




# Clinical Practice Guidelines for Childbearing Female Candidates for Bariatric Surgery, Pregnancy, and Post-partum Management After Bariatric Surgery

Cécile Ciangura<sup>1</sup>  · Muriel Coupaye<sup>2,3</sup> · Philippe Deruelle<sup>4,5</sup> · Géraldine Gascoin<sup>6,7</sup> · Daniela Calabrese<sup>8</sup> · Emmanuel Cosson<sup>9,10</sup> · Guillaume Ducarme<sup>11</sup> · Bénédicte Gaborit<sup>3,12</sup> · Bénédicte Lelièvre<sup>13</sup> · Laurent Mandelbrot<sup>14</sup> · Niccolo Petrucciani<sup>15</sup> · Didier Quilliot<sup>16,17</sup> · Patrick Ritz<sup>18</sup> · Geoffroy Robin<sup>5,19</sup> · Agnès Sallé<sup>20</sup> · Jean Gugenheim<sup>21,22</sup> · Jacky Nizard<sup>23</sup> · BARIA-MAT Group

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## Abstract

Emerging evidence suggests that bariatric surgery improves pregnancy outcomes of women with obesity by reducing the rates of gestational diabetes, pregnancy-induced hypertension, and macrosomia. However, it is associated with an increased risk of a small-for-gestational-age fetus and prematurity. Based on the work of a multidisciplinary task force, we propose clinical practice recommendations for pregnancy management following bariatric surgery. They are derived from a comprehensive review of the literature, existing guidelines, and expert opinion covering the preferred type of surgery for women of childbearing age, timing between surgery and pregnancy, contraception, systematic nutritional support and management of nutritional deficiencies, screening and management of gestational diabetes, weight gain during pregnancy, gastric banding management, surgical emergencies, obstetrical management, and specific care in the postpartum period and for newborns.

**Keywords** Pregnancy · Bariatric surgery · Obstetrical management · Nutritional management · Guidelines

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✉ Cécile Ciangura  
cecile.ciangura@aphp.fr

Muriel Coupaye  
muriel.coupaye@aphp.fr

Philippe Deruelle  
pderuelle@unistra.fr

Géraldine Gascoin  
GeGascoin@chu-angers.fr

Daniela Calabrese  
daniela.calabrese@aphp.fr

Emmanuel Cosson  
emmanuel.cosson@aphp.fr

Guillaume Ducarme  
g.ducarme@gmail.com

Bénédicte Gaborit  
Benedicte.GABORIT@ap-hm.fr

Bénédicte Lelièvre  
BeLelievre@chu-angers.fr

Laurent Mandelbrot  
laurent.mandelbrot@aphp.fr

Niccolo Petrucciani  
nicpetrucciani@hotmail.it

Didier Quilliot  
quilliot.d@orange.fr

Patrick Ritz  
patrick.ritz@wanadoo.fr

Geoffroy Robin  
Geoffroy.ROBIN@CHRU-LILLE.fr

Agnès Sallé  
AgSalle@chu-angers.fr

Jean Gugenheim  
gugenheim.j@chu-nice.fr

Jacky Nizard  
jacky.nizard@aphp.fr

Extended author information available on the last page of the article

## Introduction

Bariatric surgery (BS) is increasingly performed worldwide on patients with severe obesity [1], mostly women. Most of these women are of childbearing age [2, 3], and thus an increase in the number of pregnancies after BS is expected. Emerging evidence suggests that BS improves pregnancy outcomes of women with obesity by reducing the rates of gestational diabetes, pregnancy-induced hypertension, and macrosomia. However, the risks of a small-for-gestational-age (SGA) fetus and prematurity are increased [4]. Existing clinical guidelines emphasize the need to plan pregnancy and raise awareness concerning the risks of surgical complications and nutritional deficiencies but report several areas without specific recommendation due to lack of evidence [5–14]. Nevertheless, practical and comprehensive guidelines are needed for practitioners to cover the various issues related to pregnancy management in this context. The aim of our multidisciplinary working group was to analyze the current literature on pregnancy after BS and propose guidelines for practitioners to improve routine care and avoid occurrence of rare but dramatic complications. We report the process followed by the working group and summarize the guidelines concerning childbearing candidates for BS, pregnancy, and post-partum management after BS.

## Protocol

We defined the questions to be addressed by performing a survey of the routine care provided by specialized obesity-care centers (Centres Spécialisés Obésité or CSO, the tertiary care level in the French healthcare system identified by the Regional Health Agencies following the launch of a national obesity plan in 2011) [15]. We identified 12 main topics: preferred type of surgery for women of childbearing age, timing between BS and pregnancy, contraception after BS, specific nutritional support and management of nutritional deficiencies, modalities for screening and treatment of gestational diabetes, weight gain during pregnancy, gastric banding management, surgical emergencies, obstetrical management, management during the postpartum period and for newborns, and the overall care pathway.

We developed the guidelines following the protocol designed by the French National Authority for Health (Haute Autorité de Santé, HAS, a national institute which performs tasks similar to the UK National Institute for Health and Care Excellence, NICE) as published on its website [16]. This methodology includes (1) a comprehensive literature search, (2) a series of workshops attended by members of the working group (three meetings for the present guidelines), and (3) an amendment of the guidelines considering the opinions

expressed by a large multidisciplinary reading group (109 individuals were involved) obtained through a critical reading.

The literature search was performed until May 2019 using four electronic databases (PubMed, Web of Science, Cochrane Library, and National Guideline Clearinghouse (Agency for Healthcare Research and Quality)). Recommendations were graded from A to C depending on the level of evidence provided by the reviewed studies (Table 1 of supplementary data). When no study was available, recommendations were based on expert opinion. Our multidisciplinary task force included general and bariatric surgeons, physicians with a specialty in nutrition, diabetologists, gynecologists and obstetricians, pediatricians, clinical biologists, and representatives of associations of patients with obesity and was supported by all relevant French scientific societies related to obesity (AFERO, Association Française d'Etude et de Recherche sur l'Obésité), bariatric surgery (SOFFCO.MM, Société Française et Francophone de Chirurgie de l'Obésité et des Maladies Métaboliques), obstetrics and gynecology (CNGOF, Collège National des Gynécologues et Obstétriciens Français), nutrition (SFNCM, Société Francophone de Nutrition Clinique et Métabolisme), pediatrics (SFN, Société Française de Néonatalogie; SFP, Société Française de Pédiatrie), diabetology (SFD, Société Francophone du Diabète), and the national coordination and consultation group of specialized obesity treatment centers.

## Recommendations

All recommendations have been graded from A to C, as indicated above; when not graded, they represent expert opinions.

### Obstetrical Management and Clinical Care Pathway

The risk of a SGA fetus and prematurity increase following BS [4, 17, 18]. Thus, reliable dating of pregnancies is important, relying on an early dating ultrasound (at a theoretical gestational age of approximately 8 to 10 weeks) if the menstrual cycle is irregular. Pregnant women should have a standard monthly antenatal medical appointment, which is standard recommended practice in countries such as France [19] (grade B). A closer prenatal surveillance is required in settings where monthly visits are not standard practice. This antenatal care should be coordinated by an obstetrician and include measurement of fundal height at each visit and an additional ultrasound examination during the third trimester to screen for SGA. In the case of clinical and/or ultrasound suspicion of SGA or additional risk factors of SGA, evaluation and surveillance should be adapted as per specific guidelines [20].

A multidisciplinary antenatal approach is recommended and should include competent surgical advice if there is a suspicion of surgical complications. Pregnant women with a history of BS must inform the obstetrical team.

## Type of Surgery to Propose to Women of Childbearing Age with Obesity

There is no scientific evidence yet available to guide the choice of the most appropriate surgical procedure for women of childbearing age. Women should be informed of the risks of surgical complications after procedures involving the small intestine, such as Roux-en-Y gastric bypass (GBP), as well as after adjustable gastric banding (AGB), and the higher frequency of SGA and nutritional deficiencies after GBP [17, 21, 22] and biliopancreatic diversion (BPD) [23, 24] (grade C). Available data on pregnancy after sleeve gastrectomy are insufficient to recommend this intervention over others [23, 25–27] (grade C). An indication of omega-loop GBP, single anastomosis duodenoileal bypass (SADI), or BPD should be considered with caution, given the nutritional deficiencies and cases of undernutrition associated with these procedures [28, 29] (grade C).

## Timing of Pregnancy After Bariatric Surgery

A minimal interval of 12 months between BS and pregnancy is recommended to allow the weight of the patient to stabilize [5–7, 10, 11, 13, 14, 30, 31] (grade C). Special attention is required if surgery occurred many years earlier, as loss to follow-up and nutritional deficiencies are likely [32] (grade C) or if the pregnancy begins less than 12 months after surgery, as this would require reinforced nutritional and obstetric monitoring. A shorter interval can be considered in cases of advanced maternal age or reduced ovarian reserve [9, 33, 34] (grade C), but must be balanced against the risk of nutritional deficiencies and residual obesity-related comorbidities.

## Contraception After Bariatric Surgery

Contraception must be started prior to surgery [6, 9, 14]. All contraceptives (hormonal and intrauterine devices) are effective in women with obesity [35] (grade B). Nevertheless, long-acting reversible contraceptives (etonogestrel implants and intrauterine devices) appear to be the best options before and after BS [6, 7, 9, 36, 37] (grade C).

If the prescription of long-acting reversible contraception is not chosen, the following elements must be considered when prescribing an oral contraceptive:

- Increased risk of venous thromboembolism and arterial thrombosis related to combined oral contraceptives. Such a risk requires discontinuation of combined oral contraceptives at least 4 to 6 weeks before, and at least 6 weeks after surgery, and substitution by another contraceptive method [37, 38] (grade C).
- Increased risk of contraceptive failure if there are digestive disorders (vomiting, diarrhea) [39, 40]

- The type of surgical procedure:
  - For AGB and sleeve gastrectomy, oral contraceptives can be used without a theoretical risk of failure, unless there is vomiting or diarrhea [40] (grade C).
  - For Roux-en-Y GBP, there is a low level of evidence concerning the effectiveness of such contraceptive methods [41–46] (grade C).
  - For BPD [14, 47] (grade C), SADI, and omega-loop GBP, oral contraception is contraindicated due to significant theoretical malabsorption of such compounds.

## Nutritional Management

Women should ideally have a consultation before conception, or as soon as pregnancy is diagnosed, with a physician with expertise in the management of bariatric-surgery patients [14, 48].

## Systematic Minimal Nutritional Supplementation

When planning a pregnancy, regardless of the type of surgery\*, systematic supplementation should include daily multivitamins containing trace elements with at least 10 mg zinc and 1 mg copper, and no more than 5000 IU vitamin A, preferably in the form of beta carotene [5, 6, 13]. In addition, daily intake of 0.4 mg folic acid is recommended (grade A), with a maximum of 1 mg per day (5 mg per day if there is a history of neural-tube defects) [7, 8, 19].

During pregnancy, the following supplementation is recommended, regardless of the type of surgery\*:

- If there is regular nutritional monitoring:
  - Adapt the multivitamins as described above, if necessary
  - Add folic acid up to 12 weeks gestation [19] (grade A)
  - Continue the usual supplementation (if compatible with pregnancy)
- In the absence of a biological assay during the previous year or in the absence of correction of known deficiencies:
  - Add or adapt multivitamins as described above
  - Add folic acid up to 12 weeks gestation
  - Add systematic supplements at the minimal dose without waiting for the results of the assays: 50 to 80 mg iron per day and 1000 µg vitamin B12 once a week, orally

It is recommended to systematically refer the patient to a registered dietitian to assess energy and protein

intake [13]. The recommended daily protein intake should be at least 60 g [5, 6, 49]. If necessary, prescription of oral protein supplements can be an option [23, 25, 50].

\*For BPD and other similar procedures, pregnancy must be followed by a physician with expertise in clinical nutrition who is familiar with such procedures that result in malabsorption, because larger doses of supplements are often required.

**Table 1** Recommended testing before and during pregnancy for all types of surgery

	Preconception and as soon as the woman is pregnant	At least every trimester of pregnancy	In case of
Hemogram	X	X	
Ferritin	X	X	
Transferrin saturation	X	X	
Albumin	X	X	
Transthyretin or prealbumin	X	X	
25 OH vitamin D	X	X	
Parathyroid hormone	X	X	
Calcium	X	X	
Phosphorus	X	X	
Serum and erythrocyte folates	X	X	
Vitamin B12	X	X	
Prothrombin time	X	X	
Magnesium	X	X	
Zinc	X	X	
Vitamin B1	X		- Repeated vomiting (emergency) - Initial deficiency
Vitamin A	X		- At each trimester of pregnancy in case of Bypass and other derivations - Initial deficiency
Selenium	X		- Initial deficiency
Copper and ceruloplasmin			- Anemia refractory to iron supplementation - Multiple and severe deficiencies
Vitamin K			- Bleeding - Multiple and severe deficiencies
Vitamin PP			- Pellagra, neurological disorders - Multiple and severe deficiencies
Vitamin B6			- Neurological disorders - Multiple and severe deficiencies
Vitamin C			- Scurvy, anemia refractory to iron supplementation - Multiple and severe deficiencies
Vitamin E			- Anemia, ophthalmoplegia - Peripheral neuropathy

**Table 2** Usual observed values of biological assays performed in general healthy pregnant women

Micronutrient marker	Country of the study	Data are 2.5th–97.5th percentile, unless otherwise stated				Conversion for usual units
		General population	First trimester	Second trimester	Third trimester	
Albumin (g/L)	Germany [57] <sup>d</sup> Norway [66] <sup>m</sup>	36.5–47.9 nd	7–17 GW: 32.2–43.2 nd	17–24 GW: 27.9–36.9 36.7 ± 2.0	23.1–34.6 33.8 ± 1.9	
Prealbumin (mg/dL)	Various [53]	R: 41–53	R: 31–51	R: 26–45	R: 23–42	
Retinol (µmol/L)	Various [53]	R: 17–34	R: 15–27	R: 20–27	R: 14–23	
B carotene (µmol/L)	France [58] <sup>e</sup>	1.4–50	0.66–1.92	nd	0.52–1.78	1 µmol/L = 286 ng/mL
	Various [53]	R: 0.7–3.49	R: 1.12–1.64	R: 1.22–1.54	R: 1.01–1.47	1 ng/mL = 1.67 IU/L
	France [58] <sup>e</sup>	0.1–0.6	< 0.85	nd	< 0.84	1 µmol/L = 537.63 ng/mL
Vitamin B1 (nmol/L)	Great Britain [59] <sup>f</sup>	Threshold: < 66.5	40.4–159.6	nd	16.57–160.83	1 nmol/L = 0.337 ng/mL
Vitamin B6 (nmol/L)	Brazil [60] <sup>g</sup>	nd	Med: 35.8 [28.6–44.3]	Med: 21.0 [15.8–26.3]	Med: 16.8 [12.9–20.3]	1 nmol/L = 0.247 ng/mL
Plasma folate (ng/mL)	France [58] <sup>e</sup>	3–17	0.79–12.23	nd	< 13.65	1 nmol/L = 0.44 ng/mL
	Denmark [54] <sup>a</sup>	nd	2.64–14.96	2.2–9.68	1.76–9.68	
	Various [53]	R: 5.4–18.0	R: 2.6–15.0	R: 0.8–24.0	R: 1.4–20.7	
Erythrocyte folate (ng/mL)	France [58] <sup>e</sup>	175–700	105–827	nd	30–1022	1 nmol/L = 0.44 ng/mL
	Various [53]	R: 150–450	R: 137–589	R: 94–828	R: 109–663	
Vitamin B12 (pg/mL)	France [58] <sup>e</sup>	200–950	51–549	nd	36–400	1 pmol/L = 1355.36 pg/L
	Denmark [54] <sup>a</sup>	nd	70.8–357.1	53.9–86.3	52.4–245.7	
	Germany [55] <sup>b</sup>	nd	CI 95%: 166.7–395.8	CI 95%: 156.5–59.6	CI 95%: 118.8–146.1	
	Various [53]	R: 276–966	R: 118–438	R: 130–656	R: 99–526	
Vitamin E (µmol/L)	France [58] <sup>e</sup>	12–48	17.68–36.50	nd	22.21–49.25	1 µmol/L = 430.69 ng/mL
	Various [53]	R: 11.61–41.79	R: 16.25–30.18	R: 23.22–37.15	R: 30.18–53.4	
25-OH vitamin D (nmol/L)	USA [61] <sup>h</sup>	Threshold: < 50	Med: 65.0 (SD: 23.5) (winter 57.5; spring 63.8; autumn 67.5; summer 70)	Med: 37 [Q1:15.3–Q3: 60.8]	Med: 56.5 [Q1: 34–Q3: 80.5]	1 nmol/L = 0.40 ng/mL
	Great Britain [59] <sup>f</sup>	nd	Med: 37.5 [Q1:26–Q3:48.8]	Med: 37 [Q1:15.3–Q3: 60.8]	Med: 46.0 [Q1: 30.5–Q3: 68.5]	
	Swiss [62] <sup>i</sup>	nd	nd	nd	nd	
Parathyroid hormone (pmol/L)	Various [53]	R: 35–200	R: 45–67.5	R: 25–55	R: 25–45	1 pg/mL = 1 ng/L = 0.106 pmol/L
	USA [61] <sup>h</sup>	nd	Med: 1.2 (winter 1.59; spring 1.22; autumn 1.11; summer 1.07)	nd	nd	
	USA [63] <sup>j</sup>	1.3–5.4	1.9 ± 1.0	1.9 ± 1.0	2.2 ± 1.3	
	Ireland [64] <sup>k</sup>	nd	nd	Mean (CI 95%): 0.98 (0.89–1.08)	nd	
	Various [53]	R: 0.85–5.41	R: 1.06–1.59	R: 1.91–2.65	R: 0.95–2.76	
Calcium (mmol/L)	France [58] <sup>e</sup>	2.25–2.62	1.92–2.74	nd	1.57–2.63	1 mmol/L = 40 mg/L
	Various [53]	R: 2.18–2.55	R: 2.2–2.65	R: 2.05–2.25	R: 2.05–2.43	

**Table 2** (continued)

Micronutrient marker	Country of the study	Data are 2.5th–97.5th percentile, unless otherwise stated				Conversion for usual units
		General population	First trimester	Second trimester	Third trimester	
Copper ( $\mu\text{mol/L}$ )	France [58] <sup>e</sup>	12.9–25.3	16.4–36.3	nd	17.9–43.4	1 $\mu\text{mol/L}$ = 63.5 ng/mL
	Spain [56] <sup>c</sup>	nd	12.55–33.92	23.62–38.47	19.94–41.53	
Ferritin ( $\mu\text{g/L}$ )	Various [53]	R: 11.0–22.0	R: 17.6–31.3	R: 26.0–34.8	R: 20.5–37.8	1 mmol/L = 445 ng/mL
	Great Britain [59] <sup>f</sup>	Threshold: < 15	Med: 42.5 [Q1: 27–Q3: 74.3]	Med: 10.5 [Q1: 7–Q3: 20.8]	Med: 9 [Q1: 7–Q3: 15.3]	
Magnesium (mmol/L)	Denmark [54] <sup>a</sup>	nd	8–123	6–48	7–64	1 mmol/L = 24.3 mg/L
	Germany [57] <sup>d</sup>	10–90	7.1–106.4	4.1–65.6	3.8–49.8	
Selenium ( $\mu\text{g/L}$ )	Various [53]	R: 10–50	R: 6–130	R: 2–230	R: 0–116	1 $\mu\text{mol/L}$ = 78.96 ng/mL
	France [58] <sup>e</sup>	0.72–0.95	0.35–1.13	nd	0.65–0.69	
Zinc ( $\mu\text{mol/L}$ )	Germany [57] <sup>d</sup>	0.71–0.94	0.7–0.96	0.66–0.87	0.57–0.91	1 $\mu\text{mol/L}$ = 65.4 ng/mL
	Various [53]	R: 0.62–0.95	R: 0.66–0.91	R: 0.62–0.91	R: 0.45–0.91	
	Spain [56] <sup>c</sup>	nd	69.3–147.9	51.2–146.9	55.7–118.9	1 $\mu\text{mol/L}$ = 78.96 ng/mL
	Various [53]	R: 63–160	R: 116–146	R: 75–145	R: 71–133	
	France [58] <sup>e</sup>	11–16.5	6.09–13.39	nd	5.46–12.76	1 $\mu\text{mol/L}$ = 65.4 ng/mL
	USA [65] <sup>l</sup>	nd	7.7–16.3	6.2–15.6	5.4–14.0	
	Spain [56] <sup>c</sup>	nd	7–14.77	6.76–11.93	6.13–12.14	1 $\mu\text{mol/L}$ = 65.4 ng/mL
	Various [53]	R: 11.47–18.4	R: 8.72–13.46	R: 7.8–12.23	7.64–11.77	

GB Great Britain, GW gestational week, Med median, nd no data, Q quartile, R range (minimum-maximum combined with 2.5–97.5th percentiles if available)

<sup>a</sup> [54] 434 women,  $30 \pm 3.9$  years, mean BMI:  $24 \pm 3$  kg/m<sup>2</sup>

<sup>b</sup> [55] 39 women,  $29.1 \pm 3.6$  years, mean BMI:  $23.1 \pm 4.7$  kg/m<sup>2</sup>

<sup>c</sup> [56] 159 women

<sup>d</sup> [57] 52 women, median age: 32 years (SD: 4 years), median BMI: 24 kg/m<sup>2</sup> (SD: 4 kg/m<sup>2</sup>)

<sup>e</sup> [58] 50 women,  $28 \pm 4.5$  years, mean BMI  $22.8 \pm 6.9$  kg/m<sup>2</sup>

<sup>f</sup> [59] 189 women,  $27.9 \pm 6.2$  years; median BMI 24.7 kg/m<sup>2</sup>

<sup>g</sup> [60] 186 women, 20–40 years

<sup>h</sup> [61] 586 Caucasian women, mean age: 32.3 years, BMI: nd

<sup>i</sup> [62] 305 women,  $32.9 \pm 5.2$  years, median BMI: 22.9 kg/m<sup>2</sup>

<sup>j</sup> [63] 111 women,  $27 \pm 5.6$  years, 78 with BMI < 30 kg/m<sup>2</sup>, 33 with BMI > 30 kg/m<sup>2</sup>

<sup>k</sup> [64] 142 women,  $33.4 \pm 3.8$  years, BMI  $25.8 \pm 4.3$  kg/m<sup>2</sup>

<sup>l</sup> [65] 3,742 women < 34 GW, 85% Afro-American, 15% white American

<sup>m</sup> [66] 853 women,  $30.5 \pm 4.3$  years, BMI: nd



## Nutritional Assessment and Supplementation in the Case of Nutritional Deficiency

We recommend adapting systematic nutritional supplementation based on deficiencies identified during the initial nutritional assessment (Table 1), which needs to be repeated quarterly [6, 51, 52].

During pregnancy, there are no specific validated standards for the required levels of vitamins and trace elements. However, there is a 25 to 30% physiological decrease in the levels of albumin, hemoglobin, vitamins A, B9, B12, and D, parathyroid hormone (PTH), calcium, ferritin, magnesium, selenium, and zinc, whereas vitamin E, copper, and ceruloplasmin increase, and prealbumin appears to remain

stable [53–66]. The usual observed values in general healthy pregnant women are summarized in Table 2 as an indication for practitioners. These usual values are issued from a comprehensive review of the literature published in 2009 [53], and a synthesis of studies published since 2010 and conducted in European and American populations [54–66] (grade C).

A prescription strategy for supplements, in the case of deficiency, is presented in Table 3 [7, 8, 25, 50, 51, 67, 77, 80, 81]. Deficiency correction should be assessed 1 month later and the substitution treatment adapted based on the subsequent quarterly biological assessment. In the case of no deficiency, next assessment is recommended during the following trimester.

**Table 3** Prescription of supplements in the case of nutritional deficiency

Micronutrient marker deficiency	Dose for supplementation (based on the possible physiological decrease of micronutrient marker levels during pregnancy)
Iron [7, 8, 50, 67]	<ul style="list-style-type: none"> <li>- gradually increase the oral dose up to a maximum of 240 mg iron in several intakes per day, if necessary associated with vitamin C to increase absorption.</li> <li>- respect physiological decrease in ferritin levels (high ferritin levels are also associated with small for gestational age)</li> <li>- discuss intravenous iron only if iron deficiency anemia persists, despite the maximum tolerated oral supplementation. A careful evaluation of the benefit/risk ratio is recommended before any use of injectable iron; in particular, the physiological decrease in hemoglobin levels during pregnancy (normal hemoglobin <math>\geq</math> 11 g/dL for each trimester of pregnancy) must be respected</li> </ul>
Vitamin D [25, 50, 68, 69]	- initial dose of 3000 IU per day (i.e., 100,000 IU per month), to be adjusted to blood levels of 25 OH vitamin D
Vitamin B12 [70]	<ul style="list-style-type: none"> <li>- increase the frequency of oral doses (for example, 1000 <math>\mu</math>g per day for 8 days and then twice a week)</li> <li>- or 1000 <math>\mu</math>g intramuscular injection every month, or even weekly</li> </ul>
Folates [51, 71]	<ul style="list-style-type: none"> <li>- start with increasing the dose from the initial 0.4 mg per day to 0.8 mg per day to adjust blood levels of folic acid</li> <li>- a dose of greater than 0.8 mg per day may be required to correct a folic acid deficiency</li> </ul>
Calcium [72]	<ul style="list-style-type: none"> <li>- increase the dose to 1500 mg per day distant from iron intake</li> <li>- increase dietary calcium intake</li> <li>- interpretation of the results must account for the physiological decrease in parathyroid hormone during pregnancy and the correction of calcium by serum albumin</li> </ul>
Magnesium [73]	100 to 300 mg oral magnesium per day
Zinc [73–75]	15 to 60 mg oral zinc gluconate per day, fasting in the morning or at bedtime
Selenium [76]	50 to 100 $\mu$ g oral selenium per day
Vitamin B1 [51]	<ul style="list-style-type: none"> <li>- urgently and systematically supplement patients who are repeatedly vomiting, without waiting for the laboratory result, with 100 to 500 mg vitamin B1 per day intravenously or intramuscularly. If it is not possible to measure blood vitamin B1 levels in vomiting patients, systematic vitamin B1 supplementation is still recommended</li> <li>- in the absence of vomiting, 250 to 500 mg oral vitamin B1 per day</li> </ul>
Vitamin A [51, 77–79]	<ul style="list-style-type: none"> <li>- start with a dose of 10,000 IU/day</li> <li>- a dose of greater than 10,000 IU/day may be required to correct a vitamin A deficiency and may be proposed after discussion within the group, depending on the evolution of blood vitamin A levels and the clinical situation</li> </ul>

**Table 4** Definition of abnormal glycaemia before and during pregnancy after bariatric surgery in comparison to general population

	General population	After bariatric surgery
Screening conditions	Only high-risk women	All women
Before pregnancy	* FPG	* FPG and HbA1c * Normal if FPG < 100 mg/dL and HbA1c < 6%
Early pregnancy	* FPG * GDM if FPG ≥ 92 mg/dL	* FPG and HbA1c * GDM if FPG ≥ 92 mg/dL and/or HbA1c ≥ 5.9%
24–28 GW (only if early pregnancy test is negative)	* 75-g OGTT * GDM if ≥ 1 value from OGTT exceed diagnosis thresholds - FPG ≥ 92 mg/dL - 1 h PG ≥ 180 mg/dL - 2 h PG ≥ 153 mg/dL	<i>Sleeve and AGB:</i> * 75-g OGTT * GDM if ≥ 1 value from OGTT exceed diagnosis thresholds - FPG ≥ 92 mg/dL - 1 h PG ≥ 180 mg/dL - 2 h PG ≥ 153 mg/dL <i>OGTT not well tolerated and GBP:</i> * One week of CBG monitoring with usual diet and physical activity levels * GDM if ≥ 20% of all CBG exceed glycemic targets - before meals ≥ 95 mg/dL - 1 h PP ≥ 140 mg/dL - 2 h PP ≥ 120 mg/dL 1 h and 2 h PP alternately
CBG targets if GDM diagnosed	- before meals < 95 mg/dL - 2 h PP < 120 mg/dL	- before meals < 95 mg/dL - 2 h PP < 120 mg/dL In case of GBP: 1 h and 2 h PP alternately, with 1 h PP < 140 mg/dL
Post-partum	75 g OGTT	FPG and HbA1c

AGB adjustable gastric banding, CBG capillary blood glucose, FPG fasting plasma glucose, GBP gastric bypass, GDM gestational diabetes mellitus, GW gestational weeks, OGTT oral glucose tolerance test, PG plasma glucose, PP post prandial, 1 h one hour, 2 h two hours

## Screening and Management of Gestational Diabetes Mellitus

The strategy for screening abnormal glycaemia before and during pregnancy is presented in Table 4. We consider many specificities after BS. First, women are usually still with excess weight, and at risk of abnormal glycaemia before pregnancy and of gestational diabetes mellitus (GDM) [17, 82–88] (grade C). Second, fasting plasma glucose, which decreases after BS [89–91], and HbA1c level, which is associated with an increased risk of perinatal morbi-mortality (≥ 5.9%) [92, 93], can be used during early pregnancy (grade C). Finally, 75 g-OGTT (oral glucose tolerance test) may be not well tolerated [94–96] and may induce hypoglycemia at 2 h, especially after GBP [81, 84, 96]. Therefore, a 1-week self-monitoring of capillary blood glucose with samples before each meal, and alternately 1 or 2 h after the start of each meal can be an alternative screening test after 24 weeks gestation [96, 97]. Once diagnosed, GDM should immediately be managed by lifestyle modifications, self-monitoring of blood glucose, and insulin therapy if glycemic targets are not achieved [98] (grade B).

## Weight Gain During Pregnancy

No scientific evidence concerning gestational weight gain and pregnancy outcomes after BS is available. Thus, it is not possible to suggest weight-gain recommendations that would differ from those based on maternal BMI for the general population (Table 5) [6, 99, 100]. Dietary and sometimes

psychological care should be reinforced if weight gain is below or above recommended targets.

## Optimal Band Adjustment During Pregnancy

AGB deflation is associated with higher maternal weight gain, and thus systematic deflation is not recommended during pregnancy [101–103] (grade C). AGB inflation is not recommended either throughout pregnancy and rapid deflation is indicated if digestive symptoms appear [6, 104–106] (grade C), without X-rays. First-line radiological imaging should be performed by magnetic resonance imaging (MRI) if a complication is suspected. If not rapidly available, a computed tomography scan with digestive clouding using a water-soluble contrast product is recommended. Otherwise, an upper gastrointestinal series is recommended to urgently decide whether removal of the AGB is required.

**Table 5** Recommended weight gain during pregnancy according to the IOM (Institute of Medicine) [99]

Pregestational BMI (kg/m <sup>2</sup> )	Mean weekly weight gain during the second and third trimesters (kg)	Total recommended weight gain during pregnancy (kg)
BMI < 18.5	0.5	12.5–18
BMI from 18.5 to 24.9	0.4	11.5–16
BMI from 25.0 to 29.9	0.3	7–11.5
BMI ≥ 30	0.2	5–9



## Management of a Surgical Emergency During Pregnancy

Women presenting with unusual abdominal pain and/or vomiting must be urgently assessed by a digestive surgeon, ideally with expertise in BS, because of an increased risk of intestinal obstruction (internal hernia) after Roux-en-Y GPB and AGB slippage during pregnancy [5, 6, 106–108] (grade C). In case of doubt, first-line imaging should be performed by magnetic resonance imaging (MRI) [109]. If not rapidly available, a computed tomography scan with contrast injection and digestive opacification with a water-soluble contrast product is indicated and should not be delayed due to pregnancy [110, 111]. Patient education must include clinical signs that require urgent surgical examination.

## Breastfeeding and the Postpartum Period

Breastfeeding is recommended as for any woman [6, 112], as long as maternal nutritional monitoring and supplementation are performed according to the same guidelines as during pregnancy [5, 6, 14, 113, 114]. Non-steroidal anti-inflammatory drugs should be avoided in women with GBP and other types of intestinal bypass to avoid gastric ulceration [5].

## Neonatal Care

We recommend informing the pediatrician about the history of maternal BS, the risks of SGA and prematurity [4, 17, 18, 48] (grade B), and the risk of nutritional deficiencies for the neonate [68]. Although cases of anemia, neurological dysfunction, hypocalcemia, bleeding, microphthalmia, and microcephaly (because of vitamin B12, B9, K, and A deficiency) have been reported [25, 51] (grade C), no routine nutritional assessment nor systematic supplementation of the newborn is recommended. There is no specific recommendation for short- and long-term monitoring of children born after BS [115–118].

## Conclusion

In conclusion, an increased awareness concerning the health risks for the mother and fetus during pregnancy after BS is necessary. These clinical practice recommendations from a multidisciplinary task force provide guidance to improve patient management in this setting and for childbearing female candidates for BS. Delivering appropriate information to practitioners and to women considering pregnancy after BS, and implementing efficient clinical care pathways are needed to improve pregnancy-related outcomes. Insufficient evidence was available for a number of questions we addressed and many unresolved issues remain, such as optimal maternal nutritional care for healthy in utero programming and long-term

outcomes of children born after BS. Longer-term data through large-scale cohort studies with precise phenotyping are needed to make pregnancy safer for women of childbearing age undergoing BS.

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**French Study Group for Bariatric Surgery and Maternity including all listed authors and Virginie Castera, MD<sup>1</sup>, Régis Coutant, MD, PhD<sup>2</sup>, Thierry Dupré, MD<sup>3</sup>, Hubert Johanet, MD<sup>4</sup>, Marie Pigeyre, MD, PhD<sup>5</sup>, Brigitte Rochereau, MD<sup>6</sup>, Véronique Taillard, MD<sup>7</sup>, Claudine Canale<sup>8</sup>, Anne-Sophie Joly<sup>8</sup>**

<sup>1</sup>Department of Endocrinology, St Joseph Hospital, Marseille, France

<sup>2</sup>Department of Pediatrics, Angers University Hospital, Angers, France

<sup>3</sup>Assistance Publique-Hôpitaux de Paris, Bichat Hospital, Department of Biochemistry, Paris, France; Société Française des Vitamines et Biofacteurs

<sup>4</sup>Clinique Turin, Paris, France

<sup>5</sup>Department of Nutrition, CHRU Lille, University Lille, Lille, France

<sup>6</sup>Antony, France

<sup>7</sup>Department of Nutrition, CHU Nîmes, Nîmes, France

<sup>8</sup>Collectif National des Associations d'Obèses (CNAO)

## Compliance with Ethical Standards

**Conflict of Interest** E.C. declares personal fees from Astra Zeneca, Lifescan, Medtronic, MSD, personal fees and non-financial support from Novartis, Novo-Nordisk, Lilly, Roche Diagnostics, Sanofi, Abbott, Orkyn, grants from Fondation Roche, Air liquide, outside the submitted work. G.R. declares personal fees from MSD laboratory Merck-Serono Laboratory, Ferring Laboratory, Teva Laboratory, outside the submitted work. All other authors declare no conflict of interest.

## References

1. Angrisani L, Santonicola A, Iovino P, et al. IFSO worldwide survey 2016: primary, Endoluminal, and Revisional procedures. *Obes Surg*. 2018;28(12):3783–94.
2. Direction de la recherche, des études, de l'évaluation et des statistiques. Chirurgie de l'obésité : 20 fois plus d'interventions depuis 1997 [Internet]. *Etudes & Résultats*; 2018 [cited 2018 Dec 3]. Available from: <https://drees.solidarites-sante.gouv.fr>
3. Menke MN, King WC, White GE, et al. Contraception and conception after bariatric surgery. *Obstet Gynecol*. 2017;130(5):979–87.
4. Kwong W, Tomlinson G, Feig DS. Maternal and neonatal outcomes after bariatric surgery; a systematic review and meta-analysis: do the benefits outweigh the risks? *Am J Obstet Gynecol*. 2018;218(6):573–80.
5. American College of Obstetricians and Gynecologists. ACOG practice bulletin no. 105: bariatric surgery and pregnancy. *Obstet Gynecol*. 2009;113(6):1405–13.
6. Busetto L, Dicker D, Azran C, et al. Practical recommendations of the obesity management task force of the European Association

- for the Study of obesity for the post-bariatric surgery medical management. *Obes Facts*. 2017;10(6):597–632.
7. Mechanick JI, Youdim A, Jones DB, et al. Clinical practice guidelines for the perioperative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient-2013 update: cosponsored by American Association of Clinical Endocrinologists, the Obesity Society, and American Society for Metabolic & bariatric surgery. *Endocr Pract*. 2013;19(2):337–72.
  8. Parrott J, Frank L, Rabena R, et al. American Society for Metabolic and Bariatric Surgery Integrated Health Nutritional Guidelines for the surgical weight loss patient 2016 update: micronutrients. *Surg Obes Relat Dis*. 2017;13(5):727–41.
  9. [rcog.org](http://www.rcog.org.uk/en/guidelines-research-services/guidelines/sip17/) [Internet]. London: Royal College of Obstetricians & Gynaecologists; c2015 [cited 2018]. Available from : <https://www.rcog.org.uk/en/guidelines-research-services/guidelines/sip17/>
  10. [bomss.org](http://www.bomss.org) [Internet]. UK: British Obesity & Metabolic Surgery Society; c2014 [cited 2018 Dec 2]. Available from: <http://www.bomss.org.uk/wp-content/uploads/2014/09/BOMSS-guidelines-Final-version1Oct14.pdf>.
  11. Lehman Center Weight Loss Surgery Expert Panel. Commonwealth of Massachusetts Betsy Lehman Center for Patient Safety and Medical Error Reduction Expert Panel on weight loss surgery: executive report. *Obes Res*. 2005;13(2):205–26.
  12. Sauerland S, Angrisani L, Belachew M, et al. Obesity surgery: evidence-based guidelines of the European Association for Endoscopic Surgery (EAES). *Surg Endosc*. 2005;19(2):200–21.
  13. O’Kane M, Parretti HM, Hughes CA, et al. Guidelines for the follow-up of patients undergoing bariatric surgery. *Clin Obes*. 2016;6(3):210–24.
  14. [has-sante.fr](http://www.has-sante.fr) [Internet]. Saint Denis : Obésité: prise en charge chirurgicale chez l’adulte. *Recomm Bonne Prat*; c2009 [cited 2018 Dec 1]. Available from: [https://www.has-sante.fr/portail/jcms/c\\_765529/fr/obesite-prise-en-charge-chirurgicale-chez-l-adulte](https://www.has-sante.fr/portail/jcms/c_765529/fr/obesite-prise-en-charge-chirurgicale-chez-l-adulte)
  15. [solidarites-sante.gouv.fr](http://www.solidarites-sante.gouv.fr) [Internet]. Paris : Plan obésité: les 37 centres spécialisés; c 2016 [cited 2018 Dec 1]. Available from: <https://solidarites-sante.gouv.fr/soins-et-maladies/prises-en-charge-specialisees/obesite/article/plan-obesite-les-37-centres-specialises>.
  16. [has-sante.fr](http://www.has-sante.fr) [Internet]. Saint Denis : Guide méthodologique recommandations pour la pratique clinique; c2010 [cited 2018 Dec 1]. Available from: [https://www.has-sante.fr/portail/upload/docs/application/pdf/2011-01/guide\\_methodologique\\_recommandations\\_pour\\_la\\_pratique\\_clinique.pdf](https://www.has-sante.fr/portail/upload/docs/application/pdf/2011-01/guide_methodologique_recommandations_pour_la_pratique_clinique.pdf).
  17. Galazis N, Docheva N, Simillis C, et al. Maternal and neonatal outcomes in women undergoing bariatric surgery: a systematic review and meta-analysis. *Eur J Obstet Gynecol Reprod Biol*. 2014;181:45–53.
  18. Yi X, Li Q, Zhang J, et al. A meta-analysis of maternal and fetal outcomes of pregnancy after bariatric surgery. *Int J Gynaecol Obstet*. 2015;130(1):3–9.
  19. [has-sante.fr](http://www.has-sante.fr) [Internet]. Saint Denis : Suivi et orientation des femmes enceintes en fonction des situations à risque identifiées; c2016 [cited 2018 Dec 1]. Available from: [https://www.has-sante.fr/portail/upload/docs/application/pdf/suivi\\_des\\_femmes\\_enceintes](https://www.has-sante.fr/portail/upload/docs/application/pdf/suivi_des_femmes_enceintes)
  20. [cngof.fr](http://www.cngof.fr) [Internet]. Recommandations pour la pratique clinique: retard de croissance intra-utérin. [cited 2019 June 21]. Available from: [http://www.cngof.asso.fr/data/RCP/CNGOF\\_2013\\_FINAL\\_RPC\\_reiu.pdf](http://www.cngof.asso.fr/data/RCP/CNGOF_2013_FINAL_RPC_reiu.pdf)
  21. Chevrot A, Kayem G, Coupaye M, et al. Impact of bariatric surgery on fetal growth restriction: experience of a perinatal and bariatric surgery center. *Am J Obstet Gynecol*. 2016;214(5):655.e1–7.
  22. Kjaer MM, Nilas L. Pregnancy after bariatric surgery—a review of benefits and risks. *Acta Obstet Gynecol Scand*. 2013;92(3):264–71.
  23. Mead NC, Sakkatos P, Sakellaropoulos GC, et al. Pregnancy outcomes and nutritional indices after 3 types of bariatric surgery performed at a single institution. *Surg Obes Relat Dis*. 2014;10(6):1166–73.
  24. González I, Rubio MA, Cordido F, et al. Maternal and perinatal outcomes after bariatric surgery: a Spanish multicenter study. *Obes Surg*. 2015;25(3):436–42.
  25. Hazart J, Le Guennec D, Accoceberry M, et al. Maternal nutritional deficiencies and small-for-gestational-age neonates at birth of women who have undergone bariatric surgery. *J Pregnancy*. 2017;2017:4168541.
  26. Rottenstreich A, Elchalal U, Kleinstern G, et al. Maternal and perinatal outcomes after laparoscopic sleeve gastrectomy. *Obstet Gynecol*. 2018;131(3):451–6.
  27. Coupaye M, Legardeur H, Sami O, et al. Impact of Roux-en-Y gastric bypass and sleeve gastrectomy on fetal growth and relationship with maternal nutritional status. *Surg Obes Relat Dis*. 2018;14(10):1488–94.
  28. Topart P, Becouam G, Delarue J. Weight loss and nutritional outcomes 10 years after biliopancreatic diversion with duodenal switch. *Obes Surg*. 2017;27(7):1645–50.
  29. De Carolis S, Botta A, Del Sordo G, et al. Influence of biliopancreatic diversion on pregnancy outcomes in comparison to other bariatric surgery procedures. *Obes Surg*. 2018;28(10):3284–92.
  30. Patel JA, Patel NA, Thomas RL, et al. Pregnancy outcomes after laparoscopic Roux-en-Y gastric bypass. *Surg Obes Relat Dis*. 2008;4(1):39–45.
  31. Parent B, Martopullo I, Weiss NS, et al. Bariatric surgery in women of childbearing age, timing between an operation and birth, and associated perinatal complications. *JAMA Surg*. 2017;152(2):1–8.
  32. Thereaux J, Lesuffleur T, Païta M, et al. Long-term follow-up after bariatric surgery in a national cohort. *Br J Surg*. 2017;104(10):1362–71.
  33. Sheiner E, Edri A, Balaban E, et al. Pregnancy outcome of patients who conceive during or after the first year following bariatric surgery. *Am J Obstet Gynecol*. 2011;204(1):50.e1–6.
  34. Rasteiro C, Araújo C, Cunha S, et al. Influence of time interval from bariatric surgery to conception on pregnancy and perinatal outcomes. *Obes Surg*. 2018;28(11):3559–66.
  35. Lopez LM, Bernholm A, Chen M, et al. Hormonal contraceptives for contraception in overweight or obese women. *Cochrane Database Syst Rev* 2016;(8):CD008452.
  36. Ciangura C, Corigliano N, Basdevant A, et al. Etonogestrel concentrations in morbidly obese women following Roux-en-Y gastric bypass surgery: three case reports. *Contraception*. 2011;84(6):649–51.
  37. [sfendocrino.org](http://www.s fendocrino.org) [Internet]. Contraception hormonale chez la femme à risque métabolique et vasculaire; c2010 [cited 2018 Dec 1]. Available from : <http://www.s fendocrino.org/article/46/consensus-et-recommandations-de-la-sfe-et-partenaires-et-du-gte>
  38. Robinson GE, Burren T, Mackie IJ, et al. Changes in haemostasis after stopping the combined contraceptive pill: implications for major surgery. *BMJ*. 1991;302(6771):269–71.
  39. <http://inpes.santepubliquefrance.fr> [Internet]. Saint-Denis : Stratégies de choix des méthodes contraceptives chez la femme; c2004 [Cited 2018 Dec 1]. Available from: <http://inpes.santepubliquefrance.fr/70000/dp/04/dp041207.pdf>
  40. Centers for Disease Control and Prevention (CDC). Update to CDC’s U.S. Medical Eligibility Criteria for Contraceptive Use, 2010: revised recommendations for the use of contraceptive methods during the postpartum period. *MMWR Morb Mortal Wkly Rep*. 2011;60(26):878–83.
  41. Vilallonga R, Himpens J, van de Vrande S. Long-term (7 years) follow-up of Roux-en-Y gastric bypass on obese adolescent patients (<18 years). *Obes Facts*. 2016;9(2):91–100.
  42. Mengesha B, Griffin L, Nagle A, et al. Assessment of contraceptive needs in women undergoing bariatric surgery. *Contraception*. 2016;94(1):74–7.


43. Mody SK, Hacker MR, Dodge LE, et al. Contraceptive counseling for women who undergo bariatric surgery. *J Women's Health*. 2011;20(12):1785–8.
44. Choi JY, Scarborough TK. Stroke and seizure following a recent laparoscopic Roux-en-Y gastric bypass. *Obes Surg*. 2004;14(6):857–60.
45. Merki-Feld GS, Skouby S, Serfaty D, et al. European society of contraception statement on contraception in obese women. *Eur J Contracept Reprod Health Care*. 2015;20(1):19–28.
46. Ginstman C, Frisk J, Carlsson B, et al. Plasma concentrations of etonogestrel in women using oral desogestrel before and after Roux-en-Y gastric bypass surgery: a pharmacokinetic study. *BJOG*. 2019;126(4):486–92.
47. Gerrits EG, Ceulemans R, van Hee R, et al. Contraceptive treatment after biliopancreatic diversion needs consensus. *Obes Surg*. 2003;13(3):378–82.
48. Guelinckx I, Devlieger R, Vansant G. Reproductive outcome after bariatric surgery: a critical review. *Hum Reprod Update*. 2009;15(2):189–201.
49. Stevens B, Buettner P, Watt K, et al. The effect of balanced protein energy supplementation in undernourished pregnant women and child physical growth in low- and middle-income countries: a systematic review and meta-analysis. *Matern Child Nutr*. 2015;11(4):415–32.
50. Devlieger R, Guelinckx I, Jans G, et al. Micronutrient levels and supplement intake in pregnancy after bariatric surgery: a prospective cohort study. *PLoS One*. 2014;9(12):e114192.
51. Jans G, Matthys C, Bogaerts A, et al. Maternal micronutrient deficiencies and related adverse neonatal outcomes after bariatric surgery: a systematic review. *Adv Nutr*. 2015;6(4):420–9.
52. Rottenstreich A, Elazary R, Goldenshluger A, et al. Maternal nutritional status and related pregnancy outcomes following bariatric surgery: a systematic review. *Surg Obes Relat Dis*. 2019;15(2):324–32.
53. Abbassi-Ghanavati M, Greer LG, Cunningham FG. Pregnancy and laboratory studies: a reference table for clinicians. *Obstet Gynecol*. 2009;114(6):1326–31.
54. Milman N, Bergholt T, Byg K-E, et al. Reference intervals for haematological variables during normal pregnancy and postpartum in 434 healthy Danish women. *Eur J Haematol*. 2007;79(1):39–46.
55. Koebnick C, Heins UA, Dagnelie PC, et al. Longitudinal concentrations of vitamin B(12) and vitamin B(12)-binding proteins during uncomplicated pregnancy. *Clin Chem*. 2002;48(6 Pt 1):928–33.
56. Izquierdo Alvarez S, Castañón SG, Ruata MLC, et al. Updating of normal levels of copper, zinc and selenium in serum of pregnant women. *J Trace Elem Med Biol*. 2007;21(Suppl 1):49–52.
57. Larsson A, Palm M, Hansson L-O, et al. Reference values for clinical chemistry tests during normal pregnancy. *BJOG Int J Obstet Gynaecol*. 2008;115(7):874–81.
58. Hininger I, Favier M, Arnaud J, et al. Effects of a combined micronutrient supplementation on maternal biological status and newborn anthropometrics measurements: a randomized double-blind, placebo-controlled trial in apparently healthy pregnant women. *Eur J Clin Nutr*. 2004;58(1):52–9.
59. Brough L, Rees GA, Crawford MA, et al. Effect of multiple-micronutrient supplementation on maternal nutrient status, infant birth weight and gestational age at birth in a low-income, multi-ethnic population. *Br J Nutr*. 2010;104(3):437–45.
60. Mujica-Coopman MF, Franco-Sena AB, Farias DR, et al. Vitamin B-6 status in Unsupplemented pregnant women is associated positively with serum docosahexaenoic acid and inversely with the n-6-to-n-3 fatty acid ratio. *J Nutr*. 2017;147(2):170–8.
61. Haddow JE, Neveux LM, Palomaki GE, et al. The relationship between PTH and 25-hydroxy vitamin D early in pregnancy. *Clin Endocrinol*. 2011;75(3):309–14.
62. Krieger J-P, Cabaset S, Canonica C, et al. Prevalence and determinants of vitamin D deficiency in the third trimester of pregnancy: a multicentre study in Switzerland. *Br J Nutr*. 2018;119(3):299–309.
63. Hollis BW, Johnson D, Hulsey TC, et al. Vitamin D supplementation during pregnancy: double-blind, randomized clinical trial of safety and effectiveness. *J Bone Miner Res*. 2011;26(10):2341–57.
64. Hemmingway A, O'Callaghan KM, Hennessy Á, et al. Interactions between vitamin D status, calcium intake and parathyroid hormone concentrations in healthy White-skinned pregnant women at northern latitude. *Nutrients*. 2018;10(7):E916.
65. Tamura T, Goldenberg RL, Johnston KE, et al. Maternal plasma zinc concentrations and pregnancy outcome. *Am J Clin Nutr*. 2000;71(1):109–13.
66. Gustafsson MK, Romundstad PR, Stafne SN, et al. Alterations in the vitamin D endocrine system during pregnancy: a longitudinal study of 855 healthy Norwegian women. *PLoS One*. 2018;13(4):e0195041.
67. Peña-Rosas JP, De-Regil LM, Dowswell T, et al. Daily oral iron supplementation during pregnancy. *Cochrane Database Syst Rev*. 2012;12:CD004736.
68. Gascoin G, Gerard M, Sallé A, et al. Risk of low birth weight and micronutrient deficiencies in neonates from mothers after gastric bypass: a case control study. *Surg Obes Relat Dis*. 2017;13(8):1384–91.
69. Maugeri A, Barchitta M, Blanco I, et al. Effects of vitamin D supplementation during pregnancy on birth size : a systematic review and meta-Analysis of randomized controlled trials. *Nutrients*. 2019;11(2):E442.
70. Rhode BM, Arseneau P, Cooper BA, et al. Vitamin B-12 deficiency after gastric surgery for obesity. *Am J Clin Nutr*. 1996;63(1):103–9.
71. Cawley S, Mullaney L, McKeating A, et al. A review of European guidelines on periconceptional folic acid supplementation. *Eur J Clin Nutr*. 2016;70(2):143–54.
72. WHO. Guideline: Calcium supplementation in pregnant women. Geneva: WHO, 2013. [cited 2018 Dec 2]. Available from: [http://www.who.int/nutrition/publications/micronutrients/guidelines/calcium\\_supplementation/en/](http://www.who.int/nutrition/publications/micronutrients/guidelines/calcium_supplementation/en/)
73. Pathak P, Kapil U. Role of trace elements zinc, copper and magnesium during pregnancy and its outcome. *Indian J Pediatr*. 2004;71(11):1003–5.
74. Sallé A, Demarsy D, Poirier AL, et al. Zinc deficiency: a frequent and underestimated complication after bariatric surgery. *Obes Surg*. 2010;20(12):1660–70.
75. Ladipo OA. Nutrition in pregnancy: mineral and vitamin supplements. *Am J Clin Nutr*. 2000;72(1 Suppl):280S–90S.
76. Tara F, Maamouri G, Rayman MP, et al. Selenium supplementation and the incidence of preeclampsia in pregnant Iranian women: a randomized, double-blind, placebo-controlled pilot trial. *Taiwan J Obstet Gynecol*. 2010;49(2):181–7.
77. McGuire S. WHO guideline: vitamin a supplementation in pregnant women. Geneva: WHO, 2011; WHO guideline: vitamin a supplementation in postpartum women. Geneva: WHO, 2011. *Adv Nutr*. 2012;3(2):215–6.
78. Pereira S, Saboya C, Chaves G, et al. Class III obesity and its relationship with the nutritional status of vitamin A in pre- and postoperative gastric bypass. *Obes Surg*. 2009;19(6):738–44.
79. Machado SN, Pereira S, Saboya C, et al. Influence of Roux-en-Y gastric bypass on the nutritional status of vitamin A in pregnant women: a comparative study. *Obes Surg*. 2016;26(1):26–31.
80. Switkowski KM, Jacques PF, Must A, et al. Maternal protein intake during pregnancy and linear growth in the offspring. *Am J Clin Nutr*. 2016;104(4):1128–36.
81. Falcone V, Stopp T, Feichtinger M, et al. Pregnancy after bariatric surgery: a narrative literature review and discussion of impact on pregnancy management and outcome. *BMC Pregnancy Childbirth*. 2018;18(1):507.



82. Sheiner E, Menes TS, Silverberg D, et al. Pregnancy outcome of patients with gestational diabetes mellitus following bariatric surgery. *Am J Obstet Gynecol*. 2006;194(2):431–5.
83. Amsalem D, Aricha-Tamir B, Levi I, et al. Obstetric outcomes after restrictive bariatric surgery: what happens after 2 consecutive pregnancies? *Surg Obes Relat Dis*. 2014;10(3):445–9.
84. Feichtinger M, Stopp T, Hofmann S, et al. Altered glucose profiles and risk for hypoglycaemia during oral glucose tolerance testing in pregnancies after gastric bypass surgery. *Diabetologia*. 2017;60(1):153–7.
85. Ducarme G, Revaux A, Rodrigues A, et al. Obstetric outcome following laparoscopic adjustable gastric banding. *Int J Gynaecol Obstet*. 2007;98(3):244–7.
86. Magdaleno R, Pereira BG, Chaim EA, et al. Pregnancy after bariatric surgery: a current view of maternal, obstetrical and perinatal challenges. *Arch Gynecol Obstet*. 2012;285(3):559–66.
87. Sheiner E, Willis K, Yogev Y. Bariatric surgery: impact on pregnancy outcomes. *Curr Diab Rep*. 2013;13(1):19–26.
88. Booth H, Khan O, Prevost T, et al. Incidence of type 2 diabetes after bariatric surgery: population-based matched cohort study. *Lancet Diabetes Endocrinol*. 2014;2(12):963–8.
89. Peterli R, Steinert RE, Woelnerhanssen B, et al. Metabolic and hormonal changes after laparoscopic Roux-en-Y gastric bypass and sleeve gastrectomy: a randomized, prospective trial. *Obes Surg*. 2012;22(5):740–8.
90. Buse JB, Caprio S, Cefalu WT, et al. How do we define cure of diabetes? *Diabetes Care*. 2009;32(11):2133–5.
91. Bonis C, Lorenzini F, Bertrand M, et al. Glucose profiles in pregnant women after a gastric bypass : findings from continuous glucose monitoring. *Obes Surg*. 2016;26(9):2150–5.
92. Hughes RCE, Moore MP, Gullam JE, et al. An early pregnancy HbA1c  $\geq 5.9\%$  (41 mmol/mol) is optimal for detecting diabetes and identifies women at increased risk of adverse pregnancy outcomes. *Diabetes Care*. 2014;37(11):2953–9.
93. Mañé L, Flores-Le Roux JA, Benaiges D, et al. Role of first-trimester HbA1c as a predictor of adverse obstetric outcomes in a multiethnic cohort. *J Clin Endocrinol Metab*. 2017;102(2):390–7.
94. Andrade HF, de A, Pedrosa W, Diniz M de FHS, Passos VMA. Adverse effects during the oral glucose tolerance test in post-bariatric surgery patients. *Arch Endocrinol Metab*. 2016;60(4):307–13.
95. Roslin MS, Dudiy Y, Brownlee A, et al. Response to glucose tolerance testing and solid high carbohydrate challenge: comparison between Roux-en-Y gastric bypass, vertical sleeve gastrectomy, and duodenal switch. *Surg Endosc*. 2014;28(1):91–9.
96. Cosson E, Pigeire M, Ritz P. Diagnosis and management of patients with significantly abnormal glycaemic profiles during pregnancy after bariatric surgery: PRESAGE (pregnancy with significantly abnormal glycaemic exposure - bariatric patients). *Diabetes Metab*. 2018;44(4):376–9.
97. Benhalima K, Minschart C, Ceulemans D, et al. Screening and Management of Gestational Diabetes Mellitus after bariatric surgery. *Nutrients*. 2018;10(10):E1479.
98. Metzger BE, Buchanan TA, Coustan DR, et al. Summary and recommendations of the fifth international workshop-conference on gestational diabetes mellitus. *Diabetes Care*. 2007;30(Suppl 2):S251–60.
99. Rasmussen KM, Yaktine AL, editors. Institute of Medicine (US) and National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines. *Weight Gain During Pregnancy: Reexamining the Guidelines* [Internet]. Washington: National Academies Press; 2009 [cited 2018 Dec 1]. Available from: <http://www.ncbi.nlm.nih.gov/books/NBK32813/>
100. Grandfils S, Demondion D, Kyheng M, et al. Impact of gestational weight gain on perinatal outcomes after a bariatric surgery. *J Gynecol Obstet Hum Reprod*. 2019;48(6):401–5.
101. Quyên Pham T, Pigeire M, Caiazzo R, et al. Does pregnancy influence long-term results of bariatric surgery? *Surg Obes Relat Dis*. 2015;11(5):1134–9.
102. Weiss HG, Nehoda H, Labeck B, et al. Pregnancies after adjustable gastric banding. *Obes Surg*. 2001;11(3):303–6.
103. Martin LF, Finigan KM, Nolan TE. Pregnancy after adjustable gastric banding. *Obstet Gynecol*. 2000;95(6 Pt 1):927–30.
104. Dixon JB, Dixon ME, O'Brien PE. Birth outcomes in obese women after laparoscopic adjustable gastric banding. *Obstet Gynecol*. 2005;106(5 Pt 1):965–72.
105. Dixon JB, Dixon ME, O'Brien PE. Pregnancy after lap-band surgery: management of the band to achieve healthy weight outcomes. *Obes Surg*. 2001;11(1):59–65.
106. Vrebosch L, Bel S, Vansant G, et al. Maternal and neonatal outcome after laparoscopic adjustable gastric banding: a systematic review. *Obes Surg*. 2012;22(10):1568–79.
107. Stuart A, Källen K. Risk of abdominal surgery in pregnancy among women who have undergone bariatric surgery. *Obstet Gynecol*. 2017;129(5):887–95.
108. Chevrot A, Lesage N, Msika S, et al. Digestive surgical complications during pregnancy following bariatric surgery: experience of a center for perinatology and obesity. *J Gynecol Obstet Biol Reprod*. 2016;45(4):372–9.
109. Krishna S, McInnes MDF, Schieda N, et al. A diagnostic accuracy of MRI for diagnosis of internal hernia in pregnant women with prior Roux-en-Y gastric bypass. *AJR Am J Roentgenol*. 2018;211(4):755–9.
110. Goldberg-Stein S, Liu B, Hahn PF, et al. Body CT during pregnancy: utilization trends, examination indications, and fetal radiation doses. *AJR Am J Roentgenol*. 2011;196(1):146–51.
111. Shetty MK. Abdominal computed tomography during pregnancy: a review of indications and fetal radiation exposure issues. *Semin Ultrasound CT MR*. 2010;31(1):3–7.
112. Jans G, Devlieger R, De Preter V, et al. Bariatric surgery does not appear to affect Women's breast-Milk composition. *J Nutr*. 2018;148(7):1096–102.
113. Monshi B, Stockinger T, Vigel K, et al. Phrynoderma and acquired acrodermatitis enteropathica in breastfeeding women after bariatric surgery. *J Dtsch Dermatol Ges*. 2015;13(11):1147–54.
114. Celiker MY, Chawla A. Congenital B12 deficiency following maternal gastric bypass. *J Perinatol*. 2009;29(9):640–2.
115. Dell'Agnolo CM, Cyr C, de Montigny F, et al. Pregnancy after bariatric surgery: obstetric and perinatal outcomes and the growth and development of children. *Obes Surg*. 2015;25(11):2030–9.
116. Berglund D, Willmer M, Näslund E, et al. Differences in gestational weight gain between pregnancies before and after maternal bariatric surgery correlate with differences in birth weight but not with scores on the body mass index in early childhood. *Pediatr Obes*. 2014;9(6):427–34.
117. Guénard F, Tchernof A, Deshaies Y, et al. Methylation and expression of immune and inflammatory genes in the offspring of bariatric bypass surgery patients. *J Obes*. 2013;2013:492170.
118. Smith J, Cianflone K, Biron S, et al. Effects of maternal surgical weight loss in mothers on intergenerational transmission of obesity. *J Clin Endocrinol Metab*. 2009;94(11):4275–83.

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## Affiliations

Cécile Ciangura<sup>1</sup>  • Muriel Coupaye<sup>2,3</sup> • Philippe Deruelle<sup>4,5</sup> • Géraldine Gascoïn<sup>6,7</sup> • Daniela Calabrese<sup>8</sup> • Emmanuel Cosson<sup>9,10</sup> • Guillaume Ducarme<sup>11</sup> • Bénédicte Gaborit<sup>3,12</sup> • Bénédicte Lelièvre<sup>13</sup> • Laurent Mandelbrot<sup>14</sup> • Niccolo Petrucciani<sup>15</sup> • Didier Quilliot<sup>16,17</sup> • Patrick Ritz<sup>18</sup> • Geoffroy Robin<sup>5,19</sup> • Agnès Sallé<sup>20</sup> • Jean Gugenheim<sup>21,22</sup> • Jacky Nizard<sup>23</sup> • BARIA-MAT Group

<sup>1</sup> Assistance Publique-Hôpitaux de Paris, Pitié-Salpêtrière Hospital, Departments of Nutrition and Diabetology, Institute of Cardiometabolism and Nutrition (ICAN), Sorbonne University, 47-83 Boulevard de l'Hôpital, 75013 Paris, France

<sup>2</sup> Assistance Publique-Hôpitaux de Paris, Louis Mourier Hospital, Department of Explorations Fonctionnelles, Colombes, University Paris Diderot, Paris, France

<sup>3</sup> Association Française d'Etude et de Recherche sur l'Obésité (AFERO), France

<sup>4</sup> Department of Obstetrics and Gynecology, Strasbourg University Hospital, Strasbourg, France

<sup>5</sup> Collège National des Gynécologues et Obstétriciens Français (CNGOF), Paris, France

<sup>6</sup> Department of Neonatal Medicine, Angers University Hospital, Angers, France

<sup>7</sup> Société Française de Néonatalogie et Société Française de Pédiatrie, Paris, France

<sup>8</sup> Assistance Publique-Hôpitaux de Paris, Louis Mourier Hospital, Department of Digestive Surgery, Colombes, University Paris Diderot, Paris, France

<sup>9</sup> Assistance Publique-Hôpitaux de Paris, Jean Verdier Hospital, Department of Endocrinology-Diabetology-Nutrition, Bondy, 10 UMR U557 INSERM/U11125 INRA/CNAM, University Paris13, Bobigny, France

<sup>10</sup> Société Francophone du Diabète (SFD), Paris, France

<sup>11</sup> Department of Obstetrics and Gynecology, Departemental Hospital, La Roche-sur-Yon, France

<sup>12</sup> Assistance Publique-Hôpitaux de Marseille, Department of Endocrinology, Metabolic Diseases and Nutrition, Marseille, INSERM, INRA, C2VN, Aix Marseille University, Marseille, France

<sup>13</sup> Laboratory of Pharmacology and Toxicology, Angers University Hospital, Angers, France

<sup>14</sup> Assistance Publique-Hôpitaux de Paris, Louis Mourier Hospital, Department of Gynecology and Obstetrics, Colombes, University Paris Diderot, Paris, France

<sup>15</sup> Assistance Publique-Hôpitaux de Paris, Henri Mondor Hospital, Division of Digestive Surgery and Liver Transplantation, UPEC University, Créteil, France

<sup>16</sup> Department of Diabetology-Endocrinology-Nutrition, CHRU Nancy, INSERM 954, University of Lorraine, Nancy, France

<sup>17</sup> Société Francophone Nutrition Clinique et Métabolisme (SFNCM), France

<sup>18</sup> Department of Endocrinology, Metabolic Diseases and Nutrition, Toulouse University Hospital, UMR1027, Paul Sabatier University, Toulouse, France

<sup>19</sup> Department of Medical Gynecology, and Sexology and Department of Assisted Reproductive Technologies and Fertility Preservation, Jeanne de Flandre Hospital, Lille, EA4308 "gametogenesis and gamete quality", Lille University, Lille, France

<sup>20</sup> Department of Diabetology-Endocrinology-Nutrition, Angers University Hospital, Angers, France

<sup>21</sup> Division of Digestive Surgery and Liver Transplantation, Nice University Hospital, University of Nice, Nice, France

<sup>22</sup> Société Française et Francophone de Chirurgie de l'Obésité et des Maladies Métaboliques (SOFFCOMM), France

<sup>23</sup> Assistance Publique-Hôpitaux de Paris, Pitié-Salpêtrière Hospital, Department of Gynecology and Obstetrics, Sorbonne University, Paris, France