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ORIGINAL CONTRIBUTIONS

Pregnancy After Bariatric Surgery: a Comparative Study of Post-Bariatric Pregnant Women Versus Non-Bariatric Obese Pregnant Women

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Abstract

Purpose To evaluate the impact of bariatric surgery on the gestational outcomes.

Materials and Methods Retrospective study of pregnant women hospitalized for delivery in the maternity in Curitiba, Brazil, who had a body mass index (BMI) greater than or equal to 30 kg/m^2 and/or who had undergone bariatric surgery. Interviews were performed, and the patients' medical records and antenatal information cards were evaluated.

Results Ninety-three pregnant women who had bariatric surgery and 205 obese pregnant women were selected. A lower occurrence of hypertensive diseases was observed in pregnant women who had undergone bariatric surgery (14%) compared with obese pregnant women (56.6%). Moreover, a reduced occurrence of diabetes was found in post-bariatric pregnant women (16.1%) compared with obese pregnant women (30.2%). There were no differences in the frequency of prematurity, in delivery methods, or in postpartum complications. There was a higher number of cases of babies who were small for gestational age and a lower number of babies who were large for gestational age in the post-bariatric group. When comparing obese pregnant women to post-bariatric pregnant women who had remained obese, a reduced frequency of hypertensive diseases and diabetes was found in the latter group, but the weight difference between their newborns was not statistically significant.

Conclusion There was a lower occurrence of health-related issues complicating pregnancy among women who had undergone bariatric surgery, but these women's newborns were more likely to be small for gestational age, a finding which was less significant the less weight the mother had lost.

Keywords Pregnancy · Bariatric surgery · Obesity

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Introduction

Bariatric surgery has become more common in prenatal medical practice owing to the increasing number of obese women of fertile age.

Obese women carry a higher risk of developing gestational diabetes and hypertension. Obesity increases the risk of miscarriages, post-term pregnancy, need for induced labor, and cesarean section. Neonatal risks such as macrosomia, dystocia, and future cardiovascular risk also tend to increase [1–6].

Several studies have demonstrated that pregnant women who have undergone bariatric surgery have lower risks of gestational diabetes, gestational hypertension, and delivering macrosomic fetuses compared with obese pregnant women because obesity is a risk factor for all these outcomes [6–11]. Studies have also shown slight differences in terms of these outcomes among the techniques used in bariatric surgery [8, 12].

Nutritional disorders resulting from bariatric surgery have been shown to affect fetal growth and to cause an increased incidence of small-for-gestational-age fetuses [6–11, 13]. This influence has been more evident in patients operated with dysabsorption and mixed techniques than in those who undergo strictly restrictive surgery as shown by recent systematic reviews [8].

At present, there is no protocol establishing a minimum time between bariatric surgery and pregnancy, but studies have not demonstrated worse outcomes on comparing pregnancies before and after a milestone of 18 months and 2 years after bariatric surgery [14, 15].

A frequent doubt in clinical practice, due the gestational desire of an obese woman, is the indication of bariatric surgery before gestation. Few studies in the literature compared gestational outcomes in different degrees of obesity. This study sought to compare the pregnancy-related and neonatal outcomes of a population of obese pregnant women with different grades of overweight to those of pregnant women who had undergone bariatric surgery, to assist in this decision-making.

Methodology

This study was performed in the maternity ward of a hospital complex which is a center of reference in the Southern region of Brazil. It was submitted to, evaluated by, and approved by the Ethics Committee of the Obstetrics and Gynecology Department of the Health Sciences Sector of the Federal University of Paraná (UFPR) and by the Human Research Ethics Committee of the UFPR Clinics Hospital Complex. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

A retrospective study included pregnant women who had received prenatal care and who were admitted to the maternity ward in question for delivery between June 2014 and June 2016. The inclusion criteria were as follows: pregnant women with a BMI greater than or equal to 30 kg/m^2 when prenatal care began and/or who had undergone bariatric surgery before becoming pregnant. The exclusion criteria were twin pregnancies and patients who had not received prenatal care.

The sample was divided into two groups for comparison: the obese group consisted of pregnant women with BMIs greater than or equal to 30 kg/m^2 at the beginning of the pregnancy and who had not undergone bariatric surgery; and the post-bariatric group, which consisted of pregnant women with any BMI but who had undergone bariatric surgery prior to pregnancy.

To establish these groups, trained researchers monitored all delivery admissions and applied the inclusion and exclusion criteria. The data collection forms were then completed retrospectively with socioeconomic and demographic data, as well as information on the pregnancies, deliveries, the immediate postpartum period, neonatal outcomes, and data on bariatric surgery; the latter of which were obtained through interviews with mothers and through analyses of patients' records and antenatal information cards.

Mothers' weights at hospitalization, heights, and education levels were obtained from standard admission forms used in the department. Pre-gestational hypertension, preeclampsia, gestational diabetes and type 2 diabetes, anemia, and preterm delivery were the pregnancy complications evaluated. The criteria for the diagnosis of gestational diseases and neonatal complications were based on definitions from the World Health Organization (WHO). These details are outlined in Table 1. Gestational age was calculated based on the first prenatal ultrasound. Delivery outcomes were defined as vaginal delivery, cesarean delivery, or delivery requiring the use of forceps. Of pregnant women, post-bariatric surgery was questioned about the surgical technique, the time between bariatric surgery, and gestation and pre-surgical weight.

The newborns' birth weight as measured at birth was evaluated as normal, SGA, or large for gestational age (LGA) based on the Fenton curve. Other data collected included the one-minute and five-minutes Apgar scores, the indication for neonatal ICU care, respiratory distress, fetal malformations, and total hospitalization time. Diagnostic criteria are shown in Table 1.

The data from the standard collection sheet were organized in an Excel spreadsheet (Microsoft Office 2007), and a statistical analysis was performed. The results of the quantitative variables were described as means, medians, minimum values, maximum values, and standard deviations. Frequencies and percentages of qualitative variables were also considered. Student's t test for independent samples or the Mann-Whitney non-parametric test (when appropriate) were used to compare the quantitative variables of the two study groups (pregnant women who had undergone bariatric surgery versus obese pregnant women). The normality condition of the variables was evaluated using the Kolmogorov-Smirnov test. The qualitative variables were compared using Fisher's exact test or the chi-square test. P values less than or equal to 0.05 indicated statistical significance. The data were analyzed using the SPSS Statistics program, version 20 (IBM).

Results

From June 2014 to June 2016, 93 pregnant women who had undergone bariatric surgery and 205 obese pregnant women were admitted to the maternity ward of the Clinics Hospital Complex of the Federal University of Paraná (UFPR).

Table 1 Diagnostic criteria based on the WHO definitions of the diseases considered in this study [16]

Diseases	Diagnosis
Systemic arterial hypertension	Diagnosis prior to gestation of systemic arterial hypertension (SAH) or systolic pressure greater than 140 mmHg and/or diastolic pressure greater than 90 mmHg since the first gestational trimester
Preeclampsia	Systolic pressure greater than or equal to 140 mmHg and/or 90 mmHg for diastolic pressure, started after 20 weeks of gestation in previously normotensive women and associated with development of proteinuria, i.e., at least 300 mg/L of protein in 24-h urine or at least 1+ of protein by single-sample quantitative tape methods or occurrence of proteinuria after 20 weeks of gestation in previously hypertensive patients
Diabetes mellitus	Diagnosis prior to gestation or fasting blood glucose greater than or equal to 126 mg/dL in the first trimester
Gestational diabetes	First trimester: glucose greater than or equal to 92 mg/dL and less than 126 mg/dL. Second trimester: overload of 75 g of glucose glycemia greater than or equal to 92 mg/dL for fasting and/or 180 mg/dL for 60 min after overload and/or 153 mg/dL for 120 min after overload
Anemia	Mild: hemoglobin between 10.9–10 g/dL, Moderate: hemoglobin between 9.9 and 8 g/dL, Severe: hemoglobin less than 8 g/dL
Premature births	Gestational age at birth less than 37 weeks
Respiratory distress	Need for masked breathing cycles and Amsterdam Medical Breath Unit (AMBU), Continuous Positive Airway Pressure (CPAP) or tracheal gold intubation
Fetal malformation	Any fetal anatomical change
Neonatal ICU	Any length of stay in neonatal ICU, even less than 24 h

The mean age of the post-bariatric group was 31.7 years (range of 20 to 43 years), and the mean age of the obese group was 29.9 years (range of 14 to 46 years). Most of the women in the study had a high school diploma as their highest level of education (54.8% of the post-bariatric women and 53.2% of the obese women), while 10.7% of obese pregnant women and 30.1% of the post-bariatric women had completed higher education ($p < 0.001$).

The mean BMI at the start of prenatal care was 29 kg/m^2 (19.6 to 49.5 kg/m^2) in the post-bariatric group and 35.3 kg/m^2 (30 to 52.2 kg/m^2) in the obese group, $p < 0.001$. The mean BMI before delivery was 32.7 kg/m^2 (23.7 to 52.3 kg/m^2) in the post-bariatric group and 39.2 kg/m^2 (30 to 58.5 kg/m^2) in the obese group, $p < 0.001$. Weight gain during pregnancy presented a mean of 10 kg in the post-bariatric group (− 14 to 31 kg) and 10.3 kg in the obese group (− 13 to 35 kg), p 0.704. In the post-bariatric group, the mean BMI pre-surgery was 45.8 kg/m^2 (33.3 to 59.5 kg/m^2).

The interval between surgery and pregnancy was less than one year in 12.9% (n 12) women, one to five years in 62.4% (n 58), five to 10 years in 20.4% (n 19), and more than 10 years in 4.3% (n 4). Information about the surgical technique used was obtained by questioning the pregnant women, and all of them stated the use of mixed techniques (gastric bypass surgery with gastric restrictive surgery). In 46.2% of the cases, it was possible to confirm this information by analyzing the patients' medical records, and Roux-en-Y gastric bypass was performed in all these cases.

When the presence of diseases complicating pregnancy was evaluated, 47.3% of the pregnant women in the post-bariatric group and 89.3% of the pregnant women in the obese group exhibited at least one pregnancy-related complication, as detailed in Table 2. The presence of bariatric surgery was a protective factor against the development of the pregnancy-related diseases considered in this study: odds ratio (OR), 0.11 (95% CI, 0.06–0.20).

In the assessment of the increase in blood pressure levels (Table 2), the presence of bariatric surgery was found to be a protective factor for blood pressure complications: OR, 0.12 (95% CI, 0.07–0.24).

The difference in the number of diabetes diagnoses was significant between the groups ($p = 0.010$), and the presence of bariatric surgery was a protective factor against complications involving blood glucose levels: OR, 0.44 (95% CI, 0.24–0.83). The analysis of diabetes treatments involving diet alone or based on a combination of diet and medication (insulin and/or metformin) revealed that 48.4% of the obese women and

Table 2 Distribution of gestational diseases comparing obese group versus post-bariatric group

Gestational diseases	Obese, n (%)	Post-bariatric, n (%)	p
Anemia	26 (12.7%)	40 (43%)	< 0.001
Diabetes	62 (30.2%)	15 (16.1%)	0.010
BP diseases	116 (56.6%)	13 (13.9%)	< 0.001
Systemic hypertension	72 (35.1%)	8 (8.6%)	< 0.001
Preeclampsia	69 (33.6%)	7 (7.5%)	< 0.001

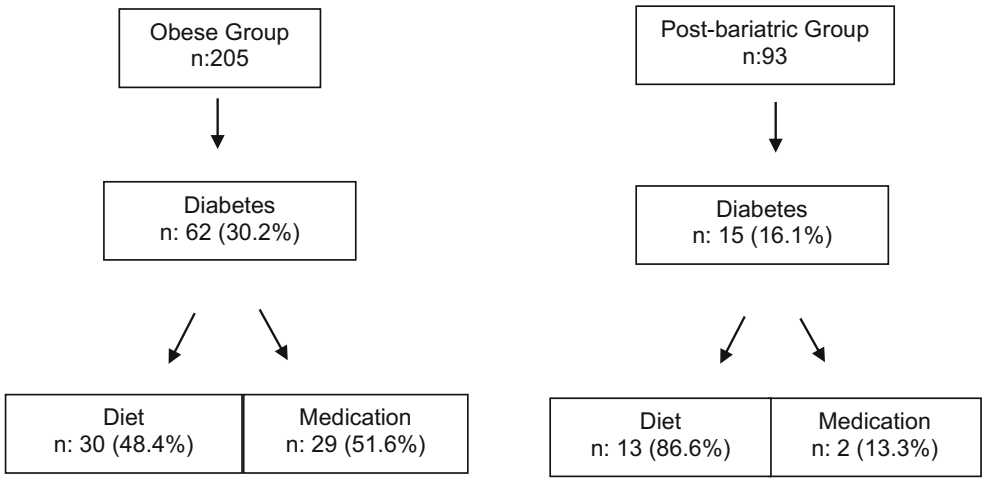

Fig. 1 Comparison of gestational treatment of diabetes among group obese versus post-bariatric group

86.6% of the post-bariatric women were able to control blood glucose levels with diet alone (Fig. 1).

No differences in pregnancy outcomes were found between the groups (Table 3). When neonatal outcomes were considered, one- and five-minutes Apgar scores at birth did not differ significantly between the groups, with the same medians in both groups (one-min score of eigth and five-min score of nine). Mean infant weight at birth differed significantly between the groups, with a mean of 3011.5 g (695 to 4370 g) in the post-bariatric group and a mean of 3317.9 g (600 to 4925 g) in the obese group ($p < 0.001$). Weight relative to gestational age also differed significantly between the groups ($p < 0.001$), as shown in Table 3.

There was no significant difference in the incidence of respiratory distress or fetal malformations between groups Table 3. There was a greater indication of monitoring in neonatal ICU among newborns from the group of post-bariatric mothers (16.1% versus 7.8% of newborns) relative to that of the newborns from obese mothers. Hospital stays longer than 48 h were also assessed, and they were necessary for 52% of the neonates from the mothers in the obese group and for 42.9% of the neonates from the mothers in the post-bariatric group, p 0.116.

Table 3 Comparison of gestational and neonatal outcomes among group obese versus post-bariatric group

	Obese, *n* (%)	Post-bariatric, *n* (%)	*p*
Premature delivery	22 (10.8%)	13 (14%)	0.686
Normal delivery	85 (41.7%)	40 (43%)	0.899
Forceps	9 (10.5%)	2 (5%)	0.500
Cesarean delivery	119 (58.3%)	53 (57%)	0.899
SGA	23 (11.3%)	22 (23.7%)	< .001
LGA	33 (16.2%)	3 (3.2%)	< 0.001
Neonatal ICU	16 (7.8%)	15 (16.1%)	0.04
Respiratory distress	19 (9.3%)	13 (14%)	0.232
Fetal malformation	3 (1.5%)	5 (5.4%)	0.114
Hospital stay > 2 days	105 (52%)	39 (42.9%)	0.166

Post-bariatric pregnant women who remained obese (BMI ≥ 30 kg/m^2) were compared with the women in the obese group; the latter of which was divided into two subgroups: those for whom bariatric surgery was not indicated (BMI ≥ 30 and < 35 kg/m^2) and those for whom bariatric surgery could be indicated (BMI ≥ 35 kg/m^2).

Pregnant women who remained obese after bariatric surgery experienced fewer health issues complicating pregnancy than the obese pregnant women for whom bariatric surgery was not indicated (BMI ≥ 30 and < 35 kg/m^2): 45.2% versus 89.4%, respectively ($p < 0.001$). Thus, bariatric surgery remains a protective factor against pregnancy-related health issues, with an OR of 0.10 (95% CI, 0.04–0.25). Details are provided in Table 4. This lower rate of health issues was also statistically significant when morbidly obese women (BMI ≥ 35 kg/m^2) were compared with post-bariatric women ($p < 0.001$): 45.2% of the post-bariatric women experienced these issues, while 89.1% of the obese pregnant women experienced them, a result which again maintains bariatric surgery as a protective factor against pregnancy-related health issues: OR, 0.10 (95% CI, 0.04–0.26); Table 4. As detailed in Table 4, there was no significant difference in birth weight relative to gestational age between the three subgroups ($p = 0.353$), but there was a tendency toward more frequent cases of newborns who were LGA as the mother's BMI increased, as well as a tendency toward newborns who were SGA among mothers who had bariatric surgery.

Discussion

When compared with the women in the obese group, the post-bariatric women in this study experienced fewer pregnancy-related complications but also had more fetuses that were SGA. Because of the heterogeneity of the populations

Table 4 Comparison of gestational and neonatal outcomes in post-bariatric pregnant with BMI ≥ 30 kg/m^2 versus obese pregnant with BMI ≥ 30 and < 35 kg/m^2 and obese pregnant with BMI ≥ 35 kg/m^2

	Post-bariatric BMI ≥ 30, *n* (%)	Obese BMI ≥ 30 and < 35, *n* (%)	*p*	Obese BMI ≥ 35, *n* (%)	*p*
Pregnancy					
BP diseases	3 (9.7%)	56 (49.6%)	< 0.001	60 (65.2%)	< 0.001
Diabetes	4 (12.9%)	30 (26.5%)	0.153	32 (34.8%)	0.023
Anemia	11 (40.7%)	15 (14.7%)	0.006	11 (12.6%)	0.004
Cesarean delivery	19 (61.3%)	61 (54.5%)	0.545	58 (63.0%)	1
Hospital stay > 2 days	12 (38.7%)	47 (42%)	0.838	54 (58.7%)	0.063
Neonatal					
Premature birth	2 (6.5%)	14 (12.5%)	0.523	8 (8.7%)	1
Neonatal ICU	5 (16.1%)	9 (8%)	0.185	7 (7.6%)	0.176
Hospital stay > 2 days	14 (4.7%)	60 (54.1%)	0.539	45 (49.5%)	0.836
SGA	6 (19.4%)	13 (11.6%)	0.353	10 (10.9%)	0.149
LGA	2 (6.5%)	15 (13.4%)	0.353	18 (19.6%)	0.149

reported in the literature, it is very difficult to compare these results to other studies on post-bariatric pregnant women. However, there are points on which the vast majority of authors agree, particularly in terms of the reduced risks of blood pressure and blood glucose issues among post-bariatric pregnant women, given the importance of weight reduction in the treatment of these diseases [6–9, 12, 13, 17].

Some authors have also reported an influence from maternal body weight on these effects. Belogolovkin et al. [18] stratified the BMIs of obese and post-bariatric women, compared them to those of non-obese pregnant women, and found higher rates of preeclampsia among post-bariatric pregnant women who had maintained BMIs greater than or equal to 40 kg/m^2, as well as higher rates of cesarean deliveries; however, they did not find a clear association between maternal weight and the newborn's birth weight.

Our goal in stratifying post-bariatric patients who remained obese and obese pregnant women by BMI was to determine whether this reduction in fetal birth weight and in the occurrence of pregnancy-related complications persisted.

When obese pregnant women had BMIs below 35 kg/m^2 and were therefore not candidates for bariatric surgery in Brazil, the lower rate of blood pressure–related issues remained ($p = 0.035$), and there was no significant difference in the rate of diabetes ($p = 0.075$). When comparing these women without indication for surgery to those with BMIs greater than or equal to 35 kg/m^2 (therefore with the possibility of surgical indication), significantly lower rates of blood pressure–related complications ($p < 0.001$) and of blood-glucose-related complications ($p = 0.023$) were observed in the former group. When diabetes was considered, post-bariatric women were found to have better control over their disease than the women in the obese group.

There was no statistically significant difference between the groups in terms of type of delivery ($p = 0.899$). Cesarean delivery was much more common in both groups, a preference which is frequently observed in Brazil. The Brazilian Ministry of Health 2015 data reported a cesarean delivery rate of 55% [19]. WHO data show that a cesarean delivery rate greater than 10% does not reduce maternal, neonatal, or perinatal mortality rates [19].

There was no difference between the groups in terms of rate of premature births. The vast majority of studies, including those with large cohorts, failed to find higher rates of prematurity among babies born from post-bariatric pregnant women [7, 8, 12, 20, 21]. However, Johansson et al. [22] and Abenhaim et al. [9] reported a trend toward shorter-term pregnancies among post-bariatric pregnant women in paired comparisons to other pregnant women based on BMI, age, parity, and grade of overweight. Roos et al. [23] reported higher rates of preterm births in bariatric pregnant women in a paired comparison with pregnant women based on BMI, age, and parity, as well as in a comparison with obese women eligible for surgery. However, when subgroups were analyzed, the risk was higher among pregnant women with BMIs lower than or equal to 30 kg/m^2. The correlation between this risk and BMI became less definite but still significant as BMI increased, and the results suggest that substantial weight loss may negatively influence the duration of gestation.

In the current study, there was a higher rate of babies who were SGA and a lower rate of babies who were LGA in the post-bariatric group than in the obese group, but when only the post-bariatric mothers who remained obese were compared to the women in the obese group, the differences in these rates were no longer statistically significant. Many authors have reported lower birth weights, higher rates of SGA neonates, and lower rates of LGA neonates among post-bariatric mothers [7, 8, 12, 13, 20–22]. The same study by Roos et al. [23] that reported an influence of maternal weight on prematurity also reported that there was no increase in

SGA cases among pregnant women with a BMI greater than or equal to 35 kg/m^2 at the beginning of prenatal care. Thus, our results can corroborate this substantial influence of maternal BMI on neonatal birth weight.

The newborn from the post-bariatric group had higher indication of neonatal ICU care, but this fact did not influence total hospitalization time. Therefore, neonatal ICU care may have been related to the monitoring of possible complications of lower birth weight, as it did not reflect in prolonged hospitalizations and there was no difference in the occurrence of respiratory distress and malformations, two important causes of intensive care. Comparing post-bariatric patients who remained obese group and the obese group, there was no difference between neonatal UCI care indication, suggesting a strong influence of maternal BMI post-bariatric on the neonatal outcome. Analyzing the need for prolonged hospitalization (greater than 48 h) was higher in the obese group (52% × 42.9%), reflecting a higher incidence of clinical intercurrence in these newborns. Almost none of the studies in the literature reported significant differences in neonatal complications, mortality rates, or malformations in deliveries by post-bariatric women.

The factors that may limit the studies and influence the outcomes are the substantial differences in schooling years, the cultural level among the patients, and the fact that we did not evaluate smoking habits. These factors can directly influence birth weight. Some groups presented a small *n*-value, which consequently reduced the comparative power. Further, data were collected at a single medical center, indicating that the results have limited external validity, but the medical center is the reference center for a large geographic region. However, the collection of different types of data (medical records and interviews) may guarantee a greater reliability of the data.

Conclusion

We can demonstrate that bariatric surgery decreases the risk of pregnancy-related complications; even in a pregnant woman that remains obese after bariatric surgery, this reduction is maintained. We also showed that when there is no substantial maternal weight loss, birth weight is less affected.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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