Outcome of subsequent pregnancies in women with complete uterine rupture: A population-based case–control study

Dorthe Louise Ahrenkiel Thisted1,2 | Steen Christian Rasmussen3 | Lone Krebs3,4

1Department of Gynecology and Obstetrics, University of Copenhagen, Holbaek Hospital, Denmark
2Department of Gynecology and Obstetrics, Zealand University Hospital, Roskilde, Denmark
3Department of Gynecology and Obstetrics, University of Copenhagen, Amager Hvidovre Hospital, Hvidovre, Denmark
4Department of Clinical Medicine, University of Copenhagen, Copenhagen, Denmark

Correspondence
Dorthe L. A. Thisted, Department of Gynecology and Obstetrics, University of Copenhagen, Holbaek Hospital, Smedelundsgade 60, 4300 Holbaek, Denmark.
Email: thiding@yahoo.dk

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Abstract
Introduction: In the attempt of a trial of labor after a cesarean section approximately one in 200 women experience a complete uterine rupture. As a complete uterine rupture is associated with an adverse perinatal outcome, data regarding subsequent pregnancies are needed to provide proper care and guidance to women with a complete uterine rupture when informing them of future possibilities. The objective of this study was to investigate the fetal and maternal outcomes in subsequent pregnancies after a complete uterine rupture.

Material and Methods: Retrospective population-based case–control study. Denmark 1997–2017. A total of 175 women with complete uterine rupture during an attempted trial of labor after cesarean (TOLAC) at term (cases) and a corresponding group of 272 women with no uterine rupture during an attempted TOLAC at term (controls) were labeled as index deliveries. Index deliveries were included from January 1, 1997 to December 31, 2008. From the date of the index delivery to December 31, 2017 the information on subsequent pregnancies and deliveries, and on referral to hospital with any obstetric or gynecological diagnosis were retrieved from the Danish Medical Birth Registry and National Patient Registry. Main outcome measures were miscarriage, perinatal death, neonatal morbidity, preterm birth, and recurrence of uterine rupture. Outcome measures were compared between cases and controls.

Results: After the index deliveries; there were 109 pregnancies and 70 deliveries after gestational age 22 +0 weeks in the population of cases. In the population of controls, there were 183 pregnancies and 126 deliveries after 22 +0 weeks. Cases had a significantly higher risk of miscarriage (odds ratio [OR] 3.99; 95% confidence interval [CI] 1.36–13.17). The incidence of uterine rupture was 8.6% among cases and 0.8% among controls (OR 11.7; 95% CI 1.36–543.1). Among cases, 98.6% had live-born infants, and none of these had severe neonatal morbidity. No significant association was found between previous complete uterine rupture and preterm delivery, placenta previa,
hysterectomy in relation to subsequent births, diagnosis such as meno/metrorrhagia, dysmenorrhea, or procedures such as hysteroscopy or hysterectomy.

**Conclusions**: In pregnancies following complete uterine rupture continuing after 22^{+0} weeks, maternal and fetal outcomes are good when managed promptly with cesarean delivery.

**Key words**
cesarean section, trial of labor after cesarean, uterine rupture

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**1 | INTRODUCTION**

In the attempt of a trial of labor after a cesarean section (TOLAC), approximately one in 200 women experience a complete uterine rupture. Complete uterine rupture is defined as a direct communication between the uterine cavity and the peritoneum due to a complete rupture of the myometrium. The complete uterine rupture is associated with both very high perinatal asphyxia-related mortality and morbidity and immediate high maternal morbidity, such as severe hemorrhage and peripartum hysterectomy.

Seen from the perspective of the severe perinatal outcome, there is a substantial need for data that can serve as a guide when informing women with complete uterine rupture about the risks associated with a new pregnancy. As complete uterine rupture is a rare event, there are few previous studies investigating the risk associated with a forthcoming pregnancy and delivery. Most of these studies are either reports of case series or studies including fewer than 50 women with a previous complete uterine rupture.

The aim of this study was to investigate the fetal and maternal outcomes in subsequent pregnancies in a population of women with previous complete uterine rupture and the association between this condition and early pregnancy complications and complications related to the delivery. Furthermore, we also report potential gynecological morbidity following a complete uterine rupture, such as menorrhagia/metrorrhagia, dysmenorrhea, infertility, and genital prolapse.

**2 | MATERIAL AND METHODS**

Risk factors for complete uterine rupture in the Danish population have previously been evaluated in a population-based case-control study. From January 1, 1997 to December 31, 2008, all women with a complete uterine rupture, a singleton term pregnancy, and an attempted TOLAC were identified in the Danish Medical Birth Registry (DMBR). Information from the registry was validated against medical records. Only women with a complete uterine rupture, documented in the operative report of the cesarean delivery, were included. Women with incomplete uterine rupture/dehiscence were not included. After validation of cases, controls were identified as the following two consecutive deliveries in the DMBR among women with a singleton term pregnancy and no uterine rupture (complete or incomplete) during attempted TOLAC. Further inclusion criteria were: only one previous cesarean performed in Denmark and an available medical record. Information regarding controls was also validated against medical records, and only controls that met the above criteria were included in the study. As a result, controls were included if the TOLAC was successful, or if the TOLAC failed and no uterine rupture was diagnosed at the cesarean delivery. All the cases and controls had had exactly one previous cesarean section. At the attempted TOLAC 89.7% of the case women and 20.1% of the controls delivered by a cesarean section. All primary cesarean sections and all cesarean sections at the attempted TOLAC index delivery were performed through low transverse uterine incisions.

Validation of both cases and controls was performed by DT and LK. In all, 175 cases and 272 controls were included in the study. After review of the medical records, 121 controls were excluded, mainly because of multiple gestation, planned repeat cesarean section, preterm delivery, and unavailable medical record (fig. 1 in Ref.\(^{16}\)). In the same period 62,475 women were registered as having had a previous cesarean section. Of these, 39,472 (63.2%) planned a vaginal delivery in the following pregnancy at term.

The present study is a follow-up study of these cases (n = 175) and controls (n = 272). Cases and controls were labeled as "index deliveries". The follow-up period was from the date of the index delivery to December 31, 2017. Information regarding subsequent pregnancies and deliveries and any referral to hospital (outpatient clinics and/or admittance) with an obstetric or gynecological diagnosis was retrieved from the DMBR, and the National Patient Registry.

The information retrieved from the registries is based on the codes according to the International Statistical Classification of Diseases and Related Health Problems, 10th Revision. Information regarding any procedure is based on the codes according to Nordic Medico-statistical Committee classification of surgical procedures.

From the registries data regarding early pregnancy complications such as first- and second-trimester abortions were retrieved. Data...
regarding any obstetric outcome including adverse obstetric and perinatal outcomes such as perinatal death, admittance to neonatal intensive care unit, preterm delivery, emergency cesarean section, and recurrence of uterine rupture (complete or incomplete), were retrieved. Data in the DMBR did not differentiate between complete and incomplete uterine ruptures until 2014. Unfortunately, we did not have permission to review medical records for this follow-up study. Even though multiple gestations were excluded in index pregnancies, they were not excluded in the follow-up of subsequent pregnancies.

Hence, data on neonates in pregnancies that continued after gestational age (GA) $22^{+0}$ weeks included one twin pregnancy among cases and six among the controls.

Data in the DMBR regarding postpartum hemorrhage were of poor quality until January 1, 2012. From January 1, 2012, it became mandatory in Denmark to report the amount of hemorrhage in milliliters in all deliveries. In this study, the majority of subsequent deliveries after the index delivery were before 2012, and postpartum hemorrhage is therefore reported indirectly by other outcome measures such as adherent placenta and/or the immediate requirement of either hysterectomy, reoperation for severe bleeding after cesarean section, need for the B-lynch suture, or manual exploration of the uterus. In Denmark, manual exploration of the uterus, and therefore registration of the procedure, is only performed in women with a vaginal delivery and postpartum hemorrhage exceeding 1000 mL. Manual exploration in women with a successful vaginal birth after cesarean is not performed routinely.

Data regarding gynecological morbidity after the index delivery such as menorrhagia/metrorrhagia, dysmenorrhea, uterine fibroids, genital prolapse or infertility were also retrieved from the registries, as were any recordings of a gynecological surgical procedure such as hysterectomy, hysteroscopy or sterilization. Diagnoses and procedures were collected in the period from the 90th day after the index delivery to December 31, 2017.

Outcome measures were compared between cases and controls. Odds ratios (OR) with 95% confidence intervals (CI) were calculated by use of marginal two-by-two contingency tables, and $p$ values (two-sided) derived from Fisher’s exact test were reported. If one cell contained a zero count, Fisher’s exact test was performed and the two-sided $p$ value was reported. Comparison of mean values was

![Flow chart of future pregnancies in cases and controls with or without previous complete uterine rupture (index deliveries) during an attempted trial of labor after cesarean. GA, gestational age (weeks); TOLAC, trial of labor after cesarean. *Refers to the first pregnancy after the index delivery that continued beyond GA $22^{+0}$ (including woman with a subsequent pregnancy that ended before GA $22^{+0}$ weeks who became pregnant again). Information regarding pregnancies shorter than GA $22^{+0}$ is presented in Table 2.](image-url)
performed by use of Student’s t test and \( p \) values below 0.05 were considered statistically significant.

Reporting of the study followed the STROBE guidelines.\(^{19} \)

Information was entered into a database (SAS 9.4; SAS Institute Inc.) and analyzed using STATA 12.1. Data were entered into the database, validated and managed by DT and SCR.

2.1 Ethical approval

The study was approved by the Danish Data Protection Agency (initial journal number: 2008-41-2256, initial approval on May 23, 2008; extended approval journal number 2015-41-4105, initial approval date July 15, 2015, extended approval date January 31, 2017) and by the Danish National Board of Health (journal number: 3-3013-168-1; approval date September 7, 2012).

3 RESULTS

In the 175 cases with complete uterine rupture and 272 controls, we were able to retrieve information from the registries for 174 cases and 269 controls (Figure 1). From the inclusion in the study (date of index delivery) until December 31, 2017, 13 women were lost to complete follow up in the National Patient Registry because of emigration, death, or change of Personal ID code. The mean interval from index delivery until loss to follow up was 9 years and 11 months (11 months to 18.3 years).

Maternal characteristics and neonatal outcome at index delivery among cases and controls are presented in Table 1. Among cases from the index deliveries, 5.2% were stillbirths and among the neonates born alive, the incidence of Apgar score below 7 at 5 minutes was 41.2%. More than half of the neonates born alive (53.9%) were admitted to the neonatal intensive care unit and only 146 of the live-born neonates (88.5%) were alive after 28 days (Table 1).

The number of women who conceived after the index delivery did not differ significantly between cases and controls (\( n = 75 \) [43.1%] vs \( n = 117 \) [43.5%]) (Figure 1). However, the number of pregnancies among the women who actually conceived was significantly higher among the controls than among cases (\( p = 0.02 \)). Among cases with a subsequent pregnancy, there was a significantly higher risk of miscarriage in the first trimester (OR 3.99; 95% CI 1.36–13.17) (Table 2). There was no difference in the rate of terminated first-trimester pregnancies between cases and controls. The mean interval between the index delivery and first subsequent pregnancy was 32.9 months in cases and 38.5 months in controls.

### Table 1 Maternal and neonatal characteristics at index delivery

| Characteristics at index delivery | Cases (\( n = 174 \)) | Controls (\( n = 269 \)) | OR (95% CI) | \( p \) value |
|----------------------------------|------------------------|---------------------------|-------------|--------------|
| **Maternal characteristics**     |                        |                           |             |              |
| Maternal age; years\(^a\)        | 32.06 (21.42–43.75)    | 32.19 (19.25–47.25)       | 0.773       |              |
| Maternal BMI; kg/m\(^2\)         | 25.44 (17.79–47.84)    | 24.23 (16.60–47.45)       | 0.023       |              |
| Maternal height; cm\(^a\)        | 167 (150–184)          | 167 (149–186)             | 0.987       |              |
| Parity including index           | 2.55 (2–6)             | 2.78 (2–6)                | 0.006       |              |
| Cesarean delivery                | 156 (89.7)             | 54 (20.1)                 |             |              |
| Smoking\(^b\)                    | 21 (12.1)              | 49 (18.2)                 | 0.60 (0.33–1.08) | 0.082 |
| Smoking, missing data            | 11 (6.3)               | 20 (7.4)                  |             |              |
| **Neonatal characteristics**     |                        |                           |             |              |
| Gestational age; days            | 282.8 (255–299)        | 281.9 (261–299)           | 0.284       |              |
| Stillbirth                       | 9 (5.2)                | 1 (0.4)                   | 14.6 (1.98–642.94) | 0.001 |
| Characteristics of neonates alive at birth | 165 (94.8) | 268 (99.6) |
| Death within 28 days             | 19 (11.5)\(^c\)        | 1 (0.4)\(^d\)             | 34.7 (5.38–1448) | <0.001 |
| Age at perinatal death; days     | 3.43 (0–20)            | 0                         |             |              |
| Death within 29–365 days         | 1 (0.6)\(^d\)          | 0                         | 0.354       |              |
| Apgar score \(<7 at 5 min\)      | 68 (41.2)\(^c\)        | 2 (0.7)\(^d\)             | 93.2 (23.8–792.5) | <0.001 |
| Missing data (Apgar score)       | 7 (4.2)\(^c\)          | 2 (0.7)\(^d\)             |             |              |
| Admitted to NICU                 | 89 (53.9)\(^c\)        | 18 (6.7)\(^d\)            | 16.26 (8.9–30.3) | <0.001 |
| NICU (days) if admitted          | 7.4 (1–48)             | 6.1 (1–15)                | 0.578       |              |

Note: Data are \( n \) (% or mean (range) unless otherwise specified. Values of \( p \) were determined by Student’s t test, or Fisher’s exact test.

Abbreviations: BMI, body mass index; CI, confidence interval; NICU, neonatal intensive care unit; OR, odds ratio.

\(^a\) Data from previous study.\(^{16} \)

\(^b\) Any use of cigarettes during pregnancy including smoking cessation during first trimester.

\(^c\) Denominator \( n = 165 \).

\(^d\) Denominator \( n = 268 \).
Even though all cases were scheduled for a planned cesarean delivery, 21.4% were delivered by emergency cesarean section, and 12.9% were delivered by an emergency cesarean section during labor (Table 3). The incidence of uterine rupture was 8.6% among cases and 0.8% among controls (OR 11.7; 95% CI 1.36–543.1). Of the six women with a recurrent uterine rupture among the cases, four of the ruptures occurred before onset of labor, at GA 35\(\text{11}^{6}\), 37\(\text{10}^{6}\), 37\(\text{3}^{3}\), and 38\(\text{0}^{6}\) weeks, respectively. The two uterine ruptures occurring after onset of labor were at GA 31\(\text{11}^{6}\) and GA 39\(\text{3}^{6}\) weeks. Both women went into labor before the scheduled planned cesarean section. The uterine rupture in the control woman occurred at GA 41\(\text{1}^{6}\) during a TOLAC.

The mean interval between the index delivery and the subsequent delivery complicated by a uterine rupture during labor was 32.4 months (range 22.1–41.4 months) and the mean interval between the index delivery and the subsequent uterine rupture occurring before onset of labor was 38.8 months (range 15.9–69.5 months).

We found no association between previous uterine rupture and placenta previa. Hysterectomy in relation to labor, use of the B-Lynch suture, reoperation for deep hemorrhage in obstetric surgery, and manual exploration/manual removal of the placenta occurred only in controls (Table 3).

| TABLE 2 | Outcome in first and second trimester (gestational age <22 weeks) in pregnancies following the index delivery |
|--------|----------------------------------------------------------|
| Pregnancies after index delivery | Cases (n = 174) Pregnancies (n = 109) | Controls (n = 269) Pregnancies (n = 183) | OR (95% CI) | p value |
| Women who conceived after index delivery | 75 (43.1) | 117 (43.5) | 0.98 (0.66–1.47) | 1.00 |
| Women who delivered after index delivery | 59 (54) | 98 (54) | 0.90 (0.59–1.36) | 0.61 |
| Total number of deliveries after index delivery | 70 (64.2) | 126 (68.9) | | |
| Pregnancies among women who conceived after index delivery | 1.39 (1–4) | 1.70 (1–9) | | 0.02 |
| Interval from index delivery to first subsequent pregnancy (months) | 32.9 (0.7–110.8) | 38.5 (3–134.4) | | 0.07 |
| Interval from index delivery to first subsequent delivery (months) | 40.4 (11.0–107.8) | 47.1 (10.0–134.4) | | 0.14 |
| Induced abortions/miscarriages after index delivery | | | | |
| First trimester (GA <12 weeks) | 35 (32.1) | 40 (21.9) | 1.69 (0.95–2.98) | 0.07 |
| Ectopic pregnancy | 0 | 2 (1.1) | | 0.53 |
| Miscarriage | 13 (11.9) | 6 (3.3) | 3.99 (1.36–13.17) | <0.01 |
| Pregnancy terminated | 22 (20.2) | 32 (17.5) | 1.19 (0.62–2.27) | 0.64 |
| Second trimester (GA 12 to <22 weeks) | 4 (3.7) | 12 (6.6) | 0.54 (0.12–1.86) | 0.43 |
| Miscarriage | 4 (3.7) | 10 (5.5) | 0.66 (0.15–2.36) | 0.58 |
| Pregnancy terminated | 0 | 2 (1.1) | | 0.53 |
| Missing gestational age (first and second trimesters) | 0 | 5 (2.7) | | |
| Total (induced abortions/miscarriages) | 39 (35.8) | 57 (31.1) | 1.23 (0.72–2.09) | 0.44 |

Abbreviations: CI, confidence interval; GA, gestational age; OR, odds ratio.

Data are n (%) or mean (range) unless otherwise specified. Values of p were determined by Student’s t test, or Fisher’s exact test.

\(\text{a Delivery after GA 22}^{\text{10}}\) weeks.
There was one stillbirth among the cases (at GA 31\(\text{+}0\), pregnancy was complicated by a complete uterine rupture), and one stillbirth among the controls (at term, no uterine rupture). Also, we found a significantly higher risk of need for continuous positive airway pressure (OR 4.43; 95% CI 1.56–13.6) and a significantly lower birthweight (3247 g vs 3420 g; \(p=0.03\)) among the neonates of cases than among those of controls. We did not find any significant difference between cases and controls regarding Apgar scores after 5 minutes or umbilical cord pH (Table 3).

Little association was found between previous complete uterine rupture and long-term maternal gynecological morbidity (Table 4). Treatment for ileus was undertaken only in cases (\(n=7\)), and surgery for genital prolapse only in controls (\(n=8\)). We did not find any association between a previous complete uterine rupture and a future diagnosis of menorrhagia/metrorrhagia or uterine fibroids or a future hysterectomy or hysteroscopy (Table 4).

### DISCUSSION

In this retrospective population-based registry case–control study, we found a significantly increased risk of first-trimester miscarriage among women with previous complete uterine rupture. Even though all woman with previous complete uterine rupture were scheduled

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**TABLE 3** Outcome in pregnancies after index delivery with gestational age ≥22\(\text{+}0\) weeks

| Outcome                                      | Cases (n = 174) deliveries (n = 70) | Controls (n = 269) deliveries (n = 126) | OR (95% CI)       | \(p\) value |
|----------------------------------------------|------------------------------------|----------------------------------------|-------------------|-------------|
| Obstetric outcome/procedures                 |                                    |                                        |                   |             |
| Uterine rupture                              | 6 (8.6)                            | 1 (0.8)                                | 11.7 (1.36–543.1) | <0.01       |
| Placenta previa                              | 1 (1.4)                            | 1 (0.8)                                | 1.81 (0.02–143.3) | 0.67        |
| Adherent placenta/manual exploration of the uterus | 0                                  | 5 (4.0)                                |                   | 0.16        |
| Peripartum hysterectomy/B-Lynch suture/ reoperation | 0                                  | 2 (1.6)                                |                   | 0.54        |
| Planned TOLAC                                | 0                                  | 74 (58.7)                              |                   | <0.01       |
| Cesarean delivery (CD)                       | 70 (100)                           | 52 (41.3)                              |                   | <0.01       |
| Planned CD before onset of labor             | 48 (68.6)                          | 35 (27.8)                              | 5.67 (2.86–11.32) | <0.01       |
| Emergency CD                                 | 15 (21.4)                          | 15 (11.9)                              | 2.02 (0.85–4.77)  | 0.08        |
| Before onset of labor                        | 6 (8.6)                            | 5 (4.0)                                | 2.27 (0.55–9.74)  | 0.18        |
| During labor                                 | 9 (12.9)                           | 10 (7.9)                               | 1.71 (0.58–4.95)  | 0.26        |
| Unknown type of CD                           | 7 (10)                             | 2 (1.6)                                |                   |             |
| Neonatal\(^a\)                               |                                    |                                        |                   |             |
| Live birth                                   | 70 (98.6)                          | 131 (99.2)                             | 0.53 (0.01–42.54) | 0.65        |
| Stillbirth                                   | 1 (1.4)                            | 1 (0.8)                                | 1.87 (0.02–148)   | 0.65        |
| Apgar <7 at 5 min                            | 1 (1.4)                            | 3 (2.3)                                | 0.62 (0.01–7.88)  | 0.68        |
| Umbilical cord pH <7.00                      | 0                                  | 2 (1.5)                                |                   |             |
| Missing data pH                              | 25 (35.7)                          | 50 (38.2)                              |                   | 0.55        |
| CPAP                                         | 14 (20.0)                          | 7 (5.3)                                | 4.43 (1.56–13.6)  | <0.01       |
| NICU                                         | 16 (22.9)                          | 19 (14.5)                              | 1.67 (0.74–3.73)  | 0.17        |
| NICU (days) if admitted                      | 7.8 (1–32)                         | 7.7 (1–31)                             |                   | 0.51        |
| Birthweight (grams)                          | 3247 (1935–4320)                   | 3420 (1572–4900)                       |                   | 0.03        |
| GA at birth (days)                           | 262 (217–277)                      | 275 (233–301)                          |                   | <0.01       |
| GA: ≥37\(\text{+}0\) (weeks)                 | 59 (84.3)                          | 112 (88.9)                             | 0.67 (0.26–1.75)  | 0.35        |
| GA: 34\(\text{+}0\)–36\(\text{+}6\) (weeks) | 8 (11.4)                           | 10 (7.9)                               | 1.50 (0.49–4.45)  | 0.42        |
| GA: 28\(\text{+}0\)–33\(\text{+}6\) (weeks) | 3 (4.3)                            | 3 (2.4)                                | 184 (0.24–14.0)   | 0.6         |
| GA: 22\(\text{+}0\)–27\(\text{+}6\) (weeks) | 0                                  | 0                                     |                   |             |
| GA: missing                                  | 1 (0.8)                            |                                       |                   |             |

Note: Data are \(n\) (%) or mean (range) unless otherwise specified. Values of \(p\) were determined by Student’s \(t\) test, or Fisher’s exact test.

Abbreviations: CD, cesarean delivery; CI, confidence interval; CPAP, continuous positive airway pressure; GA, gestational age; NICU, neonatal intensive care unit; OR, odds ratio; TOLAC, trial of labor after cesarean.

\(^a\) The data regarding neonates include seven twin pregnancies (one among cases and six among controls). All neonatal characteristics except gestational age and birthweight refer to live-born infants.
for a planned cesarean delivery at no later than GA 39 weeks, the incidence of recurrent uterine rupture was 8.6%. More than half of the ruptures occurred before onset of labor. Maternal and neonatal outcomes were excellent. No association was found between previous uterine rupture and placenta previa. Hysterectomy in relation to birth, use of the B-Lynch suture, and reoperation for deep hemorrhage in obstetric surgery only occurred in controls. Long-term complications in the form of ileus were only seen in women with previous uterine rupture (cases) and genital prolapse occurred only in controls.

A strength of this study is that we only included validated cases of complete uterine rupture at the index delivery.  The index pregnancies were included at the date of attempted TOLAC and the long follow-up period from the inclusion until December 31, 2017 is another strength because we were able to retrieve information regarding any subsequent pregnancy or gynecological morbidity. The population-based character of the study enabled us to describe a large population and not only to include the result of their subsequent deliveries but also to report occurrence of early pregnancy complications and long-term maternal morbidity.

One limitation of this study is the lack of information on whether uterine ruptures in the subsequent pregnancies were complete or incomplete. The low incidence of serious adverse neonatal outcome indicates that the majority of the uterine ruptures were either incomplete or were handled promptly. Another limitation of this study is clearly the indirect reporting of hemorrhage in association with birth.

The association between previous complete uterine rupture and first-trimester complications has not been described in previous studies. However, O’Neill et al found that previous cesarean delivery was associated with increased risk of sub-fertility, increased interval to subsequent pregnancy, and stillbirth. A possible explanation for our findings could be that cases were more likely than controls to seek medical care for an early miscarriage given that they had previously led a major medical event. The higher incidence of genital prolapse in the controls with no previous complete uterine rupture is most likely explained by a higher rate of vaginal delivery. This is in accordance with a recent study from Sweden. The higher incidence of ileus among cases is most likely associated with the increased number of open abdominal surgical procedures, ie the procedure related to the complete uterine rupture and the procedure related to the following cesarean delivery. Tulandi et al found that the number of cesarean deliveries is associated with an increased risk of symptomatic adhesions.

Chibber et al and Fox et al suggested that a cesarean should be planned to GA 36–37 weeks (GA 35 weeks if the woman had a previous classical cesarean scar). Frank et al elaborated a decision-analytic model using a theoretical cohort of 1000 women with a previous uterine rupture and suggested that delivery should be planned from GA 34 to 36 weeks. The authors concluded that the majority of woman would benefit from delivery at GA 35 weeks. The model attempts to find the balance between neonatal morbidity related to preterm delivery and the neonatal and maternal morbidity related to a recurrent uterine rupture. The risk of a recurrent uterine rupture was estimated to increase from 1.86% at GA 34 weeks to 3.86% at GA 36 weeks.

An incidence of recurrent uterine rupture of 8.6% is relatively high in the present study. However, the numbers included both incomplete and complete ruptures and occurrence of severe adverse outcomes (perinatal deaths, peripartum hysterectomy) was extremely rare and did not differ between cases and controls. Our findings are supported by the few previous studies and case-series reports, all of which concluded that pregnancies following a uterine rupture are associated with a satisfying maternal and fetal outcome.

### Conclusion

There is no evidence suggesting that a woman with a previous complete uterine rupture should be advised against a future pregnancy when delivery is by a planned cesarean section before

### TABLE 4 Maternal gynecological morbidity after index delivery; from 90 days after index delivery to December 31, 2017

| Risk factors            | Cases (n = 174) | Controls (n = 269) | OR (95% CI) | p value |
|-------------------------|----------------|--------------------|-------------|---------|
| Diagnosis               |                |                    |             |         |
| Menorrhagia/metorrhagia | 19 (10.9)      | 32 (11.8)          | 0.91 (0.47–1.72) | 0.87    |
| Dysmenorrhea            | 2 (1.1)        | 5 (1.9)            | 0.61 (0.06–3.81) | 0.71    |
| Uterine fibroids        | 2 (1.1)        | 4 (1.5)            | 0.77 (0.06–5.44) | 1.00    |
| Infertility             | 6 (3.4)        | 2 (0.7)            | 4.77 (0.84–48.7) | 0.06    |
| Genital prolapse        | 0              | 8 (3.0)            | 0.02        |         |
| Ileus/adhesions         | 7 (4.0)        | 0                  | <0.01       |         |
| Procedure               |                |                    |             |         |
| Hysterectomy            | 6 (3.4)        | 10 (3.7)           | 0.93 (0.27–2.87) | 1.00    |
| Hysteroscopy            | 12 (7.0)       | 11 (4.0)           | 1.73 (0.68–4.45) | 0.20    |
| Sterilization           | 14 (8.0)       | 12 (4.5)           | 1.87 (0.78–4.55) | 0.15    |

Note: Data are n (%). Values of p were determined by Student’s t test, or Fisher’s exact test. Abbreviations: CI, confidence interval; OR, odds ratio.
onset of labor, or early in labor in the case of preterm delivery. Women should be advised of a small-to-modest risk of uterine rupture in subsequent pregnancy. Given the increased risk of a recurrent uterine rupture before the onset of labor, we suggest that the repeat cesarean section in women with complete uterine rupture should be planned no later than 37–38 completed gestational weeks.

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CONFLICT OF INTEREST
The authors have stated explicitly that there are no conflicts of interest in connection with this article.

AUTHOR CONTRIBUTIONS
LK and DLAT designed the study and directed its implementation, including field activities, quality assurance, and control and analytic strategy. LK and DLAT conducted the literature review and prepared the manuscript. Data were entered into the database, validated and managed by DLAT and SCR.

ORCID
Dorthe Louise Ahrenkiel Thisted https://orcid.org/0000-0002-0201-9552
Lone Krebs https://orcid.org/0000-0001-5433-4776

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