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ORIGINAL CONTRIBUTIONS

Timing of Gestation After Laparoscopic Sleeve Gastrectomy (LSG): Does It Influence Obstetrical and Neonatal Outcomes of Pregnancies?

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Abstract

Aim We aimed to evaluate the effect of pregnancy timing after laparoscopic sleeve gastrectomy (LSG) on maternal and fetal outcomes.

Methods Women with LSG were stratified into two groups with surgery-to-conception intervals of ≤ 18 months (early group) or > 18 months (late group). Only the first delivery after LSG was included in this study. We compared maternal characteristics, pregnancy, and neonatal outcomes and adherence to the Institute of Medicine's (IOM) recommendations for gestational weight gain (GWG) in the two groups.

Results Fifteen patients conceived ≤ 18 months after surgery, with a mean surgery-to-conception interval of 5.6 ± 4.12 months, and 29 women conceived > 18 months following LSG, with a mean surgery-to-conception interval of 32.31 ± 11.38 months, $p < 0.05$. There was no statistically significant difference between the two groups regarding birth weight, gestational age, cesarean deliveries (CD), preterm birth, whether their child was small or large for their gestational age, or in the need of neonatal intensive care. There was no correlation between mean weight loss from operation till conception, mean weight gain during pregnancy, and mean body mass index (BMI) at conception between birth weight in either study group. Inadequate and normal GWG was significantly higher in the early group, whereas excessive GWG was significantly higher in the late group (X^2, 20.780; $p = < 0.001$).

Conclusion The interval between LSG and conception did not impact maternal and neonatal outcomes. Pregnancy after LSG was overall safe and well-tolerated.

Keywords Laparoscopic sleeve gastrectomy · Surgery-to-conception time interval · Perinatal · Maternal outcomes · IOM

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Introduction

Obesity is an epidemic in nearly every society around the globe [1]. It has become an important and alarming health issue in Turkey [2–4]. Obesity during pregnancy increases the frequency of obstetrical complications, including pre-eclampsia, gestational diabetes mellitus (GDM), miscarriage, macrosomia, cesarean delivery (CD), labor induction, and anesthetic complications [5]. Weight loss prior to pregnancy is critical for improving maternal and fetal health outcomes [6]. Bariatric surgery (BS) is a treatment option for morbidly obese patients [7]. The number of bariatric procedures performed annually is rapidly increasing worldwide [8] and laparoscopic sleeve gastrectomy (LSG) has recently emerged as the preferred surgical option [6, 9]. A large proportion of the patients undergoing bariatric operations are women, mostly of childbearing age (15–44 years) [10]. Bariatric operations are effective at achieving weight loss, but is it safe to become pregnant following these operations? Advantages of BS include reduced risk of hypertensive disorders, gestational diabetes, fetal macrosomia [11], and cesarean delivery (CD) [12]. Infants born after maternal BS have a lower birth weight and reduced risk of macrosomia, but they may also have an increased risk of being small for their gestational age (SGA) [13].

The impact of BS on birth weight and the risk of SGA may even be larger during the first post-operative year. As the greatest weight loss occurs during the first 6–18 months post-surgery, this period theoretically carries the highest risk of malnutrition for both the mother and the fetus. During this period, maternal caloric intake is markedly reduced and rapid weight loss is seen, whereas the nutritional requirements of the fetus and metabolic disturbances are rapidly increasing [14–16]. During the second year after surgery, the rate of weight loss decreases and weight stabilizes with the catabolic post-operative phase no longer prevailing [17, 18].

Therefore, the American Congress of Obstetricians and Gynecologists (ACOG) currently recommends avoiding pregnancy for 12–24 months following BS (2009, reconfirmed 2013) [15], while the American Association of Clinical Endocrinology (AACE), the Obesity Society (TOS), and the American Society for Metabolic and Bariatric Surgery (ASMB) recommend avoiding pregnancy for 12–18 months following BS [19]. There is sparse scientific evidence on the optimal timing for pregnancy following LSG, and little is known about the influence of pregnancy timing on post-bariatric surgery complications [20]. However, no conclusive evidence exists suggesting that pregnancy during the first post-operative year is unsafe [20].

Some relatively small studies have examined the subject of the timing of pregnancy after BS; most of them included different time intervals between pregnancy and BS or a mixture of different BS techniques. None of the studies have found significant differences in perinatal outcomes between the early and late conception groups [17, 21–26].

Therefore, in view of the increasing prevalence of post-BS pregnancies, we performed a retrospective cohort study to evaluate obstetric and neonatal outcomes by surgery-to-conception interval following LSG for morbid obesity.

Materials and Methods

A retrospective, observational study was conducted to evaluate the maternal and fetal health outcomes of 69 pregnancies in 55 women who had previously undergone LSG between 2012 and 2017 at the University of Health Sciences, Fatih Sultan Mehmet Training and Research Hospital. Institutional review board approval was obtained. Of these 55 women, one woman with twin pregnancy and five with missing data were excluded, leaving 63 pregnancies in 49 women for statistical analysis. One pregnancy was electively terminated during the first trimester for non-medical reason. Two were ectopic pregnancies. Sixteen pregnancies after LSG resulted in spontaneous abortions (SAB; loss of pregnancy before 20 week's gestation). After these were excluded, there remained 44 full-term pregnancies. If a patient had more than one pregnancy after BS, only the first delivery was included in this study. Women were stratified by whether they had a surgery-to-conception interval of ≤ 18 months (early group) or > 18 months (late group). We compared maternal characteristics, pregnancy, and neonatal outcomes in the two groups.

Gestational weight gain was defined as the difference between the final weight and the weight at the conception (kg) and was recorded for each patient as underweight, overweight, or normal, according to the recommended weight gain for their body mass index (BMI) at conception [27]. Prematurity was defined as a gestational age of less than 37 weeks at birth. Low birth weight was defined as a newborn weight of less than 2500 g. Macrosomia was defined as a newborn weight of greater than 4000 g. Large-for-gestational-age (LGA) infants were defined as those with a birthweight above the 90th percentile, and small-for-gestational-age (SGA) as those with a birthweight below the 10th percentile.

Statistical Analysis

The statistical analysis was calculated using the Statistical Package for Social Sciences (SPSS, Inc., Chicago, IL, USA) for Windows software. Results were expressed as mean ± SD. Comparisons between baseline demographic characteristics were made using a Student's *t* test for parameters with normal distribution and a Wilcoxon rank-sum test for parameters with non-normal distribution. A Pearson correlation analysis was made between weight loss and neonatal outcomes. The

comparison of categorical variables was performed using a $\chi 2$ test. Results were analyzed with a 95% confidence interval, and probability levels of less than 0.05 were considered significant.

Results

Demographic Characteristics

The study sample consisted of 15 patients who conceived ≤ 18 months after surgery, with a mean surgery-to-conception interval of 5.6 ± 4.12 months (range 1–15 months), and 29 women conceived > 18 months following LSG, with a mean surgery-to-conception interval of 32.31 ± 11.38 months (range 19–61 months), $p < 0.05$ (Table 1). The two groups were statistically similar with regard to maternal age at the time of conception. BMI at conception was higher in the early group than in the late group (34.21 ± 6.73 kg/m^2 versus 29.26 ± 5.64 kg/m^2, $p = 0.022$).

There was no difference in mean weight at conception between the two groups (89.47 ± 19.20 kg versus 80.36 ± 13.08 kg, $p = 0.07$). There was a significant difference in mean weight loss from operation till conception between the two groups (30.87 ± 16.92 kg versus 48.88 ± 12.58 kg, $p < 0.01$) (Table 1).

Pregnancy Course and Outcomes

There was a significant difference in mean weight gain during pregnancy between the two groups (0.67 ± 11.08 kg versus 15.67 ± 7.28 kg, $p < 0.01$). Inadequate and normal GWG was significantly higher in the early group (X^2 6.187, $p = 0.013$; and X^2 7.427, $p = 0.006$, respectively), whereas excessive GWG was significantly higher in the late group (X^2 20.780; $p = < 0.001$) (Table 2).

There was no difference in mean weight and BMI after delivery between the two groups (90.13 ± 14.87 kg versus 96.03 ± 15.86 kg, $p = 0.232$; and 34.59 ± 6.05 kg/m^2 versus 34.97 ± 6.67 kg/m^2, $p = 0.850$).

There was no difference in mode of delivery or type of labor between the two groups. The groups were similar in terms of indications for CD (Table 2).

In our study, gestational diabetes, hypertension, preeclampsia, and postpartum hemorrhage were not recorded.

Neonatal Characteristics and Outcomes

There was no significant difference in the mean gestational age at delivery when comparing the early group (38.27 ± 1.02 weeks) to the late group (38.26 ± 1.41 weeks; $p = 0.975$) (Table 3). Birth weight was not significantly different between the two groups (3010 ± 591.69 g versus 2948.45 ± 610.70 g; $p = 0.749$) (Table 3).

There was no difference in the rate of LGA births, low birthweight, or macrosomia between the two groups (Table 3). There was a 20% (*n*:3) SGA rate among neonates in the early group, whereas 27.6% (*n*:8) were SGA in the late group (p = ns); there was no significant difference between the two groups. In our study, no congenital anomalies were identified during pregnancy in either group (Table 3).

There was no correlation in the mean weight loss from operation until conception between birth weight in the early and late groups ($r = -0.243$, $p = 0.383$ versus $r = -0.267$, $p = 0.161$).

There was a direct correlation between maternal weight at conception and birthweight in both the early and late groups, but there was no statistically significant difference between groups ($r = 0.397$, $p = 0.143$ versus $r = 0.319$, $p = 0.092$). Although there was no correlation between maternal weight at conception and birthweight when the early and late groups were calculated

Table 1 Demographic characteristics of the study population

	The early group (≤ 18 months)	The late group (> 18 months)	*p* values
Number of patients (*n*)	*n* = 15	*n* = 29	
Maternal age at operation (years)	31.2 ± 5.78	29.93 ± 4.68	0.463
Maternal age at conception (years)	32.4 ± 5.68	33.34 ± 4.79	0.564
Height before LSG (m)	1.62 ± 0.7	1.66 ± 0.6	0.048
Weight before LSG (kg)	120.33 ± 11.58	129.24 ± 16	0.041
BMI before LSG (kg/m^2)	46 ± 2.84	46.89 ± 6.20	0.603
Weight loss from operation till conception, kg	30.87 ± 16.92	48.88 ± 12.58	< 0.01
Weight at conception (kg)	89.47 ± 19.20	80.36 ± 13.08	0.07
BMI at conception (kg/m^2)	34.2 ± 6.73	29.26 ± 5.64	0.022
Interval from surgery to conception, months	5.6 ± 4.12 (1–15)	32.31 ± 11.38 (19–61)	< 0.01

BMI, body mass index

Table 2 Pregnancy course and outcomes

	The early group (≤ 18 months)	The late group (> 18 months)	*p* values
Number of patients, (*n*)	*n* = 15	*n* = 29	
Weight at delivery (kg)	90.13 ± 14.87	96.03 ± 15.86	0.232
BMI at delivery (kg/m^2)	34.59 ± 6.05	34.97 ± 6.67	0.85
Weight gain during pregnancy (kg)	0.67 ± 11.08	15.67 ± 7.28	< 0.01
Pre-gestational BMI			
Normal weight 18.5–24.9, *n* (%)	1 (6.7%)	8 (27.5%)	ns
Overweight 25–29.9, *n* (%)	2 (13.3%)	7 (24.2%)	ns
Obese > 30, *n* (%)	12 (80%)	14 (48.3%)	ns
Adherence to the IOM criteria			
Insufficient, *n* (%)	8 (53.3%)	5 (17.2%)	0.013
Appropriate, *n* (%)	7 (46.7%)	3 (10.4%)	0.006
Excessive, *n* (%)	0	21 (72.4%)	< 0.001
Mode of delivery			
Cesarean deliveries, *n* (%)	11 (73.33%)	21 (72.41%)	ns
Vaginal, *n* (%)	4 (26.67%)	8 (27.59%)	ns
Indications for C/S			
Maternal request, *n* (%)	4 (36.4%)	6 (28.5%)	ns
Cephalopelvic disproportion, *n* (%)	1 (9.1%)	1 (4.76%)	ns
Low birthweight < 2500 g, *n* (%)	1 (9.1%)	1 (4.76%)	ns
Repeat, *n* (%)	4 (36.4%)	11 (52.37%)	ns
Preterm delivery, *n* (%)	1 (9.1%)	1 (4.76%)	ns
Cord entanglement, *n* (%)	0	1 (4.76%)	ns

BMI, body mass index; IOM, Institute of Medicine

separately, there was a correlation when all data were used in a statistical analysis ($r = 0.344$, $p = 0.02$). There was no correlation between mean weight gain during pregnancy and birthweight in either the early or the late group ($r = 0.043$, $p = 0.878$ versus $r = -0.233$, $p = 0.23$). There was no correlation between mean BMI

Table 3 Neonatal characteristics and outcomes

	The early group (≤ 18 months)	The late group (> 18 months)	*p* values
Number of patients, (*n*)	*n* = 15	*n* = 29	
Gender (F/M)			
Male, *n* (%)	7 (46.7%)	16 (55.18%)	
Female, *n* (%)	8 (53.3%)	13 (44.82%)	
Birthweight	3010 ± 591.69	2948.45 ± 610.70	0.749
Low birthweight < 2500 g, *n* (%)	2 (13.33%)	7 (24.13%)	ns
High birthweight > 4000 g, *n* (%)	0	1	ns
Normal birthweight 2500–4000 g, *n* (%)	13 (86.67%)	21 (72.41%)	ns
SGA, *n* (%)	3 (20%)	8 (27.6%)	ns
LGA, *n* (%)	0	1 (3.5%)	ns
AGA, *n* (%)	12 (80%)	20 (68.9%)	ns
Congenital malformations,(*n*)	0	0	
Transfer to NICU, (*n*)	0	0	
Gestational age (week)	38.27 ± 1.02	38.26 ± 1.41	0.975
Prematurity, (*n*)	2	1	ns

BMI, body mass index; IOM, Institute of Medicine; SGA, small-for-gestational-age; LGA, large-for-gestational-age; AGA, average for gestational age

at conception and weight in either the early or the late group ($r = 0.339$, $p = 0.216$ versus $r = -0.366$, $p = 0.051$).

Discussion

Surgery-to-Conception Interval

We identified very few studies comparing pregnancy outcomes within the first year up to 18 months following surgery. We found no statistically significant differences with regard to birthweight, gestational age, preterm birth, SGA, or LGA between early and late groups. Our findings are consistent with the literature. Başbuğ et al. [28] showed that no difference has been observed in the incidence of CD, birthweight, or SGA between early (< 18 months) or late (> 18 months) groups with LSG. Two other studies [29, 30] showed no significant differences with regard to neonatal outcomes between those conceived less than 18 months after gastric bypass surgery and those who conceived more than > 18 months after gastric bypass surgery.

Sheiner et al. [21] concluded that there were no statistically significant differences with regard to neonatal outcomes between 104 women who conceived during or 385 women who conceived after the first year following restrictive and malabsorptive surgeries.

A similar study performed in Denmark found no statistically significant difference with regard to neonatal outcomes between 158 women who conceived during or 128 who conceived after the first following gastric bypass surgery [17]. Norgaard et al. [31] did not find any association between surgery-to-conception interval and birthweight in women with previous RYGB.

A multicenter French cohort study also found that neonatal outcomes were not significantly different for different intervals between surgery and conception [32]. Dao et al. [23] included 34 pregnancies after gastric bypass surgery and Dixon et al. [22] included 79 pregnancies in women following laparoscopic adjustable gastric banding (LABG); neither study showed a significant difference in the incidences of CD, birthweight, or SGA, between the early (< 1 year) and late (> 1 year) groups.

Neonatal Outcomes

Prematurity Our data showed one preterm delivery in the early group and one in the late group. Data comparing the rates of preterm delivery between earlier (< 12 months and < 18 months) and later (> 12 months and > 18 months) pregnancies are conflicting, with the majority reporting no significant differences [21, 23, 25, 30]. Patel et al. [24] studied 26 pregnancies, stratified by time between conception and surgery, and found that early (< 12 months) pregnancies were associated with more preterm deliveries.

Birthweight We found no statistically significant difference with regard to birthweight, SGA, or LGA between the two groups. Başbuğ et al. [28] showed that mean birth weight was lower in the early (< 18 months) group than in the late (> 18 months) group with LSG, but the difference was not statistically significant. Similar results were found in other studies; they found no significant differences in birth weight between patients who conceived within 18 months and who conceived > 18 months after restrictive and malabsorptive surgery [25, 29, 30].

Dao et al. [23] showed that there was no significant difference in birthweight between early (< 12 months) and late (> 12 months) groups after gastric bypass surgery, which was in accordance with Kjær [17]. Sheiner et al. [21] reviewed 498 pregnancies after restrictive and malabsorptive BS and found no significant difference in birthweight or macrosomia between the early (< 12 months) and late (> 12 months) groups.

In our study, there was no correlation in mean BMI at conception between birthweight in early and late groups. But, we showed that the higher BMI at conception, the higher the birthweight. Our findings were consistent with those of Ducarme et al. [33].

Miscarriage Only pregnancies that ended in a live birth were included in this study. Therefore, we did not investigate the relation between time from surgery to conception and miscarriage. This may be important. In our study, a miscarriage rate of 37.5% was identified in the early group and 19.4% in the late group. But, there was no difference in mean miscarriage between the two groups (X^2 2401; $p = 0.145$).

The rates of fetal loss has been identified at around 30% in normal pregnancies [34, 35]. A few studies have evaluated the impact of BS on the incidence of miscarriage. The rates vary between 4.9 and 29% after restrictive procedures, and between 4 and 34.7% after mixed procedures [6, 26, 36, 37].

One study showed a significantly higher rate of spontaneous miscarriage after BS compared with pregnancies preceding surgery [38]. Dao et al. [23] showed that the patients in the early group had a higher incidence of miscarriage (24%) than the late group (0%); however, this was not statistically significant because the study size was too small. Another study found that there was no significant difference between the early and late groups [39]. On the other hand, González et al. [26] showed that the patients in the early group had a higher incidence of fetal loss (35.5%) than the late group (16.3%). Large, more systematic studies are needed in this area.

Maternal Pregnancy Outcomes

Cesarean Delivery

Our cesarean delivery (CD) rates were similar in the early and late groups and there was no significant difference in the mode of delivery or type of labor between the two groups. The groups were similar in terms of indications for CD in our study. This is in accordance with most studies and reviews on the topic of BS, and most have found a similar CD rate in their early and late groups [17, 21, 23–25, 28, 30, 40]. But, some studies showed a higher incidence of CD in the late group than in the early group [29].

The CD rate was high in our study following BS: 11 (73.33%) cases in the early group and 21 (72.41%) cases in the late group, respectively. The CD rate in Turkey is high (53% of all deliveries) [41]. The frequency of CD in post-BS pregnant women varies between 15.4 and 61.5% [42].

This difference might be caused by local clinical practice, the difference in BMI of the pregnant women at birth; the preferences of the caregiver, hospital, and/or pregnant woman; a previous CD; obesity; fertility treatments; fetal macrosomia; and maternal age [38, 43]. In general, the main cause of CD is the occurrence of a previous CD; however, this was responsible for just four (26.7%) cases in the early group and 11 (40%) cases in the late group in our study.

Obesity is also a well-known risk factor for CD [44, 45]. Ducarme et al. [46] showed that women who had BS had half the rate of CD of the obese controls. Some past studies have mentioned an increased risk of CD in post-operative women when compared to non-obese controls, but no difference when compared to obese or severely obese controls [24, 47], whereas others state the opposite [37, 42, 48]. Obesity increases the risk of CD, and this risk is proportional to the degree of obesity [43]. The majority of the women in both groups in our study still had a BMI above 30 kg/m^2 at delivery. They were still obese. This high BMI at delivery might be the cause of the relatively high rate of CD in our patients. Age at conception was not shown to be a contributing factor. The time to pregnancy after LSG also had no impact on CD rates.

Maternal Weight Gain

In our study, the average maternal weight at conception was similar in both groups. BMI at conception in the early group was significantly higher than the late group. But, BMI after delivery was similar in both groups. Thus, patients in the early group were still able to lose weight despite becoming pregnant within 18 months of their BS. Although BS induces a significant weight loss, the majority of the women in our study were still overweight or obese at conception in both groups. This is in accordance with other studies [17, 21, 23]. This might suggest that weight loss or reaching a target weight would be more appropriate than a fixed time interval.

The available data describing the effect of time to conception on gestational weight gain are inconclusive. In our study, the late group gained significantly more weight during pregnancy. These results are in accordance with Rasteiro et al. [30]. Similarly, other studies [22, 23] have shown significantly higher gestational weight gain in the late group (time threshold of 12 months). Stentebjerg et al. [29] showed that there was no significant difference in weight gain during pregnancy between study groups using a time threshold of 18 months. Similar results were found in other studies [25, 28]. Yau et al. [49], considering a time threshold of 24 months, found that gestational weight gain was similar in both groups.

Excessive weight gain increases the risk of preeclampsia, GDM, and CD [50]. Most obese pregnant women have excessive gestational weight gain [51]; in several studies, BS has been shown to reverse this [22, 46]. On the other hand, reduced weight gain is associated with prematurity and low birthweight, although this finding remains controversial [8]. The Institute of Medicine makes recommendations for adequate weight gain according to the preconception BMI [27]; however, there is very little evidence regarding adherence to IOM criteria following LSG [29, 49].

In our study, inadequate and normal GWG was significantly higher in the early group, whereas excessive GWG was significantly higher in the late group. Although the obese population is predisposed to excessive weight gain during pregnancy, in our study, 80% of the women in the early group had a BMI above 30 kg/m^2 at conception and 53.3% of the women had insufficient GWG. It might be that these women who were in early group were still in the catabolic phase after their LSG and therefore unable to maintain sufficient weight gain during pregnancy, as their body weight had still not stabilized and was preventing adequate weight gain. In our late group, 48.3% of the women had a BMI above 30 kg/m^2 at conception and 72.4% of the women gained weight excessively. These results are in accordance with Stentebjerg et al. [29]. After 18 months post-BS, bariatric patients failed to lose weight at all during pregnancy. Studies have shown that the effect of RYGB on weight tapers off after some years [52]. Our results show that the surgery-to-conception interval in the group that gained excessive weight according to the IOM was significantly longer than in the groups that gained insufficient and appropriate amounts of weight. But Yao et al. [49] showed that gestational weight gain according to IOM was similar in both groups by a time threshold of 24 months. In our study, birthweight tended to increase with increasing GWG across both groups.

Conclusion

The major finding of our study was that patients who conceived within the first post-operative 18 months (early group) had comparable short-term perinatal outcomes compared to patients who conceived after the 18 months (late group). The interval between LSG and conception did not have an effect on maternal or neonatal health outcomes. This study is one of the largest addressing surgery-to-conception interval in pregnant women post-LSG. While our patients all had the same LSG procedure, other similar studies used mixed populations of different gastric bypass methods and gastric banding [21–25].

This study had some limitations, due to its retrospective nature—namely the impossibility of evaluating certain nutritional deficits, such as folic acid and magnesium—and the fact that it was not possible to obtain all the parameters of all the pregnant women and their newborns.

Author Contribution Seda Sancak, as principal investigator, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Compliance with Ethical Standards

To conduct the study, the institutional review board approval was obtained. The study was carried out in accordance with the Declaration of Helsinki (2013) of the World Medical Association.

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

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