

A Review of Obstetrical Outcomes and Complications in Pregnant Women after Bariatric Surgery

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مراجعة لنتائج ومضاعفات التوليد في النساء الحوامل بعد عمليات جراحة البدانة

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ABSTRACT: Bariatric surgery (BS) is a novel treatment for weight reduction with longer lasting health benefits. This review aimed to summarise the available evidence regarding the fetomaternal outcomes and the most common challenges and complications in pregnancies following BS. Google Scholar (Google LLC, Mountain View, California, USA) and PubMed® (National Library of Medicine, Bethesda, Maryland, USA) databases were searched for articles published until December 2018. A total of 64 articles were included in this review and results showed that BS mitigates the risk of gestational diabetes mellitus, hypertensive disorders in pregnancy and fetal macrosomia. However, it can also have detrimental effects on fetomaternal health. There is paucity of data regarding small for gestational age intrauterine growth restriction, premature rupture of membranes and long-term effects on the children born to women who underwent BS.

Keywords: Bariatric Surgery; Nutritional Deficiencies; Obesity; Pregnancy; Surgical Injuries.

المخلص: تستخدم عمليات جراحة البدانة كعلاج مبتكر لتخفيض الوزن لتحقيق فوائد صحية طويلة الأمد، هدفت هذه المراجعة البحثية إلى إلقاء الضوء وتلخيص الأدلة المتوفرة والمتعلقة بنتائج ب صحة الأم والجنين والتحديات والمضاعفات الشائعة في حالات الحمل التي تلي هذه الجراحة، تم البحث في قواعد بيانات باحث جوجل العلمي (شركة جوجل، كاليفورنيا، الولايات المتحدة الأمريكية) والبيبيد (من المكتبة الوطنية للطب، ماريلاند، الولايات المتحدة الأمريكية) عن المقالات المنشورة حتى ديسمبر 2018، تم تضمين ما مجموعه 64 مقالة في هذه المراجعة البحثية، وأظهرت النتائج أن عمليات البدانة تخفف من خطر الإصابة بسكري الحمل، اضطرابات ارتفاع ضغط الدم في الحمل وخطر الإصابة بأعراض ضخامة الجنين، ومع ذلك، يمكن أن يكون لهذه الجراحات آثار ضارة على صحة الجنين، هناك ندرة في البيانات المتعلقة بقصر النمو الجنيني داخل الرحم، وتمزق الأغشية المبكر والمضاعفات طويلة الأجل على الأطفال المولودين لنساء خضعوا لعمليات جراحة البدانة.

الكلمات المفتاحية: جراحة البدانة؛ النقص الغذائي؛ السمنة؛ الحمل؛ الإصابات الجراحية.

THE WORLD HEALTH ORGANIZATION (WHO) estimates that 13% of the world's population is suffering from obesity.¹ In the UK, obesity rates have increased in women of reproductive ages from 24.2% in 2005 to 28.3% in 2015.^{2,3} The Centre for Maternal and Child Enquiries highlighted that obesity was responsible for 35% of maternal mortality and 30% of perinatal mortality from 2000 to 2003.⁴

Pregnant women with obesity have an increased risk of early pregnancy loss, hypertensive disorders in pregnancy, gestational diabetes mellitus (GDM), small for gestational age (SGA) newborns, difficult prolonged labour, increased caesarean section (CS) rates, thromboembolism, stroke, myocardial infarction and wound infections.⁵⁻⁹ The National Institute for Health and Clinical Evidence recommends bariatric surgery (BS) for women with a body mass index of >40

kg/m².¹⁰ There are many research papers emphasising the fetomaternal benefits after undergoing BS. This paper aimed to summarise the most recent evidence about fetomaternal outcomes, maternal nutritional deficiencies and complications after BS and highlights areas for future research.

Methods

Google Scholar (Google LLC, Mountain View, California, USA) and PubMed® (National Library of Medicine, Bethesda, Maryland, USA) databases were used in this non-systematic and narrative review to search for publications only in English using a combination of keywords specific to the review's purpose. Considering the high variability in various sources of information, a descriptive synthetic approach was adopted to include

articles published until December 2018. Studies with clearly defined inclusion and exclusion criteria and those that focused on pregnancies after BS addressing fetomaternal outcomes, nutritional deficiencies and complications of BS were included. Initially, a total of 220 articles were identified. Subsequently, the search was refined by using more specific keywords, either alone or in combination, such as “bariatric surgery”, “pregnancy”, “obstetrical outcome” and “medical complications” or “surgical complications”. Finally, 64 articles were included in this review after screening to ensure their relevance to the topic.

Results

PREGNANCY RELATED MEDICAL COMPLICATIONS AFTER BARIATRIC SURGERY

Case-control, cohort studies and some case reports have shown that pre-conception BS is associated with a reduction of GDM and hypertension during pregnancy.^{11–13} Pre-conceptional BS is associated with short- and long-term fetomaternal complications during pregnancy—which include fetal anomalies, intrauterine growth restriction (IUGR), malnutrition, prolonged labour, increase in induction of labour, postpartum weight retention and juvenile obesity in children.^{14–16} However, pregnancies following BS may also be associated with many medical, surgical and obstetric morbidities.^{17,18}

Weintraub *et al.*'s retrospective study, conducted at a tertiary care centre in Israel, studied the effect of BS on pregnancy outcome between 1988 and 2006.¹⁹ They analysed 301 pregnant women who had never had BS and 507 pregnant women after BS and showed that there was a significant reduction in GDM (17.3% versus 11.0%; $P = 0.009$) and hypertension (23.6% versus 11.02%; $P = 0.001$) in women after BS.¹⁹

Kwong *et al.*'s systematic review and meta-analysis of 17 cohort studies demonstrated that there was a reduction in hypertensive disorders in pregnancy (odds ratio [OR]: 0.57, confidence interval [CI]: 0.30–1.09), GDM (OR: 0.55, CI: 0.32–0.97) and fetal macrosomia (OR: 0.34, CI: 0.17–0.69) following BS.²⁰ Luck *et al.* reported similar results with the addition of a cost-effectiveness strategy for women with anovulation to improve their overall pregnancy rate.²¹

Johansen *et al.*'s study included 627,693 singleton pregnancies from the Swedish Medical Birth Registry from 2006 to 2011. Of the pregnant women, 670 had prior BS and this revealed a decrease in GDM (1.9% versus 6.8%, OR: 0.25, CI: 0.13–0.18; $P = 0.001$); the frequency of macrosomic fetuses were also reduced in

this group (8.6% versus 22.4%, OR: 0.33, CI: 0.24–0.44; $P < 0.001$).²²

Sheiner *et al.* reported a higher rate of hypertension in pregnancy (5.4% versus 1.7%; $P < 0.001$) and GDM (9.4% versus 5.0%; $P = 0.001$) after BS; however, this association was insignificant on multiple logistic regression analysis.²³ Conversely, Patel *et al.* found no statistically significant difference in GDM and hypertension between pregnant women with and without BS.²⁴

PERINATAL OUTCOME AND CONGENITAL MALFORMATIONS

Sheiner *et al.* described 298 deliveries after BS and compared the outcomes to a control group of 159,210 subjects from 1988 to 2002.²³ There was no significant difference of perinatal mortality and congenital abnormalities between the two groups (0.3% versus 1.5%; $P = 0.10$ and 5.0% versus 4.0%; $P = 0.355$, respectively).²³ Dixon *et al.* studied 79 pregnancies after BS and reported one duodenal atresia and one stillbirth at 41 gestational weeks.²⁵ Due to paucity of data in this regard, more research is needed to evaluate the risk of congenital malformations as some case reports have shown increased risk of neural tube defects after BS.^{26,27}

There may be developmental delays in children born to women who had BS prior to their pregnancy.²⁷ Johansson *et al.* studied long-term growth, neuropsychosomatic and speech development in children born to women after BS in Brazil.²² Speech developmental defects were seen in these children; however, this important observation requires more research and follow-up of children born after BS.²² Patel *et al.* and Cools *et al.* reported delays in speech, visual and neurological development in children born to women after BS.^{24,26} The results are presented in Table 1.

PREMATURITY AND PREMATURE RUPTURE OF MEMBRANES

There is no significant difference in premature births and premature rupture of membranes after BS compared to those who did not undergo BS.^{24,25}

Sheiner *et al.* found a positive correlation between premature rupture of membranes and BS (OR: 1.9; $P = 0.001$).²³ The underlying mechanism is not fully understood and needs more research to elucidate this relationship.

FETAL GROWTH AND BIRTH WEIGHT

BS has been found to be associated with reduction of fetal macrosomia (birth weight $>4,000$ g).^{26–28} Weintraub *et al.* demonstrated a significant reduction in macrosomia in pregnancies after BS versus women with

Table 1: Summary of previous studies regarding obstetrical outcomes after bariatric surgery^{20–22,23,28,30,31,34,57,59,60}

Author and year of publication	Significant positive changes compared to control	Significant negative changes compared to control	Conclusion
Kwong <i>et al.</i> ²⁰ (2016)	• Lower GDM, HTN, PPH, macrosomia and PE	• Higher SGA, IUGR and still birth	BS can be helpful to reduce obstetrical complications but is associated with increased risk of still births and growth restriction.
Luck <i>et al.</i> ²¹ (2016)	• Lower GDM, PE and macrosomia	• Higher SGA, preterm birth, CS, maternal death and NND	BS before pregnancy reduces many obstetrical complications and is a cost-effective strategy to improve the pregnancy outcome for women who are anovulatory.
Johansson <i>et al.</i> ²² (2015)	• Lower GDM, PE and macrosomia	• Higher NND, SGA and CS	BS is a cost-effective strategy for women who are anovulatory to improve fertility and overall pregnancy rate, but it is associated with an increase in SGA, CS and NND.
Sheiner <i>et al.</i> ²³ (2004)	• None	• Higher PROM, labour induction, failed induction, IUGR and CS	No change in GDM or perinatal complications after BS.
Dell'Agnollo <i>et al.</i> ⁵⁷ (2015)	• Lower GDM, PE, PIH and sleep apnoea	• Lower birth weight • Higher CS and preterm birth	Except for a high index of SGA, it can be concluded that BS is safe. Growth in children was found to be adequate. Although changes in speech and development were detected, no factor was found to have an association with pregnancy after BS.
Stephansson <i>et al.</i> ⁵⁹ (2017)	• Lower risk of labour induction, post-term pregnancy, obstetrical anal sphincter injuries, PPH and 5 minutes Apgar score	• Higher SGA and preterm births	BS is associated with a decrease in adverse pregnancy outcomes.
Getahun <i>et al.</i> ⁶⁰ (2013)	• Lower PE, abruptio placenta, chorioamnionitis, GDM, fetal distress, labour induction, macrosomia, RDS and neonatal sepsis	• Higher surgical site wound, infection and CS	The results suggest that BS may be associated with selected adverse perinatal outcomes. Targeted nutritional intervention and intrapartum care are key elements for a good perinatal outcome.
Costa <i>et al.</i> ³⁰ (2018)	• Lower GDM, HTN, PPH and CS	• Higher aortic dilatation, microphthalmia, RDS, necrotising enterocolitis and preterm births	Neonatal outcome may vary depending upon the BS technique. Gastric banding is associated with less risk of malnutrition compared to other types of surgeries, so nutritional evaluation is important to avoid a devastating neonatal outcome.
Harreiter <i>et al.</i> ³¹ (2018)	• Lower GDM, PE, PIH, CS, macrosomia, SGA, IUGR and venous thrombosis • Higher vaginal births and vaginal birth after previous CS	• None	Obstetrical complications decrease after gastric band surgeries.
Zozzaro-Smith <i>et al.</i> ²⁸ (2016)	• Lower macrosomia, CS, GDM, PE and PIH	• None	Pregnancy after BS is safe. Perinatal outcome is comparable to the general population.
Falcone <i>et al.</i> ³⁴ (2018)	• Higher fertility • Lower macrosomia	• Parenteral nutrition needed by 2.5% • Slightly higher SGA	Pregnancy rate increases after BS but might require nutritional supplementation.

GDM = gestational diabetes mellitus; HTN = hypertensive disorders in pregnancy; PPH = postpartum haemorrhage; PE = pre-eclampsia; SGA = small for gestational age; IUGR = intrauterine growth restriction; BS = bariatric surgery; CS = caesarean section; NND = neonatal death; PROM = premature rupture of membranes; PIH = pregnancy-induced hypertension; RDS = respiratory distress syndrome.

obesity who have not undergone BS (3.2% versus 7.6%; $P = 0.004$).¹⁹

Sheiner *et al.* found an increased rate of IUGR in pregnancies after BS compared to those without BS (5% versus 2%; $P = 0.001$). However, after multivariate analysis this finding became insignificant (OR: 1.4; $P = 0.063$).²³ Patel *et al.* also found a significant reduction in fetal macrosomia after BS; nevertheless, they also noted an increased rate of SGA fetuses among women

post-BS compared to those who had never undergone BS (11.5% versus 0.5%; $P < 0.001$).²⁴ Dixon *et al.* reported no significant difference in birth weight between pregnancies with and without BS.²⁵

The timing of pregnancy after BS has not been demonstrated to have an impact on birth weight. Dao *et al.* reported on 34 patients who became pregnant after BS between 2001 and 2004; there was no significant difference between birth weight among 21 women

Table 2: Summary of previous studies related to nutritional deficiencies and fetomaternal outcomes after bariatric surgery^{16,26,27,36,43–46,48,49}

Author and year of publication	Maternal complication	Fetal complication	Long-term fetomaternal complication	Interval between BS and pregnancy
Cools <i>et al.</i> ²⁶ (2006)	<ul style="list-style-type: none"> Nutritional deficiencies Hypoplastic anaemia 	<ul style="list-style-type: none"> Multiple congenital anomalies Iron deficiency anaemia Preterm labour 	<ul style="list-style-type: none"> Blindness Epilepsy Deafness 	2 years
Monkhouse <i>et al.</i> ⁴⁸ (2009)	<ul style="list-style-type: none"> Preterm labour Anaemia 	<ul style="list-style-type: none"> Preterm delivery 22 gestational weeks 	<ul style="list-style-type: none"> Perinatal death 	3 years
Vrebosch <i>et al.</i> ⁴⁹ (2012)	<ul style="list-style-type: none"> Preterm labour 27 gestational weeks Iron deficiency anaemia 	<ul style="list-style-type: none"> <i>Hydrocephalus</i> <i>Hypoplastic corpus callosum</i> Atrophy of cerebral cortex 	<ul style="list-style-type: none"> Visual disturbances Deafness Growth restriction 	5 years
Adam <i>et al.</i> ³⁶ (2017)	<ul style="list-style-type: none"> Abdominal pain at 33 gestational weeks 	<ul style="list-style-type: none"> Congenital abnormalities Hydrocephalus Coagulation problems Cerebral haemorrhage 	<ul style="list-style-type: none"> Perinatal death 	3 years
Kaska <i>et al.</i> ²⁷ (2013)	<ul style="list-style-type: none"> Thiamine deficiency <i>Hyperemesis gravidarum</i> Wernicke encephalopathy Megaloblastic anaemia 	<ul style="list-style-type: none"> Neural tube defects Preterm delivery anaemia 	<ul style="list-style-type: none"> Deafness Delay in speech 	3–24 months
Guelinckx <i>et al.</i> ¹⁶ (2008)	<ul style="list-style-type: none"> Vitamin K deficiency 	<ul style="list-style-type: none"> Cerebral haemorrhage 	<ul style="list-style-type: none"> Perinatal death 	2 years
Smets <i>et al.</i> ⁴³ (2006)	<ul style="list-style-type: none"> Vitamin A deficiency 	<ul style="list-style-type: none"> Bilateral microphthalmia 	<ul style="list-style-type: none"> Delay in speech 	8 years
Devlieger <i>et al.</i> ⁴⁴ (2014)	<ul style="list-style-type: none"> Vomiting Iron deficiency anaemia Vitamin A deficiency 	<ul style="list-style-type: none"> Neural tube defects Preterm birth Intracranial haemorrhage 	<ul style="list-style-type: none"> Epilepsy 	3–24 months
Bebber <i>et al.</i> ⁴⁵ (2011)	<ul style="list-style-type: none"> Vitamin B12 deficiency in breast milk Iron deficiency anaemia 	<ul style="list-style-type: none"> Macrocytic anaemia 	<ul style="list-style-type: none"> None 	18 months
Pelizzo <i>et al.</i> ⁴⁶ (2014)	<ul style="list-style-type: none"> Protein nutritional deficiency Malabsorption Low fat content in breast milk 	<ul style="list-style-type: none"> Neural tube defects Iron deficiency anaemia Neutropenia 	<ul style="list-style-type: none"> None 	7–24 months

BS = bariatric surgery.

who became pregnant within one year compared to 13 women who conceived one year after BS.²⁹

MODE OF DELIVERY

Regarding mode of delivery, BS itself is not an indication for CS. Costa *et al.* and Harreiter *et al.* both reported a decrease in CS after BS.^{30,31} Conversely, Sheiner *et al.* found a higher CS rate after controlling for cofounders (25.2% versus 12.2%, OR: 2.4; $P < 0.001$).²³ However, case-control studies did not show any significant difference in CS after BS.^{24,32} The American College of Obstetricians and Gynaecologists Committee Opinion showed an increase in CS rates and though this may be due to previous CS, maternal request or other obstetrical indications, data is sparse about increased CS rates following BS.^{33,34}

NUTRITIONAL DEFICIENCIES

Nutritional deficiencies are well-recognised complications of BS and may lead to a reduction in vitamin B, fat-soluble vitamins, folic acid, iron and calcium.^{35,36}

The underlying aetiological factor is thought to be a decreased production of gastric acid leading to a decreased absorption of micronutrients.^{37,38}

Iron, thiamine and vitamins A, K and D deficiencies are common in pregnancies after BS. Wernicke encephalopathy and anaemia may occur due to the deficiency of thiamine and iron, respectively.³⁹ Vitamin D deficiency can lead to bone loss and dental problems in the mother and child.^{40,41} Nutritional deficiencies may also cause fetal malformations and fetal growth restriction. Cools *et al.*'s study showed that deficiency of micronutrients, specifically folic acid, vitamin K and A, can adversely affect the fetus, not only *in utero*, but also later in life.²⁶ Neural tube defects, anaemia, preterm births, cerebral haemorrhage, perinatal death, failure to thrive, blindness, deafness, growth retardation and epilepsy have also been reported in some studies, although more observation and follow-up is needed [Table 2].^{26,27,42,43}

Nutritional deficiencies can be compensated with pre-pregnancy consumption of 5 mg of folic

acid daily which should be continued until 12 weeks of gestation. Other vitamins, minerals and nutrients should be administered in recommended quantities to avoid further deficiencies.^{44,45}

SURGICAL COMPLICATIONS IN PREGNANCY AFTER BARIATRIC SURGERY

Like other surgical procedures, BS has many complications depending upon the type of surgery. The most common complications of BS include small bowel obstruction, volvulus, intussusception, gastric band erosion, slipping of gastric band, gastric ulcers, stitch-line leak and potentially life-threatening peritonitis.^{46–49}

Symptoms of BS complications may mimic common symptoms of physiological changes during pregnancy and require vigilant management. Stuart *et al.*'s study found a higher rate of laparotomies in pregnancies after BS (1.5% versus 0.1%, OR: 11.3%, 95% CI: 6.9–18.5) and higher incidence of intestinal obstruction (1.5% versus 0.02%, OR: 34.3, 95% CI: 11.9–98.7) in Sweden.⁵⁰ A recent case report by Petrucciani *et al.* showed thrombosis in the small intestine of a 29-year-old pregnant female who had BS six years earlier and presented at 24 weeks of gestation.⁵¹ She presented with severe abdominal pain and upon ultrasound scan, was found to have fluid collection in her abdomen. Laparotomy was performed by a bariatric and a general surgeon who found ischaemia of the small intestine. The small intestine was resected and a hysterotomy was performed to deliver a stillborn fetus.⁵¹ Maggard *et al.*'s systematic review showed three maternal and five neonatal deaths with surgical intervention in 20 cases during pregnancy after BS.⁵² The majority of these interventions were due to internal hernias; gastric band migration, slipping and erosion have also been reported and some of these cases have had laparoscopic removal of gastric bands.^{51,52}

Discussion

Obesity is increasing exponentially among women of reproductive age. Concurrently, rates of BS are rising as this solution is a favourable option for weight loss among this population.

Dixon *et al.* found no difference in perinatal outcome in conception occurring within one or two years after BS.²⁵ Patel *et al.* reported an increase in preterm deliveries in pregnancies within one year of BS.²⁴ With the current available data, it is advisable to avoid pregnancy for at least one year following BS.⁵³

Dao *et al.* and Roehrig *et al.* reported fertility improvements in women after BS; the likelihood of unintentional pregnancy was also higher.^{29,54} Therefore, contraceptive options should be discussed with women

who have undergone BS, especially considering the questionable absorption of oral contraceptive pills; this is also supported by the American College of Obstetricians and Gynecologists clinical guidelines on pregnancy after BS.³³

Luck *et al.*'s study showed that in pregnancies after BS, there is a reduction in hypertensive disorders in pregnancy, GDM and macrosomic fetuses but it has also been found that there is an increase in IUGR and SGA fetuses.²¹

It should be noted that many studies included in this review are case-control and cohort studies that have variable results and exhibit heterogeneity. Studies about congenital malformations and neonatal outcomes are underpowered with no homogeneity. Some of these studies have used a control group without prior BS. Skull *et al.* and Bilenka *et al.* used the patients as their own controls.^{32,55} Cools *et al.* and Huerta *et al.* stated that there was no long-term follow-up data for children born to mothers who had BS.^{26,56}

Few studies addressed nutritional deficiencies and there is no evidence-based recommended daily nutritional intake requirements for pregnant women who had undergone BS.^{40,41} More detailed studies with long-term follow-up are required to determine the relationship between BS and nutritional deficiencies, congenital malformations, IUGR, SGA and long-term effects on children after birth.

Post-BS pregnancies are high risk and demand careful management by obstetricians, nutritionists and bariatric surgeons. Peri-conceptional, antenatal, intrapartum and postpartum assessment and management are essential in dealing with all issues and complications.⁵⁶ Pre-pregnancy assessments of nutritional status, specifically the intake of folic acid, vitamin B12, calcium and iron, can prevent many complications during the antenatal period.

Early assessment by a senior obstetrician are important in such cases and anomaly scans should be performed to exclude neural tube defects and other fetal malformations. Screening for SGA by ultrasound for fetal growth (growth-curves, amniotic fluid index and umbilical artery Doppler) should be conducted for diagnosis and follow-up.^{57–60} Any abdominal pain in such pregnancies warrants early scanning and involvement of surgical colleagues. There is no contraindication for vaginal births in these pregnancies except for other obstetrical indications.

Postpartum care is routine with additional dietary assessment to avoid nutritional deficiencies in the neonate and breastfeeding must be strongly encouraged. Discussion about future contraception is also particularly important considering the lower absorption of oral contraceptives which might affect their efficacy.

Conclusion

The included observational, case-control and cohort studies are suggestive of a decrease in the incidence of GDM, hypertensive disorders in pregnancy and macrosomia in pregnancies after BS. However, there is a lack of robust data regarding the risk of IUGR, fetal anomalies and SGA after BS, necessitating the need for more research. CS rates also remain high following BS and nutritional deficiencies require careful attention to ensure adherence to nutritional supplements in addition to careful monitoring regarding early detection and treatment. Moreover, there is no international consensus regarding the management of post-BS pregnancies due to their novelty, hence an evidence-based guideline is urgently needed. In addition, follow-up studies should focus on obstetrical outcome and long-term neonatal effects in children born to women who have undergone BS prior to their pregnancy.

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