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# Obesity, diabetes, and the risk of infections diagnosed in hospital and post-discharge infections after cesarean section: a prospective cohort study

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**Key words**
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## Abstract

*Objective.* To assess the impact of obesity and diabetes on the risk of post-cesarean infections. *Design.* Prospective cohort study. *Setting.* Obstetric departments at three hospitals in Denmark. *Population.* 2,492 consecutive women having cesarean section (CS) from February 2007 to August 2008. *Methods.* We collected complete data from medical records and databases on CS, body mass index, diabetes (type 1, type 2, and gestational), and post-cesarean infections. Post-discharge infections diagnosed by general practitioners were ascertained through positive microbiological cultures and antibiotic prescriptions. *Main Outcome Measures.* Cumulative incidences of infections within 30 days after CS. *Results.* Of 2,492 women having CS, 373 (15.2%) were obese and 123 (4.9%) had diabetes. Overall, 458 women (18.4%) had a post-cesarean infection within 30 days and 174 (7.0%) were diagnosed in-hospital. The risk of post-cesarean infections was higher among obese than non-obese women: adjusted (for diabetes and emergency/elective CS) odds ratio (OR)=1.43; 95% confidence interval (CI): 1.09–1.88, particularly for in-hospital infections (OR=1.86; 95%CI: 1.28–2.72). After controlling for obesity and mode of CS, type 2 or gestational diabetes were weak predictors of infection risk (OR=1.18; 95%CI: 0.72–1.93), whereas the adjusted OR in women with type 1 diabetes was 1.65 (95%CI: 0.64–4.25). Among diabetic women, obesity increased the risk of post-cesarean infections more than twofold; the adjusted ORs were 2.06 (95%CI: 1.13–3.75) for infections overall and 2.74 (95%CI: 1.25–6.01) for in-hospital infections. *Conclusion.* Obesity increases the risk of post-cesarean infections and diabetes further strengthens this association.

**Abbreviations:** CS, cesarean section; BMI, body mass index; UTI, urinary tract infection; GP, general practitioner; OR, odds ratio; CI, confidence interval; HbA1c, glycosylated hemoglobin level.

## Introduction

The incidence of cesarean section (CS) deliveries is increasing rapidly in Europe and the rest of the world. In some regions in Latin America, 50% of all babies are currently delivered by CS (1). In Denmark, the proportion of CS has increased from 13% of all deliveries in 1997 to 22% in 2007 (2). Postpartum infection is one of the most frequent complications after CS (3–5). The source of infection can be endogenous, caused by the microbial flora present on the mother's skin, endometrium or cervix, or exogenous, caused by microbial contamination from the environment. To prevent post-cesarean infections, it is important to clarify the risk factors in pregnant women.

The prevalence of overweight and obesity as well as diabetes has increased rapidly worldwide, including in pregnant women (6–8). Obese women may have increased susceptibility to infections because of the effects of obesity on the immune system, skin barriers, wound healing, mobility, and coexisting chronic diseases including diabetes, which could increase infection risk by itself (9,10). Cohort studies have shown that women with a body mass index (BMI) $>30 kg/m^2$ have a two- to threefold increased risk of post-cesarean infection, such as wound infection, urinary tract infection (UTI), endometritis, or pneumonia, compared with non-obese women (5,11,12). Other studies found that obesity doubled the risk specifically for post-cesarean wound infection (13–16).

Three cohort studies reported a 1.4–2.5 times increased risk for post-cesarean wound infection for women with diabetes (14,17,18), whereas two other studies failed to find an association (19,20). BMI and diabetes are associated (9,21,22) and in one study it was found that the presence of diabetes and obesity together would increase the risk of wound infection ninefold (14). The existing studies have limitations; few were prospectively designed and, importantly, a minority of the studies included post-discharge infections (5,13,15,16,19). Moreover, women with type 1 diabetes may be at a higher risk of post-cesarean infection than women with type 2 or gestational diabetes because of a longer disease duration and higher serum glucose levels (23), yet few studies have examined different types of diabetes separately (20,24).

Little data exist on the possible effect of interaction between obesity and diabetes on the risk of post-cesarean infections. In this prospectively designed cohort study, we examined the 30-day risk of post-cesarean infection associated with obesity and diabetes in a large cohort of patients, with complete follow-up data on both infections diagnosed in hospital and post-discharge infections.

## Material and methods

This cohort study was conducted in the former Aarhus County of Denmark (0.65 million inhabitants) from 1 February 2007 to 31 August 2008. In Denmark, most health services are tax-financed and free of charge. All residents have free access to a general practitioner (GP) of their choosing and to all public hospitals for examinations, treatments, and giving birth. During the study period, virtually all births in the county took place at three public hospitals, two of which were district hospitals and one of which was a university hospital. Less than 1% of women gave birth at home and no children were born at private hospitals or clinics. Since 1968, all Danish residents are assigned a unique civil registration number that enables unambiguous electronic linkage between all administrative and medical databases.

All women who underwent CS during the 19-month study period were prospectively identified from operation lists recorded in the administrative system at each of the three hospitals. If the woman gave birth more than once during our study period, we only included the first birth. Only residents of the former Aarhus County were included. According to national guidelines, CS is categorized as elective if it was planned more than eight hours prior to delivery and the woman was not in labor; otherwise, it was categorized as an emergency CS. Since April 2007, the national guidelines have recommended administration of prophylactic antibiotics (cefuroxime 1.5g intravenously) be given to all women having CS just before the start of the operation. Prior to this date, prophylactic antibiotics were recommended only for women having emergency CS and were given after the umbilical cord was clamped. In all three hospitals, the Joel Cohen incision was applied, and epidural anesthesia and urinary catheter were used following similar guidelines.

### *BMI and diabetes*

Data on pre-pregnancy BMI ($kg/m^2$) and diabetes were obtained from birth forms completed by midwives.

We divided the cohort into BMI categories ($<20$, 20.0–24.9, 25.0–29.9, 30.0–34.9, and $\geq 35 kg/m^2$) similar to those used by WHO. However, we used another cut-off point for the lowest BMI category because there were only a few participants with BMI $<18.5 kg/m^2$. These categories incorporate the current definitions of overweight ($BMI=25.0–29.9 kg/m^2$) and obesity ($BMI \geq 30 kg/m^2$).

Diabetes was registered according to the *International Classification of Diseases* 10th revision (ICD-10) codes, as O24.0 for pre-gestational type 1 diabetes, O24.1 for pre-gestational type 2 diabetes, and O24.4 for gestational diabetes. Based on the observed sample size and clinical considerations, we classified diabetic women as having any diabetes (yes or no), and then also further subclassified diabetes as being type 1, type 2 or gestational diabetes. Information regarding current insulin treatment was obtained by linkage with the Prescription Databases of the former Aarhus County. All prescribed drugs are sold through pharmacies, which are equipped with a computerized accounting system registering data on outpatient drug prescriptions directly in the database of prescriptions. For the diabetic women, available glycosylated hemoglobin levels (HbA1c) within the last three months before delivery were also obtained from the County's laboratory database.

Baseline characteristics of the women and their deliveries were obtained from medical records and included parity (primi- or multiparous), type of hospital (district or university), mode of CS (emergency or elective), gestational age in weeks, duration of procedure in minutes, smoking habits (smoking during pregnancy or nonsmoker), length of stay at hospital after CS, and estimated intra-operational blood-loss ≥700ml (yes or no) (25).

## *Post-cesarean infections*

The main outcome in our study was any post-cesarean infection, defined as an infection diagnosed in hospital or post-discharge within 30 days after delivery (26).

To identify early and/or more severe infections we defined post-cesarean infections diagnosed in hospital as infections that were detected during the hospital admission for cesarean section, during hospital readmission, or at visits to hospital outpatient clinics within 30 days after delivery.

Detailed data regarding clinical signs of infection, body temperature, urine-stick screening results, readmissions, and reoperations because of infection within 30 days were obtained from hospital medical records. From the laboratory information system MADS, which contains the dates and results of all microbiologic cultures analyzed at the Department of Clinical Microbiology, Aarhus University Hospital, Skejby, since 1981 (27), we obtained dates of sampling and results of all microbiologic cultures performed at any of the county's hospitals or by GPs within 30 days after CS. From the Clinical Biochemistry Registry, which contains the dates and results of all biochemistry analyses from hospitals and GPs in the former Aarhus County, we obtained data on C-reactive protein and leukocyte counts. Data on antibiotic treatments during the hospital stay were obtained from the hospitals' electronic databases. Drugs were classified according to the Anatomical Therapeutic Chemical (ATC) system. From the Danish National Patient Registry, we obtained codes on discharge diagnosis and surgical procedures related to infections (28). The registry includes civil registration number, surgical procedures, and up to 20 hospital diagnoses. Diagnoses are coded by physicians according to the Danish version of the *International Classification of Diseases*, 10th revision (ICD-10). Surgical procedures are coded by physicians according to the *Nordic Classification of Surgical Procedures* (NCSP, Uppsala, Sweden, 2nd revision).

For the definition of infections diagnosed in hospital, we used a set of slightly modified criteria from the Centers for Disease Control and Prevention, Atlanta, GA, USA (26). We classified the women as having a UTI if they fulfilled at least one of two criteria. The first was a urine culture with ≥100,000 colony-forming units per ml (cfu/ml) plus one or more of the following clinical criteria recorded in their medical file: frequency, urgency, dysuria, or suprapubic tenderness. The second criterion was a UTI classified as one or more of these clinical criteria plus a positive dipstick for leukocytes and/or nitrate, or a urine culture with ≤100,000cfu/ml of a single pathogen in a patient treated with antibiotics for a UTI, or a clinical UTI diagnosis recorded in their medical file together with instituted antibiotic therapy if no positive urine culture was present.

We recorded a bloodstream infection if the woman had either a pathogen isolated from a blood culture or one or more of the following clinical signs recorded in her medical file: body temperature >38.0°C, chills, or hypotension together with any of the following: (1) a common skin contaminant isolated from two blood cultures drawn on separate occasions, (2) a common skin contaminant isolated from blood cultures from a patient with an intravascular access device and treatment with appropriate antimicrobial therapy, (3) a positive antigen test for pneumococci in the bloodstream.

We recorded a wound infection if the woman had one or more of the following criteria: (1) a positive culture from the operation wound or an associated abscess (deep, superficial, or organ/space); (2) purulent drainage from the wound noted in the medical file; (3) reoperation because of infection; or (4) a clinical diagnosis of post-cesarean wound infection made by a physician.

Endometritis was defined according to criteria from the Danish National Center for Hospital Hygiene (29) and recorded if the women had lower abdominal pain and/or discharge/bleeding from the cervix, and at least two of the following clinical signs or symptoms recorded in their medical files: body temperature >38.0°C, uterine tenderness, purulent drainage from the cervix, endometrial pathology shown by gynecologic examination or ultrasound, increased leukocyte count ($>12\times10^9$/l) or C-reactive protein (>200nmol/l), or a positive culture from the cervix or uterus.

Mastitis was defined as one of the following: (1) microorganisms isolated from a culture of the affected breast tissue or from fluid obtained by incision and drainage or by needle aspiration; (2) breast abscess or other evidence of infection seen during surgery or at histopathologic examination; or (3) temperature >38.0°C, local inflammation of the breast, and clinical diagnosis of mastitis made by a physician.

Suspected infection was categorized as a body temperature >38.0°C, blood cultures negative or not done, no apparent focus of infection, and started on antibiotic therapy. To avoid inclusion of infections that were already present or incubating at the time of delivery, we did not include infections for which antibiotic treatment was started and/or positive cultures were obtained on the date of delivery.

We defined post-discharge infections as infections diagnosed outside of the hospital by the woman's GP. These infections were identified either by the presence of a positive microbiological culture in the laboratory information system submitted by the GP after discharge, or a record of any antibiotic prescription filled after discharge from the hospital. Data on antibiotics retrieved after discharge were obtained from the Prescription Databases of the former Aarhus County. This database includes all prescriptions filled for drugs that are reimbursed by the National Health Service, and excluded only a few types of systemic antibiotics, i.e. quinolones, tetracyclines, and ointments containing antibiotics.

### *Statistical analyses*

We followed all women from the date of their CS until 30 days after that date. We computed the cumulative incidence of any infection (diagnosed in hospital or post-discharge) according to our two main exposure variables; the presence of obesity (BMI $\geq$30kg/m$^2$) compared with an absence of obesity (BMI $<$30kg/m$^2$), and any diabetes compared with no diabetes. Furthermore, we estimated the risk of infection diagnosed in hospital or post-discharge infection according to different BMI categories compared with the reference BMI category of 20.0–24.9kg/m$^2$. We also analyzed the risk of infection diagnosed in hospital or post-discharge infection according to the types of diabetes. To evaluate whether the presence of diabetes strengthened any association between obesity and infection, we repeated the analyses for obesity while stratifying by the presence of diabetes, using women who had neither obesity nor diabetes as the reference group (30). Diabetes-stratified analyses were also performed for severe obesity (BMI$\geq$35).

In all analyses, we used multivariable logistic regression to estimate relative risks represented by odds ratios (ORs) with 95% confidence intervals (CIs) of post-cesarean infections while adjusting for mode of delivery (emergency CS/elective CS), and the presence of diabetes (yes/no) or obesity (yes/no).

Data were analyzed using STATA 9.2 (Stata Corporation, College Station, TX, USA).

The study was conducted according to the guidelines of the regional scientific ethics committee for use of clinical and laboratory data and approved by the Danish Data Protection Agency (No. 2006-41-6766).

## Results

A total of 2,492 women who had CS were included. Of these, 1,372 required an emergency CS (55.1%) and 1,120 underwent elective CS (44.9%). Maternal characteristics according to the presence or absence of obesity and/or diabetes are listed in Table 1. Obesity was present in 373 (15.2%) of 2,461 women (data on BMI was missing for 31 women) and 555 (22.6%) were overweight (Table 2). There were 123 (4.9%)

**Table 1.** Demographic and obstetric characteristics of 2,492 women having cesarean sections in Aarhus County, Denmark, between February 2007 and August 2008, according to the presence of obesity or diabetes.

| Characteristics | Total N=2,492 | Non-obese women BMI<30kg/m$^2$ N=2,088[a] | Obese women BMI≥30kg/m$^2$ N=373[a] | Non-diabetic women N=2,369 | Diabetic women N=123 |
|---|---|---|---|---|---|
| *Mode of cesarean section* | | | | | |
| Elective | 1,120 | 949 (45.5%) | 161 (43.2%) | 1,064 (44.9%) | 56 (45.5%) |
| Emergency | 1,372 | 1,138 (54.5%) | 212 (56.8%) | 1,305 (55.1%) | 67 (54.5%) |
| *Gestational age* (weeks)[b] | 2,489 | 38.4 ± 2.6 | 38.4 ± 2.5 | 38.4 ± 2.6 | 37.9 ± 1.9 |
| *Parity* | | | | | |
| Primiparous | 1,108 | 957 (46.3%) | 141 (38.6%) | 1,065 (45.5%) | 43 (35.5%) |
| Multiparous | 1,354 | 1,109 (53.7%) | 224 (61.4%) | 1,276 (54.5%) | 78 (64.5%) |
| Missing | 30 | 22 | 8 | 28 | 2 |
| *Estimated blood loss* | | | | | |
| <700ml | 2,283 | 1,917 (94.2%) | 336 (92.3%) | 2,173 (94.0%) | 110 (92.4%) |
| ≥700ml | 147 | 119 (5.8%) | 28 (7.7%) | 138 (6.0%) | 9 (7.3%) |
| Missing | 62 | 52 | 9 | 58 | 4 |
| *Duration of CS procedure* (min)[b] | 2,205 | 25.4 ± 10.8 | 29.6 ± 10.7 | 26.0 ± 10.9 | 27.5 ± 10.9 |
| *Type of hospital* | | | | | |
| District hospital | 818 | 655 (31.4%) | 161 (43.2%) | 795 (33.6%) | 23 (18.7%) |
| University hospital | 1,674 | 1,433 (68.7%) | 212 (56.8%) | 1,574 (66.4%) | 100 (81.3%) |
| *Maternal age* (years)[b] | 2,409 | 32.0 ± 4.7 | 32.4 ± 4.9 | 32.0 ± 4.7 | 33.6 ± 4.8 |
| *Smoking habit* | | | | | |
| Nonsmoker | 2,082 | 1,762 (84.4%) | 305 (81.8%) | 1,982 (83.7%) | 100 (81.3%) |
| Smoking during pregnancy | 269 | 216 (10.3%) | 46 (12.3%) | 253 (10.7%) | 16 (13.0%) |
| Unknown | 141 | 110 (5.3%) | 22 (5.9%) | 134 (5.7%) | 7 (5.7%) |
| *Length of stay after CS* (days)[b] | 2,492 | 4.06 ± 3.65 | 4.12 ± 3.96 | 4.05 ± 3.70 | 4.48 ± 3.32 |

BMI, body mass index; CS, cesarean section.
[a]BMI not available in 31 women.
[b]Values are presented as mean ± SD.

**Table 2.** Association between body mass index, diabetes, and any infection within 30 days post-cesarean section in 2,492 women.

| BMI[a] (kg/m²) | No. of CS | No. (%) with infection | Crude OR | 95%CI | Adjusted OR[b] | 95%CI |
|---|---|---|---|---|---|---|
| <30 | 2,088 | 365(17.5) | 1 (ref) | | | |
| ≥30 | 373 | 89(23.9) | 1.48 | 1.14–1.93 | 1.43 | 1.09–1.88 |
| <20.0 | 311 | 64(20.6) | 1.26 | 0.92–1.72 | 1.29 | 0.94–1.76 |
| 20.0–24.9 | 1,222 | 209(17.1) | 1 (ref) | | | |
| 25.0–29.9 | 555 | 92(16.6) | 0.96 | 0.74–1.26 | 0.96 | 0.73–1.25 |
| 30.0–34.9 | 225 | 43(19.1) | 1.15 | 0.80–1.65 | 1.12 | 0.78–1.62 |
| 35.0–39.9 | 103 | 32(31.1) | 2.18 | 1.40–3.40 | 2.11 | 1.35–3.32 |
| ≥40 | 45 | 14(31.1) | 2.19 | 1.14–4.19 | 2.10 | 1.09–4.06 |
| Diabetes | No. of CS | No. (%) with infection | Crude OR | 95%CI | Adjusted OR[c] | |
| Diabetes (all) | 123 | 29(23.6) | 1.40 | 0.91–2.14 | 1.26 | 0.81–1.96 |
| No diabetes | 2,369 | 429(18.1) | 1 (ref) | | | |
| Type 2 + GestD | 100 | 23(23.0) | 1.35 | 0.84–2.18 | 1.18 | 0.72–1.93 |
| Type 1 | 23 | 6(26.1) | 1.60 | 0.63–4.07 | 1.65 | 0.64–4.25 |

BMI, body mass index; CS, cesarean section; Gest D, gestational diabetes; OR, odds ratio.
[a]BMI not available for 31 women.
[b]Adjusted for diabetes (yes/no) and mode (emergency/elective) of CS.
[c]Adjusted for BMI <30/≥30kg/m² and mode (emergency/elective) of CS.

diabetic women, of whom 23 women had type 1, 10 had type 2, and 90 had gestational diabetes (Table 2). Measurements of HbA1c were available within the last three months before delivery in 90 (73.2%) of the diabetic women. The median HbA1c was 6.1% (interquartile range 5.5–6.7%).

In total, 458 (18.4%) acquired at least one infection within 30 days after CS (Table 2). Among the women with emergency CS, 281 (20.5%) acquired an infection, 131 (9.5%) of which were diagnosed in hospital. Of women with elective CS, 177 (15.8%) acquired an infection, 43 (3.8%) of which were diagnosed in hospital. Overall, 3.3% had an in-hospital diagnosed wound infection (data not shown). Compliance with recommendations of prophylactic antibiotics was fulfilled in 96% of women with emergency CS and in 76% of women with elective CS.

The risk of post-cesarean infection was 23.9% for obese women vs. 17.5% in non-obese women (Table 2), corresponding to an adjusted OR after controlling for presence of diabetes and mode of CS of 1.43 (95%CI: 1.09–1.88). The ORs of infection in different BMI categories compared with normal weight are presented in Table 2. Severe obesity was associated with a 2.1-fold (95%CI: 1.35–3.32) increased risk of infection, and very severe obesity (BMI≥40kg/m$^2$) was associated with a similar 2.1-fold (95%CI: 1.09–4.06) increased risk. Restricting the infections to infections diagnosed in hospital further strengthened the adjusted risk estimate in women with very severe obesity (Table 3).

The risk of post-cesarean infection was 23.6% for diabetic and 18.1% for non-diabetic women, corresponding to an adjusted OR of 1.18 (95%CI: 0.76–1.82) (Table 2). Among women with type 1 diabetes, we found an adjusted OR of 1.65 (95%CI: 0.64–4.25) (Table 2), whereas restriction to in-hospital infections resulted in a twofold increased risk, with an OR=2.07 (95%CI: 0.60–7.21) (Table 3). There was no clear association between HbA1c >6.1% and post-cesarean infection, neither for any infection (OR=0.94, 95%CI: 0.36–2.46) nor hospital-diagnosed infection (OR=0.95, 95%CI: 0.27–3.36).

Tables 4 and 5 show the risk of infections associated with diabetes alone, obesity alone, and diabetes and obesity combined. The combination of diabetes and obesity was associated with a highly increased risk of any infection (OR=2.06; 95%CI: 1.13–3.75) and of any in-hospital infection (OR=2.74; 95%CI: 1.25–6.01).

## Discussion

In this prospective cohort study including nearly 2,500 women who had CS, we found that obesity was associated with 43% higher odds of experiencing any post-cesarean infection within 30 days, and an 86% increased risk of having an infection diagnosed in hospital. Type 2 or gestational diabetes showed only a modestly increased risk of post-cesarean infections, which nearly disappeared when controlled for the presence of obesity. The estimates in our study were higher, in particular for women with very severe obesity (BMI≥40kg/m$^2$), when analyzing only infections diagnosed in hospital, compared with infections in general. This could be an expression of infections associated with obesity and/or diabetes during the early post-cesarean period, which would presumably be the most severe infections and might require hospital readmission.

**Table 3.** Association between body mass index, diabetes, and post-cesarean infection diagnosed in hospital in 2,492 women with cesarean section.

| BMI[a] kg/m$^2$ | No. of CS | No. (%) with infection | Crude OR | 95%CI | Adjusted OR[b] | 95%CI |
|---|---|---|---|---|---|---|
| <30 | 2,088 | 129(6.2) | 1 (ref) | | | |
| ≥30 | 373 | 42(11.3) | 1.93 | 1.33–2.78 | 1.86 | 1.28–2.72 |
| <20.0 | 311 | 20(6.4) | 1.01 | 0.61–1.67 | 1.08 | 0.64–1.78 |
| 20.0–24.9 | 1,222 | 78(6.4) | 1 (ref) | | | |
| 25.0–29.9 | 555 | 31(5.6) | 0.87 | 0.57–1.33 | 0.87 | 0.56–1.33 |
| 30.0–34.9 | 225 | 22(9.8) | 1.59 | 0.97–2.61 | 1.56 | 0.94–2.58 |
| 35.0–39.9 | 103 | 12(11.7) | 1.93 | 1.02–3.68 | 1.88 | 0.97–3.62 |
| ≥40 | 45 | 8(17.8) | 3.17 | 1.43–7.04 | 3.11 | 1.37–7.10 |
| Diabetes | No. of CS | *No.(%)withinfection* | Crude OR | 95%CI | Adjusted OR[c] | |
| Diabetes all | 123 | 12(9.8) | 1.47 | 0.79–2.73 | 1.23 | 0.65–2.34 |
| No diabetes | 2,369 | 162(6.8) | 1 (ref) | | | |
| Type 2 + GestD | 100 | 9(9.0) | 1.35 | 0.67–2.72 | 1.08 | 0.52–2.23 |
| Type 1 | 23 | 3(13.0) | 2.04 | 0.60–6.95 | 2.07 | 0.60–7.21 |

BMI, body mass index; CS, cesarean section; Gest D, gestational diabetes; OR, odds ratio.
[a]BMI not available for 31 women.
[b]Adjusted for diabetes (yes/no) and mode (emergency/elective) of CS.
[c]Adjusted for BMI <30/≥30kg/m$^2$ and mode (emergency/elective) of CS.

**Table 4.** Obesity, severe obesity, and crude and adjusted 30-day ORs for any post-cesarean infection stratified by diabetes in 2,492 women with cesarean section.

| | Post-cesarean infection n=458 | No post-cesarean infection n=2,034 | Crude OR (95%CI) | Adjusted OR (95%CI) |
|---|---|---|---|---|
| Obesity, unstratified[a] | | | | |
| BMI <30kg/m$^2$ | 365 | 1,723 | 1 (ref) | |
| BMI ≥30kg/m$^2$ | 89 | 284 | 1.48 (1.14–1.93) | 1.43 (1.09–1.88)[b] |
| Severe obesity, unstratified[a] | | | | |
| BMI <35kg/m$^2$ | 408 | 1,905 | 1 (ref) | |
| BMI ≥35kg/m$^2$ | 46 | 102 | 2.11 (1.46–3.03) | 2.04 (1.40–2.95)[b] |
| Obesity, stratified[a] | | | | |
| BMI <30kg/m$^2$ | | | | |
| No diabetes | 352 | 1,667 | 1 (ref) | |
| Diabetes present | 13 | 56 | 1.10 (0.59–2.03) | 1.10 (0.59–2.03)[c] |
| BMI ≥30kg/m$^2$ | | | | |
| No diabetes | 73 | 247 | 1.40 (1.05–1.86) | 1.39 (1.04–1.85)[c] |
| Diabetes present | 16 | 37 | 2.05 (1.13–3.72) | 2.06 (1.13–3.75)[c] |
| Severe obesity, stratified[a] | | | | |
| BMI <35kg/m$^2$ | | | | |
| No diabetes | 389 | 1,831 | 1 (ref) | |
| Diabetes present | 19 | 74 | 1.21 (0.72–2.02) | 1.20 (0.72–2.01)[c] |
| BMI ≥35kg/m$^2$ | | | | |
| No diabetes | 36 | 83 | 2.04 (1.36–3.06) | 2.02 (1.35–3.04)[c] |
| Diabetes present | 10 | 19 | 2.48 (1.14–5.37) | 2.55 (1.17–5.54)[c] |

BMI, body mass index; OR, odds ratio.
[a]BMI not available for 31 women.
[b]Adjusted for diabetes (yes/no) and mode (emergency/elective) of CS.
[c]Adjusted for mode (emergency/elective) of CS.

In a USA study, Myles et al. (12) found an increased risk of post-cesarean infections diagnosed in hospital (data from hospital admissions and outpatient clinics, follow-up duration not defined) in obese women compared with normal weight women with an unadjusted relative risk of 3.0. The post-cesarean proportion of infections diagnosed in hospital was 14.8%, compared with 7.0% in our study. In a matched cohort study, Riley et al. (20) compared the presence of post-cesarean infections diagnosed in hospital (endometritis, wound infection, and septic pelvic thrombophlebitis,

**Table 5.** Obesity, severe obesity, and crude and adjusted 30-day ORs for post-cesarean infection diagnosed in hospital stratified by diabetes in 2,492 women with cesarean section.

| | In-hospital infection n=174 | No in-hospital infection n=2,318 | Crude OR (95%CI) | Adjusted OR (95%CI) |
|---|---|---|---|---|
| Obesity, unstratified[a] | | | | |
| BMI $<$30kg/m$^2$ | 129 | 1,959 | 1 (ref) | |
| BMI $\geq$30kg/m$^2$ | 42 | 331 | 1.93 (1.33–2.78) | 1.86 (1.28–2.72)[b] |
| Severe obesity, unstratified[a] | | | | |
| BMI $<$35kg/m$^2$ | 151 | 2,162 | 1 (ref) | |
| BMI $\geq$35kg/m$^2$ | 20 | 128 | 2.24 (1.36–3.69) | 2.15 (1.28–3.59)[b] |
| Obesity, stratified[a] | | | | |
| BMI $<$30kg/m$^2$ | | | | |
| No diabetes | 125 | 1,894 | 1 (ref) | |
| Diabetes present | 4 | 65 | 0.93 (0.33–2.60) | 0.93 (0.33–2.60)[c] |
| BMI $\geq$30kg/m$^2$ | | | | |
| No diabetes | 34 | 286 | 1.80 (1.21–2.68) | 1.77 (1.19–2.65)[c] |
| Diabetes present | 8 | 45 | 2.69 (1.24–5.84) | 2.74 (1.25–6.01)[c] |
| Severe obesity stratified[a] | | | | |
| BMI $<$35kg/m$^2$ | | | | |
| No diabetes | 143 | 2,077 | 1 (ref) | |
| Diabetes present | 8 | 85 | 1.37 (0.65–2.88) | 1.35 (0.64–2.85)[c] |
| BMI$\geq$35kg/m$^2$ | | | | |
| No diabetes | 16 | 103 | 2.26 (1.30–3.92) | 2.20 (1.26–3.85)[c] |
| Diabetes present | 4 | 25 | 2.32 (0.80–6.77) | 2.52 (0.85–7.46)[c] |

BMI, body mass index; OR, odds ratio.
[a]BMI not available for 31 women.
[b]Adjusted for diabetes (yes/no) and mode (emergency/elective) of CS.
[c]Adjusted for mode (emergency/elective) of CS.

follow-up duration not defined) in women with insulin-treated diabetes with that of non-diabetic controls. The authors found no difference in the risk of post-cesarean infections diagnosed in hospital between the two groups. In contrast, Takoudes et al. (18) found a clearly increased risk of post-cesarean wound infections (data from hospital admissions and outpatient clinics) in women with pre-gestational type 1 or 2 diabetes compared with non-diabetic women, but follow-up time was twice as long in the diabetic women.

We analyzed pre-gestational type 1 diabetic women separately and found a 2.1-fold increased risk of infections diagnosed in hospital, although statistical precision was limited. Schneid-Kofman et al. (14) found a 3.7% prevalence of wound infections diagnosed in hospital, which is close to our result of 3.3%. Our finding that the combination of diabetes and obesity increased the risk of infections more than expected is also in line with Schneid-Kofman et al., who found a ninefold increased risk of post-cesarean wound infection in the presence of both diabetes and obesity. We extended these findings by showing that diabetes combined with a BMI $<$30kg/m$^2$ does not seem to confer any substantially increased risk of infection. As an additional finding we observed a slightly increased risk (adjusted OR 1.29) of post-cesarean infections in women with a BMI $<$20. This finding could be a marker for malnutrition impairing normal immune function or undiagnosed subclinical conditions.

This study has strengths and limitations. The main strengths of our study are its large size and the complete follow-up for post-discharge infections, including those treated by the women's GPs. We had almost complete, prospectively collected BMI values. If the obese women had understated their pre-pregnancy weight, the association between baseline obesity and risk of infection would be overestimated. Also, obese women may have gained further excessive weight during pregnancy, but unfortunately, we had no data on the weight gain. Moreover, physicians may have followed obese women more closely for infection, or have been more likely to start antibiotic treatment and/or hospitalize obese women with infection as compared with leaner women. Such a bias would also cause an overestimation of the relative risk associated with obesity.

We prospectively collected detailed data and validated all episodes of infections diagnosed in hospital. However, our post-discharge infection outcomes rely partly on antibiotic prescriptions, which were not independently validated, as surrogate markers of infection. Although we adjusted for important mutual confounding by obesity and diabetes as well as for mode of CS, other potential confounders may have affected our risk estimates. Finally, even in this large study, we had limited statistical precision for estimating the risk of post-cesarean infections associated with diabetes.

In conclusion, our results show that obesity is associated with a markedly higher risk of post-cesarean infections, whereas diabetes does not seem to increase infection risk substantially among non-obese women. Obesity is a lifestyle symptom that is difficult to deal with during pregnancy; therefore, efforts to reduce obesity in women should be made before they reach childbearing age in addition to the necessary efforts during pregnancy.

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