI (*r* = .268, *P* = .008) and diastolic pressure (*r* = .282, *P* = .005). The correlation with systolic blood pressure was not statistically significant.

Because the preoperative weight change was significantly associated with the LOS, we stratified the patient population by the quintile of weight change before OGB. The patients in the top quintile (*n* = 20) had gained .52 lb/wk (range .52–1.59), with a mean weight gain of .93 $\pm$.07 lb/week. This group of patients had a significantly greater BMI (66.8 versus 51.4 kg/m², *P* < .001) and longer LOS (10.2 versus 5.9 days, *P* = .004). Other characteristics,

including blood pressures and HOMA-IR values, did not differ from those of the rest of the population. Of the 20 patients in this group, 10 (50%) had an extended LOS, defined as ≥ 7 days (top quintile of the LOS). In contrast, only 8 (10.5%) of the 76 patients without preoperative weight gain had a LOS of ≥ 7 days ($P < .001$, chi-square). Additional nonparametric analysis of the differences between the patients hospitalized for ≥ 7 days and the rest of the patient population indicated that only SICU admission and a preoperative weight gain of $\geq .52$ lb/wk were significantly different (likelihood ratio, calculated from the chi-square analysis).

In the lowest quintile of the preoperative weight change, the mean weight loss was $.56 \pm .19$ lb/wk. In this subgroup (weight loss $\geq .20$ lb/wk), 1 (6.5%) of 16 patients had an extended hospital stay compared with 17 of the remaining 83 patients in this group (20.5%, $P = .179$, chi-square). The mean LOS ($6.2 \pm .9$ versus $6.8 \pm .7$ days, $P = .69$), BMI, insulin resistance, and age were not statistically different between the group with preoperative weight loss and the rest of the patient population.

SICU admission

Of the 100 patients, 18 were admitted to the SICU for a mean duration of 8.8 days (range 1–36, median 4 ± 2.4). Of these 18 patients, 14 (78%) were white, 2 were black, and 2 were Hispanic (11% each). The gender distribution was slightly in favor of men compared with the total population studied (39% of the SICU group versus 21% of the total patient population were men). A comparison of patient characteristics between the SICU and non-SICU groups is listed in Tables 2 and 3. Relative to the 81 patients without an SICU admission, those admitted to the SICU weighed more ($P = .088$, ANOVA) and were slightly older (44.7 ± 2.3 versus 40.5 ± 1.1 years, $P = .1$, ANOVA) although these differences were not statistically significant. Most notable in the SICU group was the greater degree of insulin resistance, determined by HOMA-IR assessment (10.7 ± 1.3 versus 5.9 ± 0.6 , $P = .001$, ANOVA). No significant differences were seen in the HOMA-IR values between the ethnic and gender groups among the patients admitted to the SICU. Two other differences were noted in the SICU group. The preoperative weight gain and baseline serum triglyceride levels were significantly greater among the SICU patients. As expected, admission to the SICU increased the LOS significantly, from a mean of 5.9 ± 0.5 days to 10.8 ± 2.0 days ($P = .035$, ANOVA). Although the systolic and diastolic blood pressure tended to be greater in the SICU patients, these differences were not statistically significant.

We also compared the gender and racial distributions and prevalence of co-morbidities between the SICU and non-SICU subgroups, for admissions lasting ≥ 3 days (Table 3). Prolonged SICU admissions were greatest among patients with sleep apnea and diabetes (approximately 26% for each subgroup compared with 14% for the total population). Sleep apnea was the most prevalent co-morbid condition among the SICU patients, at about 85% ($P < .005$). Of the patients with a diagnosis of sleep apnea, 25.9% were admitted to the SICU compared with only 2.2% of patients not previously diagnosed with sleep apnea. Using the results summarized in Table 3, a likelihood ratio analysis suggested that sleep apnea (likelihood ratio 12.8, $P = .001$) and, possibly, diabetes (25.8% of those with diabetes versus 10.3% without diabetes were admitted to the SICU, likelihood ratio 3.7, $P = .068$) were significantly associated with SICU admission. Only 2 black patients ($<5\%$ of the black subgroup) were admitted to the SICU, making it difficult to interpret the importance of race as a risk factor from the data presented in Table 3.

As listed in Table 3, 36.8% of patients in the top quintile of preoperative weight gain (gain of $\geq .52$ lb/wk) were admitted to the SICU compared with only 10.3% of those without preoperative weight gain. These results indicated a significant likelihood ratio of 6.9 for the association between preoperative weight gain and SICU admission rate ($P = .009$).

From the univariate analysis results, the risk of perioperative complications necessitating SICU admission appeared to increase with an increasing BMI, the rate of preoperative weight gain (pounds per week during final 3–4 weeks), increasing degree of insulin resistance, and elevated serum triglyceride levels. A pre-existing diagnosis of sleep apnea and diabetes also appeared to be risk factors for SICU admission. Therefore, to determine which of these variables independently resulted in a prolonged SICU admission (≥ 3 days), a multivariate logistic regression analysis was used. The results of this analysis are summarized in Table 4. Only a diagnosis of sleep apnea and a preoperative weight gain were associated with an increased risk of an SICU admission. The fasting triglyceride level, but not BMI or HOMA-IR, was a significant covariate. Therefore, the results of the present study suggest that for morbidly obese patients undergoing OGB, the risk associated with preoperative weight gain is independent of the degree of existing obesity, as measured by the BMI.

In the lowest quintile of the preoperative rate of weight change, the mean weight loss was $56 \pm .19$ lb/wk. In this subgroup (weight loss $\geq .20$ lb/wk), 3 (18.8%) of 16 patients were admitted to the SICU compared with 15 (18.1%) of the 83 remaining patients (likelihood ratio for association between preoperative weight loss and SICU admission rate .004, $P = .95$).

Discussion

The results of the present retrospective study suggest that weight gain is an important determinant of perioperative morbidity in patients undergoing OGB, independent of the BMI. We have based our conclusion on the observation that the rate of weight change before OGB had a stronger association with the hospital LOS and prolonged admission to the SICU (≥ 3 days) than did the BMI. The patients' BMI at OGB was not significantly related to the perioperative LOS or SICU admission rate in all statistical models in which the rate of preoperative weight change was included. Other studies have previously failed to show a significant association between the BMI and bariatric surgical risk [4]. Similarly, our results have confirmed the findings of others that hypertension and sleep apnea [9] are likely risk factors in patients undergoing OGB.

As a retrospective chart review, the present study had several limitations. First, it had an unbalanced design, limiting its power to detect possible differences related to ethnicity, gender, and age. Second, all the data were collected from routine clinical visits, which contributed to the statistical variance, further limiting its power. An examination of the analysis presented in Table 4 provides an assessment of the statistical power of the present study. In the patients with no weight gain before surgery, the probability of a longer hospital stay (≥ 7 days) was .11. For a study population of 100, α of 0.05, power of .80, and R^2 of .35, a minimal detectable odds ratio of 2.71 would be required (with a critical z of 1.64) [23]. Despite these limitations, the effect for weight gain on the hospital stay and prolonged SICU admission achieved statistical significance because of its relatively large magnitude. Furthermore, in the logistic regression model, the triglyceride level (Table 4), which was a significant risk factor, might also be a marker of excess nutrient intake and a positive energy balance. However, the present study with its imbalanced and uncontrolled design might not have had adequate statistical power to evaluate the effect of other potentially important risk factors such as hypertension, diabetes, and insulin resistance.

Another limitation of the present study was that we did not determine the specific causes and perioperative complications that could have led to the differences in the LOS. Thus, although it was possible that conditions other than perioperative morbidity could have contributed to the longer LOS, this interpretation was most unlikely given the present data.

As noted in the “Methods” section, decisions about discharging patients were determined using a uniform protocol for postoperative care that was applied to all patients. Feeding was progressed systematically, with each patient required to complete a minimal observation time at dietary stages 1–3. Thus, the minimal hospital stay was 4 days (only 6 patients), with most ($n = 56$) patients discharged on hospital day 5, as mandated by the protocol. Therefore, the longer hospitalization times can only be explained by either the presence of complications or an intolerance to diet advancement. Furthermore, the longer LOSs were mostly accounted for by the SICU admissions (Table 2). Also, to decrease the possibility of “routine” admission to the SICU, which might not have signified a significant medical complication, we excluded those admissions that lasted <3 days. Thus, the data in Table 4 represent the risk of SICU admission for significant medical complications requiring intensive monitoring and treatment.

Although the published data are replete with studies documenting the benefits of weight loss [24–28], much less is known about the physiologic effects and clinical implications of weight gain. This is especially important because of the possibility that body weight can be gained more rapidly than it is usually lost in the morbidly obese with a high prevalence of binge-eating behavior. The mechanisms by which weight gain (positive energy balance) affects perioperative morbidity in obese patients are unclear and remain mostly hypothetical. However, we noted from the present study that hypertension (diastolic blood pressure) and sleep apnea were also associated with a longer hospital LOS. Both of these conditions have been associated with insulin resistance [29–32] and elevated serum insulin and leptin levels [31,33], all of which are also influenced by the energy balance [34–37]. In addition to weight gain, our results have implicated insulin resistance with increased SICU admissions and LOS. Thus, it is possible that rapid weight gain further aggravates cardiovascular and respiratory pathophysiology, especially within the context of pre-existing insulin resistance in morbidly obese patients. Another possible mechanism by which a positive energy balance might adversely affect health is through de novo fatty acid synthesis from carbohydrate precursors. During periods of excessive carbohydrate consumption and a positive energy balance, the synthesis of new fatty acid molecules could potentially consume nicotinamide adenine dinucleotide phosphate in a manner that could affect the antioxidative capacity of the individual. This could especially be more damaging in obese individuals with increased levels of oxidative stress related to pro-inflammatory adipokines [38]. Controlled prospective and metabolic studies are needed to address this hypothesis. Finally, another possible explanation of the association between rapid weight gain and perioperative morbidity is acute enlargement of liver size, which is a known risk factor in morbidly obese patients undergoing OGB [39]. However, data on the liver size were not available for the present study.

The potential benefits of weight reduction before OGB could not be addressed by the present study, which was limited by its small sample size and a bias favoring weight gain during the preoperative period. Although all patients were initially counseled on the benefits of preoperative weight loss, they did not participate in a formal weight reduction program. Hence, we had no data to describe the compliance of the patients to the dietary and exercise protocols. That more patients actually gained weight by the time they had been scheduled for surgery was not surprising given the nature of the disease. As a retrospective study, the data we have presented are indicative of the natural history of body weight fluctuations in morbidly obese patients enrolled in a surgical obesity treatment program. Although no previous randomized controlled trials have shown the benefit of preoperative weight loss in extremely obese patients, a recent trial suggested shorter operating room times and LOSs among subjects with a BMI >50 kg/m² who had lost weight preoperatively after intragastric balloon treatment [24]. A meta-analysis of 19 studies also recently demonstrated significant

beneficial effects for preoperative weight loss on operative times and 1-year weight loss outcomes [18].

It should be emphasized that the present study was not a comprehensive attempt to define the risk factors inherent to OGB. Our results are preliminary owing to the study limitations. However, the clinical significance of these observations has been highlighted by the increasing popularity of OGB, especially among high-risk patients with multiple co-morbidities. We believe that weight gain should be avoided, especially in the last few weeks before OGB. Additional definitive clinical trials and metabolic studies are required to fully understand the effect of energy balance separately from the body mass. Thus, despite the diversity of our patient population, the formal evaluation of several possible risk factors, such as race and gender, as well as the interaction between these risk factors, was not possible owing to the limited statistical power of the present study. Although definitive conclusions about gender and ethnicity require additional research, the trend for longer hospitalization among the black men in the present study was likely related to the high prevalence rate of sleep apnea in these patients. This observation is consistent with that of previous studies showing a significantly greater prevalence of sleep apnea among obese black patients [40,41], with black obese men diagnosed with sleep apnea especially at risk of hypoxemia.

Finally, open OGB has been mostly replaced by laparoscopic procedures. Although laparoscopic GB might represent a lesser risk to the patient, our observations in the present study remain relevant because of the definite risk from any surgical procedure in the morbidly obese patient population. The possibility of reducing the risk from any surgical procedure is clinically important and ethically relevant, regardless of how small this risk might be.

Conclusion

Despite the limitations of the present retrospective study, we have reported several novel findings that could potentially improve the treatment of obese patients undergoing OGB. First, we recommend that patients enrolled in bariatric surgery treatment programs also participate in medical weight reduction before their surgical procedure. Although the potential benefit of preoperative weight loss needs to be evaluated further in prospective clinical studies, we believe the data we have presented strongly suggest a high degree of surgical risk for patients who undergo OGB with a positive energy balance. Therefore, the prevention of weight gain and, preferably, the induction of a negative energy balance and active weight loss, is an important priority for morbidly obese patients to achieve in preparation for OGB and, possibly, all major surgical procedures.

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General patient characteristics

Table 1

Race and gender	Patients (n)	Age (yr)	BMI (kg/m ²)	LOS (d)	SA (%)	DM (%)	HTN (%)	Lipid diagnosis (%)	HOMA-IR
White women	46	41.6 ± 1.5	51.8 ± 1.6	5.8 ± 0.2	52.2	23.9	43.5	32.6	6.2 ± 4.6 (37)
White men	15	45.7 ± 2.5	58.2 ± 3.4	6.7 ± 1.2	60.0	46.7	73.3	53.3	10.6 ± 5.5 (13)
Black women	19	41.6 ± 2.4	55.3 ± 2.1	5.4 ± 0.20	36.8	26.3	31.6	47.4	5.8 ± 7.0 (13)
Black men	6	40.2 ± 1.4	51.7 ± 5.1	13.5 ± 8.3 ^{*†‡}	83.3	50.0	66.7	33.3	5.1 ± 1.0 (3)
Hispanic women [§]	13	34.9 ± 2.3	60.4 ± 5.9	9.0 ± 9.6	69.2	38.5	15.4	38.5	5.9 ± 3.2 (11)
All	99	41.3 ± 1.0	54.5 ± 1.3	6.7 ± 0.6	53.5	30.7	42.6	38.6	6.8 ± 5.2 (77)

Data presented as mean ± standard error of mean, unless otherwise noted; number in parentheses indicates number of data points included in analysis, if different from number of patients.

BMI = body mass index (at patient presentation); LOS = length of hospital stay; SA = sleep apnea; DM = diabetes mellitus; HTN = hypertension; HOMA-IR = homeostatic model analysis–insulin resistance; ANOVA = analysis of variance.

^{*} $P = .005$ for black men versus white women (ANOVA and post hoc comparison using Tukey's test).

[†] $P = .033$ for black men versus white men (ANOVA and post hoc comparison using Tukey's test).

[‡] $P = .007$ for black men versus black women (ANOVA and post hoc comparison using Tukey's test).

[§] Data from 1 Hispanic man not shown.

Table 2

General patient characteristics stratified by intensive care unit admission

Parameter	SICU admission		ANOVA F value (df)	P value
	Yes	No		
Age (yr)	44.8 ± 2.3	40.5 ± 1.1	2.612 (1, 97)	.109
BMI (kg/m ²)	59.2 ± 3.6	53.5 ± 1.3	2.968 (1, 96)	.088
Preoperative weight change* (lb/wk)	.52 ± .13	.06 ± .06	9.506 (1, 94)	.003
LOS (d)	10.9 ± 2.0	5.8 ± .5	12.321 (1, 97)	.001
Systolic blood pressure (mm Hg)	137.2 ± 6.8	129.9 ± 2.1	1.828 (1, 97)	.180
Diastolic blood pressure (mm Hg)	82.9 ± 3.4	82.0 ± 1.2	.085 (1, 97)	.771
HOMA-IR	10.8 ± 1.3	5.9 ± .6	11.583 (1,75)	.001
Total cholesterol (mg/dL)	213.5 ± 13.3	201.6 ± 3.2	1.651 (1, 88)	.202
LDL cholesterol (mg/dL)	136.6 ± 10.9	123.7 ± 3.0	2.327 (1, 85)	.131
HDL cholesterol (mg/dL)	44.4 ± 1.6	48.4 ± 1.4	1.738 (1, 90)	.191
Triglycerides (mg/dL)	225.4 ± 47.7	143 ± 7.5	9.594 (1,90)	.003

SICU = surgical intensive care unit; LDL = low-density lipoprotein; HDL = high-density lipoprotein; other abbreviations as in Table 1.

Data are mean ± standard error of mean.

* Difference in body weight between patients' last visit and surgery.

Table 3

Summary of selected variables in relationship to prolonged* surgical intensive care unit admission

Variable	With condition admitted/without condition admitted [†]	SICU admissions (%)	Likelihood ratio [‡]	P value [§]
Gender			3.7	.073
Female	11.4/30.0	60.0		
Male	30.0/11.4	40.0		
Race			3.9	.140
White	19.7/18.5	80.0		
Black	4.2/34.0	6.7		
Hispanic	14.3/23.9	13.3		
Hypertension	20.4/10.7	60.0	2.0	.172
Sleep apnea	25.9/2.2	93.3	12.8	.001
Diabetes	25.8/10.3	53.3	3.7	.068
Dyslipidemia	17.9/13.6	46.7	0.34	.578
Weight gain [¶]	36.8/10.3	46.7	6.9	.009

SICU = surgical intensive care unit.

* SICU admissions 3 days.

[†] Ratio of ICU incidence in patients with and without condition.[‡] Likelihood ratio calculated from chi-square analysis.[§] Two-sided asymptotic significance.[¶] Patients with average weight gain of .52 lb/wk.

Table 4

Summary of logistic regression analysis of possible risk factors for prolonged* surgical intensive care unit admission

Parameter	Coefficient B $\pm$ SE	Odds ratio	P value
Factors			
Sleep apnea	3.19 $\pm$ 1.52	24.3	.036
Diabetes	1.75 $\pm$ 1.48	5.7	.24
Weight gain [†]	2.83 $\pm$ 1.28	17.0	.026
Covariates			
Initial BMI (kg/m ²)	.062 $\pm$.04	1.1	.12
HOMA-IR	-.207 $\pm$.12	1.0	.81
Triglycerides (mg/dL)	.031 $\pm$.1	1.1	.013

Abbreviations as in Table 1.

* Data from SICU admissions $\geq$ 3 days.

[†] Patients with average weight gain of $\geq$.52 lb/wk during last month before surgery.