The Impact of Pregnancy on Outcomes After Bariatric Surgery

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Published online: 7 May 2020
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Abstract
Background Bariatric surgery is performed mostly on obese women of reproductive age. Many studies have analyzed pregnancy outcomes after bariatric surgery, but only a small number have studied the impact of pregnancy on the postoperative outcomes.

Purpose To study the effect of pregnancy on outcomes after bariatric surgery in women of childbearing age.

Methods From January 2010 to October 2017, a retrospective study of a prospectively maintained database was conducted at the University Hospital of Geneva (HUG), where 287 women between the ages of 18 and 45 years had undergone Roux-en-Y gastric bypass (RYGB). A comparison of the results during a 5-year follow-up was performed between women who became pregnant after their bariatric surgery (pregnancy group, n = 40) and postoperative non-pregnant women (non-pregnancy group, n = 247).

The two groups were compared for weight loss, complications, and nutritional deficiencies.

Results The pregnancy group was significantly younger (29.2 ± 5.5 vs. 36.4 ± 6.3 years, p < 0.001) and heavier (124.0 ± 18.0 kg vs. 114.7 ± 17.1 kg, p < 0.001) compared with the non-pregnancy group at the time of surgery. The percentage of excess BMI loss (%EBMI loss) was similar in both groups during the 5-year follow-up. Complications after RYGB and nutritional deficiencies were nearly identical in the two groups. The interval of time between bariatric surgery and first pregnancy was a median of 20.8 months. Out of 40 first pregnancies, 28 women completed pregnancy successfully with live birth.

Conclusion Pregnancy after bariatric surgery is safe and does not adversely affect outcomes after RYGB.

Keywords Bariatric surgery · Pregnancy · Roux-en-Y gastric bypass · Outcomes

Introduction

The ever-increasing worldwide obesity rate is responsible for several significant health issues, concerning in particular women of childbearing age. In 2016, a study conducted by the World Health Organization (WHO) showed that 39% of the world’s population over the age of 18 were overweight and 13% were obese (BMI > 30 kg/m²) [1].

In addition, obesity is related to disorders such as diabetes, hypertension, hyperlipidemia, and infertility [2]. Bariatric surgery has become a popular treatment for obesity and its co-morbidities during the last 20 years [3–5].

In obese women, pregnancy is associated with a higher risk of gestational diabetes mellitus (GDM), gestational hypertension, prematurity, malformation, infection, perinatal mortality, and cesarean section [6]. Bariatric surgery reduces GDM, hypertensive disorders, and fetal macrosomia but increases the risk of prematurity and small-for-gestational age [7–15].

More and more obese women of reproductive ages decide to undergo bariatric surgery, despite potential risks, such as induction of malnutrition, vitamin deficiency aggravated by pregnancy [16], and surgical complications such as internal hernias, bowel obstructions, abdominal pain, and cholelithiasis [17, 18].

The objective of this study is to investigate the impact of pregnancy on the evolution of outcomes after bariatric surgery by comparing the weight loss, occurrence of complications, and nutritional deficiencies in pregnant and non-pregnant women and to describe the basic fetal outcomes.

Methods

From January 2010 to October 2017, a retrospective study was conducted at the University Hospital of Geneva (HUG), where 287 women between the ages of 18 and 45 years had undergone RYGB. This is a retrospective analysis of a
prospectively maintained database, approved by the local ethics committee (number: 2019-01801).

Baseline and postoperative data were extracted during the postoperative follow-up at 1, 3, 6, 12, 18, 24, 36, 48, and 60 months.

The two groups were compared for the following parameters: weight loss, complications, and nutritional deficiencies.

Weight loss outcomes were reported as percentage of excess BMI loss (%EBMI) and percentage BMI loss (%BMI). Excess weight was defined as kilograms above the baseline weight at BMI of 25 kg/m². The %EBMI was computed by the formula 1 − [Initial BMI − Ideal BMI]/[Current BMI − Ideal BMI]. The ideal BMI was defined as 25 kg/m². The percentage of BMI loss was calculated by [Initial BMI − Current BMI / Initial BMI].

Our study analyzed postsurgical and long-term complications such as gastrointestinal problems and reoperations after RYGB.

Nutritional deficiencies in iron, folic acid, vitamin B12, vitamin D3, and calcium were included. The intake of post-surgical supplements was also evaluated.

For the statistical analysis, quantitative data were compared with the mean ± standard deviation. Student’s t test was used to compare paired measurements of continuous data. Analyses of categorical variables were performed by Fisher’s exact test. p < 0.05 was considered statistically significant.

Regarding the newborn, different data were extracted: birth weight, gestational age, type of delivery, Apgar score, umbilical pH, and interval between surgery and conception.

**Results**

From January 2010 to October 2017, 287 women of reproductive age underwent RYGB at HUG, 259 RYGB were performed by robot, 25 by laparoscopy, and 3 by laparotomy. Forty women (13.9%) became pregnant within 5 years after their bariatric surgery (pregnancy group). The “non-pregnancy group” consisted of 247 women who did not conceive within 5 years after RYGB. In total, 58 pregnancies were observed in 40 women.

The mean age at surgery was 29.2 ± 5.5 years and 36.4 ± 6.3 years for the pregnancy group and the non-pregnancy group (p = 0.001), respectively.

Women in the pregnancy group were significantly younger and heavier at the time of surgery compared with the remaining 247 women (non-pregnancy group) (Table 1). Outcomes at 1 and 3 months were similar between groups, except slight differences in calcium, vitamin D, ferritin, and acid folic blood values (Tables 2 and 3).

There were no significant differences in postoperative complications between the two groups. In the non-pregnancy group, 21 adverse events (8.5%) occurred of which five were immediate reoperations, four pulmonary embolisms, one pleural effusion, one pneumonia, one portal venous thrombosis, and one pulmonary atelectasis. Other observed complications in the non-pregnancy group were wound infection, hematemesis, laryngeal, gastric and anastomotic edemas, respiratory insufficiency, bronchospasm, pulmonary atelectasis, thrombocytopenia, esophageal stenosis, and fecaloma. The causes of reoperation were drainage of hematoma in the gallbladder bed and revision of the bypass because of anastomotic leak and mechanical ileus. In the pregnancy group, there were three adverse events (1%) with one pulmonary embolism, one pulmonary atelectasis, and one portal venous thrombosis. There was no reoperation in the pregnancy group.

The percentage of excess BMI loss did not differ significantly between the pregnancy group and the non-pregnancy group (77.7% vs. 82.8%, respectively, p = 0.4264) at 3 years, 85.6% vs. 78.6% (p = 0.3525) at 4 years, and 73.7% vs. 75.0% (p = 0.8657) at 5 years after surgery (Tables 4, 5, and 6). The percentage of BMI loss was also similar between both groups at 3-, 4-, and 5-year follow-ups. A total of 94 women in the non-pregnancy group and 17 in the pregnancy group completed their 3-year follow-up; 64 women in the non-pregnancy group and 12 in the pregnancy group completed their 4-year follow-up; and 26 in the non-pregnancy group and 12 in the pregnancy group completed their 5-year follow-up.

Long-term complications such as abdominal pain, vomiting, dysphagia, anastomotic ulcers, and reoperation did not show a statistical difference between the two groups (Table 2).

During follow-up, seven anastomotic ulcers, three suspicions of cholelithiasis, and one gastrojejunal stenosis were reported in the non-pregnancy group. In the pregnancy group, one gastrojejunal stenosis was reported. Furthermore, 31 women underwent late reoperations, four in the pregnancy group, and 27 in the non-pregnancy group. Indications included internal hernia, small bowel obstruction, umbilical hernia, appendicitis, and cholelithiasis. In the present study, no surgical emergencies were observed during pregnancy.

At 3-year follow-up, blood values for iron, ferritin, acid folic, calcium, and vitamins D3 and B12 were nearly identical in both cohorts. Moreover, both groups received similar amounts of supplements in iron, acid folic, calcium, and vitamins D3 and B12 with the exception of oral iron, which was increased in the pregnancy group. At 4-year follow-up, there was no significant difference in any supplement or blood values other than a slight diminution in mean calcium concentration in the pregnancy group. At 5-year follow-up, vitamin B12 blood values differed though, the pregnancy group having significantly higher amounts (Table 2).

Following bariatric surgery, we observed a total of 58 recognized pregnancies (range 1–3) in the pregnancy group.

Of a total of 40 first pregnancies, 28 women completed first pregnancy successfully (two of which were twins). Four
spontaneous miscarriages, two voluntary terminations of pregnancy, and one stillbirth of a 450-g infant delivered at 22 weeks were observed. The remaining five women did not give birth at the Geneva University Hospital (HUG), and there is therefore no information regarding the newborn. There was a median interval of time of 20.8 months (range 1–50.6) between RYBG and conception.

The median duration of gestation was 37.6 (range 22 0/7–40 4/7) weeks. Live birth was achieved by 19 vaginal deliveries (67.9%), by 8 cesarean sections (28.6%), and by one

Table 1 Baseline characteristics in women of childbearing age

| Groups                        | Pregnancy group (N = 40) | Non-pregnancy group (N = 247) | p value |
|-------------------------------|--------------------------|-------------------------------|---------|
| Age (years)                   | 29.2 ± 5.5               | 36.4 ± 6.3                    | 0.0001  |
| BMI (kg/m²)                   | 45.2 ± 5.2               | 43.2 ± 5.8                    | 0.0432  |
| Weight (kg)                   | 124.0 ± 18.0             | 114.7 ± 17.1                  | 0.0016  |

p value was statistically significant

Table 2 Anthropometric characteristics, complications, supplements, and blood values at 1-month follow-up

| Groups                        | At month 1 after surgery |
|-------------------------------|--------------------------|
|                               | Pregnancy group | Non-pregnancy group | p value |
| Baseline BMI (kg/m²)          | 45.1 ± 5.2       | 43.3 ± 5.9          | 0.0803  |
| Baseline weight (kg)          | 115.0 ± 17.1     | 123.6 ± 18.2        | 0.0048  |
| BMI (kg/m²)                   | 40.5 ± 4.7       | 38.9 ± 5.5          | 0.1099  |
| Weight (kg)                   | 111.2 ± 15.7     | 102.5 ± 18.5        | 0.0075  |
| %BMI loss                     | 10.2 ± 3.0       | 10.1 ± 3.6          | 0.9375  |
| %EBMI loss                    | 23.5 ± 7.7       | 25.2 ± 10.1         | 0.3379  |
| Complications                 | 8               | 46                  | 0.8254  |
| Abdominal pain                | 4               | 25                  | 1       |
| Dysphagia                     | 2               | 7                   | 0.3559  |
| Vomiting                      | 1               | 12                  | 1       |
| Hiatal hernia                 | 0               | 0                   | 1       |
| Ulcer                         | 0               | 1                   | 1       |
| Stenosis                      | 1               | 0                   | 0.137   |
| Reoperation                   | 0               | 1                   | 1       |
| Hernia                        | 0               | 0                   | 1       |
| Supplements (%)               | 37.8            | 48.1                | 0.289   |
| Folic acid                    | 2.7             | 1.3                 | 0.4474  |
| Vitamin B12                   | 10.8            | 7.3                 | 0.5049  |
| Oral iron                     | 10.8            | 11.6                | 1       |
| Intravenous iron              | 2.7             | 12.4                | 0.0937  |
| Vitamin D3                    | 10.8            | 14.1                | 0.7974  |
| Calcium                       | 5.4             | 12.9                | 0.275   |
| Blood values                  |                 |                     |         |
| Iron (5–30 μmol/l)            | 12.6 ± 4.1      | 13.2 ± 4.6          | 0.4647  |
| Ferritin (11–137 μg/l)        | 118.7 ± 80.2    | 126.2 ± 110.0       | 0.693   |
| Vitamin B12 (35–700 pmol/l)   | 363.1 ± 180.5   | 376.0 ± 147.6       | 0.6337  |
| Folic acid (6.6–35.4 nmol/l)  | 14.9 ± 6.4      | 17.6 ± 11.4         | 0.1521  |
| Calcium (2.2–2.52 mmol/l)     | 2.385 ± 0.0891  | 2.346 ± 0.094       | 0.0196  |
| Vitamin D3 (80–150 nmol/l)    | 29.3 ± 9.5      | 43.5 ± 25.9         | 0.0011  |

p value was statistically significant
vacuum sucker cup (3.6%). The median birth weight was 2737 g (range 450–3860). The median Apgar score was 8.3/8.9/9.5 after 1, 5, and 10 min after birth. The median arterial and venous pH was 7.28 and 7.36, respectively.

Out of a total of 14 second pregnancies, 9 delivered successfully, three had spontaneous miscarriages, and two were unrecorded. The median duration of gestation was 38.8 weeks (range 38 4/7–40 5/7). Seven women gave live birth by vaginal delivery (77.8%) and two by cesarean section (22.2%). The birth weight of second children was a median of 3093 g (range 2090–3670). The median Apgar score was 9.3/9.8/10; the median arterial and venous pH was 7.22 and 7.35, respectively.

Out of four third pregnancies, three delivered successfully and one was unrecorded. The median duration of gestation was 39.4 weeks (range 38 5/7–40 1/7). Live births were achieved by vaginal delivery in all cases. The median birth weight of third children was 3248 g (range 2855–3650). The median Apgar score was 9.3/10/10; the median arterial and venous pH was 7.27 and 7.39, respectively.

### Discussion

The present study investigated the impact of pregnancy on long-term outcomes after bariatric surgery. Contrary to theoretical concerns that pregnancy after bariatric surgery may limit maternal weight loss [19], this study found no differences with respect to weight loss in women who became pregnant compared with those who did not. Alatishe et al. [20]
previously reported the effect of pregnancy on bariatric surgery outcomes. Their study compared 21 women who conceived after bariatric surgery to 211 who did not. The pregnancy group lost 70.4% of excess weight compared with 70.0% in the non-pregnancy group at a median of 30 months after surgery. The authors concluded that pregnancy after bariatric surgery did not adversely affect weight loss. Thu Quyên Pham et al. [21] suggested that postoperative pregnancy slows down weight loss but has no influence on the results 5 years after bariatric operations. The %EWL was lower in the pregnancy group at 2 years (pregnancy group = 45.9% versus non-pregnancy group = 56.9%) but was similar at 5 years (47.7 versus 49.9). Globally, we report similar data in this large observational study.

Our study showed nearly identical outcomes in the pregnancy and non-pregnancy group at 1 and 3 months of follow-up, which had to be expected, as conception had not yet occurred.

Small bowel obstruction is a common health issue following bariatric surgery, principally RYGB, which can be life threatening. More specifically, the small bowel obstruction often results from internal hernias and sometimes volvulus or intussusceptions [19, 22]. Pregnancy itself may raise the risk of internal hernias resulting from increased intra-abdominal pressure and the displacement of the small intestine following the expansion of the uterus [22]. Internal herniation symptoms include sharp abdominal pains sometimes coupled with nausea and vomiting [23]. Additionally, the diagnosis of

| Table 4 Anthropometric characteristics, complications, supplements, and blood values at 3-year follow-up |
|---|
| Groups | At year 3 after surgery |
| | Pregnancy group | Non-pregnancy group | p value |
| | n = 17 | n = 94 | |
| Mean ± SD | Mean ± SD | |
| Baseline BMI (kg/m²) | 46.0 ± 5.4 | 43.0 ± 5.2 | 0.0293 |
| Baseline weight (kg) | 127.9 ± 20.2 | 113.3 ± 15.5 | 0.0009 |
| BMI (kg/m²) | 30.3 ± 6.0 | 28.6 ± 5.0 | 0.2081 |
| Weight (kg) | 84.2 ± 18.5 | 74.5 ± 14.2 | 0.0146 |
| %BMI loss | 34.3 ± 8.6 | 33.3 ± 9.5 | 0.6753 |
| %EBMI loss | 82.8 ± 24.5 | 77.7 ± 21.4 | 0.4264 |
| Complications | 4 | 34 | 0.4100 |
| Abdominal pain | 4 | 22 | 1 |
| Dysphagia | 0 | 0 | 1 |
| Vomiting | 0 | 6 | 0.5879 |
| Hiatal hernia | 0 | 0 | 1 |
| Ulcer | 0 | 0 | 1 |
| Stenosis | 0 | 0 | 1 |
| Reoperation | 0 | 3 | 1 |
| Hernia | 0 | 3 | 1 |
| Supplements (%) | 70.6 | 85.1 | 0.1651 |
| Folic acid | 0.0 | 5.3 | 1 |
| Vitamin B12 | 47.1 | 55.3 | 0.602 |
| Oral iron | 23.5 | 6.4 | 0.045 |
| Intravenous iron | 23.5 | 30.9 | 0.7739 |
| Vitamin D3 | 41.2 | 50.0 | 0.6019 |
| Calcium | 52.9 | 61.7 | 0.5925 |
| Blood values | | | |
| Iron (5–30 μmol/l) | 16.6 ± 7.5 | 17.1 ± 7.5 | 0.8071 |
| Ferritin (11–137 μg/l) | 59.1 ± 66.8 | 74.9 ± 53.5 | 0.2848 |
| Vitamin B12 (35–700 pmol/l) | 231.7 ± 104.0 | 228.8 ± 79.3 | 0.8963 |
| Folic acid (6.6–35.4 nmol/l) | 20.4 ± 15.1 | 19.0 ± 13.4 | 0.7059 |
| Calcium (2.2–2.52 mmol/l) | 2.165 ± 0.5819 | 2.2555 ± 0.2699 | 0.3069 |
| Vitamin D3 (80–150 nmol/l) | 49.1 ± 27.9 | 58.9 ± 20.5 | 0.0897 |

p value was statistically significant
internal hernias is often made on computed tomography, which is rarely performed in pregnant women. Ultimately, diagnosis is often made during surgery if there is a high suspicion of internal hernia [24, 25]. Several cases of internal herniation during pregnancy have been reported [26, 27]. Leal-González et al. [26] showed in his case report that surgical exploration during pregnancy is safe and ought to be expedited if required. Internal hernias should be suspected in pregnant patients with history of gastric bypass and symptoms of abdominal pain to avert the possibility of a miscarriage or even maternal death. We did not observe any maternal death in our study.

Obesity is related with reduced fertility usually as a consequence of anovulation [28]. It is widely accepted that weight loss following bariatric surgery decreases health issues such as polycystic ovary syndrome, anovulation, and irregular menses, which in turn improve fertility rates [29]. However, infertility should not be considered as a primary indication for bariatric surgery. Recent systematic reviews showed that 5–15% of women of childbearing age become pregnant after bariatric surgery [3, 20, 30, 31]. In this cohort, 40 of the total 287 women (13.9%) became pregnant after RYGB, which is in accordance with the current literature. Women who undergo bariatric surgery should be given fertility counseling and advised to consider contraception for at least a year following their procedure [32]. For patients with a risk of oral malabsorption, non-oral administration of hormonal contraception should be considered [29].

Protein, iron, vitamin B12, acid folic, vitamin D, and calcium are the most common nutritional deficiencies after

| Groups | At year 4 after surgery | Non-pregnancy group | p value |
|--------|-------------------------|---------------------|--------|
| n = 12 | Mean ± SD               | Mean ± SD           |        |
| Baseline BMI (kg/m²) | 42.8 ± 4.7 | 43.6 ± 4.8 | 0.5755 |
| Baseline weight (kg)  | 115.9 ± 18.7 | 115.0 ± 16.4 | 0.8553 |
| BMI (kg/m²)           | 27.6 ± 3.4  | 29.3 ± 5.5  | 0.2883 |
| Weight (kg)           | 74.8 ± 9.3  | 76.3 ± 12.2 | 0.6864 |
| %BMI loss             | 35.1 ± 9.6  | 32.5 ± 10.0 | 0.4147 |
| %EBMI loss            | 78.6 ± 24.3 | 85.6 ± 21.7 | 0.3525 |
| Complications         | 3           | 23        | 0.5295 |
| Abdominal pain        | 1           | 17        | 0.2735 |
| Dysphagia             | 0           | 0         | 1      |
| Vomiting              | 2           | 2         | 0.1151 |
| Hiatal hernia         | 0           | 0         | 1      |
| Ulcer                 | 0           | 0         | 1      |
| Stenosis              | 0           | 0         | 1      |
| Reoperation           | 0           | 2         | 1      |
| Hernia                | 0           | 2         | 1      |
| Supplements (%)       | 75.0        | 85.9      | 0.3901 |
| Folic acid            | 0.0         | 7.8       | 1      |
| Vitamin B12           | 25.0        | 45.3      | 0.2218 |
| Oral iron             | 18.3        | 4.7       | 0.5048 |
| Intravenous iron      | 33.3        | 18.8      | 0.2647 |
| Vitamin D3            | 41.7        | 57.8      | 0.3541 |
| Calcium               | 41.7        | 51.6      | 0.7543 |
| Blood values          |             |           |        |
| Iron (5–30 μmol/l)    | 18.1 ± 7.6  | 16.8 ± 7.6 | 0.6023 |
| Ferritin (11–137 μg/l)| 67.6 ± 79.4 | 82.7 ± 64.6 | 0.4760 |
| Vitamin B12 (35–700 pmol/l)| 213.9 ± 84.2 | 265.8 ± 204.5 | 0.3918 |
| Folic acid (6.6–35.4 nmol/l)| 19.1 ± 15.5 | 15.9 ± 9.3 | 0.3289 |
| Calcium (2.2–2.52 mmol/l)| 2.181 ± 0.1441 | 2.2795 ± 0.0838 | 0.0015 |
| Vitamin D3 (80–150 nmol/l)| 54.5 ± 22.6 | 61.9 ± 20.1 | 0.2506 |

*p value was statistically significant
RYGB [29]. These particular insufficiencies can potentially manifest in fetal complications [33] including preterm birth, low birth weight, neonatal hypocalcaemia or rickets, maternal osteomalacia, fetal mental retardation, and neural tube defect [34]. For women who have undergone bariatric surgery, a broad evaluation of micronutrient needs is advised [34–37]. If deficiencies are discovered, treatment should be administered to restore adequate levels. In the collected data, the mean blood levels of iron, calcium, and vitamins were similar in the both groups and the amount of prescribed supplements was virtually the same. Thus, pregnancy did not decrease blood concentration or aggravate deficiencies.

Women who became pregnant after bariatric surgery might have an increased risk for preterm and small-for-gestational-age infants [7, 38]. The outcomes of a matched controlled cohort study published by Johansson et al. [39] underlined a higher risk of small-for-gestational-age infants and shorter gestational time, although the risk of preterm birth was not significantly different. It was also suggested that pregnancy after bariatric surgery might potentially increase the risk of stillbirth or neonatal death [39]. Regarding the newborn of this study, the outcomes were good. Nevertheless, a tendency for small-for-gestational-age infants was observed. The median birth weight was 2737 g for 37.6 weeks of gestation which represents an average of lower birth weight. As the median duration of gestation was 37.5 weeks, this study did not observe an increased risk for preterm infants after RYGB. Preterm is defined as babies born alive before the 37 weeks of gestation [41]. A total Apgar score of 7–10 is considered “normal” [42]. The mean Apgar scores in this study were above 7.

### Table 6: Anthropometric characteristics, complications, supplements, and blood values at 5-year follow-up

| Groups                      | At year 5 after surgery                          |
|-----------------------------|--------------------------------------------------|
|                            | Pregnancy group | Non-pregnancy group | p value|
|                            | n = 11          | n = 36               |       |
| Mean ± SD                  | Mean ± SD       |                      |       |
| Baseline BMI (kg/m²)        | 41.9 ± 2.9      | 44.6 ± 4.9           | 0.0856|
| Baseline weight (kg)        | 114.0 ± 12.2    | 119.5 ± 17.4         | 0.342 |
| BMI (kg/m²)                 | 29.2 ± 3.3      | 30.2 ± 4.5           | 0.5318|
| Weight (kg)                 | 79.7 ± 11.5     | 80.1 ± 13.3          | 0.9228|
| %BMI loss                   | 30.1 ± 8.3      | 32.0 ± 10.6          | 0.5774|
| %EBMI loss                  | 73.7 ± 23.6     | 75.0 ± 19.8          | 0.8657|
| Complications               | 3               | 11                   | 1     |
| Abdominal pain              | 3               | 5                    | 0.3673|
| Dysphagia                   | 0               | 0                    | 1     |
| Vomiting                    | 0               | 3                    | 0.5597|
| Hiatal hernia               | 0               | 0                    | 1     |
| Ulcer                       | 0               | 0                    | 1     |
| Stenosis                    | 0               | 0                    | 1     |
| Reoperation                 | 0               | 2                    | 1     |
| Hernia                      | 0               | 1                    | 1     |
| Supplements (%)             | 72.7            | 72.2                 | 0.7129|
| Folic acid                  | 0.0             | 5.6                  | 1     |
| Vitamin B12                 | 27.3            | 52.8                 | 0.102 |
| Oral iron                   | 0.0             | 2.8                  | 1     |
| Intravenous iron            | 18.2            | 13.9                 | 1     |
| Vitamin D3                  | 54.5            | 50.0                 | 1     |
| Calcium                     | 45.5            | 55.6                 | 0.5048|
| Blood values                |                  |                      |       |
| Iron (5–30 μmol/l)          | 12.9 ± 6.0      | 18.1 ± 8.5           | 0.0618|
| Ferritin (11–137 μg/l)      | 81.6 ± 57.6     | 75.1 ± 57.9          | 0.7427|
| Vitamin B12 (35–700 pmol/l) | 260.7 ± 66.4    | 198.4 ± 59.8         | 0.0051|
| Folic acid (6.6–35.4 nmol/l)| 17.5 ± 7.9      | 18.2 ± 14.6          | 0.8627|
| Calcium (2.2–2.52 mmol/l)   | 2.243 ± 0.0549  | 2.2657 ± 0.078       | 0.3564|
| Vitamin D3 (80–150 nmol/l)  | 53.1 ± 18.8     | 55.7 ± 18.2          | 0.6781|

*p value was statistically significant*
umbilical arterial pH is 7.24 (± 0.07), and the venous pH is 7.33 (± 0.06) [43]. The mean umbilical arterial pH and venous pH of the newborn were in this range. Furthermore, the miscarriage rate of the present cohort was 11.4% (four miscarriages in 35 recorded pregnancies), which is consistent with the 10–20% miscarriage rate in the general obstetric population [44]. Therefore, our study shows that pregnancy after RYGB is safe.

Previous studies have confirmed that maternal and neonatal outcomes in women conceiving after bariatric surgery are good [20, 32, 35]. Nevertheless, it would be prudent to defer pregnancy after bariatric surgery at least for 12 months to reduce the potential risk of intra-uterine growth retardation from excessive weight loss while allowing the woman to benefit entirely of the procedure [19, 22, 29]. It is possible that the risk of internal herniation during pregnancies within the first postsurgical year is increased [23]. These pregnancies are associated with a higher rate of spontaneous abortions [45]. A careful and thorough follow-up of the women who underwent bariatric surgery should be systematically conducted during pregnancy, especially if conception happens during the first year after surgery [20].

The limitations of the present study include the retrospective nature of the data collection. Another limitation was the increasing patient dropout rate along the 5-year follow-up process. This study also did not analyze the gestational weight gain and postpartum weight loss of the women who became pregnant after RYG. Larger studies should be conducted in this sub-group population.

Conclusion

Pregnancy after bariatric surgery is safe and does not affect long-term weight loss, complications, or nutritional deficiencies; however, close monitoring of maternal weight and nutritional status is advisable. Currently, it is recommended to wait at least 1 year after bariatric surgery before conceiving to protect against harmful weight loss and the presence of comorbidities in the mother and child.

Author Contributions Conception and design: Brönnimann and Buchs. Acquisition of data: Brönnimann and Niclauss. Analysis and interpretation of data: Brönnimann, Jung, Niclauss, Hagen, Tosso, and Buchs. Drafting the article: Brönnimann and Buchs. Revising it critically for important intellectual content: Jung, Hagen, Tosso, Buchs, and Niclauss. Final approval of the version to be published: Brönnimann, Jung, Niclauss, Hagen, Tosso, and Buchs.

Compliance with Ethical Standards

Conflict of Interest A. Brönnimann, M. K. Jung, N. Niclauss, M. E. Hagen, C. Tosso, N. C. Buchs have no conflict of interest. Monika E. Hagen received personal fees and non-financial support from Intuitive Surgical Inc., Quantgene Inc., Ethicon Inc., and Verb Surgical, outside this project.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent Statement For this type of study (retrospective), formal consent is not required. However, all patients signed an informed consent form before undergoing bariatric surgery.

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