



Review article

Nutrition for pregnancy after metabolic and bariatric surgery: literature review and practical guide

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Abstract

When pregnancy follows metabolic and bariatric surgery (MBS), there are many important considerations related to nutritional status that may impact maternal and infant outcomes. Although evidence-based nutrition guidelines for pregnancy exist for the general population, there are limited practical recommendations that specifically address pregnancy after MBS. A literature search was conducted to investigate outcomes of women with a history of MBS and pregnancy. Search criteria focused on women 18 years of age and older who became pregnant after MBS. Search terms included “laparoscopic sleeve gastrectomy,” “Roux-en-Y gastric bypass,” “laparoscopic adjustable gastric banding,” “biliopancreatic duodenal switch,” and gestation terminology, and they were paired with the nutrition outcomes of interest. A total of 167 publications were identified; 46 articles were included in the final review. Data relating to gestation and fetal weight and nutrition and cardiometabolic data were extracted from the studies. Based on this review, women of childbearing age with a history of MBS should be evaluated and monitored for nutritional status before conception, during pregnancy, and postpartum. (*Surg Obes Relat Dis* 2022; ■:1–11.) © 2022 American Society for Bariatric Surgery. Published by Elsevier Inc. All rights reserved.

Key words:

Anemia; Bariatric surgery; Nutrition; Obesity; Pregnancy; Vitamin deficiency

The prevalence of metabolic and bariatric surgery (MBS) has increased over the years, with the majority of these surgeries performed on women of childbearing age [1–3]. The 4 most common surgical procedures endorsed by the American Society of Metabolic and Bariatric Surgery (ASMBS) include laparoscopic sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB), laparoscopic adjustable gastric banding (LAGB), and biliopancreatic duodenal switch (BPD/DS) [4]. A detailed description of the surgical

procedures is published elsewhere [4]. Although the single-anastomosis duodenoileal bypass with sleeve gastrectomy is an endorsed bariatric procedure by ASMBS, it was not included in the literature search because of insufficient evidence [4].

MBS has been associated with a number of health-related benefits for women with obesity who wish to become pregnant [1]. For example, ovulation with regular menstrual cycles, reduction in medication use, a healthier prepregnancy weight, improved nutritional status, increased physical mobility, reduced joint pain, and a decline in other obesity-related co-morbidities have been reported [1]. In addition, MBS has been shown to improve pregnancy

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outcomes by reducing the risk of gestational diabetes, preeclampsia, and large for gestational age infants [1,3].

Because of the anatomic changes that occur with MBS procedures, women of childbearing age are also at risk for malnutrition before conception, during pregnancy, and postpartum [3,5]. MBS has been associated with considerable changes in eating behaviors, including a reduction in the amount of food consumed and food intolerances, that can impact macronutrient composition and adequacy [3,5]. Women with procedures that alter the gastrointestinal tract such as SG, RYGB, BPD, and BPD/DS are at risk of vitamin deficiencies and anemia [4,5].

Although evidence-based nutrition guidelines for pregnancy exist for the general population, there are few available practical recommendations specific to pregnancy after MBS [4,6–8]. For women who wish to become pregnant following MBS, many questions remain with no clear guidance. Data are limited regarding safe timing for conception after surgery, the optimal level of gestational weight gain, macronutrient composition adequacy, micronutrient supplementation, and various maternal and fetal outcomes. The purpose of this article is to review the current empirical literature regarding pregnancy following MBS and to provide nutritional guidance in caring for women who become pregnant after bariatric surgery.

Methods

A literature search was conducted for articles published between January 1, 2007, and June 30, 2017, using databases from MEDLINE, Embase, EBM Reviews (including the Cochrane Database of Systematic Reviews), PsycINFO, PubMed, PubMed Central, CINAHL (Cumulative Index to Nursing and Allied Health Literature), and the Nursing Reference Center. The literature search was repeated using the same search terms between July 1, 2017, and December 15, 2020, for the purpose of identifying any newly published articles. Both searches were restricted to English-language, full-text articles that included all research study designs and were published within the past 10 years. The search was limited to studies including women 18 years of age and older who became pregnant after MBS. Studies including singleton and multiple pregnancies between conception and delivery were explored. Timing of pregnancy, gestational weight changes, cardiometabolic control during pregnancy, and nutrition adequacy of women who became pregnant after bariatric surgery were targeted as outcomes of interest.

Each surgical procedure search term was combined with search terms related to pregnancy, from conception through delivery. The surgical procedures and gestation terminology also were paired with the nutrition outcomes of interest (Table 1). One additional article was identified by hand searching the reference lists of the collected articles screened for inclusion.

Table 1

Search terms used in search strategy

Bariatric surgery; sleeve gastrectomy; Roux-en-Y gastric bypass; weight loss surgery; lap band; gastric bypass; vertical band gastrectomy; duodenal switch; *and* pregnancy; maternal fetal medicine; maternity; post-partum; postpartum; antepartum; intrapartum; labor and delivery; labor and delivery; *and* nutritional supplement; dietary supplement; micronutrient supplementation; micronutrients; multi-vitamin; multivitamin; vitamin; weight gain; gestational weight gain; protein; calories; energy intake; carbohydrates; dietary carbohydrates; oral glucose tolerance test; nutritional risk; malnutrition; nutritional deficiency; folic acid; iron; vitamin B₁₂; calcium; vitamin D; copper; thiamine; birth weight

Results and Discussion

A total of 167 publications were identified based on the search criteria; 166 articles appeared relevant and met the inclusion criteria for review. After screening 166 records, 41 articles were excluded for the reasons cited in Fig. 1. Of the 125 full-text studies reviewed, gestation and fetal weight, nutrition, and cardiometabolic data were extracted from 46 articles (7 prospective studies and 39 retrospective analyses). A critical review of the bariatric literature including a summary of the clinical assessment, monitoring, and evaluation of nutritional status for women of childbearing age after MBS is described and compared with the current guidelines of MBS and pregnancy. Additionally, timing of pregnancy, gestational weight gain, and maternal and fetal outcomes are discussed.

Timing of pregnancy

Thirty studies [9–39] reported data about the timing of pregnancy after bariatric surgery. No conclusive evidence from the literature suggested a specific period of time that should be allowed before considering a pregnancy following MBS. However, published guidelines from major professional societies (Table 2) suggest waiting at least 12 months after MBS before planning a pregnancy [4,40,41].

Several reasons for delaying pregnancy are related to increased nutrition and health concerns for both the mother and the fetus [3,5]. Within the first year after MBS, many women experience low macronutrient intake, vitamin/mineral deficiencies, endocrine/hormonal changes, medication changes, and rapid weight loss [3,5]. As a result, macro- and micronutrient inadequacies during the first 12 months following MBS may increase the risk of or exacerbate nutrient deficiencies in pregnant women owing to the metabolic demands of gestation [3,5]. As a consequence, pregnancy outcomes, including the mother's nutritional status, fetal development, and birth weight, may be jeopardized. The current recommendations suggest that women should delay pregnancy for at least 12 months following an MBS procedure.

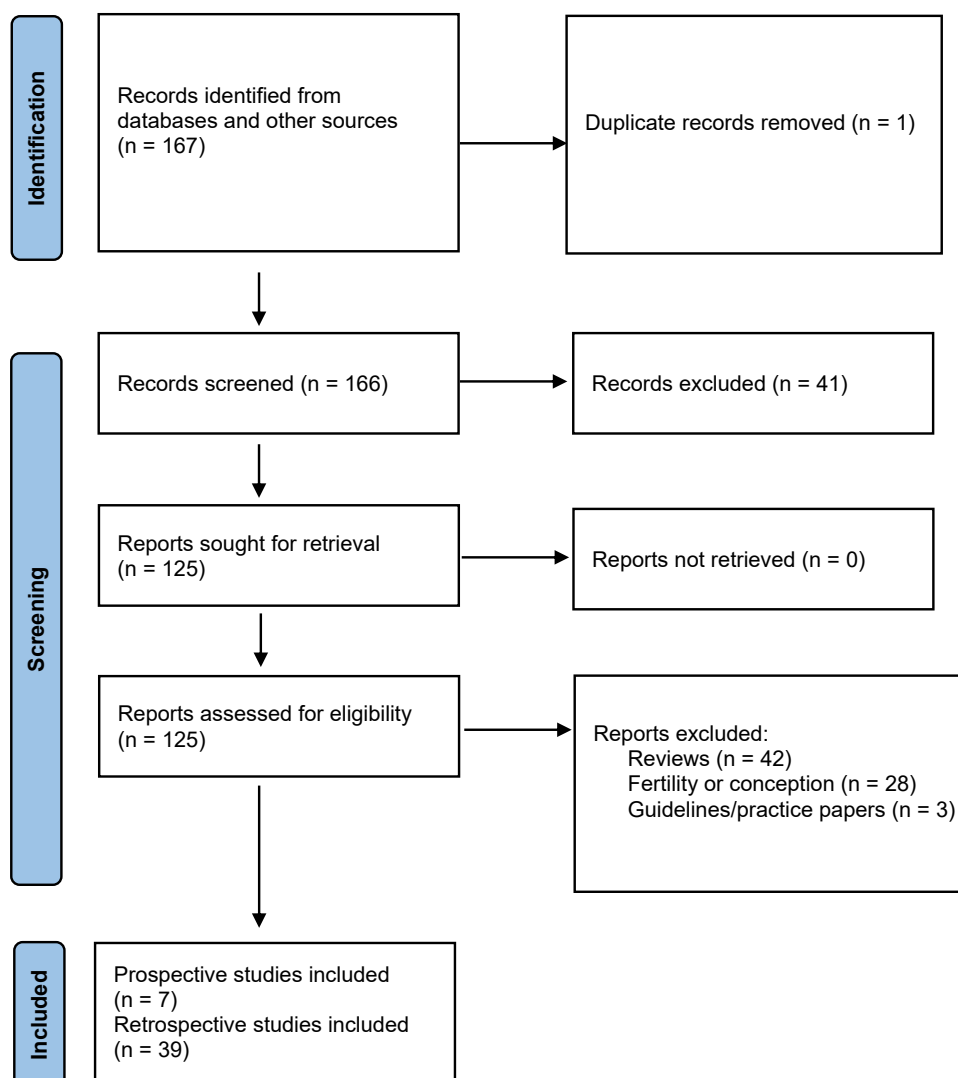


Fig. 1. Flow diagram showing identification of studies for inclusion in this review according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

Gestational weight

MBS typically leads to a significantly lower body mass index (BMI) and improved metabolic health, which can improve both the chances of conception and pregnancy

Table 2
Clinical guidelines for timing of pregnancy after bariatric surgery

Guideline	Time frame, surgery to pregnancy
ASMBS/TOS/AACE [4]	12–18 mo
ACOG [41]	12–24 mo
BARIA-MAT [40]	Minimum of 12 mo

ASMBS = American Society of Metabolic and Bariatric Surgery; TOS = The Obesity Society; AACE = American Association of Clinical Endocrinologists; ACOG = American College of Obstetricians and Gynecologists; BARIA-MAT = French Study group for Bariatric Surgery and Maternity.

outcomes [1]. Some women may still be losing weight or have a BMI ≥ 30 kg/m² at the time of conception [39]. Fourteen retrospective studies reported an average prepregnancy BMI of between 22.2 and 42.1 kg/m² in women who previously underwent MBS [10,11,13,15,20,21,26,34,36–39,42,43]. Gestational weight gain following MBS ranged from –4.1 to 23.1 kg (–9 to 50.8 lb) [10,11,13–15,20,21,26,34,36–39,42–46]. No studies reported recommendations for a desired amount of gestational weight gain in women who have undergone MBS. The Institute of Medicine (IOM) reference table for women from the general population (Table 3) may be used as a guide for gestational weight gain for most healthy women of childbearing age [6]. However, the IOM guidelines for pregnancy have not been evaluated in women who have undergone MBS. Thus, in the absence of specific guidelines

Table 3
Recommended weight gain during pregnancy based on preconception body mass index [6]

Preconception body mass index (kg/m ²)		Recommended weight gain, lb (kg)	
		Singleton	Multiple
Underweight	<18.5	28–40 (12.7–18.1)	50–62 (22.7–28.1)
Healthy	18.5–24.9	25–35 (11.3–15.9)	37–54 (16.8–24.5)
Overweight	25.0–29.9	15–25 (6.8–11.3)	31–50 (14.1–22.7)
Obesity	≥30.0	11–20 (5.0–9.1)	25–42 (11.3–19.0)

for gestational weight gain during pregnancy following MBS, the IOM recommendations may be used as an alternative tool in the post-MBS population to assist and guide gestational weight gain.

Nutrition requirements

Clinicians should focus on macronutrient quality and adequacy, nutritional status, and use clinical judgment after a thorough nutritional assessment by a registered dietician. Energy and macronutrient requirements for women who become pregnant following MBS need further research [4]. Only a few studies with limited data were reported, and they showed a wide variation in the data collected [29,47–49].

Energy and macronutrients

Four studies [29,47–49] were identified including 2 prospective cohorts [29,48] and 2 retrospective case series [47,49]. Study sample sizes ranged from 14 to 85 women with a history of MBS who became pregnant; collectively, data were analyzed from a total of 202 participants [29,47–49]. Food records ranging from 3 to 7 days were used to collect dietary information during varying time points of the 3 pregnancy trimesters in 3 of the studies [29,48,49]. One study identified protein and energy intake from transcriptions in the patient chart during the second and third trimesters [47]. Diet quality was measured by the Healthy Eating Index in 1 study [29], which compared the diets of a control group (nonsurgical women who were obese and pregnant) with those of women who had a history of MBS and were pregnant. The authors reported no change in diet quality between the 2 groups during pregnancy [29].

Energy intake for women with a history of MBS (i.e., LAGB, RYGB, and SG) and who were pregnant averaged between 1385 ± 415 kcal and 1971 ± 430 kcal during the first trimester [29,48]. Caloric intake ranged from 1222 ± 425 kcal to 1978 ± 427 kcal during the second trimester, demonstrating the most diversity in energy intake [29,48,49]. The third-trimester data showed the least variation in mean average caloric intake with 1514 ± 503 kcal to 1881 ± 835 kcal [47,48]. Based on these results, no conclusions can be drawn because of the limited evidence and self-reported data during each trimester. However, these data do

provide a reference of energy ranges for each trimester that has been documented in the literature. Energy requirements should be individualized and sufficient to meet the metabolic demands of the pregnancy and achieve fetal weight and growth targets [3].

Limited data were reported in the food records on macronutrient intake. Three studies [29,47,49] reported protein intake, although not all the studies collected data during all 3 trimesters. Based on self-reported intake, an approximate average of protein intake ranged from 46.7 to 80 g/d across all 3 trimesters [29,47,49]. The current recommendation for women with a history of MBS is >60 g/day, which does not take into consideration protein requirements for pregnancy [4,6]. Although there are no recommendations for carbohydrate intake after MBS, 1 study [29] reported that women with a history of MBS averaged approximately 49% of total calories consumed in the form of carbohydrate during the first 2 trimesters of pregnancy. According to the IOM general (non-MBS) pregnancy guidelines [6], carbohydrate intake in this study falls within the recommended range of 45%–65% of total calories per day. Total fat intake was reported in 3 studies [29,48,49]. Total fat intake ranged from approximately 14.2% to 35.9% across 3 trimesters. Some individuals fall below the IOM general pregnancy recommendation of 20%–35% total energy intake from dietary fat [6]. Based on these findings with a limited number of studies, self-reported food records, and the absence of clear guidelines for women with a history of MBS during pregnancy, macronutrient composition and adequacy should be evaluated and monitored by a registered dietician throughout pregnancy [3,4,6].

Neither the ASMBS nor the IOM Dietary Reference Intakes provide clear evidence on macronutrient intake during pregnancy after MBS [4,50–52]. However, Table 4 does identify general nutrition information that may be useful to guide protein, carbohydrate, and energy in women who become pregnant following MBS [4,50–52].

Micronutrients

Nineteen studies [9,10,13–15,17,21–24,27,28,33,34,43,46,53–55] reported data on the most common micronutrients impacting fetal growth and maternal health in pregnancies following MBS. Most studies recruited a small number of women and did not report supplement recommendations, supplement adherence, or supplement composition. Thus, the quality of the evidence from these studies was considered marginal. No studies identified participants with above-normal serum values or toxicity for any micronutrient.

Table 5 provides a comparison of the Dietary Reference Intake recommendations for micronutrients during pregnancy in women who have not undergone MBS with the general (i.e., nonpregnant) clinical practice guidelines for bariatric surgery (nonpregnant) [4,8,40,50–52,56]. Bariatric

Table 4
Macronutrient guidelines after MBS (ASMBS/TOS/AACE) and clinical guidelines for pregnancy in the general population (IOM)

Factor	ASMBS/TOS/AACE [4]	IOM guidelines for pregnancy [6]
Population	Women who have undergone MBS	General population
Energy	No recommendation	2nd trimester: +340 kcal/d 3rd trimester: +452 kcal/d <i>Note:</i> Based on BMI of 18.5–24.9 kg/m ²
Protein	Individualized, with minimal 60 g/d and up to 1.5 g/kg ideal weight	71 g/d ^{*†}
Carbohydrate	No recommendation	10–35 kcal/d 45–65 kcal/d 175 g/d [†] ; total fiber 28 g/d [†]
Fat	No recommendation	20–35 kcal/d
Fluid	No recommendation	3.0 L/d ^{†‡}

MBS = metabolic and bariatric surgery; ASMBS = American Society of Metabolic and Bariatric Surgery; TOS = The Obesity Society; AACE = American Association of Clinical Endocrinologists; IOM = Institute of Medicine.

* Based on grams of protein per kilogram of body weight for the reference body weight, that is, for adults, 0.8 g/kg of body weight for the reference body weight.

[†] Recommended Daily Allowances.

[‡] Total water includes all water contained in food, beverages, and drinking water.

surgery micronutrient recommendations are often higher than what is recommended for pregnant women who have not undergone MBS and may exceed the tolerable upper intake levels for vitamin A, vitamin D, and iron [4,8,40,50–52,56]. A biochemical assessment is recommended to determine micronutrient nutritional status and guide supplementation recommendations for women after MBS, both before conception and during pregnancy [8].

Vitamin B₁ (thiamine)

Two studies [10,24] included data on thiamine; both noted low thiamine values in post-MBS women during all trimesters. Low levels of adherence to supplementation were reported in both studies after MBS and during pregnancy [10,24].

Vitamin B₁₂

Six studies [9,10,15,17,22,27] reported data on vitamin B₁₂ levels in pregnant women who had undergone MBS. A subgroup of participants was found to have low serum vitamin B₁₂ levels in all the studies [9,10,15,17,22,27]. However, reference ranges were not consistent between the studies, making it difficult to draw clear conclusions. One study [9] reported low B₁₂ values in women taking multivitamin supplements containing 12 µg of B₁₂ daily. In a second study [15], low serum B₁₂ levels also were reported in women taking both a multivitamin and additional oral B₁₂ supplementation. Three other studies [24,28,34] reported a protocol of providing monthly vitamin B₁₂ injections (1000 µg) during pregnancy as opposed to recommending oral B₁₂ supplementation. Based on these findings, screening of vitamin B₁₂ status should be conducted on all women who become pregnant following MBS. Supplementation dose may vary based on the route of administration and patient adherence [4].

Folic acid

Four retrospective studies [9,10,12,15] included information on folic acid in samples of women who became pregnant after MBS. Supplementation instructions varied from a daily multivitamin with 0.4 mg folic acid to 1.0 mg folic acid per day for pregnancy after an RYGB or BPD procedure [9,12]. Low folic acid serum values were reported among a subgroup of participants in all 3 trimesters of pregnancy [9,10,12]. Two studies [10,12] reported low rates of adherence to supplementation prior to conception and throughout pregnancy. Two adverse fetal outcomes and 1 miscarriage were reported in association with inadequate folic acid supplementation [10,15]. One infant was born with spina bifida to a mother with a folate deficiency after SG [10]. One miscarriage and 1 birth defect also were identified [15].

Updated supplementation recommendations for all women of reproductive age have been put forward, stratified by risk of neural tube defect (NTD) [57]. Within this risk stratification model, women with class II obesity (BMI ≥35 kg/m²) and those at risk for gastrointestinal malabsorption following MBS would be categorized as at moderate risk for NTD [57]. To reduce the risk of NTD, all women who have undergone MBS and are planning a pregnancy should take 1.0 mg of folic acid supplementation. Red blood cell folate concentrations >906 nmol/L are considered optimal to reduce the risk of folate-related NTD [58].

Vitamin A (retinol) and beta-carotene

One prospective and 4 retrospective studies [10,23,24,28,44] included data on vitamin A in women becoming pregnant after MBS. Three studies [23,24,44] reported women with low vitamin A levels taking vitamin supplements ranging from 1500 to 3000 µg/d. Low vitamin A levels also were identified in 4 studies

Table 5
Comparison of micronutrient recommendations for MBS clinical practice guidelines (nonpregnant) and pregnancy

Micronutrient	Bariatric surgery (nonpregnant) pregnancy			
	United States [4,8]	Britain [56]	France [40]	DRI/RDA/AI [47–49]
Vitamin B ₁ (thiamine)	At least 12, preferably 50–100 mg/d	Include in multivitamin; add oral thiamine for first 3–4 mo after surgery; if symptoms, give 200–300 mg/d orally, twice daily (i.e., vomiting, poor oral intake, dysphagia, fast weight loss)	If deficient: 250–500 mg/d oral if not vomiting; if repeated vomiting: 100–150 mg/d IV or IM	1.4 mg/d (UL: ND)
Vitamin B ₁₂	350–500 µg/d oral or 1000 µg IM monthly	Routine IM injections	1000 µg once per week (oral); if deficient: increase frequency or IM	2.6 µg/d (UL: ND)
Folic acid	0.8–1.0 mg/d for women of childbearing age	Multivitamin with 0.4–0.8 mg/d	Multivitamin with 0.4–1.0 mg/d; if history of neural tube defects: 5 mg/d	0.6 mg/d (UL: 1)
Vitamin A	5000–10,000 IU/d	Include in multivitamin; for BPD/DS: 10,000 IU/d	Multivitamin with no more than 5000 IU/d, preferably in the form of β-carotene; if deficient: 10,000 IU/d	10,000 IU/d, (2567 RAE), β-carotene preferred
Vitamin D	3000 IU/d	2000–4000 IU/d, supplement to keep 25-hydroxyvitamin D ≥75 mmol/L	If deficient: 3000 IU/d	600 IU/d (UL: 4000)
Vitamin E	15 mg/d	BPD/DS: 100 mg/d	No recommendation	15 mg/d (UL: 1000)
Vitamin K	90–120 µg/d (BPD/DS:300 µg/d)	BPD/DS: 300 µg/d	No recommendation	90 µg/d (UL: ND)
Calcium	1200–2400 mg/d, depending on surgery type	800–1200 mg/d; ensure good dietary intake; supplement as needed	If deficient: 1500 mg/d and increase dietary intake	1000 mg/d (UL: 2500)
Copper	1–2 mg/d	2 mg/d	Multivitamin with at least 1 mg/d	1 mg/d (UL: 10)
Iron	45–60 mg/d	45–60 mg/d (100 mg/d for menstruating women)	50–80 mg/d	27 mg/d (UL: 45)
Selenium	No recommendation	Include in multivitamin	If deficient: 50–100 µg/d	60 µg/d (UL: 400)
Zinc	8–22 mg/d	RYGB/SG: 15 mg/d; BPD/DS: 30 mg/d	Multivitamin with at least 10 mg/d; if deficient: 15–60 mg/d	11 mg/d (UL: 40)

MBS = metabolic and bariatric surgery; DRI = dietary reference intakes; RDA = Recommended Dietary Allowance; AI = adequate intake; IV = intravenous injection; IM = intramuscular injection; UL = tolerable upper intake level; ND = not determinable; BPD/DS = biliopancreatic diversion duodenal switch; RAE = retinol activity equivalents; RYGB = Roux-en-Y gastric bypass; SG = sleeve gastrectomy.

[10,23,24,44] among participants in all trimesters; night blindness was noted among some women with low vitamin A levels. In another study [28], low vitamin A levels were identified in the cord blood of newborns, with higher rates of vitamin A deficiency found in newborns of mothers after RYGB compared with the control group (mothers who had no history of obesity). Although all the reviewed studies reported low vitamin A levels, no mention was made of excess intake, vitamin A toxicity, or adverse effects related to toxicity. The recommended upper limit for retinol supplementation is 10,000 IU/day for post-MBS patients [4]. The retinol form of vitamin A should be avoided during pregnancy because of the risk of teratogenicity [8]. The vitamin A supplementation recommendation prior to conception is 5000 IU of a β -carotene formulation [4].

Vitamin D

Eight studies [10,14,15,21,22,24,28,46] reported data on vitamin D in pregnancy after MBS. Low vitamin D values were reported in 2 studies [10,46] among participants taking vitamin D supplements in all trimesters. Although low levels of vitamin D are commonly reported after MBS, 1 study [28] found that cord blood 25-OH vitamin D levels were within the normal range in infants born to mothers following RYGB.

Calcium

Three studies [9,14,28,46] reported calcium data. Two studies [28,46] found that women who become pregnant following bariatric surgery had low calcium blood values. However, dietary intake of calcium was not reported, and calcium supplementation data were inconsistently reported among the studies [28,46].

Zinc

Five studies [10,21,22,28,44] reported data for zinc; all the data were collected on women who had undergone an RYGB procedure. One study found no difference in the prevalence of zinc deficiency during pregnancy 12 months before or after bariatric surgery [22]. Low serum zinc levels were found in participants in 4 of the studies [21,22,28,44], whereas 1 study [44] reported that maternal zinc values were sufficient in participants across all trimesters [21,22,28,44]. Although participants were instructed to take 15 mg of zinc supplementation daily in 1 observational study, low zinc values were still recorded in some women, raising the question of whether the participants in this study were adherent to supplementation instructions [44]. The recommendation for zinc after MBS is slightly higher than the general recommendations for zinc in pregnancy [4,6]. Therefore, women who have undergone an RYGB or BPD/DS should be screened annually for zinc deficiency if the primary sites of absorption (duodenum and proximal jejunum) are bypassed [8].

Iron

Seventeen studies [9,10,12,14,17,21,22,24,27,28,33,34,43,53–55,59] reported data on 1 or more indices of iron-deficient anemia, including serum iron, ferritin, and hemoglobin, in women who became pregnant after MBS. Insufficiency and deficiency were not consistently defined in the reviewed studies because of the variability found in the reference values used to determine adequacy. In general, most studies identified low iron status prior to conception in some women after bariatric surgery. Additionally, low iron levels were found in women who were taking supplements containing iron. The degree of supplementation and adherence to supplementation were generally not specified. Two articles [14,34] reported treatment with intravenous (IV) iron supplementation; 1 study reported that IV iron and iron transfusions were more common for pregnancies occurring more than 4 years after RYGB compared with fewer than 4 years after RYGB [34]. Clinical guidelines recommend that all women of childbearing age who have had bariatric surgery should take at least 45–60 mg of elemental iron daily to support iron stores [4]. Preexisting nutrient deficiencies including iron should be addressed before conception [4]. Clinical recommendations also support IV iron infusion if iron deficiency does not respond to oral therapy [4].

Maternal–fetal outcomes

Gestational diabetes

None of the studies included in this review examined maternal or fetal outcomes in women with type 2 diabetes prior to pregnancy. Nine studies [11,15,16,21,27,39,42,43,54] reported a lower incidence of gestational diabetes (GD) among pregnancies after MBS compared with pregnancies in women with obesity who had not undergone MBS or in women who were matched on the basis of weight. Two large retrospective studies [27,39] compared women who underwent MBS with a cohort of nonsurgical women with prepregnancy BMIs ≥ 30 kg/m². Both studies included a surgical group with a variety of MBS procedures and demonstrated a slightly lower risk of developing GD in women whose pregnancies occurred after MBS [27,39]. Two other studies [43,54] produced similar results, with lower or no incidence of GD development in the MBS group compared with those with obesity in the general population. Although most studies showed improvements in rates GD after MBS, 2 studies [37,60] reported inconsistent findings. Two other studies [16,42] compared pregnancies in the same women before and after MBS. Both studies noted a reduction in GD occurrence in pregnancies after MBS compared with pregnancies prior to surgery [16,42]. A recent meta-analysis confirmed a reduction in GD following MBS compared with patients matched for preoperative BMI [61].

Table 6
Practical suggestions for healthcare providers

Subject	Suggestions
Preconception optimization	<ul style="list-style-type: none"> • Evidence suggests that women should avoid pregnancy for at least 12 months after all MBS procedures [4,40,41]. • Existing MBS and pregnancy clinical practice guidelines [4,6] may be used in addition to therapeutic judgment to guide macronutrient composition, nutrient adequacy, energy requirements, and micronutrient supplementation prior to conception and during pregnancy for women who have undergone MBS.
Pregnancy	<ul style="list-style-type: none"> • The Institute of Medicine clinical guidelines for pregnancy [6] may be used to guide gestational weight gain among women who have undergone MBS. • Frequent assessment and monitoring of biochemical nutritional status by a clinician prior to conception, during pregnancy, and postpartum may be beneficial in identifying and preventing micronutrient insufficiencies. • Consultation with a bariatric surgeon and a nutrition evaluation by a registered dietician may be beneficial for pregnant women who have undergone MBS and who have persistent nausea, vomiting, or hyperemesis symptoms.

MBS = metabolic and bariatric surgery.

Oral glucose tolerance testing

Three studies [9,26,45] reported observations of reactive hypoglycemia during oral glucose tolerance testing in pregnant women who had undergone RYGB. The authors of these studies noted the need for alternative testing methods or glucose regulation criteria in pregnancy after MBS, though no specific recommendations were included.

Hypertension and preeclampsia

Twenty articles [11,14–18,20,25,27,37–39,42,43,53–55,60,62] included data on hypertensive disorders and pregnancy after MBS. Both improvements and worsening of hypertension were reported in these pregnancies. There was no clear distinction made in the reviewed studies between chronic hypertension and the development of preeclampsia.

Seven studies [11,37,39,43,53,55,60] compared pregnancies among women who had undergone MBS and women with obesity or women of healthy weight who had not undergone MBS. All these studies noted that hypertensive disorders were less prevalent in pregnant women who had undergone MBS than in pregnant nonsurgical women with obesity. One study [60] reported an incidence of

hypertension that was 2–3 times more frequent in both the obesity and MBS cohorts compared with the healthy BMI cohort. Preeclampsia was not significantly higher in women who had undergone RYGB, but it was significantly more prevalent in those with obesity when compared with the cohort within the healthy BMI category [60].

Most studies show lower rates of hypertensive disorders during pregnancies that occur after MBS compared with pregnancies of women with obesity who have not undergone MBS [61]. However, 1 retrospective analysis [62] found higher rates in mothers with a history of MBS compared with individuals with obesity in the general population. Although mixed outcomes were reported, weight loss due to MBS is generally effective in lowering blood pressure and may improve maternal outcomes among individuals with obesity [4].

Nausea and vomiting in pregnancy

None of the identified studies included data on nausea, vomiting, or hyperemesis symptoms during pregnancy in women who have undergone MBS. One retrospective study [29] did report complications of intestinal obstructions from

adhesions or hernias in this population, with the assumption that increased intra-abdominal pressure due to pregnancy was a contributing factor. Other causes of persistent nausea, vomiting, or hyperemesis symptoms beyond hormonal changes from pregnancy should be investigated by a bariatric surgeon (i.e., early anatomic ulcer, stricture, hypoglycemic symptoms, or medications) [4]. A nutrition evaluation by a registered dietician should include a diet history of macronutrient intake, food intolerances, supplement type and compliance, fluid intake, and whole-blood thiamine levels to determine nutrition adequacy and intervention [8].

Fetal weight

Twenty-eight studies [10,11,14–17,20,21,25,26,28,31,35–37,39,43,53–55,59,60,62–67] reported fetal weight in pregnancies of women who had undergone MBS prior to conception. Thirteen articles [11,14,28,36,39,54,55,62–67] compared mothers with previous MBS with nonsurgical cohorts of women with obesity or normal weight; 2 studies [37,60] included a healthy BMI control group, and 13 studies [10,15–17,20,21,25,26,31,35,43,53,59] had no comparison group. Fetal weight was reported most often by category of small or large for gestational age. In the reviewed studies, there was a lack of data to determine the incidence of preterm births in this population. However, a recent meta-analysis [61] suggests that the risk of small for gestational age is more prevalent in births to mothers who have undergone a previous MBS than in mothers with obesity who have not. Conversely, a decreased prevalence in large for gestational age births to mothers with prior bariatric surgery is commonly cited [61].

State of the current evidence base and practical suggestions

The available evidence is limited by small sample sizes, study design, and lack of methodologic rigor. Most studies include retrospective data that do not include important baseline factors that may influence outcomes. These factors include optimal timing of pregnancy in comparison with surgery, observation of weight changes from before to after surgery and from before surgery to pregnancy, macro- and micronutrient intake prior to pregnancy, adherence to post-MBS vitamin/mineral supplement recommendations, prevalence and treatment of post-MBS micronutrient deficiencies prior to pregnancy, medical conditions that may influence pregnancy outcomes, and nutritional intake during pregnancy. Variations in biochemical nutritional analysis and conclusions drawn from these reports must be taken into consideration with respect to clinical judgment. Table 6 represents practical suggestions for healthcare providers gleaned from the evidence reported in this literature search.

Conclusion

Quality improvement, nutrition initiatives, and nutrition research are needed regarding preconception, maternal health, and fetal growth to support women of childbearing age who have had bariatric surgery. Existing nutrition research should be expanded to examine postpartum and infant outcomes in this special population of women.

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