Aim: This study aimed to clarify outcomes of pregnancies in women with previous bariatric surgery (BS).

Methods: A national questionnaire was conducted targeting all 408 perinatal institutions in Japan. Responses were obtained from 229 institutions, of which four reported a total of five singleton pregnancies and subsequent deliveries in women with previous BS in 2018. Outcomes of these women (BS group) were investigated.

Case presentations: One woman (20.0%) delivered without preeclampsia prior to undergoing BS. Among the five women, median maternal age was 36 years, and median interval between previous BS and conception was 28 months. Mean maternal body mass index decreased by 10.5 between BS and conception and increased by 4.57 between conception and delivery. Three women (60.0%) developed preeclampsia (hypertension and proteinuria), two women had chronic hypertension at conception that developed into superimposed preeclampsia, and one woman had new-onset preeclampsia. Three women (60.0%) had type 2 diabetes mellitus (including overt diabetes in pregnancy), and none had new-onset gestational diabetes mellitus. One woman had a preterm delivery at 32 gestational weeks via cesarean section due to abruptio placentae caused by preeclampsia. All five women gave birth to live appropriate-for-gestational age infants with no abnormalities.

Conclusion: The incidence of preeclampsia is high among pregnant women with previous BS who have diabetes mellitus at conception.
an acceptable durability of up to five years. However, the occurrence of complications such as leakage from the staple line and intractable gastroesophageal reflux disease has also been noted.

The number of pregnancies in women with previous BS has increased worldwide. Pregnant women with a history of BS have been reported to have better maternal outcomes, as BS decreases the incidence of gestational diabetes mellitus (GDM). However, incidence rates of low birthweight infants and preterm delivery are increased.

In 2009, the American College of Obstetricians and Gynecologists (ACOG) published a practice bulletin for the management of pregnant women with previous BS. Although BS has been increasingly performed in Japan in recent years, few reports published in English have described pregnant Japanese women with a history of BS.

This study aimed to clarify the characteristics and maternal/neonatal outcomes of pregnant Japanese women who previously underwent BS.

Methods

Case series presentation

This case series study was approved by the Hokkaido University Hospital Institutional Review Board (No. 019-0336). All participants in each institution provided written informed consent to participate in the study after delivery.

The first questionnaire survey was conducted in 2019 to determine the number of pregnancies and deliveries in 2018 in Japanese women who had undergone BS. Questionnaire forms were distributed to all 408 perinatal centers in Japan with neonatal intensive care units certified by the Japanese Ministry of Health, Labour, and Welfare on December 31, 2018. A second questionnaire was mailed to institutions which had responded to the first questionnaire to examine the characteristics and outcomes of the pregnant women with previous BS who were identified in the first questionnaire survey.

Preeclampsia was diagnosed in women who developed both hypertension and significant proteinuria at ≥ 20 gestational weeks (GW). Hypertension was defined as the occurrence of systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg. Gestational hypertension was defined as hypertension occurring at ≥ 20 GW in the absence of significant proteinuria (a single urine protein/creatinine ratio > 0.27 or a protein loss > 0.3 g/24-h urine collection). Patient risk factors for preeclampsia were calculated by entering patient information, excluding biophysical measurements, into a risk calculator (Fetal Medicine Foundation, London, UK).

Narrative literature review

Cases reported in the English literature (cohort studies, case-control studies, and systematic reviews) on “pregnancy after bariatric surgery” since 2010 were identified using PubMed and MEDLINE (October 2021) with the search terms “bariatric surgery” and “pregnancy.” In addition, pertinent reports found in the reference list of retrieved studies were also reviewed.

Case series

Initial questionnaire forms were distributed to 408 institutions, of which 229 (56.1%) responded. Among these, four institutions reported a total of five singleton pregnancies in Japanese women with previous BS who delivered infants in 2018; there were no qualifying cases in 2016 or 2017. All five women had no maternal family history of preeclampsia, did not smoke during pregnancy, and had no history of systemic lupus erythematosus and/or anti-phospholipid syndrome. One woman (Case 1) achieved a singleton pregnancy with clomiphene citrate; the remaining four women achieved a singleton pregnancy spontaneously.

Among the five women, four and one had undergone LSG and LAGB, respectively. There were a total of 127,355 deliveries among the 229 institutions; thus, the frequency of deliveries by Japanese women who previously underwent BS was 0.0039% (5/127,355) in the present study.

The characteristics and maternal/neonatal outcomes of the five women are summarized in Table 1. The frequency of preeclampsia was 60.0% (3/5), and the frequency of preeclampsia among those with DM was 100% (3/3).

Case 1

A 38-year-old multiparous woman underwent LSG at age 36 to treat type 2 DM she had developed at age 35. Previously, at age 31, she had delivered an infant vaginally at 39 GW without preeclampsia or GDM. The interval between BS and conception was 16 months. Her body mass index (BMI) was 33.6 at the time of BS, 28.5 before conception, and 33.1 at delivery. She was treated for mild hypertension before conception and developed superimposed preeclampsia (severe hypertension plus proteinuria). She delivered a live infant vaginally at 38 GW. The infant weighed 3,005 g and was appropriate for gestational age (AGA) (SD + 0.03), with no abnormalities. At 25 months after delivery, the patient had no hypertension, DM, or subsequent pregnancy.

Case 2

A 36-year-old nulliparous woman underwent LSG at age 33 to treat type 2 DM she had developed at age 28. The interval between BS and conception was 27
### Table 1. Characteristics and maternal/neonatal outcomes of five pregnant women with previous bariatric surgery

|                         | Overall | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 |
|-------------------------|---------|--------|--------|--------|--------|--------|
| **Type of bariatric surgery** |         | LSG    | LSG    | LSG    | LAGB   |        |
| **Age (years)**         | 28      | 35     | 28     | 39\(^1\) | —      | —      |
| **Onset of DM**         | [25–35] | 28     | 28     | 39\(^1\) | —      | —      |
| **At LSG/LAGB**         | 33      | 36     | 33     | 37     | 28     | 28     |
| **At delivery**         | 36      | 36     | 36     | 40     | 30     | 32     |
| **Interval between LSG/LAGB and conception (months)** | 28      | 16     | 27     | 30     | 28     | 36     |
| **Primiparous (%)**     | 80.0%   | No\(^2\) | Yes    | Yes    | Yes    | Yes    |
| **Body mass index**     |         |        |        |        |        |        |
| **At LSG/LAGB**         | 33.6    | 33.6   | 30.0   | 58.8   | 39.4   | 33.6   |
| **At conception**       | 28.3    | 28.5   | 27.1   | 44.6   | 28.3   | 22.9   |
| **At delivery**         | 30.3    | 33.1   | 28.4   | 49.8   | 30.3   | 28.1   |
| **GW at delivery (weeks)** | 38.9  | 38.9   | 32.6   | 37.6   | 40.4   | 40.0   |
| **Cesarean section (%)** | 40.0%   | No\(^3\) | Yes\(^3\) | Yes\(^4\) | No    | No    |
| **Live birth**          | 100%    | Yes    | Yes    | Yes    | Yes    | Yes    |
| **Infant abnormalities** | 0.0%    | No     | No     | No     | No     | No     |
| **Birthweight (g)**     | 2,890   | 3,005  | 1,736  | 2,705  | 2,890  | 3,270  |
| **Birthweight SD**      | 0.03    | 0.03   | 0.01   | 0.30   | −0.48  | 0.37   |
| **Sterility before conception** | 20.0%  | Yes\(^5\) | No     | No     | No     | No     |
| **DM at conception and complications, type** | 60.0%  | Yes\(^6\) | Yes\(^6\) | Yes\(^6\) | Overt | No\(^7\) |
| **Onset of GDM**        | 0.0%    | No     | No     | No     | No     | No     |
| **CH at conception**    | 40.0%   | Yes    | Yes    | No     | No     | No     |
| **Onset of HDP and type** | 60.0%  | Yes\(^8\) | Yes\(^8\) | Yes\(^8\) | PE\(^8\) | No     |

Data are presented as median (minimum–maximum) or frequency. LSG, laparoscopic sleeve gastrectomy; LAGB, laparoscopic adjustable gastric banding; DM, diabetes mellitus; GW, gestational weeks; SD, standard deviation; GDM, gestational diabetes mellitus; CH, chronic hypertension; sPE, superimposed preeclampsia; PE, preeclampsia; Overt, overt diabetes in pregnancy.

\(^1\)Overt diabetes in pregnancy was diagnosed during the early period of pregnancy. \(^2\)The patient had a previous vaginal delivery with preeclampsia (hypertension plus proteinuria) but without GDM, and had a live birth (female infant of 3,430 g at 39 GW) before undergoing LSG. She was diagnosed with diabetes mellitus four years after the delivery. \(^3\)The patient underwent LSG due to the onset of abruptio placentae induced by PE. \(^4\)The patient underwent LSG after experiencing arrest of labor. \(^5\)The sterility caused by polycystic ovary syndrome was treated with clomifene. \(^6\)The patient had diabetic nephropathy, diabetic retinopathy, and diabetic neuropathy. \(^7\)The patient had impaired glucose tolerance before LSG. \(^8\)sPE or PE was diagnosed as hypertension and proteinuria.
months. Her BMI was 30.0 at the time of BS, 27.1 before conception, and 28.4 at delivery. She was treated for mild hypertension before conception and subsequently developed superimposed preeclampsia (severe hypertension plus proteinuria). She delivered a live preterm infant at 32 GW via cesarean section due to abruptio placentae caused by preeclampsia. The infant weighed 1,736 g and was AGA (SD + 0.01), with no abnormalities. At 24 months after delivery, the patient had hypertension and DM and was being treated with oral medications. She had no subsequent pregnancy.

**Case 3**

A 40-year-old nulliparous woman underwent LSG at age 37 to treat her obesity. The interval between BS and conception was 30 months. Her BMI was 58.8 at the time of BS, 44.6 before conception, and 49.8 at delivery. She had no hypertension before conception but was diagnosed early on with overt diabetes in pregnancy. She developed preeclampsia (severe hypertension plus proteinuria) and delivered a live infant vaginally at 37 GW. The infant weighed 2,705 g and was AGA (SD + 0.30), with no abnormalities. At 35 months after delivery, the patient had hypertension and DM and was being treated with oral medications. She had no DM or subsequent pregnancy.

**Case 4**

A 30-year-old nulliparous woman underwent LSG at age 28 to treat her obesity. The interval between BS and conception was 28 months. Her BMI was 39.4 at the time of BS, 28.3 before conception, and 30.3 at delivery. She had no hypertension before conception and did not develop preeclampsia or GDM. She delivered a live infant vaginally at 40 GW. The infant weighed 2,890 g and was AGA (SD − 0.48), with no abnormalities. At 25 months after delivery, the patient had no hypertension, DM, or subsequent pregnancy.

**Case 5**

A 32-year-old nulliparous woman underwent LAGB at age 28 to treat her obesity. The interval between BS and conception was 36 months. Her BMI was 33.6 at the time of BS, 22.9 before conception, and 28.1 at delivery. She had no hypertension before conception and did not develop preeclampsia or GDM. She delivered a live infant vaginally at 40 GW. The infant weighed 3,270 g and was AGA (SD + 0.37), with no abnormalities. At 37 months after delivery, the patient had no hypertension, DM, or subsequent pregnancy.

**Discussion**

This case series study yielded the following three observations: 1) the frequency of subsequent deliveries after BS was 0.0039% in 2018 in Japan; 2) pregnant women with previous BS had higher incidence rates of DM (60.0%) and chronic hypertension (40.0%) at conception than those in the control group; and 3) three pregnant women (60.0%) with previous BS who had DM at conception developed preeclampsia.

To our knowledge, this is the first study to report that Japanese pregnant women, especially those with DM, who had undergone BS had a high risk of preeclampsia. In terms of risk factors for preeclampsia, three women in the present study were at advanced maternal age (≥35 years), one woman had obesity before becoming pregnant (BMI ≥ 30.0), three women were overweight before becoming pregnant (25.0 ≤ BMI < 30.0), two women had chronic hypertension, and four women had type 2 DM (including a history of DM before BS) or overt diabetes in pregnancy. Even though these women had undergone BS before becoming pregnant, they might have still developed preeclampsia because they were at high risk. Thus, Japanese pregnant women with a history of BS might still be at high risk of developing preeclampsia.

In all five pregnant women, BMI decreased between BS and conception and increased between conception and delivery (Figure 1A). The decrease in BMI between BS and conception was especially high (> 10.0) in three women (60.0%, Cases 3–5).

Among previous retrospective studies on pregnant women with a history of BS (Table 2), one study reported that pregnant women who had undergone BS had a significantly lower incidence of GDM, but with an increased incidence of low birthweight (<2,500 g) infants. Another retrospective study reported that, compared with women who were no longer obese at conception, women who were still obese at conception delivered infants at a significantly lower gestational age and had higher rates of preterm delivery and lower birthweight, and that maternal outcomes of pregnant women with previous BS were poor due to a high incidence of preeclampsia. This occurred because pregnant women who had undergone BS to treat DM, but who still had DM at conception, also had chronic hypertension at conception. Notably, the incidence of type 2 DM is higher in Japan than in the United States or Western Europe. In a recent study in Japan, type 2 DM was reported to be a risk factor for preeclampsia, and the prevalence of preeclampsia was 0.2–9.2%.

According to the ACOG, “contraceptive counseling is important for adolescents because pregnancy rates after BS are double the rate in the general adolescent population (Level B)”. Previous retrospective studies have found a relationship between outcomes of pregnancies and the interval between BS and conception. Compared with pregnant women who conceived within the first 18 months postoperatively, those who conceived later had
a higher BMI at conception, higher gestational weight gain, and lower hemoglobin levels in early-pregnancy and post-delivery periods. In the present study, the decrease in BMI between BS and conception in one woman who conceived early after BS (Case 1) was similar to the median decrease in BMI of four women who conceived later (Cases 2–5) (Figure 1A). However, the median decrease in BMI between BS and conception in two women who had undergone BS to treat DM and obesity (Cases 1–2) was significantly lower than that of the three women without DM, who had undergone BS to treat only obesity (Cases 3–5).

Women who become pregnant after undergoing BS have a high incidence of maternal anemia. Maternal anemia reportedly occurred in 24.2% and 15.6% of pregnant women with previous BPD and RYGB, respectively. Among Japanese pregnant women who had undergone MS, 69% developed maternal anemia (hemoglobin < 11 g/dl), and their neonates had a lower median birthweight than neonates of those who had undergone LAGB or LSG. Trends of hemoglobin levels in the five women included in the present study (Figure 1B) indicate that three women (60.0%, Cases 1–3) developed maternal anemia (hemoglobin < 11 g/dl).

Previous studies have compared the maternal and neonatal outcomes of pregnant women who had undergone two or three types of BS. Pregnant women with previous RYGB had a greater weight loss compared to those with a history of LSG, although the mean weight before pregnancy and weight gain during pregnancy were similar between the two groups. While pregnant women with previous LAGB had a higher maternal weight gain and a higher incidence of gestational hypertension, those with previous MS had a higher incidence of maternal anemia and a lower neonatal birth weight. Thus, LAGB and MS might not be the best options for BS in Japanese women who wish to become pregnant later. Among the five women included in the present study, the oldest woman, who underwent LAGB in 2014, had the longest interval between BS and conception; the remaining four women underwent LSG. In recent years, LSG has become the most common BS performed in Japan, and fortunately may be the type of BS performed in the future for all women in Japan who desire subsequent pregnancies.

In a previous report, pregnant women with previous BS often presented with deficiencies of iron, vitamin B12, zinc, and vitamin D. In Japan, pregnant women with vitamin D deficiency are particularly rare. Thus, most obstetricians would not emphasize the importance
Table 2. Summary of previous studies reporting the maternal and neonatal outcomes of pregnant women with previous bariatric surgery (BS)

| Participants | Risk factors | Higher incidence | Lower incidence |
|--------------|--------------|------------------|-----------------|
| **Case control study** | | | |
| Johansson K (Sweden)\(^3\) | 670 women Control: 627,023 | · Low birthweight (< 2,500 g) infants | · GDM |
| Rottenstreich A (United States)\(^4\) | 119 women Matched control: 119 | · Lower birthweight infants | · GDM |
| **Case cohort study** | | | |
| France\(^5\) | 54 women 63 pregnancies | Still obese at conception | · Lower gestational age | · Preterm delivery | · Lower birthweight |
| Rottenstreich A (Israel)\(^9\) | 154 women | Conception within the first 18 months after BS | · Higher gestational weight gain | · Lower hemoglobin levels in early pregnancy and after delivery |
| Basbug A (Turkey)\(^10\) | 23 women | Conception within the first 18 months after BS | · Higher BMI at conception | · Higher early dumping syndrome |
| Portugal\(^14\) | 39 women | | · Preterm delivery |
| **Case cohort study - Types of BS** | | | |
| Mead NC (Greece)\(^11\) | 113 women 150 children (BPD, RYGB, and SG) | BPD and RYGB | · Maternal anemia |
| Watanabe A (Japan)\(^12\) | 24 women (LAGB, LSG, and MS) | LAGB | · Higher maternal weight gain | · Higher gestational hypertension |
| | | MS | · Maternal anemia (hemoglobin < 11 g/dl) | · Lower neonatal birth weight |
| Coupaye M (France)\(^13\) | 123 women (RYGB and SG) | RYGB | · Higher maternal weight loss after BS |
| **Systematic review** | | | |
| Schenkelars N\(^15\) | 110 full-text (29 detailed) | | · HDP | · Preeclampsia |
| Akhter Z\(^16\) | 33 studies 14,880 pregnancies after BS 3,979,978 controls | | · Perinatal mortality | · LGA infants |
| Al-Nimr Ri\(^17\) | 13 studies | | · Lower birthweight infants |
| Kwong W\(^18\) | 20 studies 8,364 women after BS 2,800,000 controls | | · SGA infants | · GDM |
| Yi XY\(^19\) | 11 studies | | · SGA infants | · GDM |

HDP: Hypertensive disorder in pregnancy; LGA: Large for gestational age; SGA: Small for gestational age; NICU: Neonatal intensive care unit; FGR: Fetal growth restriction.
of measuring vitamin D levels during pregnancy. In fact, all women in the present study had not had their vitamin B12, zinc, and vitamin D levels checked throughout the course of pregnancy.

Since 2015, several systematic reviews have been conducted on pregnant women with previous BS (Table 2). Most of these reviews reported that pregnant women with previous BS had lower incidence rates of GDM, hypertensive disorders of pregnancy, and macrosomia infants, but higher incidence rates of preterm birth and small-for-gestational-age infants. Some also described surgical complications, especially internal herniation during pregnancy, associated with previous BS during pregnancy. In the present study, none of these surgical complications were noted.

The strength of this study is that it included women from four different institutions in Japan who delivered infants after previous BS. Thus, there is less bias in this study compared to studies involving only one institution. However, the present study also has a limitation worth mentioning, namely, the small sample size. Further case-control studies with larger numbers of participants will be necessary.

In conclusion, Japanese pregnant women with previous BS had a high incidence of preeclampsia. Some pregnant women who had undergone BS to treat DM still had DM, as well as chronic hypertension, at conception.

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Conflict of interest

The authors declare that they have no conflicts of interest regarding the publication of this case series.

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