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Associations of Pregnancy After Bariatric Surgery with Long-Term Weight Trajectories and Birth Weight: LABS-2 Study

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Abstract

Objective: To examine whether pregnancy following bariatric surgery affects long-term maternal weight change and offspring birth weight.

Methods: Using data from the Longitudinal Assessment of Bariatric Surgery (LABS)-2 study, we used linear regression to evaluate percent change in total body weight over a 5-year follow-up period among reproductive-aged women who underwent Roux-en-Y gastric bypass (RYGB) or laparoscopic adjustable gastric banding (LAGB), and the association of bariatric procedure type and offspring birth weight.

Results: Of 727 women with preoperative age of 36.1 ± 6.3 years (mean ± SD) and body mass index of 46.9 ± 7.0 kg/m^2, 80 (11%) reported at least one pregnancy. After adjusting for covariates, percent change in total body weight was not significantly different between women who became pregnant and those who did not during a 5-year follow-up period (β = 2.02, 95% CI: −1.03 to 5.07; P = 0.19). Additionally, mean birth weight was not significantly different between mothers who underwent RYGB vs. LAGB (P = 0.99).

Conclusions: Postoperative pregnancy did not diminish long-term weight loss in women in the LABS-2 study. Our finding of comparable weight loss is relevant for providers counseling women of reproductive age on weight-loss expectations and family planning following bariatric surgery.

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AUTHOR CONTRIBUTIONS: CSH advised on statistical analyses, drafted and revised the manuscript, and approved the manuscript as submitted. BMW, JEM, WJP, and AP designed the study. CSH and JQP contributed to the design of the study. MRE prepared the dataset and conducted statistical analyses. All authors contributed to the interpretation of the data, critically reviewed the manuscript, and approved the manuscript as submitted.

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Keywords

bariatric surgery; pregnancy; weight loss; obesity; birth weight

Introduction

Bariatric surgery has emerged as the most efficacious option for initial and sustained weight loss in adults with severe obesity (1). However, individual weight loss is variable and may be followed by some weight rebound, which can also vary by bariatric surgery type and is typically detectable beginning the first year after surgery (1, 2). Numerous physiological and behavioral factors may contribute to variability in initial weight loss and rebound. These include family environment, genetics, level of adoption of healthy-lifestyle practices, differences in gut hormone levels and central nervous system receptor responses to such hormones, postoperative use of medications which may be associated with changes in weight (i.e., diabetes medications, antipsychotics, and glucocorticoids), or remission, improvement, lack of change in or development of medical conditions that may influence weight. The increase in obesity and severe obesity prevalence in reproductive-age women coincides with a rise in bariatric surgery in this population that constitutes approximately half of all patients undergoing bariatric surgery procedures (3-7). Pregnancy represents a unique metabolic state for women that might result in a subsequent propensity for sustained weight gain after delivery (8, 9).

Women with an elevated body mass index (BMI) who become pregnant have an increased likelihood of having a large-for-gestational age (LGA; i.e., birth weight >90th percentile for gestational age and sex) or macrosomic (i.e., >4,000 gm) infant (10, 11). Infants who are LGA or macrosomic have an increased risk of later-life obesity and development of other chronic diseases (12-14). Alternatively, multiple systematic reviews and meta-analyses have shown that the risk of a small-for-gestational age (SGA; i.e., birth weight <10th percentile for gestational age and sex) infant is increased after bariatric surgery (15-20), which also has potential short- and long-term health consequences. The increased risk of SGA might be mediated by the nutrient-restricted maternal environment, in which body weight is undergoing a dramatic and rapid reduction. This is believed to be an issue following procedures which include a malabsorptive component (e.g., gastric bypass), particularly related to micronutrients, as opposed to those that are purely restrictive (e.g., gastric banding) (20, 21). This difference is important in planning for surgery and subsequent pregnancies.

Few studies have investigated whether pregnancy after bariatric surgery influences long-term weight loss response. The available studies had important limitations such as small sample size, lack of applicability to a U.S. population, or retrospective design (22-26). In two available studies, weight loss after bariatric surgery was significantly greater among women who did not become pregnant compared to those who did (22, 23). In three other studies, pregnancy after bariatric surgery was not associated with significantly different weight loss compared to non-pregnant groups (24-26).

To provide additional data on this question, we utilized a large, prospective, and well-characterized cohort study, the Longitudinal Assessment of Bariatric Surgery (LABS)-2 study (27), to examine whether postoperative pregnancy affected weight loss trajectories in reproductive-aged women, and the implications of the type of bariatric surgery on offspring birth weight.

Methods

Study population

A full description of the LABS-2 study methods can be found elsewhere (27, 28). In brief, the study enrolled and prospectively followed a large cohort of adults undergoing bariatric surgery for the first time between 2006 and 2009 in one of 10 hospitals from various areas across the U.S. These participants were studied for up to seven years. Because our analysis is focused on pregnancy, we limited this population using criteria described along with our additional methods below.

Inclusion and Exclusion criteria

Female participants from the LABS-2 cohort who subsequently underwent either Roux-en-Y gastric bypass (RYGB) or laparoscopic adjustable gastric banding (LAGB) and were preoperatively aged 18 to 45 years were included in our analyses (Figure 1). We excluded participants who were missing weight measurements at the 5-year follow-up visit. Among women who became pregnant, we also excluded those for whom no due date was reported, those whose pregnancy started ≤6 months or ≥5 years after bariatric surgery, and those who had a multifetal gestation (twins or greater).

Measures

Outcomes.—Participants' weights were measured at baseline and at annual postoperative follow-up visits through 5-years. Generally, weight was measured at in-person follow-up visits with the Tanita Body Composition Analyzer (model TBF-310; Tanita Corporation of America, Inc., Arlington Heights, IL). When not obtained in-person, clinical weight was recorded as measured by research or medical personnel using other scales. If neither in-person nor clinical weights were available, participants' self-reported weight was used. Self-reported weights in the LABS-2 study have been previously described in detail and validated (29). The primary outcome, percent change in total body weight, was calculated as the difference between weight at baseline and the 5-year follow-up visit weight divided by baseline weight. Our secondary outcome, birth weight, was collected through participant self-report in the LABS-2 Reproductive Health Pregnancy Questionnaire.

Exposures.—Postoperative pregnancy status was our independent variable for evaluating percent change in total body weight. Details about pregnancy were prospectively collected through participant self-report using the LABS-2 Reproductive Health Pregnancy Questionnaire. Last menses date and gestational age were not obtained as part of data collection using this questionnaire. Estimated gestational age was back-calculated by subtracting 40 weeks from women's self-reported due date to identify a date for the start of pregnancy, then the difference between that date and the pregnancy end date was calculated (birth date for live birth; date of still birth; date pregnancy ended for ectopic or tubal pregnancy, miscarriage, or abortion). For the analysis of birth weight, the independent variable was bariatric surgery type (RYGB or LAGB), which was obtained from the Surgeon's Questionnaire Form.

Covariates.—Maternal age, height, race, ethnicity, education, household income, smoking status, and diabetes diagnosis were assessed at baseline. BMI was calculated as weight in kilograms divided by height in meters square, using height at baseline and weight for each follow-up visit. Diagnosis of diabetes was previously described (30) and used hemoglobin A1c (HbA1c) (≥6.5%; 48 mmol/mol) and fasting glucose levels (>6.9 mmol/L), and self-report involving diabetes status, use of antidiabetic medications, and being hospitalized due to a diabetes-related complication. Additional covariates collected through self-report on the Reproductive Health Pregnancy Questionnaire were: expected due date, gestational weight gain, receipt of prenatal care (yes or no), gestational diabetes occurrence (yes or no), pregnancy outcome (live birth or not a live birth), and mode of delivery (vaginal delivery or C-section).

Statistical Analyses

Descriptive statistics were used to summarize participants' baseline characteristics stratified by pregnancy status as well as characterize live births by bariatric procedure type (RYGB or LAGB). Frequencies and percentages were reported for categorical variables. Means and standard deviations (SD) or medians with interquartile range (IQR) were reported for continuous variables. Comparisons for continuous, normally distributed variables were performed with a *t* test. Multivariable linear regression was used to evaluate the relationship between postoperative pregnancy and 5-year percent change in total body weight, adjusted for covariates measured at baseline. A minimally-adjusted model included bariatric procedure type (RYGB or LAGB), preoperative age (years), and preoperative BMI (kg/m^2) *a priori*. We additionally evaluated education (high school diploma or less or any post high school education); household income (≤ $25,000, $25,000 to 49,999, or ≥ $50,000); diabetes status; and smoking status (never, former, or current smoker) for model inclusion with a 10% change-in-estimates approach (31). β-coefficients, 95% confidence intervals (CI), and p-values were reported from minimally-adjusted and fully-adjusted models.

Some LABS-2 participants had more than one pregnancy during the study period. To assess the influence of multiple pregnancies on weight-loss trajectories, we conducted a sensitivity analysis removing participants with two or more pregnancies from the dataset. We repeated the model building process described above to confirm the same variables were included then compared the values of point estimates and confidence intervals with our original model to determine whether results had substantially changed. Additionally, some women delivered within 6 months before our study cutoff of 5 years. These participants would have reduced time for postpartum weight loss. To assess this potential bias, we conducted another sensitivity analysis excluding these women and assessed model results as before. Women who had a live birth would likely gain more weight during pregnancy and retain weight over a longer period of time compared to women who did not have a live birth. Therefore, we conducted an additional sensitivity analysis comparing weight-loss trajectories of women who had a live birth to all women who had a pregnancy. Statistical analyses were conducted in SAS 9.4 (Cary, NC, USA) and R version 3.4.2 (R Core Team, Vienna, Austria).

Results

After applying eligibility criteria of preoperative age of 18 to 45 years, having undergone RYGB or LAGB procedure, and an available weight measurement at the 5-year follow-up visit, our cohort consisted of 727 women (Figure 1). Of these 727, 80 (11.0%) women reported at least one pregnancy and 647 (89.0%) did not report a pregnancy during our 5-year study period. Regarding bariatric procedure type, 556 (76.5%) women had undergone RYGB and 171 (23.5%) women had undergone LAGB. Among the RYGB group, 65 (11.7%) women reported at least one pregnancy after bariatric surgery and 491 (88.3%) did not report a pregnancy. Fifteen women (8.8%) who underwent LAGB reported at least one pregnancy after bariatric surgery and 156 (91.2%) women reported no pregnancy.

In our cohort of 727 women, preoperative age was 36.1 ± 6.3 years (mean ± SD) and baseline BMI was 46.9 ± 7.0 kg/m^2; 81.4% were identified as white, 74.3% reported post-high school education, and 44.7% reported household income less than $50,000. Women who became pregnant during the study period were, on average, younger, were more likely to be Hispanic, and less likely to have diabetes and to have ever smoked. Other baseline characteristics, including preoperative BMI status, educational attainment, income, and race were comparable by postoperative pregnancy status (Table 1). Characteristics of women stratified by pregnancy status and bariatric procedure type are available in supplementary material (Supplemental Table S1).

The average number of months between bariatric procedure and subsequent pregnancy was 31.4 ± 13.6 and 26.9 ± 13 for RYGB and LAGB, respectively. For our cohort, the mean percent change in total body weight between baseline and 5-year follow up was −26.8 ± 13.0. Figure 2 displays weight loss trajectories for each participant stratified by pregnancy status and bariatric procedure type. In our minimally-adjusted model (adjusted for procedure type, preoperative age, and BMI), percent change in total body weight between baseline and 5-years of follow-up, on average, was not significantly different between women who became pregnant compared to those who did not ($\beta = 1.81$, 95% CI: −1.11 to 4.74; $P = 0.22$; Table 2). After accounting for additional factors of maternal education, income, and smoking status, our findings for percent change in total body weight were not altered ($\beta = 2.02$, 95% CI: −1.03 to 5.07; $P = 0.19$; Table 2).

Of the 80 women who reported a pregnancy during our study period, 56 reported one pregnancy and 24 reported two or more pregnancies. Results from our sensitivity analysis limited to women with a single pregnancy were not meaningfully different in postoperative weight change than the findings that included all women with a pregnancy during the study period (Supplemental Table S2). We conducted an additional sensitivity analysis excluding 5 women who delivered within 6 months before the 5-year study cutoff. We did this to evaluate a potential bias of reduced time for these women to have postpartum weight loss. This sensitivity analysis also did not meaningfully differ from our model with all women who delivered during the study period (Supplemental Table S3). In our final sensitivity analysis, we compared weight-loss trajectories between women who had a live birth and all women who had a pregnancy. Again, we found no meaningful differences in our model of women who had a live birth compared to all women who had a pregnancy (Supplemental Table S4).

Of the 80 first pregnancies observed in our cohort, 66 were live births. Besides a higher likelihood of gestational diabetes in women who underwent RYGB, other outcomes including gestational weight gain, prenatal care, method of delivery, and gestational age at the time of delivery were not substantially different between the surgical groups (Table 3). Women who underwent RYGB and LAGB had offspring who were not significantly different in birth weight (RYGB: 3,157 g [SD: 448] vs. LAGB: 3,159 g [598]; P = 0.99). We also explored the relationship between time-to-pregnancy after surgery and infant birth weight and observed no obvious trend between these outcomes (Table 3).

Discussion

Using a large, longitudinal dataset of individuals who underwent bariatric surgery, we found that women who subsequently became pregnant, compared to those who did not, did not experience significantly different percent change in total body weight between baseline and 5-years of follow-up. Our data suggest that postoperative pregnancy is not a significant determinant of weight loss variability or a significant contributor to weight rebound following bariatric surgery.

Previous studies that investigated pregnancy and weight loss after bariatric surgery demonstrated mixed results (22-26). Of these, only one utilized a prospective design (23) and several were of shorter duration. Our study had a 5-year follow-up period and prospectively measured postoperative weight outcomes. In general, studies with a shorter follow-up period (28 to 36 months) found significantly greater weight loss among women who did not become pregnant (22, 23). Consistent with our findings, three studies with a generally longer study period (30 to 63 months) found no significant difference in postoperative weight loss between women who had a subsequent pregnancy and those who did not (24-26). Only one previous study analyzed a U.S. cohort, which occurred at one academic center (22). As such, our multi-site study adds findings from a broader U.S. population to the body of literature, which is important because weight loss after bariatric surgery may vary within and between countries with differing obesogenic environments. Finally, our sample size of 80 women with pregnancy data after bariatric surgery is one of the largest to date, and only one other identified study had a larger sample of women who became pregnant after bariatric surgery (n = 84); however, that study used a potentially less rigorous retrospective design (25).

Despite these strengths, several study limitations need to be acknowledged. The majority of women in our dataset were white, which limits the generalizability of our finding to U.S. women from minority groups. Most women, in consultation with their surgery team, chose to undergo RYGB (n = 65) and a much smaller number underwent LAGB (n = 15), limiting conclusions that can be made comparing outcomes of these two surgeries. However, the number of patients undergoing LAGB has decreased with time and the procedure is not commonly done in current practice. Because of the limited number of women who underwent LAGB and had a subsequent pregnancy, we did not assess the presence of interaction of pregnancy by surgery type or stratify our analyses, which would likely not been adequately powered. Bariatric surgery type was a statistically significant covariate in our model and should be explored in future studies as an effect modifier. Although data are recorded for some LABS-2 participants up to 7-years of follow-up, we chose a cutoff of five years. In-person visits were not done in year six because of reduced study funding, and funding was stopped before data collection in year 7 could be completed on the entire cohort. The potential selection bias of excluding these participants is uncertain, but characteristics between those with data up to the 7-year follow-up and those with data at the 5-year follow-up visit were comparable (data not shown). Additionally, in our study, birth weight data were collected through self-report. It is possible that there was an information bias, but it would likely be non-differential between the RYGB and LAGB groups. Interpretation of our findings should be made with the context of this potential bias.

Although there is a robust body of literature that has evaluated the influence of pregnancy after bariatric surgery on birth weight outcomes (20), few studies have assessed these outcomes by bariatric procedure type. We found that women who underwent RYGB had significantly greater weight loss than those who underwent LAGB. Despite this maternal weight-loss difference, in our study, we found that birth weight was not significantly different by bariatric procedure type. Because we did not have data on sex of the offspring, we could not calculate SGA or test for differences in SGA by bariatric procedure type. The three studies that have previously examined bariatric procedure type and birth weight outcomes have reported mixed results (32-34). One found that bariatric procedure type was not significantly related with the odds of having an SGA birth (32). Another study found that RYGB increased the risk of SGA and significantly reduced birth weight (33). Similarly, the third study found that women who underwent RYGB had significantly lower mean birth weight than those who underwent LAGB (34). Given the inconsistency in findings of bariatric procedure type and birth weight outcomes, well-designed prospective studies with larger samples are needed to clarify these associations.

Because of the concern for SGA births, especially during periods of rapid weight loss, general clinical guidance is for women to wait at least one to two years after bariatric surgery to become pregnant. Yet, this guidance does not appear to be based on existing evidence (19, 24), and patients do not seem to adhere to these guidelines (35). The timing between bariatric surgery and pregnancy on birth weight outcomes has also produced conflicting findings (19, 36-38). Because of small sample sizes in our study, we could not conduct formal statistical tests of timing of postoperative pregnancy and birth weight outcomes. Recent suggestions for timing between bariatric surgery and pregnancy are that it be tailored to the individual woman based on how weight loss is progressing and nutritional deficiencies are being treated (19).

In summary, using data from the large, prospective LABS-2 cohort, we found that postoperative pregnancy did not significantly change long-term weight loss during our 5-year study period. This information is of potential value to clinicians and patients of reproductive age when considering the effectiveness of these approaches should they subsequently become pregnant. On the other hand, the influence of bariatric surgery on short- and long-term outcomes on offspring remains an outstanding question, particularly because of bariatric surgery increasing the risk of SGA. Few interventions have been identified as efficacious towards reducing the adverse effects of high pre-pregnancy BMI on offspring (39, 40). As the rates of maternal obesity in the U.S. and worldwide continue to increase, evidence-based preconception interventions to reduce the harmful effects of high pre-pregnancy BMI to the mother and offspring are needed. If an evidence-based intervention, such as bariatric surgery, were shown to be an effective preventive option, it could have a profound effect not only on maternal health, but also on prevention of the intergenerational transmission of obesity.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What is already known about this subject?

- Bariatric surgery causes sustained weight loss in individuals with severe obesity.
- Pregnancy is a unique period in which rapid weight gain occurs with the potential to affect weight-loss response in individuals who had bariatric surgery.

What are the new findings in your manuscript?

- In a large, well-characterized U.S. cohort, long-term weight loss following bariatric surgery was not diminished by a subsequent pregnancy.
- Prepregnancy bariatric procedure type was not associated with differences in offspring birth weight.

How might your results change the direction of research or the focus of clinical practice?

- Additional large, prospective cohort studies in the U.S. are needed to fully understand the influence of bariatric surgery before pregnancy on short- and long-term health outcomes of women and their offspring.
- Women and their health care providers can use our findings to better understand weight-loss expectations and family planning when considering bariatric surgery or a postoperative pregnancy.

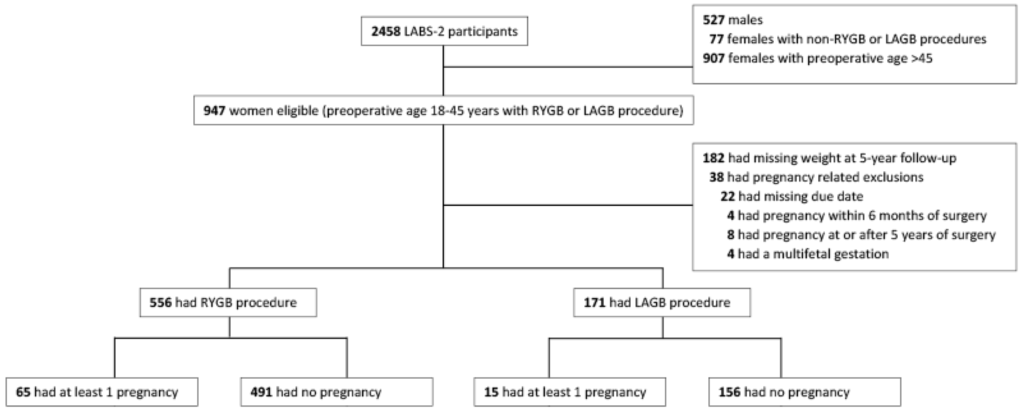

Figure 1.
Study flow diagram.

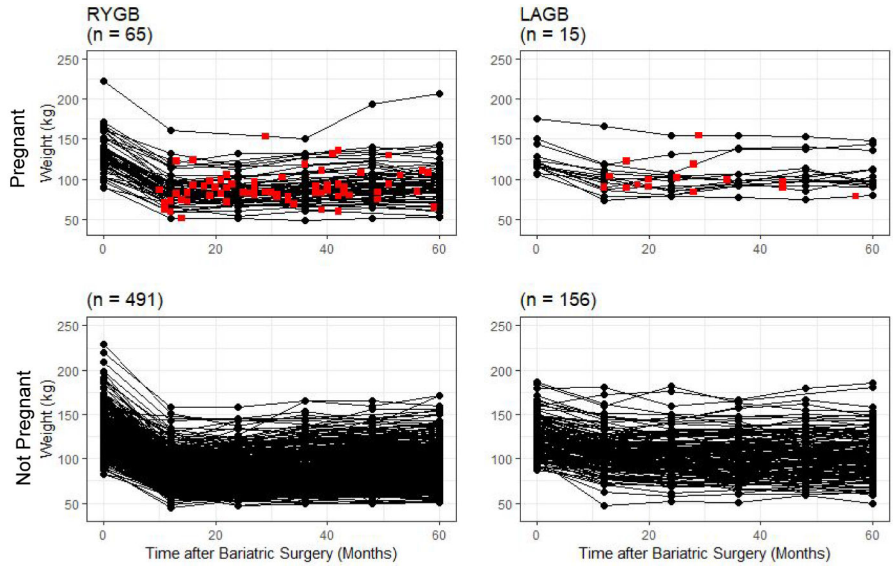

Figure 2.

Individual weight trajectories by pregnancy status during postoperative follow-up (pregnant, not pregnant) and bariatric procedure type (Roux-en-Y gastric bypass [RYGB], laporaocopic gastric banding [LAGB]). Red dots represent estimated date of conception for each pregnancy.

Table 1.

Baseline characteristics of study participants by pregnancy status during the 5-years study period

Characteristic	Pregnant (n = 80)	Not pregnant (n = 647)
Age (years), mean (SD)	30.0 (4.4)	36.9 (6.1)
Weight (kg), mean (SD)	131.0 (20.8)	128.1 (21.7)
BMI (kg/m2), mean (SD)	46.9 (6.1)	46.9 (7.1)
Diabetes, n (%)	10 (12.5)	155 (24.0)
Education, n (%)		
HS diploma or less education	13 (16.3)	119 (18.4)
Post HS education, including college	52 (65.0)	394 (60.9)
Graduate or professional degree	7 (8.8)	87 (13.4)
Missing	8 (10.0)	47 (7.3)
Hispanic, n (%)	9 (11.3)	33 (5.1)
Household income, n (%)		
Less than $25,000	13 (16.3)	116 (17.9)
$25,000 - 49,999	29 (36.3)	167 (25.8)
$50,000 - 74,999	13 (16.3)	141 (21.8)
$75,000 - 99,999	11 (13.8)	87 (13.4)
$100,000 or more	4 (5.0)	73 (11.3)
Missing	10 (12.5)	63 (9.7)
Race, n (%)		
White	67 (83.8)	525 (81.1)
Black	10 (12.5)	96 (14.8)
Other	2 (2.5)	18 (2.8)
Missing	1 (1.3)	8 (1.2)
Smoking status, n (%)		
Never smoker	55 (68.8)	381 (58.9)
Current smoker	3 (3.8)	39 (6.0)
Former smoker	22 (27.5)	219 (33.8)
Missing	0 (0.0)	8 (1.2)

Note: Data are mean (SD) or n (%) where indicated.

Table 2.

Multiple linear regression for percent change in total body weight between baseline and 5 years

Variable	Minimally-Adjusted Model Coefficient (95% CI)	P-value	Fully-Adjusted Model Coefficient (95% CI)	P-value
Pregnancy	1.81 (−1.11, 4.74)	0.22	2.02 (−1.03, 5.07)	0.19
RYGB surgery	−12.96 (−15.01, −10.92)	<0.01	−13.74 (−15.89, −11.58)	<0.01
Age	0.07 (−0.08. 0.22)	0.30	0.09 (−0.07, 0.25)	0.26
BMI (kg/m2)	−0.07 (−0.19, 0.06)	0.35	−0.07 (−0.21, 0.06)	0.28
More than HS education			2.09 (−0.22, 4.41)	0.08
Smoking status				0.03
Never smoker			Reference	
Current smoker			−4.11 (−7.99, −0.22)	0.04
Former smoker			−2.02 (−3.96, −0.08)	0.04
Household income				0.13
Less than $25,000			Reference	
$25,000 to $49,999			−0.07 (−2.65, 2.52)	0.96
$50,000 or more			−1.98 (−4.46, 0.50)	0.12

Note: RYGB, Roux-en-Y gastric bypass; BMI, body mass index; CI, confidence interval.

Table 3.

Self-reported characteristics among live births (N = 66) by procedure

	RYGB	n	LAGB	n
Maternal age (years), mean (SD)	29.4 (4.5)	56	32.9 (2.6)	10
Gestational weight gain (kg), mean (SD)	13.3 (7.3)	45	14.0 (12.3)	8
Received prenatal care, n (%)	54 (96.4)	56	9 (90.0)	10
Gestational diabetes, n (%)	5 (8.9)	56	0 (0.0)	10
Delivery method, n (%)		56		10
Vaginal delivery	33 (58.9)		6 (60.0)	
C-section	21 (37.5)		3 (30.0)	
Missing	2 (3.6)		1 (10.0)	
Infant gestational age (weeks), mean (SD)	38.9 (1.6)	56	37.9 (5.0)	10
Infant birth weight (gm)	3157 (448)	56	3159 (598)	9
Infant birth weight by timing of pregnancy after index surgery (gm), median (IQR) *		56		9
7-12 months	2835 (2807, 2863)	5	NA	1
13-24 months	3133 (2835, 3402)	16	3388 (2396, 3898)	4
25-36 months	3317 (3005, 3600)	14	3147 (3005, 3203)	3
37-48 months	3118 (3005, 3289)	13	NA	1
49-60 months	2991 (2849, 3558)	8	NA	0

Note: RYGB, Roux-en-Y gastric bypass; LAGB, laparoscopic adjustable gastric banding; SD, standard deviation; IQR, interquartile range.

Measures may not add up to 66 because of missing data.

* NA reported for categories with one or fewer observations.