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RESEARCH

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Maternal and neonatal outcomes following metabolic bariatric surgery in the United Arab Emirates

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Abstract

Background Metabolic bariatric surgery (MBS) is recommended for patients with a body mass index > 40 kg/m^2 to reduce the risk of diabetes, hypertension, and other obesity-related comorbidities. However, pregnancy following MBS increases the risk of adverse neonatal and maternal outcomes. This study aimed to investigate the association between previous MBS and adverse maternal and neonatal outcomes.

Methods This prospective cohort study recruited 209 pregnant women between July 2021 and November 2022 from a tertiary maternity hospital in Abu Dhabi, United Arab Emirates. Among them, 99 had a history of metabolic and bariatric surgery (MBS), while 110 had no prior MBS. Primary outcomes were gestational weight gain (GWG) and neonatal birth weight.

Results The mean gestational weight gain among women without MBS was 11.3 ± 5.73 kg compared with 7.9 ± 5.61 kg in women with MBS ($p < 0.001$). Chi-Square analysis revealed a significant association between low birth weight and preterm outcomes with MBS, with significantly higher prevalence of both low birth weight and preterm in the MBS group compared with the non-MBS group. Logistic regression analysis confirmed the higher risk for both low birth weight and preterm in the MBS group. Moreover, metabolic bariatric surgery was not associated with GWG, however, parity was positively associated with GWG.

Conclusions Metabolic bariatric surgery was associated with adverse neonatal outcomes without apparent adverse maternal outcomes.

Keywords Bariatric surgery, Maternal outcome, Neonatal outcome, Low birth weight, Gestational weight, Birth weight

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Background

The obesity pandemic has escalated in the Middle East because of various factors, including sedentary lifestyles and changes in eating habits [1, 2]. According to the 2021 International Federation for the Surgery of Obesity and Metabolic Disorder survey, the number of recorded metabolic bariatric surgeries (MBS) performed worldwide was 507, 298 [3]. The number of metabolic bariatric surgeries is increasing, and half of the patients were women of childbearing age [4]. In the United Arab Emirates (UAE), the most popular type of metabolic bariatric surgery is sleeve gastrectomy, followed by RYGB [5]. Women with a body mass index (BMI) of > 40 kg/m^2 [6, 7] choose MBS to achieve long-term weight loss. In addition, MBS was associated with a reduction in gestational diabetes risk, type 2 diabetes [7–9]. This is due to improved endocrine function after MBS, such as increased insulin sensitivity and incretin secretion [31]. Furthermore, MBS was associated with a reduced incidence of adverse neonatal outcomes, including admission to the neonatal intensive care unit (NICU) [8].

The association between the perinatal environment and potential future disease is well-established in the literature [9–15]. Gestational weight gain (GWG) determines neonatal health, including the birth weight [16–20]. According to the guidelines of the Institute of Medicine, adequate gestational weight among women categorized as underweight, normal, overweight, and obese are 12.5–18 kg, 11.5–16 kg, 7–11.5 kg, and 5–9 kg, respectively [21]. Inadequate GWG is associated with having small-for-gestational-age (SGA) neonates [22]. Previous studies have shown that mothers of SGA neonates had lower GWG at delivery [22, 23]. A systematic study by Kwong et al. [24] found an association between MBS and SGA neonates, intrauterine growth retardation (IUGR), and preterm births in women with a history of bariatric surgery. Moreover, insufficient GWG was associated with having IUGR and preterm neonates [25]. A short surgery-to-pregnancy time (STP) interval may negatively affect pregnancy outcomes, such as prematurity, NICU admission and having SGA neonates [26].

Despite the high prevalence of MBS in the UAE and Arab Gulf region, prospective cohort studies examining the effects of this surgery on maternal and neonatal outcomes in the region are scarce. Therefore, this study was designed to (1) assess the association of previous MBS with maternal and neonatal outcomes, including gestational weight gain and neonatal birth weight, (2) compare the impact of the type of MBS (sleeve gastrectomy vs. Roux-en-Y gastric bypass [RYGB]) on maternal and neonatal outcomes, including gestational weight gain, having neonates with low birth weight (LBW), SGA, and preterm birth, and (3) assess the impact of the STP time interval on maternal and neonatal outcomes, including gestational weight gain, having neonates with LBW, SGA, and preterm birth.

Methods

Research design

This prospective cohort study recruited 209 pregnant women with and without a history of MBS, from their first visit to a maternity hospital until delivery. The main objective of the study was to assess the effect of metabolic bariatric surgery on the maternal GWG and neonatal birth weight. GWG and neonatal outcomes, including LBW, were the primary outcomes of this study. Maternal gestational age, neonatal outcomes such as SGA and IUGR, birth defects, and neonatal death were the secondary outcomes.

Setting

This study was conducted at a major hospital serving pregnant women in the Abu Dhabi Emirate of the UAE. The study was conducted between July 2021 and November 2022. The recruited pregnant women were representative of various regions of the UAE [27]. The hospital's research and ethics committee (RP DAE/2021/102) approved this study. The participants provided both verbal and written informed consent for inclusion in the study. All procedures adhered to the principles of the Declaration of Helsinki.

Participants

The inclusion criteria of this study were as follows: pregnant women with or without MBS, aged 18–45 years, and gestational age ≤ 28 weeks at the time of recruitment. Women with a history of MBS should undergo only one bariatric surgery, either sleeve gastrectomy or RYGB. Women who underwent multiple MBS procedures or having pre-existing diabetes mellites, spontaneous abortion and having twins were excluded from the study. The recruited sample included 110 pregnant women with no previous MBS and 99 pregnant women with prior MBS (77 with sleeve gastrectomy and 22 with RYGB). To perform power analysis, G*Power was used to calculate the sample size required to test the study hypotheses. Hence, 196 participants were required to achieve 99% power, with a medium effect size and a significance level of alpha = 0.05, as recommended by Gadgil et al. [28].

In selecting the control group, first, we checked the list of pregnant women who met the study's eligibility criteria, including those who had antenatal appointments in the target recruitment hospital. Secondly, based on the medical records, we identified those meeting the study's eligibility criteria. The eligible women were approached during their clinic visit, the aims and procedures of the study were explained, and signed informed consent was obtained from those who agreed to participate. This process was followed until the target sample size was reached, including an additional 20% of participants for possible attrition during the follow-up period. A similar procedure was followed for women with a history of metabolic bariatric surgery, with the additional eligibility criterion of having undergone metabolic bariatric surgery (sleeve gastrectomy or RYGB) prior to the current pregnancy.

Data Collection

Data related to pre-pregnancy BMI, parity, history of metabolic bariatric surgery (MBS), type of MBS, date of the bariatric surgery (to calculate surgery-to-pregnancy interval) were obtained retrospectively from the medical file of the patient. The remaining maternal and neonatal relevant outcomes were collected prospectively, including gestational weight gain, diagnosis of gestational diabetes and hypertension, as well as the mode of delivery. All the neonatal outcomes, such as incidence of LBW, SGA, IUGR, macrosomia, birth weight, birth length, head circumference, Apgar score, neonatal intensive care unit admission, birth defects, and neonatal death, were collected during the follow-up period.

Maternal weights were assessed and recorded at the first visit to the hospital and subsequent follow-up visits using a calibrated weight scale. Height was measured at the first visit. Weight was recorded to the nearest 0.5 kg and height to the nearest 0.5 cm. Gestational weight gain was calculated by subtracting the weight measured at the first prenatal visit (8–12 weeks) from the weight measured at the last prenatal visit before the delivery. Gestational age determined based on the first day of the last menstrual period until the day of the delivery. women were categorized into appropriate gestational weight gain and inadequate gestational weight gain based on IOM guidelines [29].

Prematurity was defined as gestational age < 37 weeks, LBW as birth weight < 2,500 g, and macrosomia as birth weight > 4,000 g. IURG is the impairment of the fetus growth in the uterus [30]. SGA neonate is a neonate with birth weight below 10th percentile [30]. The Apgar score ranges from 0 to 10. The Apgar score 7 and above is considered as a good Apgar [31]. > it has been taken at 1 min. GDM is defined as the intolerance of glucose without a previous history of GDM [32].

Statistical Analysis

All data were analyzed using SPSS version 28 (IBM, Armonk, NY, USA). Significance was set at $p < 0.05$ for all analyses. Normality of obtained data was tested using kolmgorov-smirnov test. The Mann–Whitney test was used, and median and interquartile ranges (IQR) were reported for non-normally distributed variables. When the normality assumption was met, independent t-test was used, and data were reported as mean ± standard deviation (SD). Frequencies and percentages were used to report the categorical variables. The chi-square test was used to analyze the association between categorical variables, and Fisher's exact test if the frequency of the cell was < 5. Univariate analysis was used to assess the correlation between variables, and variables with a *p*-value of < 0.2 were entered into the multiple regression model. Multiple linear regression was used to assess predictors of gestational gain weight and neonatal birth weight. Differences in age and pre-pregnancy BMI between MBS and non-MBS groups were accounted for using propensity score matching technique, and adjustments were included in the regression analysis.

Results

The sociodemographic characteristics of the 99 pregnant women with a history of MBS and the 110 pregnant women without MBS are presented in Table 1. Women with a history of bariatric surgery were older than those without a history of MBS ($p < 0.001$) as indicated in Table 1. There was a significant difference in the pre-pregnancy BMI between women with and without a history of MBS ($p < 0.001$). Additionally, there was a significant difference in the employment status of women with and without a history of MBS ($p < 0.040$). Weight gain during pregnancy was significantly lower in women with a history of MBS than in those without a history of MBS ($p < 0.001$). Women with a history of MBS had shorter gestational age than those without a history of MBS ($p < 0.034$).

Neonates born to women with a history of MBS had a significantly lower mean birthweight compared to those without prior MBS (3.1 ± 45 g vs. 2.8 ± 53 g, $p < 0.001$), as shown in Table 2. Women with a history of MBS had significantly higher rates of LBW neonates weighing < 2,500 g (8.3% vs. 26%, $p < 0.001$), SGA neonates (1.8% vs. 16.7%, $p < 0.001$), and preterm neonates (14.7% vs. 5.5%, $p = 0.027$) than women without a history of MBS. The incidence rates of IUGR in the MBS and non-MBS cohorts were 5.2% and 0%, respectively ($p = 0.016$). The proportion of neonates with birth defects was almost four times higher in the bariatric surgery cohort than in the non-bariatric surgery cohort (8.2% vs. 2.7%), although the difference between the groups was not significant.

Maternal outcomes according to surgery type are presented in Table 3. GWG was significantly lower in the RYGB cohort than that in the sleeve gastrectomy (SG) cohort (3.5 ± 5.4 vs. 9.3 ± 4.9 kg, $p < 0.001$).

The neonatal outcomes according to surgery type are shown in Table 4. Neonates in the RYGB cohort had significantly lower birth weights than those in the SG cohort (2.522 ± 438 g and 2.909 ± 529 g, $p < 0.003$). The incidence of LBW was higher in the RYGB cohort than that in the

Table 1 Maternal and pregnancy characteristics of the study participants($n = 209$)

Variable	MBS ($n = 99$)	Non-MBS ($n = 110$)	p-value
Age, years (mean ± SD)	32.7 ± 5.25	30.3 ± 5.89	0.004[b]
Pre-pregnancy BMI, kg/m^2	29.45(5.49)	26.45 (4.61)	< 0.001[b]
Nationality			< 0.001
Emirati	90 (90.9)	76 (69.1)	
Non-Emirati	9 (9.1)	34 (30.9)	
Education			0.570
College	76 (76.8)	88(80)	
High School	23.3 (23)	22(20)	
Delivery mode			0.465
Normal Delivery	57(60.6)	60(55.6)	
Cesarean section	37(39.4)	44.4(48)	
Working			
Yes	34 (34.7)	28(25.5)	0.146
No	64 (65.3)	82 (74.5)	
Gestational Hypertension			
Yes	4(4)	2(1.8)	0.337
No	95(96)	108(98.2)	
Total GWG, kg (mean ± SD)	7.9 ± 5.61	11.2 ± 5.79	< 0.001[b]
HbA1c (4.5–5.7), % in the 2nd trimester	4.7 ± 0.34	4.7 ± 1.08	0.032[c]
Gestational age at delivery (days)	265.19 ± 11.9	268.67 ± 11.05	0.035[c]
Gestational diabetes, n (%)			0.581[a]
Yes	31 (31.3)	38 (34.9)	
No	68 (68.7)	71 (65.1)	

[a]Chi-square test, [b]independent *t*-test, [c]Mann–Whitney U test.

BS bariatric surgery, *BMI* body mass index, *SD* standard deviation, *GWG* gestational weight gain, *HbA1c* glycated hemoglobin A1c, *MBS* metabolic bariatric surgery

SG cohort (52.4% vs. 18.7%, $p < 0.002$). The incidence of IUGR was 14.3% vs. 2.6%, $p < 0.033$).

Table 5 indicates that appropriate gestational weight gain was not associated with metabolic bariatric surgery, however, it was positively and significantly associated with Parity ($p = 0.008$).

Table 6 indicates the association between MBS with the risk of LBW and Preterm.

The binary logistic regression analysis revealed that neonates for women in the MBS group were at higher risk for LBW (OD = 4.212 (95% Cl:1.436–12.353), $p = 0.009$) and for Preterm (OD = 3.030 (95% CL;1.055–8.705), $p = 0.039$) in comparison with the non-MBS group.

The impact of STP interval on neonatal outcomes is presented in Table 7. No significant differences were found between the two groups.

Table 2 Neonatal outcomes of women with and without metabolic bariatric surgery ($n = 209$)

Variable	Total *($n = 209$)	Non-MBS ($n = 110$)	MBS ($n = 99$)	p-value
Birth weight, g (mean ± SD)	2964 ± 51	3092 ± 45	2821 ± 53	< 0.001[b]
Length, cm (mean ± SD)	51 ± 3.10	51 ± 3.26	50 ± 2.69	0.096[b]
Head circumference, cm (median)	34 (33–24.8)	34 (33–35)	34 (33–34.8)	0.040[c]
NICU admission, n (%)				
No	177 (88.1)	96 (90.6)	81 (85.3)	0.247[a]
Yes	24 (11.9)	10 (9.4)	14 (14.7)	
Low birth weight, < 2,500 g, n (%)				
No	171 (83.4)	100 (91.7)	71 (74)	< 0.001[a]
Yes	34 (16.6)	9 (8.3)	25 (26)	
Macrosomia > 4, 000 g, n (%)				
No	193 (98.5)	100 (97.1)	93 (100)	0.097[a]
Yes	3 (1.5)	3 (2.9)	0 (0)	
Preterm, n (%), < 37 weeks				
No	184 (90.2)	103 (94.5)	81 (85.3)	0.027[a]
Yes	20 (9.8)	6 (5.5)	14 (14.7)	
Small for gestational age, n (%), < 10th percentiles				
No	187 (91.2)	107 (98.2)	80 (83.3)	< 0.001[a]
Yes	18 (8.8)	2 (1.8)	16 (16.7)	
Good Apgar score, n (%), >7				
No	9 (5)	7 (7.1)	2 (2.5)	0.159[a]
Yes	171 (95)	92 (92.9)	79 (97.5)	
Intrauterine growth retardation, n (%), < 10th percentile				
No	201(97.6)	110 (100)	92 (94.8)	0.016[a]
Yes	5 (2.4)	0 (0)	5 (5.2)	
Birth defects, n (%)				
No	196 (94.7)	107 (97.3)	89 (91.8)	0.077[a]
Yes	11(5.3)	3 (2.7)	8 (8.2)	
Neonatal death, n (%)				
Yes	3 (1.4)	1 (0.9)	2 (2.1)	0.601[d]
No	204 (98.6)	109 (99.1)	95 (97.9)	

[a]Chi-square test, [b]independent *t*-test, [c]Mann–Whitney U test, [d]Fisher's exact test. Apgar (appearance, pulse, grimace, activity, and respiration)

SD standard deviation, *NICU* neonatal intensive care unit, *MBS* metabolic bariatric surgery

Discussion

This study investigated maternal and neonatal outcomes in women with a history of MBS compared with those without previous MBS considering important factors including GWG, surgery type and surgery to pregnancy time interval. Sleeve gastrectomy is the most performed procedure, followed by RYGB according to International

Table 3 Maternal outcomes according to metabolic bariatric surgery type ($n = 99$) *

Variable	SG ($n = 77$)	RYGB ($n = 22$)	*p*-value
Total GWG, kg (mean ± SD)	9.3 ± 4.97	3.5 ± 5.44	< 0.001[b]
Gestational age, days (median)	266 (261–273)	265 (258–269)	0.140[c]
Delivery mode, *n* (%)			0.379[a]
Vaginal delivery	46 (63)	11 (52.4)	
Cesarean section	27 (37)	10 (47.6)	

[a] Chi-square test, [b] independent *t*-test, [c] Mann–Whitney U test

GWG gestational weight gain, *RYGB* Roux-en-Y gastric bypass, *SD* standard deviation, *SG* sleeve gastrectomy

*Twin pregnancies were excluded from analysis

Table 4 Neonatal outcomes according to metabolic bariatric surgery type

Variables	Total ($n = 99$) *	RYGB ($n = 22$)	SG ($n = 77$)	*p*-value*
Birth weight, g (mean ± SD)	2821 ± 53	2522 ± 43	2909 ± 52	0.003[b]
Length, cm (mean ± SD)	50 ± 2.70	49 ± 2.43	51 ± 2.68	0.032[b]
Head circumference, cm (median)	34 (33–34.8)	33.5 (33–34)	34 (33–35)	0.073[c]
NICU admission, *n* (%)				0.184[a]
Yes	14 (14.7)	5 (23.8)	9 (12.2)	
No	81 (85.3)	16 (76.2)	65 (87.8)	
Low birth weight, *n* (%), < 2500 g				0.002[a]
Yes	25 (26)	11 (52.4)	14 (18.7)	
No	71 (74)	10 (47.6)	61 (81.3)	
Preterm, *n* (%) < 37 weeks				0.184[a]
Yes	14 (14.7)	5 (23.8)	9 (12.2)	
No	81 (85.3)	16 (76.2)	65 (87.8)	
Small for gestational age, *n* (%), < 10th percentiles				0.098[a]
Yes	16 (16.7)	6 (28.6)	10 (13.3)	
No	80 (83.3)	15 (71.4)	65 (86.7)	
Good Apgar score, *n* (%), > 7				0.444[a]
Yes	79 (97.5)	18 (100)	61 (96.8)	
No	2 (2.5)	(0)	2 (3.2)	
Intrauterine growth retardation, n (%), < 10th percentile				0.033[a]
Yes	5 (5.2)	3 (14.3)	2 (2.6)	
No	92 (94.8)	18 (85.7)	74 (97.4)	
Birth defects, *n* (%)				0.810[a]
Yes	8 (8.2)	2 (9.5)	6 (7.9)	
No	89 (91.8)	19 (90.5)	70 (92.1)	
Neonatal death, *n* (%)				0.453[a]
Yes	2 (2.1)	0 (0)	2 (2.6)	
No	95 (97.9)	21 (100)	74 (97.4)	

[a]Chi-square test, *Twins were excluded from the analysis

Table 5 Association of the appropriate GWG with MBS, Parity, Pre-Pregnancy BMI, maternal age and gestational age

Parameter	Odds Ratio (95% CI)	*p* value
Maternal age	0. 969(0.905–1.037)	0.365
Pre-pregnancy BMI	0.983(0.920–1.049)	0.601
Parity 0 1 ≥ 2	1 4.403 (1.628–11.905) 4.177 (1.509–11.562)	0.008
Gestational Age	1.029(0.995–1.064)	0.091
Metabolic Bariatric surgery No Yes	1 1.398(0.698–2.798)	0.345

GWG Gestational weight gain, *MBS* Metabolic Bariatric Surgery, *BMI* Body Mass Index

Table 6 Association of low birth weight and preterm with MBS, Parity, Pre-Pregnancy BMI and maternal age

Parameter	Low birth weight		*Preterm	
	Odds Ratio (95% CI)	*p* value	Odds Ratio (95% CI)	*p* value
Maternal age	1.083 (0.975–1.202)	0.135	1.033 (0.937–1.140)	0.513
Pre-pregnancy BMI	0.936 (0.854–1.026)	0.160	0.969 (0.881–1.065)	0.512
Parity 0 1 ≥ 2	1 1.588 (0.312–8.096) 1.409 (0.304–6.532)	0.853	1 0.877 (0.216–3.553) 0.890 (0.250–3.165)	0.978
Gestational Age	0.876 (0.827–0.929)	< 0.001		
Appropriat**e** GWG No Yes	1 1.409 (0.493–4.026)	0.522		
Metabolic Bariatric surgery No Yes	1 4.212(1.436–12.353)	0.009	1 3.030 (1.055–8.705)	0.039

MBS Metabolic Bariatric Surgery, *BMI* Body Mass Index

*Adjusted for maternal age, pre-pregnancy BMI and parity

Federation for Surgery and Metabolic Disorders [3, 33, 34]. Restrictive procedures entail less risk than malabsorptive procedures [35]. The Arab Gulf Region has one of the highest prevalence rates of bariatric surgeries globally but less research on bariatric surgery compared to Western counterparts [36].

The main objective of the study was to assess the effect of metabolic bariatric surgery on maternal GWG and neonatal birth weight. The mean GWG of women with a history of MBS was lower than those without a history of MBS in our study (7.99 ± 0.5.61vs. 11.28 ± 5.73, $p < 0.001$). This can be justified by those women with MBS history having a higher pre-pregnancy BMI compared to women with no MBS history (29.45 vs. 26.45) Kg/m^2. This finding is consistent with a recent cohort study that compared GWG in 6,388 women with MBS history and

Table 7 The impact of the surgery-to-pregnancy interval on neonatal outcomes ($n=99$)

Variable	≤ 18 months ($n=49$)	> 18 months ($n=50$)	p-value*
Birth weight, g (mean ± SD)	2813.11 ± 580	2830.85 ± 487	0.874[b]
Length, cm (mean ± SD)	51.1 ± 2.90	50.6 ± 2.50	0.328[b]
Head circumference, cm (mean ± SD)	33.90 ± 1.41	33.54 ± 1.57	0.251[b]
NICU admission, n (%)			
Yes	6 (12.5)	8 (17)	0.534[a]
No	42 (87.5)	39 (83)	
Low birth Weight, n (%) < 2500 g			
Yes	15 (30.6)	10 (21.3)	0.297[a]
No	34 (69.4)	37 (78.7)	
Preterm, n (%) < 37week			
Yes	8 (16.7)	6 (12.8)	0.592[a]
No	40 (83.3)	41(87.2)	
Small for gestational age, n (%), < 10th percentile			
Yes	10 (20.4)	6 (12.8)	0.315[a]
No	39 (79.6)	41(87.2)	
Good Apgar score, n (%), >7			
Yes	41 (100)	38 (95)	0.147[a]
No	(0)	2 (5)	
Intrauterine growth retardation, n (%), < 10th percentile			
Yes	3 (6.1)	2 (4.2)	0.663[a]
No	46 (93.9)	46 (95.8)	
Birth defects, n (%)			
Yes	2 (4.1)	6 (12.5)	0.132[a]
No	47 (95.9)	42 (87.5)	
Neonatal death, n (%)			
Yes	2 (4.1)	0 (0)	0.157[a]
No	47 (95.9)	48 (100)	

Groups were compared using chi-square test. [a]Chi-square test; [b]independent *t*-tests; Apgar (appearance, pulse, grimace, activity, and respiration)

NICU neonatal intensive care unit, *SD* standard deviation

6,388 women without MBS and found that GWG was lower in women with MBS history than in women without MBS history [46]. Additionally, a recently published study by investigating maternal and neonatal outcomes in women with previous MBS in the UAE showed a higher BMI at booking and lower gestational weight gain [37], which is consistent with our study.

Another study supports our findings and shows that GWG in women without MBS was higher than that in women with a history of RYGB [47]. However, a study by Lesko et al. [48]. showed no significant difference in GWG between the MBS and non-MBS cohorts, contradicting the findings of this study. This may be because both groups had a similar pre-pregnancy BMI in the study by Lesko et al. and underwent different surgery types [48].

Women with a history of MBS had significantly higher rates of LBW neonates than women without a history of MBS. This result is consistent with a recently published retrospective study in Qatar showing neonates from women with bariatric surgery are at risk of LBW and preterm [38]. In addition, the present study showed that the premature birth rate in the MBS cohort was three times higher than that in the non-MBS cohort. This finding agrees with that of a previous observational study involving 314 women with a history of MBS, which reported a significantly higher incidence rate of preterm births among MBS women compared to non-MBS women [39].

Having low birth weight neonates among the MBS cohort was probably due to other mechanisms involved, including maternal nutrition and other metabolic alterations occurring in women with MBS history, as reported previously [37]. A study showed that the MBS cohort experiences low insulin resistance and low fasting glucose, which affects the fat disposition in the offspring of the MBS cohort [37]. Adequate maternal nutrition is crucial for fetal growth and development [40, 41].Optimal vitamin levels are essential for successful fertilization and preventing neonatal complications, including congenital malformations, miscarriages, and SGA [42–45]. In addition, Shah et al. [46] have demonstrated that micronutrient supplements increased the birth weight by 64 g and reduced the incidence of LBW by 14%. Vitamin B_{12} and vitamin D were lower in women with MBS than those without MBS [47]. Moreover, the intolerance to oral iron in pregnant women with MBS was higher than in women without MBS, which justified the higher need for intravenous iron among the MBS cohort [47].

In this study, the percentages of IUGR condition in neonates from the MBS cohort was higher compared with that in the non-MBS cohort, which is attributed to insufficient GWG in women with MBS, as explained in the study [25] and supported by our findings. A national analysis in the United States found an association between previous bariatric surgery and the IUGR. The study also reported higher SGA incidence in the MBS cohort compared to non-MBS cohort [48].A large study by Boller et al. [49] comparing neonatal outcomes, including SGA in 1,591 women with a history of MBS and controls, supports our findings that the percentage of SGA neonates was higher in the MBS cohort than that in the non-MBS cohort.

An association between the surgery type, mainly RYGB, and SGA incidence has been shown in this study. This finding is consistent with a meta-analysis and systematic review, which found that type surgery (RYGB) is associated with having more SGA neonates in pregnant women [50]. Similarly, a study by Carisen et al. [39] highlighted the association between RYGB and SGA incidence. A possible contributing factor to the higher incidence of SGA among women with previous RYGB is that 72% of the RYGB cohort gained less than 5 kg during pregnancy, compared to 29.9% in the SG cohort. A study by Catalano et al. [36] demonstrated that gaining ≤ 5 kg during pregnancy among overweight and obese women increased the risk of having SGA neonates.

This study showed that the birth weights of neonates born to mothers with a history of MBS were lower than those of neonates born to mothers without a history of MBS. This finding is consistent with a study conducted by Maric et al. [51], which showed that neonates born to women with a history of MBS were lighter (–200 g) than neonates born to women without a history of MBS. Moreover, a higher number of LBW neonates was observed in the RYGB cohort than in the SG cohort in the present study, which may be due to the lower GWG among the RYGB pregnant women. Further, our finding is consistent with a study conducted by Coupaya et al. [52], which showed that the mean birth weight of neonates in women with a history of RYGB was lower than that in women with a history of SG.

A study conducted by Bourke et al. [53] that investigated the effect of the surgery-to-pregnancy time interval on neonatal outcomes supports our finding that STP did not affect perinatal outcomes. Similarly, a recent review [54] assessing the risk factors leading to adverse neonatal outcomes reported a similar finding in which surgery types, mainly RYGB, led to LBW and SGA neonates, not STP. A recent study [55] investigating maternal and neonatal outcomes in 200 pregnant women with MBS history found a significant finding that women who conceived ≤ 12 months post-surgery had significantly lower GWG, and higher preterm deliveries and LBW compared to those who conceived after 12 months. In the current study, the number of LBW neonates was higher (although not significant) in women who conceived < 18 months post-surgery in comparison with those who conceived ≥ 18 months (30.6% vs. 21%). This finding is in agreement with the study of a previous study which showed that NICU admissions and preterm births were not significantly linked to timing of conception [37].

The main limitation of this study was the inclusion of women recruited from a single hospital, which restricted the generalizability of the findings to pregnant women in the UAE. We acknowledge the small sample size of our study, similar to a recent prospective study [39] that included 100 pregnant women with a history of MBS and 100 without such a history. Another limitation is the potential bias due to self-selection of the participants in the study, as some women invited to participate declined. Future studies should consider a random section procedure to reduce the bias associated with self-selection. On the other hand, the women in our study were recruited from one of the largest obstetric facilities in the UAE, which serves women with previous MBS from various regions of the country. This study is the only prospective study conducted in the Arab Gulf countries investigating previous bariatric surgery considering key factors such as surgery types, surgery to pregnancy time interval, gestational weight gain, with a control group of pregnant women without previous bariatric surgery.

Conclusions

In the present study, a significant association between MBS and neonates with low birth weight was shown. Moreover, gestational weight gain was not associated with MBS. These findings suggest that more attention should be given to pregnant women who underwent MBS to improve their pregnancy outcomes. In contrast, the STP interval had no obvious effect on maternal and neonatal outcomes. Further investigations on the impact of the surgery-to-pregnancy interval time on neonatal outcomes are warranted to confirm our findings.

Abbreviations

Apgar	Appearance, pulse, grimace, activity, and respiration
BMI	Body mass index
CI	Confidence interval
GWG	Gestational weight gain
HbA1c	Glycated hemoglobin
IUGR	Intrauterine growth restriction

LBW Low birth weight
MBS Metabolic bariatric surgery
OR Odds ratio
RYGB Roux-en-Y gastric bypass
SG Sleeve gastrectomy
SGA Small for gestational age
STP Surgery-to-pregnancy
UAE United Arab Emirates

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Authors' contributions
HIA, AAM contributed to conceptualization; AAM, HIA wrote the original draft and designed the study; AAM collected the data; AAM, MFB analyzed the data; HA supervised the data collection; MFB, HA, ASA, LCI, LS contributed to the reviewing and editing process; AAM contributed to visualization. All authors read and agreed to the published version of the manuscript.

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Data availability
The dataset used in this study is available from the first author upon request. Contact 201790103@uaeu.ac.ae to request for data used in this study.

Declarations

Ethics approval and consent to participate
Ethical approval was obtained from the Research and Ethics Committee of the Danat Al Emarat Hospital (No. RP DAE/2021/102). Written informed consent was obtained from all participants before enrollment in the study. All methods were performed in accordance with relevant guidelines and regulations.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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