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ORIGINAL CONTRIBUTIONS

Adverse Neonatal and Obstetric Outcomes in a 20-year Brazilian Retrospective Cohort of Pregnancies after Bariatric Surgery

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Abstract

Purpose Evaluation of obstetric and neonatal outcomes in a Brazilian retrospective cohort of pregnancies after Roux-en-Y gastric bypass (RYGB), regarding the 2009 Institute of Medicine (IOM) recommendations about gestational weight gain (GWG) and RYGB-conception interval. Additionally, search for intrapopulation risk factors for small gestational age (SGA) offspring and mental health assessments.

Material and methods Retrospective analysis of 132 singleton pregnancies after RYGB. Obstetric and neonatal outcomes were analyzed with stratification in above, below, or meeting the target regarding GWG guidance, and 0–12, 12–47, and ≥48 months for RYGB-conception interval. SGA risk factors were identified through Poisson regression analysis.

Results GWG below the recommendations was associated with prematurity (p 0.003). Late conceptions (≥48 months) were associated with iron deficiency (p 0.025). Parenteral iron prescription was a protective factor for SGA, with a relative risk of 0.41 (95% CI, 0.20–0.85; p 0.017), and GWG below target was a SGA risk factor, with a relative risk of 4.68 (95% CI, 1.48–14.8; p 0.008). In all, 15.2% of patients had psychopharmacological treatment during pregnancy, and 7.6% received a diagnosis of postpartum depression. Any alcohol and tobacco consumption were reported in 3.8 and 6.8% of patients, respectively.

Conclusion The recommendations regarding GWG apply to the RYGB population, and surgery-conception intervals should be individualized. The parenteral iron prescription was a protective factor for SGA, and GWG below the recommendations of the IOM was a risk factor for SGA. Psychological and psychiatric care should be offered to every possible pregnancy after RYGB.

Keywords Obesity · Bariatric surgery · Pregnancy · Mental health · Gestational weight gain

Introduction

Obesity is a chronic disease and represents an epidemy with notorious growth in the last decades. More than 600 million adults are obese worldwide, and in 2015, more than 2.4 million deaths were attributed to obesity [1]. The prevalence of obesity in adults in Brazil was estimated at 26.8% in 2019, being slightly more prevalent in women (30.2%) than in men

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(22.8%) [2]. Besides, there was a 60% increase in obesity in adults between 2006 and 2016 [3].

The association between obesity, infertility, and miscarriage is well established [4], in addition to increased rates of gestational diabetes mellitus (GDM) and preeclampsia [5]. Newborns of obese mothers have a higher risk of complications such as shoulder dystocia, traumatic brain injury, brachial plexus injury, macrosomia, meconium aspiration, and admission to the intensive care unit (ICU) [4–6].

Bariatric surgery (BS) is a safe and effective treatment option for obesity, resulting in a reduction in all-cause mortality [7]. Approximately half the patients submitted to BS are young adult females, and the procedure can decrease their risk of many obstetric and neonatal adverse events [8]. In most countries, including Brazil, BS is indicated for people with BMI $\geq$ 40 kg/m^2, independently of associated disease, and BMI $\geq$ 35 kg/m^2 in association with comorbidities with proved benefit after surgical treatment of obesity. Female infertility was included in the normative published by the Federal Council of Medicine in 2016 and now represents an excellent tool for improving obstetric and neonatal outcomes in women with obesity and who desire to get pregnant [9].

Recent consensus published by Ciangura et al. (2019) and Shawe et al. (2019) shed light on uncertain points in pregnancy after BS, such as the better surgery-conception interval, ideal gestational weight gain (GWG), and diagnosis and management of GDM. Mental health and substance abuse in these patients are also issues with scarce evidence. Congenital malformations, need for cesarean delivery and neonatal mortality associated with BS present conflicting evidence [10, 11].

Pre-pregnancy counseling and adequate contraception are essential to avoid unplanned and early conception after BS. Previous data has identified low adherence to efficacious contraceptive methods after Roux-en-Y gastric bypass (RYGB). Mody et al. reported that, among women 18–45 years old, 16.3% used no contraception and 16.3% had used oral contraceptives 2 to 12 months after surgery, an option with controversial efficacy after malabsorption component surgery [12]. Ginstman et al., in a questionnaire study performed in Sweden, reported that 24.8% of women did not receive any guidance to avoid conception in the first 12 months after surgery, and almost one-third of the cases did not use any contraceptive method in this period [13].

Pregnancy after BS is associated with a reduction in birth weight, a lower rate of large for gestational age (LGA) newborns, and a higher rate of small for gestational age (SGA) newborns [14]. A positive correlation was found between maternal protein supplementation and birth weight, while a negative correlation was found between maternal iron status and birth weight [15].

Another uncertain area is the ideal GWG after BS. In singleton pregnancies in patients without BS, the 2009 guidelines of the Institute of Medicine (IOM) advise a 12.5–18 kg gain in malnourished patients; 11.5–16 kg gain in patients with normal body weight; 7–11.5 kg gain in overweight subjects; and 5–9 kg gain in obese patients [16]. Both excessive weight gain and malnourishment worsen neonatal outcomes and are associated with comorbidities throughout life, including repercussions in the next generation [17, 18]. Currently, there is no high-quality evidence in patients after BS, and the actual consensus extrapolates recommendations from obese patients that have not undergone BS [10, 11].

A previous meta-analysis showed fewer depressive symptoms and lower use of antidepressants after BS. Evidence regarding BS and alcohol abuse, self-harm behavior, and suicide were mixed [19]. A recent Australian cohort study has shown an increased risk of mental illness after BS, with a higher risk of psychiatric hospitalization, 5-fold increased risk of self-harm, and almost 10% of deaths after BS by suicide [20]. Jans et al. reported a higher risk of depression and anxiety in pregnant obese patients after BS in comparison to pregnant obese patients without BS [21].

Despite being the second country in the world concerning the performance of BS and associated with an increasing number of women submitted to surgical obesity treatment, data about pregnancy and BS in Brazil are still scarce.

The present study aims to research the risk factors related to obstetric and neonatal adverse outcomes through an intrapopulation analysis, stratifying with the 2009 guidelines from the IOM on GWG evaluation and surgery-to-conception interval. Additionally, we will evaluate patients' mental health, substance abuse prevalence, and unplanned pregnancies to assess contraception use.

Material and methods

Participants

This is a retrospective cohort study of patients who became pregnant during follow-up after RYGB at the Center for Obesity and Metabolic Syndrome (COM) at São Lucas Hospital of the Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS), in southern Brazil, from 2000 to 2020.

The protocol of BS selection followed the Brazilian Federal Council of Medicine's indications for the procedure. According to international guidelines, patients underwent multidisciplinary evaluation before being considered ready for the procedure, with a routine psychiatric evaluation. Surgery was contraindicated in cases of severe and untreated mental illness [22, 23]. After surgery, they were instructed to schedule an outpatient follow-up when they wanted to become pregnant or found out they were pregnant. Monthly or quarterly appointments were scheduled according to clinical discretion. The daily minimal systematic nutritional supplementation includes two tablets of multivitamins (at least 10 mg of zinc, 1 mg of copper, vitamin A 5000 UI, selenium 20 mcg, and vitamin K 65 mcg), folic acid 5 mg up to 12 weeks of Gestational Age (GA), calcium citrate 1000 mg and increased dietary calcium intake, vitamin D 1000–3000 UI (to be adjusted to blood levels of 25 OH vitamin D), chelated iron 500 mg (once or twice a day, distant from calcium intake), vitamin B 100 mg and B6 100 mg, and Vitamin B12 5000 μcg by intramuscular injection every month or 1000 μcg sublingual twice a week. If ferritin levels were below 20 ng/mL, and hemoglobin below 11 g/dL, we prescribe intravenous (IV) or intramuscular (IM) iron supplements (iron sucrose 200 mg once a week for five weeks — total 1000 mg, or ferric carboxymaltose 500–1000 mg single dose). The majority of the multidisciplinary team remained the same during the 20 years of the analyzed data.

All singleton pregnancies in adult patients, older than 18 years old, after RYGB and at least one outpatient clinic appointment during pregnancy or until six months after delivery or abortion, reported from January 1, 2000, to April 30, 2020, were enrolled in the analysis. Exclusion criteria were multiple pregnancies, patients with lost to follow-up during pregnancy, and when obstetric and neonatal outcomes data were missing. A flowchart with the patient selection process is shown in Fig. 1.

Clinical assessment was extracted from medical records and included parity, age, weight, BMI at RYGB, conception, delivery or abortion, excess weight loss (EWL), GWG, and interval (in months) between RYBG and conception. When measured data were not available, declarative data were used. We evaluated the self-reported nutritional supplementation adherence at conception and the gestational planning status (planned or unplanned pregnancies).

Obstetric outcomes, including diabetes mellitus (gestational and pregestational), hypertensive disease, preeclampsia and eclampsia, and surgical complications (bowel obstruction and internal hernia), were reported. Additional parenteral iron supplementation during pregnancy was also assessed.

Neonatal outcomes evaluated included admission to the intensive care unit (ICU), congenital malformations, and neonatal anthropometric measures. Newborns with birth weight above the 90^{th} percentile were considered LGA, while those below the 10^{th} percentile were considered SGA compared to the Brazilian population's standard [24]. GA at delivery was classified as preterm (<37 weeks), at term (37 to 41 weeks), and post-term (≥42 weeks).

All patients provided written consent at pre-surgical evaluation. The HSL-PUCRS Ethics Committee approved the study protocol on May 8, 2020. The patients' data were retrieved from medical records. Obstetric and neonatal outcomes were obtained by phone contact in 51 cases.

Laboratory data

Biochemical data were collected at the first, second, and third gestational trimesters and included hemoglobin and ferritin. Anemia was defined as hemoglobin < 11 g/dL, and iron deficiency was defined as ferritin <30 ng/mL.

Mental Health

Mental health assessment was carried out before surgery with stabilization of psychiatric diseases. Any alcohol, tobacco, and illicit drug consumption were actively screened for during pregnancy, and psychiatric disorders under pharmacological treatment were recorded at every outpatient clinic attendance. Additional postpartum depression diagnosis by the psychiatric team or self-reported were registered.

Statistical analysis

Statistical analysis included mean ± standard deviation or median and percentiles 25 and 75 (P25–75) for continuous variables and absolute numbers, respectively. For mean comparisons, Student's *t*-test or ANOVA complemented by the Tukey test was used for independent samples. Frequency parameters were analyzed with percentages, and categorical variable associations were analyzed by Pearson's Chi-square test or Fisher's exact test. Confounding factors were controlled with Poisson multivariate regression analysis. The criteria for variable entrance into the analysis were a bivariate analysis $p < 0.20$, but only those with $p < 0.05$ remained in the final model. A $p \leq 0.05$ was considered significant. Data were analyzed with Statistical Package for Social Sciences (SPSS) software, version 21.0 (IBM Corp., Armonk, NY).

Results

Maternal baseline characteristics are reported in Table 1. A total of 209 singleton pregnancies were screened for eligibility. 77 cases were excluded from the analysis due to the exclusion criteria. The final analysis enrolled 132 pregnancies from 118 different patients: 117 first pregnancies, 13 second pregnancies, and 2 third pregnancies.

Considering first pregnancies after RYGB, the preoperative BMI was 48 ± 10.19 kg/m^2, with 81.1% (±26.55) excess weight loss until conception. A little over one-third of patients (39.3%) had a previous pregnancy and 6% reported a previous abortion.

The prevalence of diabetes mellitus was 6.1%, 4.6% being GDM, and 1.5% pregestational diabetes, which required insulin therapy during pregnancy. Hypertensive pregnancy disease occurred in 9.1% of patients, with 3% treated for

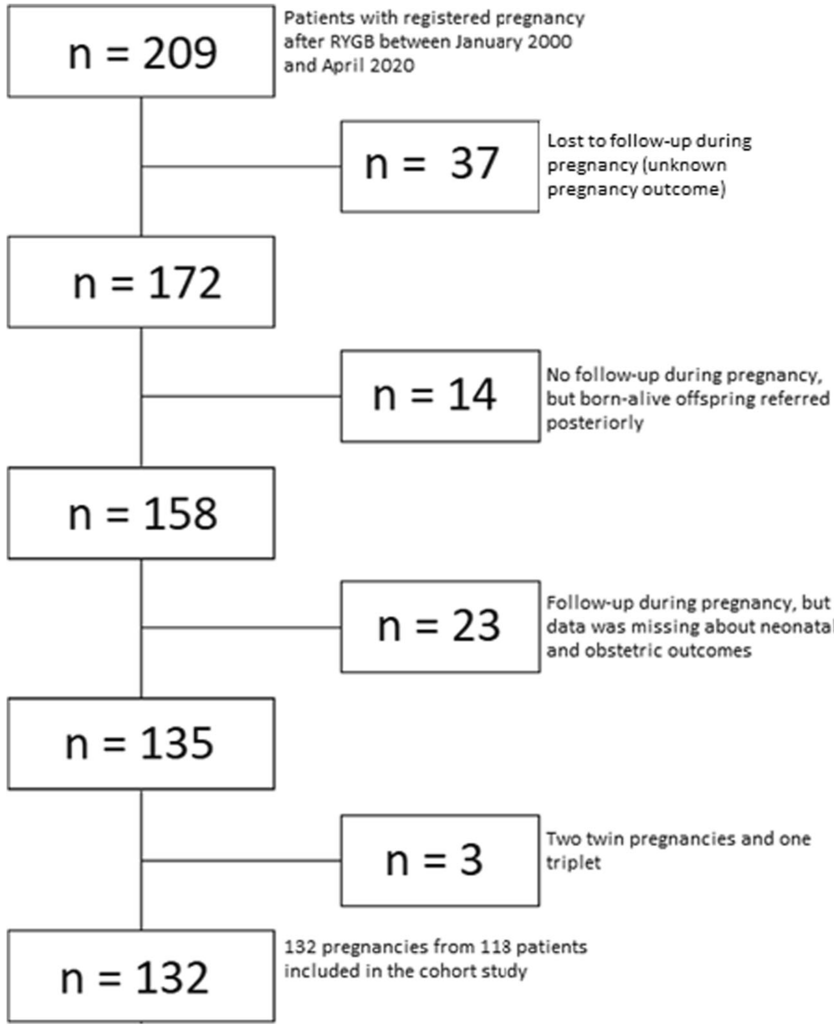

Fig. 1 Flowchart showing the patients selection process

hypertensive disease (without preeclampsia) and 6.1% for preeclampsia. No cases of eclampsia were reported.

There were no deaths related to mental disorders in the cohort. Only one case of psychiatric hospitalization during pregnancy occurred (0.8%), with preterm delivery induced by premature labor (delivery at 36 weeks of gestational age, 2400 g birth weight, and SGA). During pregnancy, psychopharmacological treatment was reported in 20 patients (15.2%), 2 of them for bipolar disorder and 18 for depression or anxiety. The pharmacological treatment duration, prescribing physician (obstetrician, psychiatrist, or other), and those under exclusive psychotherapy treatment for mental disorders during pregnancy were not assessed. Another 10 patients (prevalence of 7.6%) had a diagnosis of postpartum depression. Any alcohol consumption was reported in five patients (3.8%), and tobacco in nine patients (6.8%). No illicit drug use was recorded.

The fetal and neonatal characteristics are described in Table 2. Among singleton pregnancies, 17.8% of offspring were SGA, and only one offspring (0.8%) was LGA; 52.2% were male and 47.8% were female. In all, 9.3% of newborns required neonatal ICU admission, and 3.8% presented with a fetal malformation. There were three cases of cardiac malformation, including interatrial communication, arterial duct aneurysm, and aortic coarctation; one case of deafness, visual abnormality, microcephaly, and clubfoot, currently under genetic investigation; and only one case of anencephaly, with intrauterine diagnosis at 18 weeks gestation (data not shown).

The prevalence of surgical complications was 3.8% (5/132). The cases are briefly reported in Supplementary Table 1. No maternal or fetal deaths related to surgical complications were identified.

Almost half of the entire cohort had a planned pregnancy (48.5%), 43.9% had an unplanned pregnancy, and 7.6% were not reported. Among unplanned pregnancies, there were nine cases of abortion (15.5% of unplanned pregnancies). We also evaluated the contraception method in unplanned pregnancies, which is shown in Table 3.

Statistical analysis considering the RYGB-conception interval is detailed in Table 4. We stratified the cohort into three

Table 1 General maternal and obstetric characteristics (132 pregnancies)

Age at RYGB (first pregnancies), years	29.6 ± 4.63
Pre-surgical weight (first pregnancies), kg	123.5 ± 24.62
Pre-surgical BMI (first pregnancies), kg/m^2	48 ± 10.19
Age at first conception (post-RYGB), years	33.3 ± 4.66
Age at second conception (post-RYGB), years	33.9 ± 4.69
Age at third conception (post-RYGB), years	40 ± 5.10
BMI at conception, kg/m^2	29 ± 5.40
%EWL at conception, kg	81.1 ± 26.55
RYGB-conception interval, months	30 (16–49)
Abortion	14/132 (10.6)
Cesarean delivery (first pregnancies)	74/105 (70.47)
Vaginal delivery (first pregnancies)	31/105 (29.52)
Gestational weight gain, kg	10.23 ± 7.73
Diabetes mellitus	8/132 (6.1)
Gestational hypertensive disease	12/132 (9.1)
Previous pregnancy (first pregnancies)	46/117 (39.3)
Previous abortion (first pregnancies)	7/117 (6)
Illicit drug abuse during pregnancy	0
Alcohol consumption	5/132 (3.8)
Tobacco consumption	9/132 (6.8)
Pharmacological treatment of depression, anxiety, or bipolar disorder	20/132 (15.2)
Postpartum depression (excluding previous depression, anxiety or bipolar disorder)	10/132 (7.6)
Psychopharmacological treatment during pregnancy or postpartum depression	30/132 (22.7)
Psychiatric hospitalization	1/132 (0.8)

Data are presented as means ± SDs, proportions (n, %), or medians (interquartile ranges)

large groups: 0–12 months (hereinafter mentioned as early conception), 12–47 months, and ≥48 months (late conception). There was an increase in iron deficiency in the late conception group ($p = 0.025$). Despite the absence of statistical significance, we also observed a greater prevalence of anemia and parenteral iron prescriptions in the late conception group. There was no difference in diabetes and hypertensive disease between the three groups, but the overall prevalence was low.

As expected, there was a tendency for a higher association of congenital malformation and prematurity in the late conception group (nevertheless, without statistical significance), considering an almost 5-year variation in mean age between the early conception and late conception groups. The psychopharmacological treatment prevalence was similar in the three groups. In our cohort, cesarean delivery was higher in the 12–47 months group (p 0.031). The majority of early pregnancies were unplanned ($p < 0.001$). In the anthropometric analysis, the 12–47 months group had the highest %EWL (p 0.004),

Table 2 Fetal and neonatal characteristics

Appropriate for gestational age (live-born)	94/118 (79.7)
Large for gestational age (>90%) (live-born)	1/118 (0.8)
Small for gestational age (<10%) (live-born)	21/118 (17.8)
Birth weight (live-born), grams	3165 (2800–3365)
Birth length (live-born), centimeters	48 (47–50)
Neonatal ICU admission (live-born)	11/118 (9.3)
Congenital malformation	5/132 (3.8)
Male sex	59/113 (52.2)

Data are presented as medians (interquartile ranges) or proportions (n, %)

Table 3 Contraception use in unplanned pregnancies

Unplanned pregnancies n (frequency)	58 (43.9)
None	19 (32.8)
Injectable contraceptive (intramuscular)	4 (6.9)
Condom	11 (19)
Oral contraceptive	19 (32.8)
Vaginal ring	1 (1.7)
Intrauterine dispositive	1 (1.7)
Not reported	3 (5.2)

Data are presented in proportions (n, %)

Table 4 Statistical analysis between different timing of conception after RYGB

N	<12 months 22/132 (16.7%)	12–47 months 72/132 (54.5%)	≥48 months 38/132 (28.8%)	*p*
Maternal age, years	30.9 ± 4.8[a]	32.9 ± 4.7[a]	35.6 ± 3.4[b]	<0.001
Anemia	6/21 (28.6%)	14/70 (20.0%)	14/38 (36.8%)	0.160
Iron deficiency	8/20 (40.0%)	34/66 (51.5%)	26/35 (74.3%)*	0.025
Parenteral iron prescription	12/17 (70.6%)	42/63 (66.7%)	26/33 (78.8%)	0.463
RYGB-conception interval (months)	5.5 ± 3.2	26.9 ± 9.9	73.1 ± 29.1	-
Diabetes mellitus	1 (4.5%)	5 (6.9%)	2 (5.3%)	0.891
Preeclampsia	0 (0.0%)	3 (4.2%)	2 (5.3%)	0.571
Hypertensive disease excluding preeclampsia	1 (4.5%)	3 (4.2%)	1 (2.6%)	0.904
Birth defect	1/21 (4.8%)	1/68 (1.5%)	3/36 (8.3%)	0.232
Birth weight, grams	2947 ± 267	3094 ± 441	3029 ± 675	0.630
Small for gestational age	3/17 (17.6%)	12/65 (18.5%)	6/34 (17.6%)	0.994
Prematurity	2/17 (11.8%)	5/66 (7.6%)	8/32 (25.0%)	0.055
Abortion	4/22 (18.2%)	5/72 (6.9%)	4/38 (10.5%)	0.298
Unplanned pregnancy	21/22 (95.5%)*	29/64 (45.3%)	8/36 (22.2%)	<0.001
Private insurance	13/22 (59.1%)	52/72 (72.2%)	28/38 (73.7%)	0.435
BMI at conception, Kg/m^2	32.0 ± 6.0[b]	28.6 ± 4.9[a]	31.4 ± 6.1[b]	0.009
%EWL at conception, Kg	67.9 ± 21.5[a]	84.1 ± 21.0[b]	74.8 ± 22.7[ab]	0.004
GWG, Kg	3.82 ± 8.27[a]	11.4 ± 7.2[b]	7.52 ± 6.51[a]	<0.001
Poor adherence to RYGB micronutrient supplementation at periconception	0/22 (0.0%)	11/72 (15.3%)	7/37 (18.9%)	0.106
Internal hernia	1/20 (5.0%)	3/68 (4.4%)	0/35 (0.0%)	0.436
Psychopharmacological treatment during pregnancy or postpartum depression	5/20 (25.0%)	17/71 (23.9%)	8/37 (21.6%)	0.908
Alcohol or tobacco consumption	0/20 (0.0%)	9/71 (12.7%)	3/38 (7.9%)	0.212
Cesarean delivery	8/17 (47.1%)	53/67 (79.1%)*	23/33 (69.7%)	0.031

Data are presented as means ± SDs or proportions (n, %)

*Statistically significant association by the residual test adjusted to 5% significance.

[a,b] Same letters do not differ by Tukey's test at 5% significance

Abbreviations: *RYGB*, Roux-en-Y Gastric Bypass; *EWL*, Excess Weight Loss; *GWG*, Gestational Weight Gain

lowest BMI at conception (p 0.009), and highest GWG ($p < 0.001$).

We analyzed obstetric and neonatal outcomes related to GWG, considering the 2009 guidelines of the IOM regarding GWG targets for singleton pregnancies, independently of the RYGB-conception interval. Evaluating the BMI at conception and GWG, pregnancies were stratified as below, above, or meeting the target (Table 5). There was no difference in maternal age at delivery/abortion (p 0.845). Prematurity was associated with GWG under the target of the IOM (p 0.003). There was also a tendency for higher rates of SGA newborns in the below target group (but without statistical significance). A similar finding of hypertensive disease was observed in the above target group. No differences were observed in cesarean delivery, diabetes mellitus or ICU neonatal admission.

We performed a Poisson multiple regression analysis to identify risk factors related to SGA (Table 6). After adjusting for confounding factors, it remained statistically associated with SGA, iron prescription (IV or IM) and the 2009 IOM GWG stratification. For those with an iron prescription (IV or IM), the relative risk of SGA was 0.41 (95% CI 0.20–0.85; p 0.017) and GWG below the 2009 target of the IOM increased the risk of SGA by 4.68 times when compared with the above target group (95% CI 1.48–14.8; p 0.008).

Discussion

There are no guidelines on GWG recommendations for patients after RYGB, and the 2009 recommendations of the IOM are generally extrapolated [10, 11]. In our cohort, we found that, similarly to the population without BS, GWG below the target of the IOM is associated with preterm birth and with a tendency of increased risk of SGA [25] and GWG above

Table 5 Obstetric and neonatal outcomes stratification according to the 2009 guidelines of the IOM regarding gestational weight gain targets for singletons

Total (n)	Meeting target 39/116 (33.6%)	Below target 36/116 (31.0%)	Above target 41/116 (35.3%)	*p*
Age at delivery/ abortion, years	33.5 ± 5.1	33.0 ± 3.4	33.6 ± 5.4	0.845
Prematurity	4/38 (10.5%)	10/35 (28.6%)*	1/40 (2.5%)	0.003
Diabetes mellitus	3/39 (7.7%)	2/36 (5.6%)	2/41 (4.9%)	0.861
Preeclampsia /hypertensive disease	4/39 (10.3%)	0/36 (0.0%)	6/41 (14.6%)	0.067
Cesarean delivery	32/39 (82.1%)	23/35 (65.7%)	28/41 (68.3%)	0.231
SGA	6/38 (15.8%)	11/36 (30.6%)	4/40 (10%)	0.061
ICU admission	5/39 (12.8%)	4/36 (11.1%)	2/41 (4.9%)	0.443

Data are presented as means ± SDs or proportions (n, %). Student's *t*-test or ANOVA complemented by Tukey's test was used for independent samples. Categorical variable associations were analyzed by Pearson's Chi-square test or Fisher's exact test

*Statistically significant association by the residual test adjusted to 5% significance.

Abbreviations: *SGA*, Small for Gestational Age; *ICU*, Intensive Care Unit.

target was associated with hypertensive disease [26]. It appears that the excess GWG, which is related to macrosomia and diabetes mellitus in a population without BS [27], is counterbalanced with the well-consolidated effect of RYGB in reducing diabetes mellitus and birth weight [28]. The only LGA infant (4200 g, born at 41 weeks of GA) in our cohort was born to a mother with a BMI of 33 kg/m^2 at conception, 16 kg of GWG, and without diabetes mellitus. These findings highlight the value of the appropriate GWG vigilance and orientation in the BS population, independently of the surgery-conception interval. Also, it confirms that the guidelines of the IOM are appropriate for patients who have undergone RYGB. Our findings are similar to those found by Grandfils et al., in which GWG above the target was a protective factor against SGA when compared to the gain below the target, but not when meeting the target was the comparator. We agree that larger cohorts could confirm the difference between these two groups as well [29].

Table 6 Poisson multiple regression analysis for the identification of small for gestational age risk factors

Variables	Relative risk	95% CI	*p*
Parenteral iron prescription	0.41	0.20 to 0.85	0.017
GWG classification			
Meeting target	2.21	0.61 to 7.99	0.225
Below target	4.68	1.48 to 14.8	0.008
Above target	1.00		

The relative risk was estimated by Poisson multiple regression analysis, adjusted to predefined confounding factors (private insurance, smoking, alcohol consumption, maternal age, hypertensive disease, diabetes mellitus, anemia, prepregnancy BMI, and RYGB-conception interval)

Abbreviation: *GWG*, Gestational Weight Gain

The ideal BS-conception interval is a controversial topic. Our analysis demonstrated no major difference in neonatal and obstetric outcomes, reinforcing that the benefits of postponing pregnancy and looking for stabilized weight loss can be balanced with the risks of a pregnancy in advanced maternal age; therefore, the interval should be individualized. As demonstrated in Table 4, there was no difference in hypertensive disease outcomes, psychiatric disorder treatment, birth weight, diabetes mellitus, or SGA between the early conception and late conception groups. However, the 12–47 months interval group presented a 6.9% abortion rate, lower than the 18.2% in the early conception group, and 1.5% birth defect rates, also lower than the 8.3% in the late conception group. Confirming previous data, our analysis showed a higher association with iron deficiency in late conception [30], emphasizing the importance of adequate iron supplementation. Consequently, the longer the surgery-conception interval is, the closer the iron storage should be monitored. Also, there was a tendency of increased prematurity risk, affecting about one-fourth of the newborns in the late conception group.

Data about mental health in pregnancy after BS are scarce [11]. In southern Brazil, Hartmann et al. reported a 14% prevalence of postpartum depression in the general population [31]. Considering the 15.2% prevalence of pharmacologic treatment for psychiatric disorders during pregnancy, with the addition of a 7.6% prevalence of postpartum depression after delivery in our cohort, we observed that almost 1 in 4 patients required mental health treatment, pointing out the importance of psychological and psychiatric support for pregnant women after BS. During the pregnancy, alcohol consumption (3.8%) was lower compared to that in the general Brazilian pregnant population (10.8–17.7%). Tobacco use (6.8%) was lower (9.6–13.4%) likewise [32–35].

Gestational planning is an essential aspect of healthy motherhood. In light of recent evidence showing increased sexual function and activity after BS [36, 37], adequate contraception counseling plays a central role, even in patients with no sexual partners or conception intention. Almost one-third of women with unplanned pregnancies in our cohort were not under any contraceptive method, and another one-third were on an oral contraceptive. There is large and growing evidence of the controversy on the efficacy of oral contraceptives after RYGB, especially during the weight loss period [38]. Although we did not evaluate adherence and thus represent a possible bias, this method should be discouraged, which is the practice in our center nowadays. New prospective trials and guidelines are necessary to establish the efficacy of contraception methods.

The prevalence of cesarean delivery in singleton live-born first pregnancies was 70.5%, which is greater than the prevalence of cesarean delivery in southern Brazil (61.2%) [39], for unknown but probably multifactorial reasons. The congenital malformation rate (3.8%) was also higher than the rate in offspring of pregnancies after BS reported in a previous systematic review, ranging from 0.6 to 1.9% [40]. Their maternal age medium was 34.2 years (range: 28–41), and BMI at conception was 29 (range: 22.7–35.6) (data not shown). Further analysis will be necessary to evaluate if this discrepancy is related to advanced maternal age or other intrapopulation factors.

We performed a Poisson multiple regression analysis to find possible risk factors related to SGA. Similarly, as reported previously [29, 30], the trend in GWG was directly associated with intrauterine growth, as was shown in the almost 5-fold risk of SGA in the below GWG group compared to the above GWG group. Moreover, parenteral iron prescription was a protective factor for SGA in our cohort.

There are several limitations to our study. The first is its retrospective nature, which points out the association without causality validation. Second, the self-reported data collection of psychiatric, neonatal, and obstetric outcomes, considering that many patients had obstetric care and delivered their babies at different institutions, which raises the possibility of memory bias, and made it impracticable to ascertain the diagnostic modality of psychiatric disorders and the availability of in vitro fertilization data in this population. Nevertheless, the prevalence of psychiatric illnesses during pregnancy was probably underestimated, given that only those taking medications were recorded. Third, the high rate of known pregnancies excluded from the analysis due to absent obstetric and neonatal information or lost to follow-up, making the final data possibly not representative of the real outcomes. Nonetheless, we can draw meaningful conclusions, and our results expand our current understanding of the particularities of pregnancy after RYGB. To the knowledge of the authors, this is the most extensive data on both surgery-conception interval and GWG in the same population after RYGB and its associations with neonatal and obstetric outcomes. Also, this is the largest study on mental health and substance abuse in this population. Our findings can contribute to health care strategies and guidelines on pregnancy after RYGB.

Conclusion

Our study shows that the RYGB-conception interval should be individualized and discussed with the patient, considering maternal age and preferably waiting 12 months to achieve weight loss stabilization. Conception sooner than 12 months after surgery was associated with a tendency of higher prevalence of abortion and later than 48 months with increased risk of iron deficiency and probably congenital malformation and prematurity, demanding closer attention in these scenarios. Weight management vigilance during pregnancy is essential to optimize obstetric and neonatal outcomes. Independently of initial BMI, GWG meeting the target regarding IOM recommendations appears to be associated with reduced risk of prematurity, SGA, and hypertensive disease.

Our data on mental health demonstrated the importance of psychiatric and psychological management in this population. Additional prospective and controlled data are needed to understand better how psychiatric disorders and respective treatments affect obstetric and neonatal outcomes.

Gestational planning and counseling should start before BS, relying on constant advice about contraception, adequate conception moment, and pregnancy follow-up with a multidisciplinary and specialized team. Planning and counseling seem to be the keys to enabling a safe pregnancy after BS.

In conclusion, pregnancy after RYGB appears to be safe, and further prospective data are needed to validate the current hypothesis.

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Declarations

Ethics Approval and Consent to Participate All procedures performed in studies involving human participants were in accordance with the institutional and national research committee's ethical standards and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consent was obtained from all participants included in the study.

Conflict of Interest The authors declare no competing interests.

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