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Perinatal outcomes in pregnancy after bariatric surgery: the influence of preconception body mass index

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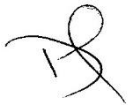
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Junho, 2022

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(Professora Doutora Lídia Mariana Rodrigues Pereira Monteiro)

Dedicatória

Para os meus avós, que me inspiraram em tudo para a pessoa que sou hoje e que acreditaram sempre em mim.

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Resumo

Introdução: A obesidade apresenta-se como um dos maiores desafios de saúde pública do século XXI. Face a isto, diversos tratamentos surgiram, entre os quais se destacam as várias modalidades de cirurgia bariátrica. Com o aumento da prevalência desta epidemia nas mulheres em idade reprodutiva, torna-se cada vez mais frequente o cenário de uma gravidez após estes procedimentos cirúrgicos, acarretando novos desafios quanto à vigilância da gravidez. Apesar de ser o tratamento mais eficaz para a obesidade moderada e grave, estando demonstrado um impacto benéfico da perda ponderal preconcecional, este nem sempre é bem sucedido.

Objetivos: Este estudo teve como objetivo avaliar a influência do Índice de Massa Corporal (IMC) preconceção nos desfechos perinatais, de grávidas submetidas a cirurgia bariatria prévia.

Métodos: Grávidas (n=69) previamente submetidas a cirurgia bariátrica foram divididas em dois grupos com base no IMC preconceção (IMC PC < 30 e IMC PC ≥ 30) para comparação dos desfechos maternofetais.

Resultados: O IMC pré-operatório das mulheres com IMC PC < 30 kg/m^2 foi significativamente inferior quando comparado com mulheres com IMC PC ≥ 30 kg/m^2 (43,06 ± 4,99 kg/m^2 vs. 49,70 ± 6,42 kg/m^2; ρ = 0,001). A percentagem de perda excessiva de IMC foi significativamente maior no grupo de IMC PC < 30 kg/m^2, quando comparada com as mulheres com IMC PC ≥ 30 kg/m^2 (93,60 ± 12,22 vs. 61,92 ± 30,36; ρ = 0,001). O IMC na admissão antes do parto era ainda significativamente inferior nas mulheres com IMC PC < 30 kg/m^2, quando comparado com as mulheres com IMC PC ≥ 30 kg/m^2 (31,60 ± 2,02 vs. 39,18 ± 5,33 kg/m^2; ρ = 0,001). As mulheres com IMC PC < 30 kg/m^2 tiveram um aumento de peso gestacional (GWG) significativamente maior quando comparado com as mulheres com IMC PC ≥ 30 kg/m^2 (15,25 ± 6,89 vs. 9,71 ± 7,54; ρ = 0,003). A percentagem de complicações neonatais foi significativamente menor em recém-nascidos de mulheres com IMC PC < 30 kg/m^2 quando comparada com as de mulheres grávidas com IMC PC ≥ 30 kg/m^2 (2,90% vs. 39,10%; ρ = 0,008).

Conclusão: Concluindo, após a cirurgia bariátrica, as mulheres com obesidade persistente experimentam uma morbilidade mais elevada no recém-nascido. Os benefícios da perda de peso após a cirurgia bariátrica sobre os desfechos adversos da gravidez associados à obesidade podem ser otimizados se as mulheres forem capazes de reverter a condição de obesidade.

Palavras-chave: Gravidez; Cirurgia Bariátrica; Obesidade; Desfechos maternofetais e perinatais

Abstract

Background: Obesity is one of the greatest public health challenges of the 21st century. Considering this, several treatments have emerged, among which the various modalities of bariatric surgery stand out. With the increasing prevalence of this epidemic in women of reproductive age, the scenario of a pregnancy after these surgical procedures is becoming more and more frequent, bringing new challenges regarding pregnancy monitoring. Although this is the most effective treatment for obesity, and a beneficial impact of preconception weight loss has been demonstrated, it is not always successful.

Objectives: This study aim was to evaluate the influence of preconception Body Mass Index (BMI) on perinatal outcomes, of pregnant women who underwent previous bariatric surgery.

Methods: Pregnant women (n=69) previously undergoing bariatric surgery were divided into two groups based on BMI preconception (BMI PC < 30 kg/m^2 and BMI PC ≥ 30 kg/m^2) for comparison of maternal-fetal outcomes.

Results: Preoperative BMI of women with PC BMI < 30 kg/m^2 was significantly lower when compared to women with PC BMI ≥ 30 kg/m^2 (43.06 ± 4.99 kg/m^2 vs. 49.70 ± 6.42 kg/m^2; ρ = 0.001). The percentage of excess BMI loss was significantly higher in the group of PC BMI < 30 kg/m^2, when compared to women with PC BMI ≥ 30 kg/m^2 (93.60 ± 12.22 vs. 61.92 ± 30.36; ρ = 0.001). BMI at admission before delivery was still significantly lower in women with PC BMI < 30 kg/m^2 when compared to women with PC BMI ≥ 30 kg/m^2 (31.60 ± 2.02 vs. 39.18 ± 5.33 kg/m^2; ρ = 0.001). Women with PC BMI < 30 kg/m^2 had significantly higher gestational weight gain (GWG) when compared to women with PC BMI ≥ 30 kg/m^2 (15.25 ± 6.89 vs. 9.71 ± 7.54; ρ = 0.003). The percentage of neonatal complications was significantly lower in newborns from women with PC BMI < 30 kg/m^2 when compared to those of pregnant women with PC BMI ≥ 30 kg/m^2 (2.90% vs 39.10%; ρ = 0.008).

Conclusion: In conclusion, after BS, women with persistent obesity experience higher newborn morbidity. The benefits of weight loss after BS on adverse pregnancy outcomes associated with obesity can be optimized if women are able to reverse the obesity condition.

Keywords: Pregnancy; Bariatric Surgery; Obesity; Perinatal and maternofetal outcomes

List of Abbreviations

ACOG – American College of Obstetricians and Gynecologists

AGB – Adjustable Gastric Band

ASA – Acetylsalicylic Acid

BMI – Body Mass Index

BP – Blood Pressure

BS – Bariatric Surgery

CMIN – Centro Materno Infantil do Norte

CS – Cesarean Section

FGR – Fetal Growth Restriction

GDM – Gestational Diabetes Mellitus

GWG – Gestational Weight Gain

HT –Hypertension

NICU – Neonatal Intensive Care Unit

PIH – Pregnancy-Induced Hypertension

PB – Preterm Birth

PC BMI – Preconception Body Mass Index

RYGB – Roux-en-Y Gastric Bypass (RYGB)

SG – Vertical Sleeve Gastrectomy (SG)

SGA – Small for Gestational Age

T2D – Type 2 Diabetes

TPB – Threat of Preterm Birth

TWL- Total Weight Loss

WHO – World Health Organization

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Introduction

According to the World Health Organization (WHO), obesity is defined as an abnormal or excessive accumulation of body fat, which extent may affect physical and/or mental health. Obesity is considered a chronic disease, of multifactorial origin, and associated with several comorbid diseases.[1,2] Obesity severity can be classified, according to WHO, by the Body Mass Index (BMI), calculated through the ratio between the weight in kilograms (kg) and the square of the height in meters (m^2).[3] The obesity classification according to BMI is currently the measure most used at a population level, being it considered at a BMI greater than or equal to 30 kg/m^2 ($BMI \geq 30\ kg/m^2$). A direct correlation between higher BMI and the presence and co morbidities has been shown.[4]

From an epidemiological point of view, obesity is currently one of the main global public health problems, whose incidence and increasing prevalence has led the WHO to declare it as a pandemic. Obesity is considered the major nutritional disorder in developed countries. In the European region, 30 to 80% of the adult population is overweight and up to one third has obesity. In Portugal, the prevalence of overweight and obesity has increased, with an estimated prevalence of 39.4% for overweight people, and 14.2% for people with obesity.[5] In turn, from an etiological point of view, it is thought that its origin may be multifactorial, with both genetic and environmental factors contributing.[6] This predisposition seems to be associated to endocrine dysregulation, changes in the intestinal microbiome, and changes in sleep/wake cycles, among others. Ultimately, obesity results from a long-term imbalance between energy intake and energy expenditure, with the individual chronically eating more than he or she expends.

Obesity seems to act both as a risk factor and as a comorbidity in several known diseases, such as Hypertension (HT) or Type 2 Diabetes (T2D), among others.[7] From a gynecological/ obstetric point of view, it is associated with a higher prevalence of sexual dysfunctions and, specifically in women of reproductive age, with infertility due to ovarian dysfunction. Pregnant women with obesity, experience an increased incidence of several disorders observed during pregnancy such as Gestational Diabetes Mellitus (GDM), Pregnancy-Induced Hypertension (PIH) or macrosomia.[8-12] It should also be added that when compared to women with normal BMI, maternal obesity is associated with a higher number of dystocia during labor and birth by caesarean section (CS).[13,14] Altogether, a higher BMI is associated with poor obstetric outcomes, with the risk of several complications being influenced directly, or indirectly by it.

Given the above, several therapeutic approaches have been attempted, starting with non-pharmacological therapy, escalating to pharmacological therapy or even surgical therapy as appropriate. Non-pharmacological treatment consists in lifestyle interventions and behavioral modifications, such as changes in the quality and quantity of food intake, regular physical exercise, and regularization of the sleep/wake cycles.[15,16] Patients who are offered bariatric surgery (BS) must have a BMI equal to or greater than 40 kg/m^2 or a BMI greater than 35 kg/m^2 in the presence of comorbidities, such as coronary heart disease, T2D, HT, and obstructive sleep apnea syndrome, among others.[17] BS presents itself as the most successful treatment for obesity, given the extent and durability of its effects, even leading to the remission of comorbid diseases, such as T2D.[18-22] In fact, the use of bariatric surgeries has been growing worldwide, with the techniques of Roux-en-Y Gastric Bypass (RYGB) and Vertical Sleeve Gastrectomy (SG) standing out in current clinical practice. It is important to mention that it is currently estimated that 80% of the patients are women, most of them in reproductive age.[23-28] This altogether with increased prevalence of obesity in the reproductive age, and all the benefits previously mentioned, the scenario of pregnancy after BS is becoming increasingly frequent.[17]

Weight loss and improvement of the maternal metabolic profile has been demonstrated to have a positive influence on perinatal outcomes associated with obesity, such as PIH, GDM, or macrosomia. However, it is associated with an increased incidence of maternal anemia and small for gestational age. Thus, despite its various benefits, new potential problems arise from BS, mainly but not limited to the malabsorption of nutrients and complications inherent to surgery itself.

It is also important to account that not all women who underwent BS lose sufficient weight to achieve obesity remission, so all the above maternal and fetal morbidities associated with obesity still prevail. In these women the risks associated with obesity are added to the risks of BS, altogether, the surveillance of pregnancy in these women can be particularly challenging.[29-31]

Aims of the study

This study aim was to characterize the pregnancies outcomes of women previously submitted to BS based on preconception BMI (PC BMI). Thus, it targets to understand how PC BMI in a pregnant woman who has previously undergone BS influences maternal and neonatal outcomes.

It is plausible to hypothesize that women who underwent BS with persistent obesity prior to the time of conception are still at a higher risk of adverse pregnancy outcomes. Our hypothesis is that the combination of obesity status and risks of BS complications may be important features to take into account during pregnancy surveillance. So, this study aim was to evaluate the impact of PC BMI on pregnancy outcomes.

Material and Methods

Groups and Variables of the Study and Data Extraction

To fulfil this aim, a retrospective design study was carried out, in an obstetric and neonatology tertiary center, Centro Materno Infantil do Norte (CMIN), evaluating pregnancies of women who had previously undergone BS and had at least one delivery from 2018 until 2020 (three years). To carry out this study, the patient's electronic medical records were reviewed. Women were then allocated into two groups according to PC BMI. The first group including women with PC BMI under 30 kg/m^2, and the second group including women with PC BMI greater or equal than 30 kg/m^2.

Variables associated with maternal medical and surgical history, anthropometric data, as well as variables related to the maternal and newborn outcomes of the pregnancy were included. Exclusion criteria included twin pregnancies, pregnancies resulting from medically assisted reproduction techniques, and pregnancies which delivery occurred at another institutions.

The characteristics of pregnant women after BS that were analyzed included: age at the time of BS (in years), type of BS procedure, preoperative body weight (in kg), the preoperative BMI (in kg/m^2), preoperative comorbid conditions including chronic HT, T2D, dyslipidemia and obstructive sleep apnea, time since BS until conception (in months), percentage of total weight loss (TWL) since BS until conception, percentage of excess BMI loss and compliance with vitamin supplementation after BS.

Obstetric outcomes analyzed included: age at pregnancy (in years), smoking habits, primiparity, chronic HT during pregnancy, use of acetylsalicylic acid (ASA) during pregnancy, and obstetric complications during pregnancy, including gestational anemia, need for intravenous iron treatment, GDM, fetal growth restriction (FGR), PIH, oligoamnios, threat of preterm birth (TPB) and preterm birth (PB).

Perinatal outcomes analyzed included: gestational weight gain (in kg), BMI at admission before delivery, gestational age at delivery (weeks), type of labor (induced or spontaneous), need for emergency CS, type of delivery (eutocic, dystocic with vacuum suction, dystocic with forceps, dystocic with CS), newborn weight (in g) and height (in cm), APGAR < 7 at 5 minutes, neonatal morbidity and mortality, admission to neonatal intensive care unit (NICU), duration of maternal hospitalization (in days after delivery) and complications during this period.

Statistical Analysis

The statistical analysis involved descriptive statistics (absolute and relative frequencies, means and standard deviations) and inferential statistics. The chi-square test for independence, Fisher's test, Student's t-test for independent samples, and Mann-Whitney test were used. The significance level for rejecting the null hypothesis was set at (α) ≤ .05. The Chi-Square assumption that there should be no more than 20% of the cells with expected frequencies less than 5 was analyzed. In situations where this assumption was not satisfied the Chi-square test by Monte Carlo simulation was used. The normality of distribution was analyzed with the Shapiro-Wilk test and the homogeneity of variances with Levene's test. When the homogeneity of variances was not satisfied, Student's T test with Welch's correction was used. Statistical analysis was performed with SPSS (Statistical Package for the Social Sciences) version 28.0 for Windows.

Results

Subject data pertaining to pregnancies in women previously submitted to BS (n=69) who had at least one delivery at a single tertiary center between January 2018 and December 2020 was retrieved. After applying the exclusion criteria, 12 pregnancies were excluded, 2 resulting from medically assisted reproduction techniques, 1 twin pregnancy and 9 which deliveries occurred at another institution, so 57 pregnancies data were considered eligible for inclusion in the analysis.

Women previously submitted to BS had a PC BMI of 30.62 ± 5.73 kg/m^2. Women pregnancies were then allocated into two groups according to PC BMI, PC BMI < 30 kg/m^2 (n=34, PC BMI 26.11 ± 2.07 kg/m^2) or PC BMI ≥ 30 kg/m^2 (n=23, PC BMI 35.55 ± 4,21 kg/m^2) (Table I). There was no significant difference in women age neither at time of surgery (27.56 ± 4.29 vs 27.17 ± 5.27 years, PC BMI < 30 kg/m^2 vs PC BMI ≥ 30 kg/m^2, ρ = 0.763), nor at PC (31.21 ± 4.08 vs 32.52 ± 5.92 years, ρ = 0.324). There was also no significant difference between the groups in time length since BS until conception (58.39 ± 49.74 vs 50.85 ± 46.42 months; ρ = 0.553). The majority of women underwent a RYGB, with no significant difference in type of BS procedure between the two groups (50.00% vs 56.50%, in PC BMI < 30 kg/m^2 vs PC BMI ≥ 30 kg/m^2: ρ > 0.05).

Preoperative body weight of women with PC BMI < 30 kg/m^2 was significantly lower when compared to women with PC BMI ≥ 30 kg/m^2 (118.03 ± 15.47 kg vs. 131.29 ± 18.33 kg; ρ = 0.006), along with a significantly lower preoperative BMI (43.06 ± 4.99 kg/m^2 vs. 49.70 ± 6.42 kg/m^2; ρ = 0.001) (Table I). Preoperative comorbidities profile also differed between the two groups, with chronic HT being numerically less frequent in women with PC BMI < 30 kg/m^2 (5.90% vs 17.40%, in PC BMI < 30 kg/m^2 vs PC BMI ≥ 30 kg/m^2), as well as T2D (2.90% vs 13.00%, in PC BMI < 30 kg/m^2 vs PC BMI ≥ 30 kg/m^2), although the difference was not statiscally significant.

After BS, the percentage of TWL until conception was significantly lower in women with PC BMI < 30 kg/m^2, when compared to women with PC BMI ≥ 30 kg/m^2 (61.42 ± 8.87 vs. 73.22 ± 11.73; ρ = 0.001). The BMI loss was significantly higher in the group of PC BMI < 30 kg/m^2, when compared to women with PC BMI ≥ 30 kg/m^2 (93.60 ± 12.22 vs. 61.92 ± 30.36; ρ = 0.001). The percentage of women after BS with persistent chronic HT prior to pregnancy was numerically lower in women with PC BMI < 30 kg/m^2 when compared to women with PC BMI ≥ 30 kg/m^2, although the difference was not statistically significant (0% vs 13.00%, PC BMI < 30

kg/m^2 vs PC BMI ≥ 30 kg/m^2, ρ = 0.061). The occurrence of adverse obstetric outcomes, namely GDM, FGR or oligoamnios, was not significantly different between the two study groups (Table II).

In contrast, significant differences in perinatal outcomes were observed. Despite BMI at admission before delivery was still significantly lower in women with PC BMI < 30 kg/m^2 when compared to women with PC BMI ≥ 30 kg/m^2 (31.60 ± 2.02 vs. 39.18 ± 5.33 kg/m^2; ρ = 0.001), women with PC BMI < 30 kg/m^2 had significantly higher gestational weight gain (GWG) when compared to women with PC BMI ≥ 30 kg/m^2 (15.25 ± 6.89 vs. 9.71 ± 7.54; ρ = 0.003) (Table III). There were no significant differences in gestational age at delivery, type of labor or delivery between the two groups.

In addition, although no significant differences were observed in newborn weight or length, between the two groups, neonatal complications were observed in a significantly higher proportion of newborns from women with PC BMI ≥ 30 kg/m^2 when compared to those of pregnant women with PC BMI < 30 kg/m^2 (39.10% vs 2.90%; ρ = 0.008). In both groups, there was no stillbirths or neonatal deaths. The need for NICU admission was not significantly different in newborn of pregnant women with PC BMI < 30 kg/m^2, while in newborn of pregnant women with PC BMI ≥ 30kg/m^2 this value was 13.60%.

There was no significant difference in puerperium complications rate nor duration of postpartum hospitalization between study groups. In particular, no significant differences were observed in the percentage of anemia (14.70% vs 13.00%, in women with PC BMI < 30 kg/m^2 vs PC BMI ≥ 30 kg/m^2) or in the duration of postpartum hospitalization (2.41 ± 0.89 and 2.91 ± 1.28%, in women with PC BMI < 30 kg/m^2 vs PC BMI ≥ 30 kg/m^{2}respectively) between the two groups.

Discussion

In any pregnancy, prenatal care is a laborious and individualized process that requires redoubled attention from the health professional on two lives under observation during a complex phase of maternal physiology and fetal development. Therefore, given the fact that the challenges associated with low-risk pregnancy are already considerable, high-risk pregnancies, such as those included in this study, are even more challenging.

Since the establishment of the obesity pandemic that BS has been widely used for the primary treatment of severe obesity. RYGB is one of the most frequently performed type of BS, given the good balance between weight loss outcomes and safety [32], as observed in our study, since 52.60% of the women enrolled had undergone this type of BS procedure. The effectiveness of BS for obesity treatment can be sized using the percentage of excess BMI loss as a measure, being that the closer the value is to 100, the greater the effectiveness of the surgery.[33] In our study, after BS, women with PC BMI < 30 kg/m^2 experienced a percentage of excess BMI of 93.60 ± 12.22%, a figure that was closer to 100% when compared to women with PC BMI ≥ 30 kg/m^2, who had a percentage of excess BMI of 61.92 ± 30.36%, which translates the greater effectiveness of BS in the first group, as anticipated. Obesity is associated with increased risk for several comorbid conditions, such as hypertension and T2D, conditions that can be improved or undergo clinical remission after significant and sustained weight loss, as observed in the majority of patients that undergo BS treatment. In our study, among pregnant women with previous comorbid conditions, such as HT, this condition only persisted in women with PC BMI ≥ 30 kg/m^2.

After BS and as anticipated, GWG was significantly higher in pregnant women with a PC BMI < 30 kg/m^2 when compared to the group of women with PC BMI ≥ 30kg/m^2, which followed the American College of Obstetricians and Gynecologists (ACOG) recommendations, since the higher the PC BMI the lower should be the weight gain.[34]

According to Abenhaim et al [35], women after obesity treatment with BS have better pregnancy outcomes when compared to those of women with untreated obesity. Notwithstanding, benefits are not devoid of an increased risk of surgical derived complications.

Pregnancy after BS is associated with increased risk of development of certain complications when compared to the general population, namely gestational anemia and FGR, while it acts as a protective factor for other conditions, such PIH and GDM.[36]

In our study it was possible to observe that the occurrence of obesity comorbidities was more frequent in pregnant women with PC BMI ≥ 30 kg/m^2 when compared to women no longer

affected with obesity (PC BMI < 30 kg/m^2). Of particular notice in our study is the occurrence of PIH that was almost twice as higher in women with PC BMI PC ≥ 30 kg/m^2 compared to women with PC BMI < 30 kg/m^2 (17.40% and 8.80% respectively; ρ = 0.423), a clinically relevant finding despite not been statistically significant. Sousa MG et. al, in a cohort of 114 women with obesity, reported a prevalence of PIH of 22.2%.[37] In our study, PIH occurred in 8.80% and 17.40% of women with PC BMI < 30 kg/m^2 and PC BMI ≥ 30 kg/m^2, respectively; a considerably lower figure than previously reported for women with untreated obesity. Therefore, it can be hypothesized that obesity treatment through BS could have been potentially protective for PIH in our patient population as well.

FGR is more frequent in women after BS when compared to general population.[38] Moreover, Lewandowska et. al, reported the prevalence of FGR of 2.3% in a cohort of 912 women whose pregnancies were accompanied at a single institution in Poland, among these women 23.8% had obesity.[39] In our study, there was also a considerable prevalence of FGR in both study groups (20.60% and 17.40%; ρ > 0.05), despite more than half of the women in both groups were under prophylactic ASA and in numerically higher percentage in those with PC BMI ≥ 30 kg/m^2. The ACOG recommends the prophylactic use of low dose of ASA in all women at increased risk of PIH, such as pre-eclampsia, and may be considered in women who have more than one moderate risk factor for this condition. Low dose of ASA is also recommended for women that present risk factors for FGR.

After BS, patients are recommended to take lifelong multivitamins supplements to prevent micronutrient deficiencies and late complications.[40-42] In our study, the compliance with vitamin supplementation after BS and during PC was under 50% in both groups and with no significant difference between groups. Thus, adherence to vitamin supplementation in our patient population must be considered poor, which carries increased risks of developing micronutrient deficiencies, anemia and severe anemia requiring interventions such as treatment with intravenous iron. So, it was unsurprising to observe a considerable percentage of women with gestational anemia. Indeed, the percentage of gestational anemia (35.30% and 30.40%; ρ = 0.780), including the percentage of pregnant women that required intravenous iron treatment (23.50% and 26.10%; ρ = 1.000), was considerable in both groups of women and presented no significant differences.

Regarding the type of delivery, pregnant women with obesity are reported to experience a higher rate of CS. In our study, it is important to highlight that although there was no significant difference in the type of delivery between groups, CS occurred more frequently in women with

PC BMI ≥ 30 kg/m^2 (35.30% in women with PC BMI < 30 kg/m^2 and 43.50% in women with PC BMI ≥ 30 kg/m^2).

As for perinatal outcomes, newborn morbidity was higher in the offspring of women with obesity, i.e., PC BMI ≥ 30 kg/m^2. In fact, neonatal morbidity was demonstrated to be higher in newborns from mothers with obesity.[43] Similarly, we herein report a morbidity rate significantly higher in newborns from women with obesity when compared to those of women that no longer presented obesity criteria (2.90% vs. 39.10%, in women with PC BMI < 30 kg/m^2 and PC BMI ≥ 30 kg/m^2, respectively; ρ = 0.008). The most common newborn morbidities were jaundice and malformations. Perinatal maternal morbidity has also been reported to be higher in women with obesity.[44] Notwithstanding, in our study, despite maternal morbidity occurred more frequently in women with obesity, there were no significant differences between the two groups.

Strengths and Limits

This study has its strengths but is not without limitations. First of all the retrospective nature of this study, precludes the extrapolation of the results. Second, the fact that this study was conducted in a small size population, it is likely to have hindered the statistical significance of some parameters.

On the other hand, it is possible to highlight some strengths. The fact, all the data was collected in a systematic way by the same researcher, that every pregnancy was monitored by the same team of obstetricians and all deliveries occurred at a single institution, confers additional robustness to the results observed.

Conclusion

PC BMI may significantly influence maternal and perinatal outcomes in pregnant women who have previously undergone BS. A lower PC BMI, bellow the obesity range, is associated with less morbidity during the pregnancy and after the deliver, with less incidence of the most common complications associated with pregnancy. A lower PC BMI had a positive influence in the newborn morbidity, where it was possible to observe that the newborns from the women who had a lower BMI had less complications. Women after BS have a high risk of gestational anemia and FGR, regardless the PC BMI.

In conclusion, the benefits of weight loss on adverse pregnancy outcomes associated with obesity can be optimized if women after BS are able to reverse the obesity condition.

Conflict of Interests

The author declares that he has no conflicts of interest and that it's not associated with any commercial group/brand/association.

Appendix

Table I - Characteristics of pregnant women after BS

Characteristics	PC BMI < 30 (n=34)	PC BMI ≥ 30 (n=23)	ρ value
Age at time of BS (years)	27.56 ± 4.29	27.17 ± 5.27	.763
Type of surgery			.273
RYGB	50.00 (17)	56.50 (13)	
SG	35.30 (12)	17.40 (4)	
AGB	14.70 (5)	26.10 (6)	
Body weight before BS (kg)	118.03 ± 15.47	131.29 ± 18.33	.006**
Height (m)	1.66 ± 0.07	1.62 ± 0.06	.029*
BMI before BS (kg/m^2)	43.06 ± 4.99	49.70 ± 6.42	.001***
Coexisting comorbidities prior to surgery			.210
None	82.40 (28)	65.20 (15)	
HT	5.90 (2)	17.40 (4)	
Type 2 Diabetes	2.90 (1)	13.00 (3)	
Dyslipidemia	5.90 (2)	4.30 (1)	
Obstructive Sleep Apnea	2.90 (1)	0.00 (0)	
Vitamin supplementation compliance	47.10 (16)	39.10 (25)	.597
Time since BS until conception (months)	50.85 ± 46.42	58.39 ± 49.74	.553
% Loss of weight between BS and conception	61.42 ± 8.87	73.22 ± 11.73	.001***
% Estimated BMI Loss	93.60 ± 12.22	61.92 ± 30.36	.001***
Chronic HT at preconception	0.00 (0)	13.00 (3)	.061

AGB – Adjustable Gastric Band; HT – Hypertension; BMI – Body Mass Index; BS – Bariatric Surgery; RYGB – Roux-en-Y Gastric Bypass; SG – Vertical Sleeve Gastrectomy (SG)
Values are expressed by means ± standard deviation or % (n).
* p ≤ .05 ** p ≤ .01 *** p ≤ .001

Table II - Obstetric outcomes of women after BS

Obstetric outcomes during pregnancy	PC BMI < 30 (n=34)	PC BMI ≥ 30 (n=23)	ρ value
Age at pregnancy (years)	31.21 ± 4.08	32.52 ± 5.92	.324
Preconception weight (kg)	72.03 ± 8.42	93.93 ± 16.32	.001***
Primiparity	47.10 (16)	52.20 (12)	.790
Smoking habits	32.40 (11)	8.70 (2)	.054
ASA prophylaxis during pregnancy	55.90 (19)	73.90 (17)	.263
Conditions during pregnancy			
Gestational anemia	35.40 (12)	30.40 (7)	.780
Intravenous iron treatment	23.50 (8)	26.10 (6)	1.000
GDM	5.90 (2)	4.30 (1)	1.000
Fetal Growth Restriction	20.60 (7)	17.40 (4)	1.000
Pregnancy Induced Hypertension (PIH)	8.80 (3)	17.40 (4)	.423
Oligoamnios	5.90 (2)	4.30 (1)	1.000
Treat of Preterm Birth	0.00 (0)	4.30 (1)	.393
Preterm Birth	2.90 (1)	10.50 (2)	.581
Gestational age at delivery (weeks)	39.10 ± 1.26	38.71 ± 2.21	.807

AH – Arterial Hypertension; ASA – Acetylsalicylic Acid; FGR – Fetal growth restriction; GDM – Gestational Diabetes Mellitus; PIH -Pregnancy Induced Hypertension
Values are expressed by means ± standard deviation or % (n).
* $p \leq .05$ ** $p \leq .01$ *** $p \leq .001$

Table III - Perinatal outcomes of women after bariatric surgery and newborns

Perinatal outcomes	PC BMI < 30 (n=34)	PC BMI ≥ 30 (n=23)	ρ value
GWG (kg)	15.25 ± 6.89	9.71 ± 7.54	.003**
BMI at admission for delivery	31.60 ± 2.02	39.18 ± 5.33	.001***
Labor			
Induced	20.60 (9)	30.40 (7)	
Spontaneous	79.41 (25)	69.57 (16)	
Type of delivery			.917
Eutocic	50.00 (17)	47.80 (11)	
Dystocic by instrumental delivery	14.70 (5)	8.70 (2)	
Cesarean section	35.30 (12)	43.50 (10)	
Emergent cesarean section	58.30 (7)	55.60 (5)	1.000
Birth weight (g)	2965.88 ± 439.13	2985.22 ± 601.15	.889
Birth height (cm)	48.18 ± 2.01	47.27 ± 2.85	.164
APGAR score < 7 at 5 minutes	0.00 (0)	0.00 (0)	
Neonatal morbidity	2.90 (1)	39.10 (9)	.008**
Jaundice	0.00 (0)	8.70 (2)	
Patent Foramen Ovalle	0.00 (0)	8.70 (2)	
Small for Gestational Age (SGA)	0.00 (0)	4.30 (1)	
Renal malformation	0.00 (0)	4.30 (1)	
Pulmonary malformation	0.00 (0)	4.30 (1)	
Hepatic malformation	0.00 (0)	4.30 (1)	
Bradycardia	0.00 (0)	4.30 (1)	
Sepsis	2.90 (1)	0.00 (0)	
Stillbirth or neonatal death	0.00 (0)	0.00 (0)	
Admission to NICU	0.00 (0)	13.00 (3)	.056
Complications during puerperium	20.60 (7)	26.10 (6)	1.000
Anemia	14.70 (5)	13.00 (3)	
Post-partum hypertension	2.90 (1)	4.30 (1)	
Surgical wound infection	0.00 (0)	4.30 (1)	
Dehiscence of sutures	2.90 (1)	0.00 (0)	
Folliculitis	0.00 (0)	4.30 (1)	
Postpartum hospitalization duration (days)	2.41 ± 0.89	2.91 ± 1.28	0.127

BMI – Body mass index; GWG – Gestational Weight Gain; NICU – Neonatal Intensive Care Unit; SGA – Small for Gestational Age

Values are expressed by means ± standard deviation or % (n).

* $p \leq .05$ ** $p \leq .01$ *** $p \leq .001$

Bibliography

1. Jung R. T. (1997). Obesity as a disease. *British medical bulletin*, *53*(2), 307–321. https://doi.org/10.1093/oxfordjournals.bmb.a011615
2. Solomon, G., Manson, E. (1997) Obesity and mortality: a review of the epidemiologic data. American Journal of Clinical Nutrition, 66, 1044S–50S.
3. Nuttall F. Q. (2015). Body Mass Index: Obesity, BMI, and Health: A Critical Review. *Nutrition today*, *50*(3), 117–128. https://doi.org/10.1097/NT.0000000000000092
4. Castro, V. A. B. (2014, August 1). Obesity, insulin resistance and comorbidities – Mechanisms of association. *Scielo Brazil.* https://www.scielo.br/j/abem/a/8rrcF9Wccfw5yJfB9YgJ9pR/?format=html.
5. Europe, W.H.O. (WHO) /. (2013). *WHO European Database on Nutrition, Obesity and Physical Activity (NOPA).* http://obesity.thehealthwell.info/search-results/who-european-database-nutrition-obesity-and-physical-activity-nopa
6. Heindel, J. J., Newbold, R., & Schug, T. T. (2015). Endocrine disruptors and obesity. *Nature reviews. Endocrinology*, *11*(11), 653–661. https://doi.org/10.1038/nrendo.2015.163
7. Calle, E. E., Thun, M. J., Petrelli, J. M., Rodriguez, C., & Heath, C. W., Jr (1999). Body-mass index and mortality in a prospective cohort of U.S. adults. *The New England journal of medicine*, *341*(15), 1097–1105. https://doi.org/10.1056/NEJM199910073411501
8. Chu, S. Y., Callaghan, W. M., Kim, S. Y., Schmid, C. H., Lau, J., England, L. J., & Dietz, P. M. (2007). Maternal obesity and risk of gestational diabetes mellitus. *Diabetes care*, *30*(8), 2070–2076. https://doi.org/10.2337/dc06-2559a
9. O'Brien, T. E., Ray, J. G., & Chan, W. S. (2003). Maternal body mass index and the risk of preeclampsia: a systematic overview. *Epidemiology (Cambridge, Mass.)*, *14*(3), 368–374. https://doi.org/10.1097/00001648-200305000-00020
10. Marchi, J., Berg, M., Dencker, A., Olander, E. K., & Begley, C. (2015). Risks associated with obesity in pregnancy, for the mother and baby: a systematic review of reviews. *Obesity reviews: an official journal of the International Association for the Study of Obesity*, *16*(8), 621–638. https://doi.org/10.1111/obr.12288
11. Costa, M. M., Belo, S., Souteiro, P., Neves, J. S., Magalhães, D., Silva, R. B., Oliveira, S. C., Freitas, P., Varela, A., Queirós, J., & Carvalho, D. (2018). Pregnancy after bariatric surgery: Maternal and fetal outcomes of 39 pregnancies and a literature review. *The journal of obstetrics and gynaecology research*, *44*(4), 681–690. https://doi.org/10.1111/jog.13574
12. Ovesen, P., Rasmussen, S., & Kesmodel, U. (2011). Effect of prepregnancy maternal overweight and obesity on pregnancy outcome. *Obstetrics and gynecology*, *118*(2 Pt 1), 305–312. https://doi.org/10.1097/AOG.0b013e3182245d49
13. Siega-Riz, A. M., Siega-Riz, A. M., & Laraia, B. (2006). The implications of maternal overweight and obesity on the course of pregnancy and birth outcomes. *Maternal and child health journal*, *10*(5 Suppl), S153–S156. https://doi.org/10.1007/s10995-006-0115-x
14. Chevrot, A., Kayem, G., Coupaye, M., Lesage, N., Msika, S., & Mandelbrot, L. (2016). Impact of bariatric surgery on fetal growth restriction: experience of a perinatal and bariatric surgery center. *American journal of obstetrics and gynecology*, *214*(5), 655.e1–655.e6557. https://doi.org/10.1016/j.ajog.2015.11.017
15. Wadden, T. A., Tronieri, J. S., & Butryn, M. L. (2020). Lifestyle modification approaches for the treatment of obesity in adults. *The American psychologist*, *75*(2), 235–251. https://doi.org/10.1037/amp0000517

16. Ruban, A., Stoenchev, K., Ashrafian, H., & Teare, J. (2019). Current treatments for obesity. *Clinical medicine (London, England)*, *19*(3), 205–212. https://doi.org/10.7861/clinmedicine.19-3-205
17. George, F. H.M. (2013). Boas práticas na abordagem do doente com obesidade elegível para cirurgia bariátrica. *Norma Da Direção-Geral Da Saúde, 1*(1), 9. http://www.dgs.pt/upload/membro.id/ficheiros/i018596.pdf
18. Buchwald, H., Avidor, Y., Braunwald, E., Jensen, M. D., Pories, W., Fahrbach, K., & Schoelles, K. (2004). Bariatric surgery: a systematic review and meta-analysis. *JAMA*, *292*(14), 1724–1737. https://doi.org/10.1001/jama.292.14.1724
19. Colquitt, J. L., Picot, J., Loveman, E., & Clegg, A. J. (2009). Surgery for obesity. *Cochrane Database of Systematic Reviews*. https://doi.org/10.1002/14651858.cd003641.pub3
20. Padwal, R., Klarenbach, S., Wiebe, N., Hazel, M., Birch, D., Karmali, S., Sharma, A. M., Manns, B., & Tonelli, M. (2011). Bariatric surgery: a systematic review of the clinical and economic evidence. *Journal of general internal medicine*, *26*(10), 1183–1194. https://doi.org/10.1007/s11606-011-1721-x
21. Picot, J., Jones, J., Colquitt, J. L., Gospodarevskaya, E., Loveman, E., Baxter, L., & Clegg, A. J. (2009). The clinical effectiveness and cost-effectiveness of bariatric (weight loss) surgery for obesity: a systematic review and economic evaluation. *Health technology assessment (Winchester, England)*, *13*(41), 1–iv. https://doi.org/10.3310/hta13410
22. Arterburn, D. E., Olsen, M. K., Smith, V. A., Livingston, E. H., Van Scoyoc, L., Yancy, W. S., Jr, Eid, G., Weidenbacher, H., & Maciejewski, M. L. (2015). Association between bariatric surgery and long-term survival. *JAMA*, *313*(1), 62–70. https://doi.org/10.1001/jama.2014.16968
23. Shawe, J., Ceulemans, D., Akhter, Z., Neff, K., Hart, K., Heslehurst, N., Štotl, I., Agrawal, S., Steegers-Theunissen, R., Taheri, S., Greenslade, B., Rankin, J., Huda, B., Douek, I., Galjaard, S., Blumenfeld, O., Robinson, A., Whyte, M., Mathews, E., & Devlieger, R. (2019). Pregnancy after bariatric surgery: Consensus recommendations for periconception, antenatal and postnatal care. *Obesity reviews: an official journal of the International Association for the Study of Obesity*, *20*(11), 1507–1522. https://doi.org/10.1111/obr.12927
24. Rottenstreich, A., Elazary, R., & Levin, G. (2018). Pregnancy after bariatric surgery and the risk of fetal growth restriction. *Surgery for obesity and related diseases: official journal of the American Society for Bariatric Surgery*, *14*(12), 1919–1920. https://doi.org/10.1016/j.soard.2018.09.004
25. Carreau, A. M., Nadeau, M., Marceau, S., Marceau, P., & Weisnagel, S. J. (2017). Pregnancy after Bariatric Surgery: Balancing Risks and Benefits. *Canadian journal of diabetes*, *41*(4), 432–438. https://doi.org/10.1016/j.jcjd.2016.09.005
26. Wax, J. R., Cartin, A., Wolff, R., Lepich, S., Pinette, M. G., & Blackstone, J. (2008). Pregnancy following gastric bypass surgery for morbid obesity: maternal and neonatal outcomes. *Obesity surgery*, *18*(5), 540–544. https://doi.org/10.1007/s11695-008-9459-1
27. Dixon, J. B., Dixon, M. E., & O'Brien, P. E. (2001). Pregnancy after Lap-Band surgery: management of the band to achieve healthy weight outcomes. *Obesity surgery*, *11*(1), 59–65. https://doi.org/10.1381/096089201321454123
28. Weiss, H. G., Nehoda, H., Labeck, B., Hourmont, K., Marth, C., & Aigner, F. (2001). Pregnancies after adjustable gastric banding. *Obesity surgery*, *11*(3), 303–306. https://doi.org/10.1381/096089201321336647
29. Akhter, Z., Rankin, J., Ceulemans, D., Ngongalah, L., Ackroyd, R., Devlieger, R., Vieira, R., & Heslehurst, N. (2019). Pregnancy after bariatric surgery and adverse perinatal outcomes: A systematic review and meta-analysis. *PLoS medicine*, *16*(8), e1002866. https://doi.org/10.1371/journal.pmed.1002866

30. Watanabe, A., Seki, Y., Haruta, H., Kikkawa, E., & Kasama, K. (2019). Maternal impacts and perinatal outcomes after three types of bariatric surgery at a single institution. *Archives of gynecology and obstetrics*, *300*(1), 145–152. https://doi.org/10.1007/s00404-019-05195-9
31. Haseeb Y. A. (2019). A Review of Obstetrical Outcomes and Complications in Pregnant Women after Bariatric Surgery. *Sultan Qaboos University medical journal*, *19*(4), e284–e290. https://doi.org/10.18295/squmj.2019.19.04.003
32. Yi, X. Y., Li, Q. F., Zhang, J., & Wang, Z. H. (2015). A meta-analysis of maternal and fetal outcomes of pregnancy after bariatric surgery. *International journal of gynaecology and obstetrics: the official organ of the International Federation of Gynaecology and Obstetrics*, *130*(1), 3–9. https://doi.org/10.1016/j.ijgo.2015.01.011
33. Chang, S. H., Stoll, C. R. T., Song, J., Varela, J. E., Eagon, C. J., & Colditz, G. A. (2014). The Effectiveness and Risks of Bariatric Surgery. *JAMA Surgery*, *149*(3), 275. https://doi.org/10.1001/jamasurg.2013.3654
34. ACOG practice bulletin no. 105: bariatric surgery and pregnancy. (2009). *Obstetrics and gynecology*, *113*(6), 1405–1413. https://doi.org/10.1097/AOG.0b013e3181ac0544
35. Abenhaim, H. A., Alrowaily, N., Czuzoj-Shulman, N., Spence, A. R., & Klam, S. L. (2016). Pregnancy outcomes in women with bariatric surgery as compared with morbidly obese women. *The journal of maternal-fetal & neonatal medicine: the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians*, *29*(22), 3596–3601. https://doi.org/10.3109/14767058.2016.1143927
36. Różańska-Walędziak, A., Walędziak, M., Bartnik, P., Kacperczyk-Bartnik, J., Janik, M., Kowalewski, P., Kwiatkowski, A., & Czajkowski, K. (2020). The Influence of Bariatric Surgery on Pregnancy and Perinatal Outcomes-A Case-Control Study. *Journal of clinical medicine*, *9*(5), 1324. https://doi.org/10.3390/jcm9051324
37. Sousa, M. G. D., Lopes, R. G. C., Rocha, M. L. T. L. F. D., Lippi, U. G., Costa, E. D. S., & Santos, C. M. P. D. (2019). Epidemiology of artherial hypertension in pregnants. *Einstein (São Paulo)*, *18*. https://doi.org/10.31744/einstein_journal/2020ao4682
38. Belogolovkin, V., Salihu, H. M., Weldeselasse, H., Biroscak, B. J., August, E. M., Mbah, A. K., & Alio, A. P. (2011). Impact of prior bariatric surgery on maternal and fetal outcomes among obese and non-obese mothers. Archives of Gynecology and Obstetrics, 285(5), 1211–1218. https://doi.org/10.1007/s00404-011-2134-0
39. Lewandowska M. (2021). Maternal Obesity and Risk of Low Birth Weight, Fetal Growth Restriction, and Macrosomia: Multiple Analyses. *Nutrients*, *13*(4), 1213. https://doi.org/10.3390/nu13041213
40. Wittgrove, A. C., Jester, L., Wittgrove, P., & Clark, G. W. (1998). Pregnancy following gastric bypass for morbid obesity. *Obesity surgery*, *8*(4), 461–466. https://doi.org/10.1381/096089298765554368
41. Dao, T., Kuhn, J., Ehmer, D., Fisher, T., & McCarty, T. (2006). Pregnancy outcomes after gastric-bypass surgery. *American journal of surgery*, *192*(6), 762–766. https://doi.org/10.1016/j.amjsurg.2006.08.041
42. Slater, C., Morris, L., Ellison, J., & Syed, A. A. (2017). Nutrition in Pregnancy Following Bariatric Surgery. *Nutrients*, *9*(12), 1338. https://doi.org/10.3390/nu9121338
43. Rastogi, S., Rojas, M., Rastogi, D., & Haberman, S. (2014). Neonatal morbidities among full-term infants born to obese mothers. The Journal of Maternal-Fetal & Neonatal Medicine, 28(7), 829–835. https://doi.org/10.3109/14767058.2014.935324
44. Vieira, C., Sarabando, R., Teixeira, N., Silva, C., & Reis, I. (2019). Impact of gestational weight gain on obstetric outcomes. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, *234*, e71. https://doi.org/10.1016/j.ejogrb.2018.08.312

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