

OBSTETRICS

The risk of adverse pregnancy outcome after bariatric surgery: a nationwide register-based matched cohort study

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OBJECTIVE: The aim of this study was to describe the risk of adverse obstetric and neonatal outcome after bariatric surgery.

STUDY DESIGN: Nationwide register-based matched cohort study of singleton deliveries after bariatric surgery during 2004–2010. Data were extracted from The Danish National Patient Registry and The Medical Birth Register. Each woman with bariatric surgery (exposed) was individually matched with 4 women without bariatric surgery (unexposed) on body mass index, age, parity, and date of delivery. Continuous variables were analyzed with the paired *t* test and binary outcomes were analyzed by logistic regression.

RESULTS: We identified 339 women with a singleton delivery after bariatric surgery (84.4% gastric bypass). They were matched to 1277 unexposed women. Infants in the exposed group had shorter mean gestational age (274 vs 278 days; $P < .001$), lower mean birthweight (3312 vs 3585 g; $P < .001$), lower risk of being large for gestational age (ad-

justed odds ratio, 0.31; 95% confidence interval, 0.15–0.65), and higher risk of being small for gestational age (SGA) (adjusted odds ratio, 2.29; 95% confidence interval, 1.32–3.96) compared with infants in the unexposed group. No statistically significant difference was found between the groups regarding the risk of gestational diabetes mellitus, preeclampsia, labor induction, cesarean section, postpartum hemorrhage, Apgar score less than 7, admission to neonatal intensive care unit or perinatal death.

CONCLUSION: Infants born after maternal bariatric surgery have lower birthweight, lower gestational age, 3.3-times lower risk of large for gestational age, and 2.3-times higher risk of SGA than infants born by a matched group of women without bariatric surgery. The impact on SGA was even higher in the subgroup with gastric bypass.

Key words: adverse pregnancy outcome, bariatric surgery, gastric bypass, pregnancy

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Obesity is associated with increased risk of several obstetric complications and the risks increase with increasing body mass index (BMI).¹ In obese and overweight women, a pregestational weight loss should therefore reduce the risk of complications such as preeclampsia, gestational diabetes mellitus (GDM), and large for gestational age (LGA) infants. When other weight loss attempts have failed, bariatric surgery offers a successful alternative against obesity.

An increasing number of obese patients worldwide have undergone bariatric surgery.² The most common procedures are the Roux-en-Y gastric bypass (RYGB) and the gastric banding.² Gastric bypass leads to weight loss through a combination of restriction of calories and malabsorption, while gastric banding acts through restriction alone. During the first postoperative year, the patients lose 30% of their excessive body weight, but nevertheless, most patients never achieve a normal BMI.³

The safety of pregnancy after bariatric surgery has been questioned by some case reports describing severe complications and even fetal death related to postoperative maternal and fetal malnutrition.⁴

Many studies have found a lower birthweight in children born by mothers with prior bariatric surgery compared with children born before surgery^{5–7} or to other control groups.^{8–12} Some studies have shown that the lower birthweight is associated with a reduced risk of macrosomia and delivery complications.^{6,13} Some studies^{8,11,13,14} describe a higher

risk of small for gestational age (SGA) infants after bariatric surgery, but only when compared with children born before bariatric surgery or to nonobese women, and not when compared with BMI-matched women without surgery.

With this nationwide study we aim to determine the risk of adverse obstetric and neonatal outcome after bariatric surgery by comparing pregnancy outcome in women with a delivery after bariatric surgery in Denmark to the risk in a BMI-, age-, and parity-matched group of women without bariatric surgery.

MATERIALS AND METHODS

The study is a nationwide register-based matched cohort study. The exposed group includes women with a singleton delivery during the period from January 2004 to December 2010 and prior bariatric surgery. The start of the inclusion period was chosen, because we wanted to match for prepregnancy BMI, which has only been systematically registered since 2004. Only the first postsurgery singleton delivery was included. Each woman

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in the exposed group was individually compared with 4 women with a singleton delivery and without prior bariatric surgery matched on prepregnancy BMI ($\pm 1 \text{ kg/m}^2$), maternal age ($\pm 1 \text{ year}$), parity, and date of delivery ($\pm 1 \text{ year}$). The unexposed women had to fulfill all 4 matching criteria but were otherwise randomly selected in the Danish Medical Birth Registry. The prepregnancy BMI was calculated using the self-reported height and prepregnancy weight registered by the women's general practitioners.

Data were retrieved from 2 sources; The Danish National Patient Register and The Danish Medical Birth Registry. The 2 registries were linked using the unique personal identification number from The Danish Civil Registration System,¹⁵ which includes all persons born alive or with permanent residence in Denmark. Data regarding the surgery was extracted from The Danish National Patient Register, where registration of all surgical procedures have been mandatory since 2003 and are encoded using the NOMESCO (Nordic Medico-Statistical Committee) Classification of Surgical Procedures. We used the codes for gastric bypass (KJDF10+11) and gastric banding (KJDF20+21). Data on maternal and fetal birth outcome were retrieved from The Danish Medical Birth Registry, which includes information on all live-born children and stillbirths after gestational age 22 weeks in Denmark and uses the *International Classification of Diseases* (ICD10).

Our primary outcome variables were gestational age and birthweight, which we used to determine whether the child was born preterm, SGA, or LGA. To calculate the risk of SGA and LGA we used the z-score, which is the deviation of the observed fetal weight from the estimated birthweight adjusted for sex and gestational age, as calculated by the formula by Marsál and coworkers.¹⁶ SGA was defined as z-score below 76% (-2 standard deviations [SDs]) and LGA as z-score above 124% ($+2$ SD). Secondary outcome variables were preeclampsia, labor induction, cesarean section, postpartum hemorrhage ($>500 \text{ mL}$), maternal hospitalization time, Apgar score at 5 min-

utes less than 7, admission to neonatal intensive care unit (NICU), and perinatal death.

Maternal and neonatal complications were defined as a data entry in the Danish Medical Birth Registry of GDM DO244*; preeclampsia included hemolysis, elevated liver enzymes and low platelet count (HELLP) DO14*; labor induction; cesarean section KMCA10*, postpartum hemorrhage $>500 \text{ mL}$ DO72*, Apgar score (5 minutes) less than 7 and admission to NICU. Regarding GDM, we also extracted data from The Danish National Patient Register because the registration of GDM in The Danish Medical Birth Registry did not include diagnosis from outpatient visits. Women with a diagnosis of preexisting diabetes mellitus were excluded from having a diagnosis of GDM. Preterm birth was defined as gestational age less than 37 weeks of gestation. Perinatal death was defined as stillborn or death within 7 days.

The study was approved by the Danish Data Protection Agency (J.nr. 2011-41-5763) and the Danish National Board of Health (J.nr. 7-505-29-1757/1).

Statistical methods

The accuracy of the matching criteria was checked by comparing the mean prepregnancy BMI, age, and parity between the exposed and the unexposed group using the *t* test. Differences between the 2 groups regarding the frequency of smokers were tested by the χ^2 test.

To make optimal use of the matched cohort design, continuous variables were compared using the paired *t* test. The outcome in the exposed women was compared with the mean outcome in the group of matched unexposed women weighted for the exact numbers of individually matched unexposed women in the group. If an exposed woman did not have any matched unexposed women, she was excluded in the analyses. For binary outcomes adjusted odds ratios (AORs) were calculated using logistic regression including the matching criteria and smoking. Data are presented as mean $\pm$ SD and AOR with 95% confidence intervals (CIs). The significance level was set to $P < .05$. Data were ana-

lyzed using STATA (release 12.1; Stata-Corp, College Station, TX).

RESULTS

We identified 355 women who had 1 or more births after bariatric surgery during the inclusion period from 2004-2010. The majority, 343 women (96.6%) had singletons. Twelve women (3.4%) had twins and were excluded. The operative procedure was RYGB in 286 (83.4%) women and gastric banding in 57 (16.6%) women. The median time from the bariatric surgery to the first postoperative birth was 629 days (range, 93-3452 days).

We were able to match 339 of the 343 singleton first deliveries after bariatric surgery. We were not able to find any matches to 4 women with gastric banding and they were excluded. Three of these women remained super obese (BMI, 48, 50, and 55 kg/m^2) and 1 had a parity of 5 at age 25. The 339 exposed women were matched on prepregnancy BMI, age, parity, and date of birth to 1344 unexposed women and after excluding 67, who delivered twins/triplets, we ended up with a 1277 unexposed women with a singleton delivery. The mean number of matched unexposed women to each exposed women were 3.8 (range, 1-4).

The 339 women treated with bariatric surgery (exposed) and the 1277 women without prior bariatric surgery (unexposed) had similar characteristics. The mean age at delivery was 31.4 years in the exposed group vs 31.3 years in the unexposed group ($P = .54$). Both groups were obese with a mean prepregnancy BMI of 32.4 and 32.2 kg/m^2 ($P = .44$), respectively. There was a higher frequency of smokers in the exposed group than in the unexposed group (21.2 vs 14.6%; $P < .01$).

Figures on gestational age, birthweight, and z-score are given in Table 1. Children born after maternal bariatric surgery (exposed) had a lower mean gestational age (274 vs 278 days; $P < .001$) compared with children without maternal bariatric surgery (unexposed), but there was no statistical significant difference in the frequency of preterm birth (<37 weeks) or birth after 42 weeks.

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