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Research Article

Perinatal Outcomes Including Breastfeeding after Bariatric Surgery in Women with Grade 3 Obesity

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Abstract

Background: Reports on perinatal outcomes following bariatric surgery (*BS*) are common, however, information on how post-surgery pregestational grade 3 obesity (BMI ≥ 40 kg/m^2) could influence these outcomes as well as breastfeeding (BF) rates is limited. **Objective:** The primary objective was to compare perinatal outcomes including BF of women with grade 3 obesity, 83 of whom had *BS* and 166 matched controls who did not (*no-BS*). The secondary objective was to determine if the severity of pregestational grade 3 obesity (low 40-44 and high BMI ≥ 45 kg/m^2) influenced these outcomes. **Methods:** Retrospective cohort study. Controls were matched by pregestational BMI, mothers' age, parity and race. **Results:** Women in the *BS* group had lower rates of gestational diabetes mellitus (GDM) (7 vs 19%), chronic hypertension (CHTN) (7 vs 23%) and preeclampsia (7 vs 17%). Among their infants, small for gestation was frequent (18 vs 2%) while macrosomia was rare (4 vs 15%). In the *BS* and *no-BS* groups, BF outcomes including exclusive (24%) and any BF (66%) were equal. In the *no-BS* high BMI subgroup, the rates of CHTN (32 vs 15%) and formula feeding at discharge (44 vs 25%) were higher and any BF rate (56 vs 75%) was lower than in the low BMI *no-BS* subgroup. **Conclusion:** Although poor fetal growth is a concern, *BS* decreased the rates of hypertensive disorders, GDM and macrosomia even in women with pregestational grade 3 obesity and higher BMI. Among women in the *no-BS* group the prevalence of CHTN and macrosomia rises while BF initiation decrease as the severity of obesity worsens.

Keywords: Bariatric surgery; Breastfeeding; Grade 3 obesity; Perinatal outcomes

Background

Current literature confirms that obesity is the most common medical condition that affects women of reproductive age across the world [1-3]. Concurrently, bariatric surgery (BS) is accepted as one of the most effective methods for substantial and sustained weight loss [4-5]. A decrease in adverse perinatal outcomes following *BS* have been extensively reported [6-9]. Since there is an inverse correlation between the severity of obesity and the rate and duration of breastfeeding (BF), the association of high pregestational body mass index (BMI ≥ 40 kg/m^2) following *BS* acquired relevance [1,3,9].

The benefits of lactation on short and long term maternal and infant health have been clearly documented [10-11]. Specifically, exclusive BF during birth hospitalization and through the first postpartum year are very important for healthy women as well

as for those with comorbidities such as diabetes, severe obesity, hypertension, and other conditions [12-13]. Regrettably, few studies on perinatal outcomes that included BF following *BS* have been published [14-18]**.**

Objective

The primary objective was to compare perinatal outcomes including BF of women with grade 3 obesity, 83 of whom had *BS* and 166 matched controls who did not (*no-BS*). The secondary objective was to determine if the severity of pregestational grade 3 obesity (low 40-44 and high BMI ≥ 45 kg/m^2) influenced these outcomes.

Subjects and Methods

This retrospective cohort investigation was approved by the Institutional Review Board of The Ohio State University Wexner Medical Center (IRB 2010H0198). Electronic maternal and neonatal records (2013-21) were reviewed. According to their prepregnancy BMI women were classified as normal (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2), obese grade 1 (30-34.9 kg/m^2), grade 2 (35-39.9 kg/m^2) or grade 3 (≥ 40 kg/m^2) [1-2]. In an earlier study of pregnancy after *BS*, we reported that at conception 6% of the mothers were normal or overweight, 19% had grade1 obesity, 19% grade 2 and 56% grade 3 obesity [18]. Some clinical and demographic data from the women with grade 3 obesity were included in the current investigation. The study group of 83 mother-infant dyads was composed of 59 women who had one pregnancy and 12 who had two pregnancies after *BS*. Thirteen of the 83 (16%) women underwent laparoscopic gastric banding (LGB), 39 (47%) had Roux-en-Y gastric bypass (RYGB) and 31 (37%) had sleeve gastrectomy (SG). The interval from *BS* to conception was calculated as the time in months (mos.) that elapsed between the surgical date and the start of the following pregnancy [18].

The 166 control group (*no-BS*) was matched electronically by race, maternal age at delivery and parity from 4785 women with grade 3 obesity (BMI ≥ 40 kg/m^2) who delivered consecutive live singletons at ≥ 34 weeks of gestation without major malformations in our institution. Gestational diabetes mellitus (GDM), Type 1 and Type 2 DM, chronic hypertension (CHTN), preeclampsia, iron deficiency anemia, polycystic ovarian syndrome (PCOS), obstructive sleep apnea (OSA) and gastroesophageal reflux disorder (GERD) were diagnosed and treated in accordance with established guidelines [18-22]. Gestational weight gain (GWG) was categorized as adequate, inadequate or excessive [23]. A secondary analysis of perinatal outcomes according to the severity of obesity for the *BS* and *no-BS* groups categorized by their pregestational BMI as low (40-44 kg/m^2) or high (≥ 45 kg/m^2) subgroups.

During their prenatal visit or on arrival to Labor and Delivery women were asked their prior BF experiences and about feeding preferences for their infants [18-19]. They were also informed of our maternal practices that included early BF, formula supplementation only if medically indicated, rooming in and the availability of fulltime lactation consultants and post discharge BF support [18-19]. As required for hospital accreditation, our institution reports BF data to the Joint Commission [13].

Following delivery, any symptomatic infants were directly transferred to the NICU for further care. Holding, skin-to-skin contact and BF were encouraged depending on the mother-infant dyad condition. Asymptomatic infants able to feed were transferred to the Newborn Nursery with their mothers for routine care and glucose monitoring [18-19]. Infants were identified as appropriate for gestational age (AGA), small for gestational age (SGA), large for gestational age (LGA) or macrosomic (birthweight ≥ 4000g) from intrauterine growth charts [18-19].

Hypoglycemia (blood glucose < 40 mg/dl) was tested with Accu-Chek® or by plasma glucose measurements starting during the first hour of life. Infants with recurrent hypoglycemia were transferred for further care to the NICU [18-19].

Exclusive BF was defined as direct feedings from the breast or from expressed breast milk alone or in combination with direct BF and partial BF by formula supplemented with direct BF or with expressed breast milk [18,19]. BF was considered initiated if, during the 24 hours preceding hospital discharge, infants were exclusively BF or BF partially [18-19].

Statistical Analysis

Comparisons of study and control groups were made with Fisher's, T-Test, Wilcoxon Two-Sample test for continuous variables and Chi-square tests for categorical variables. Multivariate logistic regressions were used to determine associations of *BS* with maternal and neonatal comorbidities and with exclusive BF and BF initiation at discharge. Variables entered into both models include *BS*, DM, CHTN, age, race, healthcare public assistance, smoking, BMI, obesity grade, GWG, parity, mode of delivery, prior BF, late prematurity, AGA, SGA, LGA, macrosomia, hypoglycemia, admission to NICU and length of stay. Significance was established at a *p*-value <0.05.

Results

Maternal Clinical and Demographics from the BS and no-BS groups

Clinical and demographic data from the *BS* and *no-BS* groups are presented in Table 1. As expected after matching, maternal age at delivery (34 ± 5 years), primiparity (35%), median pregestational BMI (44 kg/m^2) and ethnic distribution (white 70%, African American 29% and other 1%), history of smoking (29 vs 29%), advanced maternal age (39 vs 39%) and healthcare public assistance (52 vs 57%) were comparable. The time from *BS* to conception was ≤ 24 mos. for 35% of women, 25-72 mos. for 34% and ≥ 73 mos. for the remaining 31%. Among women in the *BS* group, prevalence of Type 2 DM (23 vs 9%) was more frequent, Type 1 DM was similar (7 vs 3%) whereas GDM (7 vs 19%) was less common than in the *no-BS* group.

Table 1: Maternal Clinical and Demographics from the *BS* and *no-BS* groups

	Bariatric Surgery	**Control**	***p*-value**
Mother-Infant Dyads no.	83	166	
Nulliparous no. (%)	29 (35)	58 (35)	1.000^
Mothers age at delivery (y) mean ± SD	34 ± 5	34 ± 5	1.0000*
Race: White no. (%)	58 (70)	116 (70)	1.0000†
African American no. (%)	24 (29)	48 (29)	
Other no. (%)	1 (1)	2 (1)	
Healthcare public assistance no. (%)	43 (52)	94 (57)	0.4711^
Smoking: Current no. (%)	2 (2)	12 (7)	0.2420†
Former no. (%)	22 (27)	36 (22)	
Diabetes: Gestational no. (%)	6 (7)	32 (19)	<0.0001^
Type 1 no. (%)	6 (7)	5 (3)	0.1876^
Type 2 no. (%)	19 (23)	15 (9)	0.0054^
Hypertension: Chronic no. (%)	6 (7)	39 (23)	0.0017*
Gestational no. (%)	2 (2)	21 (13)	0.0085†
Preeclampsia with severe features no. (%)	6 (7)	28 (17)	0.0059†
Polycystic ovarian syndrome no. (%)	19 (23)	20 (12)	0.0265^
Obstructive sleep apnea no. (%)	15 (18)	11 (7)	0.0054^
Gastroesophageal reflux disorder no. (%)	13 (16)	7 (4)	0.0017^
Asthma no. (%)	12 (15)	21 (13)	0.6918^
Iron deficiency anemia no. (%)	12 (15)	12 (7)	0.0684^
Post partum hemorrhage no. (%)	8 (10)	13 (8)	0.6286^
Pregestational BMI (kg/m^2) median [IQR]	44 [42,51]	44 [42,50]	0.4632‡
Prepregnant weight (kg) median [IQR]	113 [98,135]	110 [98,127]	0.1759‡
Admission weight at delivery (kg) median [IQR]	124 [112,138]	124 [114,137]	0.9635‡
Gestational weight gain (kg) median [IQR]	10 [4,16]	13 [6,22]	0.0231‡
Delivery: Vaginal no. (%)	40 (48)	68 (41)	0.4786^
Primary cesarean no. (%)	25 (30)	52 (31)	
Repeat cesarean no. (%)	18 (22)	46 (28)	
Mothers' length of stay (d) median [IQR]	3 [2,3]	4 [3,4]	<0.0001‡

Analysis: † Fisher's Exact Test, ^ Chi-Square, * T-Test, ‡ Wilcoxon Two-Sample Test

Hypertensive disorders were fewer among women in the *BS* group: CHTN (7 vs 23%), gestational hypertension (2 vs 13%) and preeclampsia with severe features (7 vs 17%). Women who had *BS* were less likely to have CHTN (aOR 0.231 CI 95% (0.081,0.658). Furthermore, 5 of 6 women with CHTN in the *BS* group and 21 of 39 in the *no-BS* group required continued antihypertensive medication before and after delivery. Concurrently, prevalence of PCOS (23 vs 12%), OSA (18 vs 7%) and GERD (16 vs 4%) was higher in the *BS* group whereas the incidence of asthma (15 vs 13%), iron deficiency anemia (15 vs 7%) and post-partum hemorrhage (10 vs 8%) were similar. Among women in the *BS* group, median pregestational (113 vs 110 kg), median admission weight at delivery (124 vs 124 kg), excessive GWG (70 vs 74%), rates of vaginal (48 vs 41%) and cesarean deliveries (52 vs 59%) were all comparable to those of women in the *no-BS* group.

Neonatal outcomes for the BS and no-BS groups

Infants born to the 83 women from the BS group and the 166 infants from the no-BS group were comparable in male gender (52 vs 57%), median gestational age (39 vs 39w) and late prematurity (17 vs 17%), but differed in birth weight (3117 vs 3472g), LGA (4 vs 21%), SGA (18 vs 2%) and macrosomia (4 vs 15%) (Table 2). Regression analysis showed that infants born after *BS* were less likely to be macrosomic (aOR 0.170 CI 95% (0.043,0.668). Fourteen infants from the *BS* group and 35 from the *no-BS* group admitted to the NICU were combined for analysis. Thirty-four of the 49 (69%) infants were transferred to the NICU directly from the delivery room, while the remaining 15 (31%) stayed with their mothers prior to transfer. Of the 49 mothers, eight had GDM, three Type 1 and thirteen Type 2 DM. Primary NICU admission diagnoses were respiratory distress (45%), hypoglycemia (22%), rule-out sepsis (12%), apnea-hypotonia-temperature instability (12%) and miscellaneous conditions (9%). Twenty-nine percent of the infants were discharged from the NICU within three days, 35% from 4-7 days and the remaining 36% later. All infants admitted to the NICU or to the Newborn Nursery and their mothers were discharged home in good condition.

Table 2: Neonatal Outcomes for the *BS* and *no-BS* groups

	Bariatric Surgery	**Control**	***p*-value**
Mother-Infant Dyads no.	83	166	
Multiparous no. (%)	54 (65)	108 (65)	1.0000^
Prior breastfeeding experience no. (%)	23 (28)	56 (34)	0.3356^
Gender (male) no. (%)	43 (52)	95 (57)	0.4171^
Gestational age (w) median [IQR]	39 [37,39]	39 [37,39]	0.9595 ‡
Late preterm (34-36 weeks) no. (%)	14 (17)	29 (17)	1.0000†
Birthweight (g) mean ± SD	3117 ± 560	3472 ± 577	<0.0001*
Intrauterine Fetal Growth			<0.0001†
Appropriate for gestation no. (%)	65 (78)	128 (77)	
Small for gestation no. (%)	15 (18)	3 (2)	
Large for gestation no. (%)	3 (4)	35 (21)	
Macrosomia no. (%)	3 (4)	24 (15)	0.0095†
Neonatal hypoglycemia no. (%)	8 (10)	29 (17)	0.1015†
Admission to NICU no. (%)	14 (17)	35 (21)	0.4301†
Infant length of stay (d) median [IQR]	3 [2,3]	3 [2,3]	0.0422‡
Mothers Intention to Feed			0.6364†
Breastfeeding no. (%)	58 (70)	125 (75)	
Partial breastfeeding no. (%)	6 (7)	11 (7)	
Formula only (%)	19 (23)	30 (18)	
Infant Feeding at Discharge			0.9928^
Exclusive breastfeeding no. (%)	20 (24)	39 (24)	
Partial breastfeeding no. (%)	35 (42)	70 (42)	
Formula only no. (%)	28 (34)	57 (34)	
Breastfeeding Initiation no. (%)	55 (66)	109 (66)	1.000^

Analysis: † Fisher's Exact Test, ^ Chi-Square, * T-Test, ‡ Wilcoxon Two-Sample Test

Mother infant feeding preferences for the *BS* and *no-BS* groups were to BF (70 vs 75%), BF partially (7 vs 7%) and FF only (23 vs 18%). Regardless of feeding preference, lactation consults were accepted equally by women from both groups (75 vs 70%). At discharge, both groups were similar in exclusive BF (24 vs 24%), partial BF (42 vs 42%), FF only (34 vs 34%) as well as in BF initiation (66 vs 66%). Regression analysis showed that women who received public assistance were less likely to initiate BF at discharge (aOR 0.668 CI 95% (0.350,1.277). On the other hand, women who had prior BF experience and intended BF exclusively were more likely to initiate BF (aOR 6.269 CI 95% (2.767,14.202).

Women with grade 3 obesity who had BS according to low and high pregestational BMI

Considering that the median BMI for the 83 women who had BS was 44 kg/m^2, the group was divided into 42 with low BMI (median 42, IQR 40,43 kg/m^2) and 41 with high BMI (median 51, IQR 47,56 kg/m^2). Maternal characteristics and outcomes of both subgroups are presented in Table 3. Advanced maternal age (44 vs 33%) and former smokers (37 vs 17%) were more common in the higher BMI subgroup. However, DM (36 vs 32%) and hypertensive disorders combined (12 vs 22%) were of similar prevalence. The difference in severity of obesity was demonstrated by median prepregnant weights (100 vs 133 kg) and by median weight on admission to the delivery room (113 vs 138 kg). However, median GWG (11 vs 10 kg) and the rate of cesarean deliveries were similar (55 vs 49) among the low and high BMI groups.

Table 3: Women with grade 3 obesity who had *BS* according to low and high pregestational BMI

	BMI ≤ 44kg/m^2	**BMI ≥ 45kg/m^2**	***p*-value**
Mother-Infant Dyads no.	42	41	
Nulliparous no. (%)	17 (41)	12 (29)	0.2843^
Mothers age at delivery (y) mean ± SD	33 ± 5	34 ± 4	0.1503*
Race: White no. (%)	30 (71)	28 (68)	0.7201†
African American no. (%)	11(26)	13 (32)	
Other no. (%)	1 (2)	0 (0)	
Healthcare public assistance no. (%)	20 (48)	23 (56)	0.4396^
Smoking: Current no. (%)	1 (2)	1 (2)	0.0765†
Former no. (%)	7 (17)	15 (37)	
Diabetes: Gestational no. (%)	8 (5)	8 (5)	1.0000^
Type 1 no. (%)	4 (7)	2 (5)	
Type 2 no. (%)	10 (24)	9 (22)	
Hypertension: Chronic no. (%)	2 (5)	4 (10)	0.4326†
Gestational no. (%)	1 (2)	1 (2)	1.0000†
Preeclampsia with severe features no. (%)	2 (5)	4 (10)	0.4326†
Polycystic ovarian syndrome no. (%)	9 (21)	10 (24)	0.7481†
Obstructive sleep apnea no. (%)	6 (14)	9 (22)	0.3642†
Gastroesophageal reflux disorder no. (%)	5 (12)	8 (20)	0.3404†
Asthma no. (%)	3 (7)	9 (22)	0.0551†
Iron deficiency anemia no. (%)	6 (14)	6 (15)	0.9640†
Post partum hemorrhage no. (%)	5 (12)	3 (7)	0.7126†
Pregestational BMI (kg/m^2) median [IQR]	42 [40,43]	51 [47,56]	<0.0001‡
Prepregnant weight (kg) median [IQR]	100 [95,110]	133 [123,149]	<0.0001‡
Admission weight at delivery (kg) median [IQR]	113 [103,121]	138 [130,158]	<0.0001‡
Gestational weight gain (kg) median [IQR]	11 [7,19]	10 [2,15]	0.2235‡
Delivery: Vaginal no. (%)	19 (45)	21 (51)	0.6014^
Primary cesarean no. (%)	12 (29)	13 (32)	
Repeat cesarean no. (%)	11 (26)	7 (17)	
Mothers length of stay (d) median [IQR]	3 [2,4]	3 [2,3]	0.9467‡

Analysis: † Fisher's Exact Test, ^ Chi-Square, * T-Test, ‡ Wilcoxon Two-Sample Test

Neonatal outcomes for the BS group according to low and high pregestational BMI

The small sample size of these *BS* subgroups made their clinical and demographic differences statistically less significant (Table 3 & 4). Main admission diagnoses to the NICU were for the low BMI group (two RDS, one SGA and two prematurity) and for the high BMI group (four RDS, three prematurity and one abstinence syndrome). Of relevance, mother infant BF preference (62 vs 78%), lactation consults (71 vs 78%), exclusive BF (21 vs 27%) and BF initiation at discharge (60 vs 73%) were similar.

Table 4: Neonatal outcomes for the BS group according to low and high pregestational BMI

	BMI ≤ 44kg/m²	**BMI ≥ 45kg/m²**	***p*-value**
Mother-Infant Dyads no.	42	41	
Multiparous no. (%)	25 (60)	29 (71)	0.2843^
Prior BF experience no. (%)	12 (29)	11 (27)	0.8593^
Gender (male) no. (%)	21 (50)	22 (54)	0.7388^
Gestational age (w) median [IQR]	39 [37,39]	38 [37,39]	0.7995‡
Late preterm (34-36 weeks) no. (%)	7 (17)	7 (17)	1.0000†
Birthweight (g) mean ± SD	3082 ± 542	3153 ± 582	0.5685*
Intrauterine Fetal Growth			1.0000^
Appropriate for gestation no. (%)	33 (79)	32 (78)	
Small for gestation no. (%)	8 (19)	7 (17)	
Large for gestation no. (%)	1 (2)	2 (5)	
Macrosomia no. (%)	1 (2)	2 (5)	0.6158^
Neonatal hypoglycemia no. (%)	4 (10)	4 (10)	1.0000†
Admission to NICU no. (%)	5 (12)	9 (22)	0.2217^
Infant length of stay (d) median [IQR]	3 [2,4]	2 [2,3]	0.8607‡
Mothers Intention to Feed			0.3282†
Breastfeeding no. (%)	26 (62)	32 (78)	
Partial breastfeeding no. (%)	4 (10)	2 (5)	
Formula only (%)	12 (29)	7 (17)	
Infant Feeding at Discharge			0.4208^
Exclusive breastfeeding no. (%)	9 (21)	11 (27)	
Partial breastfeeding no. (%)	16 (38)	19 (46)	
Formula only no. (%)	17 (41)	11 (27)	
Breastfeeding Initiation no. (%)	25 (60)	30 (73)	0.3502†

Analysis: † Fisher's Exact Test, ^ Chi-Square, * T-Test, ‡ Wilcoxon Two-Sample Test

Women with grade 3 obesity in the no-BS group according to low and high pregestational BMI

Among women in the *no-BS* group high and low BMI, nulliparity (38 vs 32%), maternal age (34 vs 34y), advanced (34 vs 34y), advanced maternal age (36 vs 41%), ethnic distribution: white (73 vs 67%), African American (25 vs 33%), other (2 vs 0%), healthcare public assistance (51 vs 62%) and past history of smoking (19 vs 24) were all statistically similar (Table 5). On the other hand, CHTN was more common among women in the high BMI group (32 vs 15%). Furthermore, 36% of women with CHTN in the low BMI group and 60% of those in the high BMI group required continued antihypertensive medication before and after delivery. The difference in severity of obesity was demonstrated by the different median BMIs (42 vs 50 kg/m^2); median prepregnant weights (100 vs 122 kg) and median weights on admission at delivery room (116 vs 136 kg). Of note, median GWG (15 vs 12 kg), excessive GWG (78 vs 70%) and rate of cesarean delivery (54 vs 65%) were similar among the low and high BMI groups.

Table 5: Women with grade 3 obesity in the *no-BS* group according to low and high pregestational BMI

	BMI ≤ 44kg/m^2	**BMI ≥ 45kg/m^2**	***p*-value**
Mother-Infant Dyads no.	84	82	
Nulliparous no. (%)	32 (38)	26 (32)	0.3881^
Mothers age at delivery (y) mean ± SD	34 ± 5	34 ± 5	0.7950*
Race: White no. (%)	61 (73)	55 (67)	0.2353†
African American no. (%)	21 (25)	27 (33)	
Other no. (%)	2 (2)	0 (0)	
Healthcare public assistance no. (%)	43 (51)	51 (62)	0.1526^
Smoking: Current no. (%)	6 (8)	6 (7)	0.6957†
Former no. (%)	16 (19)	20 (24)	
Diabetes: Gestational no. (%)	18 (21)	14 (17)	0.4770†
Type 1 no. (%)	3 (4)	2 (2)	
Type 2 no. (%)	4 (5)	11 (13)	
Hypertension: Chronic no. (%)	13 (15)	26 (32)	0.0137†
Gestational no. (%)	11 (13)	10 (12)	0.8615†
Preeclampsia with severe features no. (%)	14 (17)	15 (18)	0.8397†
Polycystic ovarian syndrome no. (%)	9 (11)	11 (13)	0.5931†
Obstructive sleep apnea no. (%)	2 (2)	9 (11)	0.0260†
Gastroesophageal reflux disorder no. (%)	6 (7)	1 (1)	0.1172†
Asthma no. (%)	8 (9)	13 (16)	0.2200†
Iron deficiency anemia no. (%)	4 (5)	8 (10)	0.2141†
Post partum hemorrhage no. (%)	7 (8)	6 (7)	0.8075†
Pregestational BMI (kg/m^2) median [IQR]	42 [41,43]	50 [46,53]	<0.0001‡
Prepregnant weight (kg) median [IQR]	100 [90,113]	122 [108,140]	<0.0001‡
Admission weight at delivery (kg) median [IQR]	116 [109,124]	136 [124,147]	<0.0001‡
Gestational weight gain (kg) median [IQR]	15 [8,23]	12 [5,21]	0.3003‡
Delivery: Vaginal no. (%)	39 (46)	29 (35)	0.3495^
Primary cesarean no. (%)	24 (29)	28 (34)	
Repeat cesarean no. (%)	21 (25)	25 (31)	
Mothers length of stay (d) median [IQR]	4 [3,4]	4 [3,4]	1.000‡

Analysis: † Fisher's Exact Test, ^ Chi-Square, * T-Test, ‡ Wilcoxon Two-Sample Test

Neonatal outcomes for the no-BS group according to low and high pregestational BMI

Most of the clinical and demographic characteristics of both neonatal subgroups were similar (Table 6). However, macrosomia affected 21% of infants in the high BMI group as compared to 8% of those in the low BMI group. Similar intention to BF was declared by women from either group (77 vs 73%) although intention to FF only was more common among women from the high BMI group (23 vs 10%). Coincidentally, at discharge women from the high BMI group FF exclusively to 44% of their infants as compared with 25% of those in the low BMI group. Finally, BF initiation was more prevalent among women in the low BMI as compared to those in the high BMI subgroup (75 vs 56%).

Table 6: Neonatal outcomes for the *no-BS* group according to low and high pregestational BMI

	BMI ≤ 44 kg/m²	**BMI ≥ 45 kg/m²**	***p*-value**
Mother-Infant Dyads no.	84	82	
Multiparous no. (%)	52 (62)	56 (68)	0.3881^
Prior BF experience no. (%)	30 (36)	26 (32)	0.5851^
Gender (male) no. (%)	48 (57)	47 (57)	0.9819^
Gestational age (w) median [IQR]	39 [37,39]	38 [37,39]	0.678‡
Late preterm (34-36 weeks) no. (%)	17 (20)	12 (15)	0.151†
Birthweight (g) mean ± SD	3389 ± 537	3557 ± 607	0.0611*
Intrauterine Fetal Growth			0.3846†
Appropriate for gestation no. (%)	68 (81)	60 (73)	
Small for gestation no. (%)	2 (2)	1 (1)	
Large for gestation no. (%)	14 (17)	21 (26)	
Macrosomia no. (%)	7 (8)	17 (21)	0.0231^
Neonatal hypoglycemia no. (%)	13 (16)	16 (20)	0.4935†
Admission to NICU no. (%)	17 (20)	18 (22)	0.7868†
Infant length of stay (d) median [IQR]	2 [2,4]	3 [2,3]	0.8327‡
Mothers Intention to Feed			0.1011†
Exclusive BF no. (%)	65 (77)	60 (73)	
Partial BF no. (%)	11 (13)	3 (4)	
Formula only (%)	8 (10)	19 (23)	
Infant Feeding at Discharge			
Exclusive BF no. (%)	20 (24)	19 (23)	1.000^
Partial BF no. (%)	43 (51)	27 (33)	0.0191^
Formula only no. (%)	21 (25)	36 (44)	0.0140^
Breastfeeding Initiation no. (%)	63 (75)	46 (56)	0.0140^

Analysis: † Fisher's Exact Test, ^ Chi-Square, * T-Test, ‡ Wilcoxon Two-Sample Test

Discussion

In general, clinical and demographic features of our study population are comparable to that of other publications [9,24-26]. Our data showed that GDM rates were lower among the patients who had *BS* [27]. Since a glucose tolerance test to diagnose GDM in a pregnancy after *BS* is unreliable, the true incidence of post *BS* GDM is unknown [28]. Long term complications of GDM include recurrence, Type 2 DM and cardiovascular disease in the mother and obesity and glucose intolerance in the offspring [29]. It has been reported that 73% of women who experienced GDM would recur in the subsequent pregnancy and they are ten times more likely to develop Type 2 DM later [29-30]. The high prevalence of Type 2 DM observed in our study may relate to the referral population of our regional center [19]. In many cases, Type 2 DM declined a few days after *BS*, however, relapses are known to occur in half of the patients [31]. Germaine to our study GDM has been associated with shorter duration of BF although for women who BF longer than three months the risk of developing Type 2 DM may decrease [32].

Pregnant women with obesity are at increased risk of adverse maternal and neonatal outcomes including hypertensive diseases, diabetes, prematurity, cesarean delivery, fetal growth abnormalities and perinatal mortality [3,33]. Although *BS* is one of the most effective methods for substantial weight loss, a proportion of patients experience clinically significant weight regain following surgery [34]. Unfortunately, if excessive, this regained weight may be associated with recurrences of previously controlled type 2 DM, hypertension, and other obesity-related comorbidities [31,34]. The data presented here indicates that the benefits of *BS* on GDM and hypertensive disorders is evident even in this heterogeneous group of women with grade 3 obesity and the highest pregestational BMI. On the other hand, our data showed that the rate of GDM, CHTN and preeclampsia was higher among women with grade 3 obesity in the low and high *no-BS* (control) group. Unfortunately, CHTN is also often associated with obesity, superimposed preeclampsia, and diabetes [19,35-38]. In light of the above, the benefits provided by *BS* to women with gestational HTN, preeclampsia and CHTN reported here are very rewarding [9,26, 38-39].

Recent reports confirm that after *BS*, patients who had PCOS and a significant and persistent weight loss, the prevalence of menstrual irregularities, hirsutism, type 2 DM, hypertension and infertility may be significantly reduced [40-41]. The unexpected high prevalence of PCOS among women who had *BS* in the current study may be related to the research design where all women have pregestational grade 3 obesity (BMI≥40kg/m^2), either due to insufficient weight loss or having substantially regained weight over time [34].

OSA is a common sleep disorder in morbidly obese adults estimated to affect up to one billion people worldwide, while among patients scheduled for *BS*, the prevalence was found to be 60 percent [42-43]. In our investigation, OSA was more prevalent in the *BS* group and it was twice as common in the high than in the low BMI subgroup.

As shown in this report, GERD although highly prevalent in adults with obesity, is also common among those who had *BS*. RYGB is the most effective treatment for GERD in patients with obesity for whom the reported resolution was as high as 45%, however the effect of other restrictive surgeries was not as impressive [44]. Due to the possibility that de novo GERD could occur after *BS*, the true prevalence of preexisting or post-*BS* GERD remains equivocal.

Obesity has been recognized as an important comorbidity in patients with asthma or asthma like symptoms [45]. Adults with grade 3 obesity, especially those with BMI ≥ 50kg/m^2 have a two and a half times higher risk of asthma as compared to adults of normal weight [45]. Of further concern is the high prevalence of asthma in children whose mothers were obese and had asthma during pregnancy [45]. Recent data showed that weight reduction triggered by *BS* may improve asthma outcomes or may decrease the need for asthma medications [46].

In the current study, iron deficiency anemia was found in 14% of *BS* and in 8% of *no-BS* controls women who received iron supplementation. Iron deficiency in obese persons or individuals with Type 2 DM may be due to low absorption and poor tolerance to iron rich food [47], The prevalence of iron deficiency anemia after *BS* varies from 18 to 53% for RYGB and between 1 and 54% for SG [48]. SG is an alternative technique that causes less perioperative and late complications, however, long term weight results appeared to be inferior to RYGB [8,24,39]. The prevalence and changing choices of *BS* procedures over time that we observed are commensurate with that seen across the world [8,18,24,39].

Earlier studies of perinatal outcomes following *BS* showed increased rates of SGA and varying rates of LGA in infants, some associated with the type of surgery and others with the duration of *BS* to conception intervals [15,18, 24-25]. The higher rates of SGA and lower rates of LGA and macrosomia after *BS* as compared to the control (*no-BS)* population noted here are in line with earlier reports [8,26].

In an effort to extend BF duration the American Academy of Pediatrics and the Academy of Breastfeeding Medicine recommend exclusive BF for all healthy infants during birth hospitalization [12]. In the US in 2019 the mean in-hospital exclusive BF rate in the general population was 52.6% and for those in the most BF supportive hospitals was 64.7% [12]. In reality, these rates are quite different from the 19 to 35% range reported for women with severe obesity, pregestational diabetes, preeclampsia or CHTN

[1,18-19,36,38]. Considering that the comorbidities affecting *BS* and *no-BS* women with Grade 3 obesity are similar to those described above, their low exclusive BF rates (24 vs 24%) although disappointing, were not unexpected.

Another predictor of BF duration, BF initiation (any BF) at discharge, was reported to be 83.2% in 2019 for the general US population [49]. In comparison, BF initiation rates among women with comorbidities like those described above ranged from 54 to 82%, thus the 66% BF initiation rate in the *BS* and *no-BS* reported here, although lower, were not surprising [18-19,36,38].

It is known that women who do not BF the first child are unlikely to BF the next [50]. Prior BF experience even among women with obesity and other comorbidities is also a good predictor of success in subsequent pregnancies [50-51]. It is of concern that in our study of the 58 *BS* and 125 *no-BS* women who intended to BF exclusively, only 86% and 80% respectively provided any BF to their infants at discharge. Regardless of the difficulties that led to an unsatisfactory BF experience it is up to health providers to explain, reassure, comfort, educate and encourage these women and their families to expect better outcomes in future pregnancies [51].

Besides the comorbidities described above there are several other obstacles to BF including race, advanced maternal age, smoking and public assistance that need to be recognized [52-55]. The lower prevalence of African American compared to white women undergoing *BS* in our study is similar to that reported by others [52]**.** Women of advanced age and smokers are less likely to initiate BF or to BF longer than non-smokers [53-54]. Public assistance for health care was reported for 52% in the *BS* and 57% in the *no-BS* group whereas BF initiation rate was low in both groups (63 vs 59%). In a recent publication we noted that women who received public assistance and had *BS* were less likely to BF exclusively (a OR 0.391, CI 95%, 0.185-0.825, respectively) [18]. Furthermore, women on public assistance are less likely to undergo *BS*, although they experience higher rates of obesity and related complications that could qualify them for this surgical option [55].

A limitation of this investigation is that the definition of exclusive BF and BF initiation at discharge used here may be applicable only to women with high-risk obstetrical conditions and to the absence of follow-up information regarding BF after discharge from the hospital [18-19]. The strength of this investigation is the addition of BF as an important perinatal outcome to *BS*. Furthermore, the obstetrical and neonatal data presented here was obtained directly from electronic medical records and not from post-delivery maternal questionnaires.

In conclusion, although poor fetal growth remains a challenge, *BS* improvement on rates of hypertensive disorders and GDM even in women with higher grade 3 obesity are definite. Regrettably, exclusive BF and BF initiation rates among women with obesity and significant comorbidities remained lower than in the general population. Learning about obstacles to BF following *BS* would be helpful to design special strategies if successful lactation is to be achieved.

Declarations

Authors' contributions

All authors participated in planning and research design, data analysis and manuscript preparation - LC, Manuscript revisions - LC, CAN, MRS, MBN, BJN and SN. The author(s) read and approved the final manuscript.

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Availability of data and materials

The data sets generated during and analyzed during the current study are not publicly available due to limitations of ethical approval involving the patient data and anonymity but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The Ohio State University Biomedical Science IRB approved on 05/02/2022 the continuation of the study #2010H0198 with waivers of informed consent and HIPAA research authorization. All methods were performed in accordance with the relevant guidelines and regulations of the declaration of Helsinki.

Competing interests

The Author(s) declare(s) that there is no conflict of interest.

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