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Maternal Outcomes associated with early preterm cesarean delivery

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Abstract

Background—Data on complications associated with classical cesarean delivery are conflicting. In extremely preterm cesarean delivery (22 0/7–27 6/7 weeks' gestation), the lower uterine segment is thicker. It is plausible that the rates of maternal complications may not differ between classical and low transverse cesarean.

Objective—To compare maternal outcomes associated with classical comparing with low transverse cesarean after stratifying by gestation (23 0/7–27 6/7 and 28 0/7–31 6/7 weeks' gestation).

Study design—We conducted a multi-hospital retrospective cohort study of women undergoing cesarean delivery at 23 0/7–31 6/7 weeks' gestation between 2005 and 2014. Composite maternal outcome (postpartum hemorrhage, transfusion, endometritis, sepsis, wound infection, deep venous thrombosis/pulmonary embolism, hysterectomy, respiratory complications, and Intensive Care Unit admission) was compared between classical and low transverse cesarean. Outcomes were calculated using multivariable logistic regression models yielding adjusted odds ratios with 95% confidence intervals and adjusted p-values controlling for maternal characteristics, emergency cesarean delivery, and comorbidities. Analyses were stratified by gestational age categories (23 0/7–27 6/7 and 28 0/7–31 6/7 weeks' gestation).

Results—Of 902 women, 221(64%) and 91 (16%) underwent classical cesarean between 23 0/7 and 27 6/7 and between 28 0/7 and 31 6/7 weeks' gestation, respectively. There was no increase in maternal complications for classical cesarean compared to low transverse cesarean between 23 0/7 and 27 6/7 weeks' gestation. However, between 28 0/7 and 31 6/7 weeks' gestation, classical

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cesarean was associated with increased risks of the composite maternal outcome (adjusted odds ratio=1.95; 95% confidence interval=1.10–3.45), transfusion (adjusted odds ratio=2.42; 95% confidence interval=1.06–5.52), endometritis (adjusted odds ratio=3.23; 95% confidence interval=1.02–10.21), and Intensive Care Unit admission (adjusted odds ratio=5.05; 95% confidence interval=1.37–18.52) compared to low transverse cesarean.

Conclusion—Classical cesarean delivery compared with low transverse was associated with higher maternal complication rates between 28 0/7 and 31 6/7 weeks, but not between 23 0/7 and 27 6/7 weeks' gestation.

Condensation

Classical cesarean delivery was associated with higher maternal complication rates in 28–31 weeks' gestation, but not in 23–27 weeks' gestation.

Keywords

Classical cesarean delivery; endometritis; Intensive Care Unit admission; transfusion; maternal complications

Introduction

Improved survival in extremely preterm infants (22 0/7–27 6/7 weeks' gestation) has led to increased intervention, including cesarean delivery.^{1, 2} The incidence of classical cesarean delivery (vertical uterine incisions) is primarily associated with gestational age, with a 50% classical cesarean delivery rate in women undergoing cesarean delivery at 23 to 26 weeks' gestation and declining substantially after 32 weeks' gestation.³ Data on complications associated with classical cesarean delivery (infection, postoperative pain, blood loss, blood transfusion, maternal Intensive Care Unit admission, and death) are conflicting due to heterogeneous groups of women (term versus preterm and various inclusion criteria).^{4–11} The lower uterine segment is not well developed at extremely preterm gestation (22 0/7 – 27 6/7 weeks gestation). It is postulated that the thicker lower uterine segment has a larger surface area of the transected myometrium leading to larger blood loss with lower uterine incision. Therefore, it is plausible that the rates of maternal complications may not differ between classical and low transverse cesarean. Due to increased incidence of intervention in extremely preterm gestations and performance of classical cesarean delivery,^{1, 2} detailed information on incidence and types of complications is important. We sought to examine the incidence of maternal morbidities associated with early preterm cesarean delivery by incision type and gestational age categories, between 23 0/7 and 27 6/7 and between 28 0/7 and 31 6/7 weeks' gestation.

Materials and methods

We performed a multi-hospital retrospective cohort study of all women with a singleton pregnancy between 23 0/7 and 31 6/7 weeks' gestation who delivered via cesarean delivery. Data were collected between January 2005 and December 2014 at four hospitals within the same health care organization: MedStar Washington Hospital Center and MedStar Georgetown University Hospital in Washington, DC and MedStar Franklin Square Medical

Center and MedStar Harbor Hospital in Baltimore, MD. We limited the analysis to singleton deliveries between 23 0/7 and 31 6/7 weeks' gestation because the rate of classical cesarean delivery rapidly declines after 32 weeks.³ We excluded women with severe maternal conditions (renal failure, acute respiratory distress syndrome, cardiovascular disease, placenta accreta, eclampsia, stroke, and major trauma) because it is difficult to separate the morbidity of these conditions from the morbidity of preterm cesarean delivery. Women with history of previous cesarean delivery were not excluded. We selected the first delivery for women who had more than one eligible cesarean delivery during the study time period. Using electronic medical record data, women who underwent cesarean delivery between 23 0/7 and 31 6/7 weeks' gestation were identified. Gestational age was established by last menstrual period and ultrasound. If gestational age by last menstrual period and by ultrasound was not in agreement, we used the guidelines of American College of Obstetricians and Gynecologists to adjust gestational age.¹² Subsequent chart abstraction was undertaken by the primary author to collect maternal demographics, indications for cesarean delivery, intraoperative and maternal outcomes. MedStar Institutional Review Board approved this study.

Uterine incision type was classified as recorded in the medical record. Uterine incisions were classified as classical cesarean delivery, low transverse cesarean delivery, or other cesarean delivery. For the analysis of maternal outcomes, uterine incisions that were started as low transverse incisions but were extended into the upper uterine segment ("J" or inverted "T" incisions) were included as part of the classical cesarean delivery group. Low vertical incisions and mid or high transverse uterine incisions were categorized into other cesarean delivery group.

Maternal demographics (age, race/ethnicity, body mass index [BMI; kg/m²], and number of prior cesarean deliveries), maternal comorbidities - pregestational diabetes, gestational diabetes, chronic hypertension, and pregnancy associated hypertensive disease (gestational hypertension, preeclampsia, hemolysis, elevated liver enzyme, low platelet [HELLP] syndrome), and information on cesarean delivery (emergent delivery, skin incision type, fetal presentation, and indication) were evaluated according to type of uterine incision. BMI was categorized as underweight (BMI <18.5 kg/m²), normal weight (BMI 18.5 to 24.9 kg/m²), overweight (BMI 25.0 to 29.9 kg/m²), and obese (BMI 30.0 or greater). Indications for cesarean delivery including non-cephalic presentation, non-reassuring fetal heart tracing, failure to progress, placenta abnormalities, intrauterine growth restriction, preeclampsia with severe features, cord prolapse, human immunodeficiency virus (HIV), active herpes simplex virus, chorioamnionitis, and fetal anomaly were collected from medical record and evaluated according to type of uterine incision. Placenta abnormalities included placenta previa and placenta abruption. Rates of cesarean incision type (classical, J or T, low transverse and other cesarean delivery) were grouped according to the gestational age.

Intraoperative and maternal outcomes were ascertained according to type of cesarean incision (classical, low transverse, and other) and by gestational age (between 23 0/7 and 27 6/7 and between 28 0/7 and 31 6/7 weeks' gestation). This gestational age category was chosen because of declining classical cesarean delivery rates after 28 weeks' gestation.³ Intraoperative outcomes included skin incision to delivery time, total operative time (skin

incision to skin closure time) and estimated blood loss. A composite maternal adverse outcome included the occurrence of at least one of the following: postpartum hemorrhage, blood transfusion, endometritis, sepsis, wound infection/separation, deep venous thrombosis/pulmonary embolism, respiratory complications (pulmonary edema/acute respiratory distress syndrome/congestive heart failure), hysterectomy, and Intensive Care Unit admission. Duration of hospital stay after delivery was also ascertained. Postpartum hemorrhage was defined as total estimated blood loss >1000 ml. Endometritis was defined as fever 38.0° C as well as abdominal tenderness. Sepsis was defined as bacteremia confirmed by blood culture. Wound infection was based on findings of cellulitis or purulent drainage from the wound. Women could have multiple morbidities. For example, if a woman had hemorrhage and required Intensive Care Unit admission; the woman was counted in both hemorrhage and Intensive Care Unit admission.

Outcomes of classical cesarean delivery and other cesarean delivery were compared with those of low transverse cesarean delivery after stratifying by gestational age (between 23 0/7 and 27 6/7 and between 28 0/7 and 31 6/7 weeks' gestation). Descriptive statistics were calculated for all study variables. Chi-square test, Fisher's exact test, or Wilcoxon rank-sum test was performed to determine associations between outcomes and type of uterine incision. Cochran-Armitage trend test was conducted to calculate the trend of the classical cesarean delivery rates. Multivariable logistic or linear regression analysis was performed to evaluate the study outcomes; skin incision to delivery time, total operative time, estimated blood loss, postpartum hemorrhage, blood transfusion, endometritis, sepsis, wound infection, respiratory complications, Intensive Care Unit admission, hospital stay and composite maternal outcome between classical cesarean delivery or other cesarean delivery and low transverse cesarean delivery (referent group). Adjusted analyses were performed by controlling for maternal age, race or ethnicity, gestational age, preterm premature rupture of membrane, preterm labor, hypertension (chronic, gestational, preeclampsia), diabetes (gestational and pregestational), emergent delivery, skin incision type, number of previous cesarean delivery, placenta abnormalities, and BMI on admission. Analyses were repeated to compare extreme preterm (between 23 0/7 and 27 6/7 weeks' gestation) and later gestation (28 0/7 and 31 6/7 weeks' gestation) among different cesarean delivery types (classical and low transverse cesarean delivery). All statistical analyses were performed using SAS 9.3 (SAS Institute Inc., Cary, NC)

Results

Of 95,469 deliveries, 1,188 (1.2%) were cesarean deliveries between 23 0/8 and 31 6/7 weeks' gestation. Of 1,188 cases of cesarean delivery, 213 deliveries with multiple gestations and 53 deliveries accompanied by severe comorbidities (20 renal failure, 10 acute respiratory distress syndrome, 8 cardiovascular disease, 6 placenta accreta, 5 eclampsia, 2 stroke, and 2 major trauma) were excluded. After excluding 20 pregnancies that represented repeat pregnancies, 902 women remained for analysis, of whom 312 (34.6%) were classical cesarean delivery, 552 (61.2%) were low transverse cesarean, and 38 (4.2%) were Other cesarean delivery.

Maternal demographic data, pregnancy outcomes, and indications for cesarean delivery are presented in Tables 1 and 2. Between 23 0/7 and 27 6/7 weeks' gestation, the classical cesarean delivery group was more likely to have higher BMI ($P=.03$), lower birth weight ($P<.001$), and non-cephalic presentation ($P=.001$) compared to the low transverse cesarean group. Between 23 0/7 and 27 6/7 weeks' gestation, the classical cesarean delivery group had higher rate of cesarean delivery indicated for non-cephalic presentation ($P<.001$). Between 28 0/7 and 31 6/7 weeks' gestation, the classical cesarean delivery group was more likely to have lower birth weight ($P<.01$), emergent delivery ($P=.03$), vertical skin incision ($P<.001$), non-cephalic presentation ($P<.001$), and chronic hypertension ($P=.02$) compared to the low transverse cesarean group. Between 28 0/7 and 31 6/7 weeks' gestation, Other cesarean delivery group was more likely to have prior uterine scar ($P<.01$).

The rates of uterine incisional type by gestational age are shown in Figure 1. The rates of classical cesarean delivery steadily decreased as gestational age advanced ($P<.01$). The rates of classical cesarean delivery were highest at 23–24 weeks' gestation (77–79%) and decreased after 28 weeks' gestation (26%). The rates of classical cesarean delivery were lowest at 30–31 weeks' gestation (8%).

Intraoperative and maternal outcomes by gestational weeks between 23 0/7 and 27 6/7 weeks' gestation are presented in Table 3. Total operative time of both primary and repeat cesarean delivery was longer in classical cesarean delivery group compared with low transverse cesarean delivery ($P<.01$). The rates of composite maternal outcome were 23.0% and 23.6% in low transverse and classical cesarean delivery, respectively. There was no difference in estimated blood loss or maternal outcomes between low transverse cesarean delivery and classical cesarean delivery. There was no difference in intraoperative and maternal outcomes between low transverse cesarean group and other cesarean delivery group (data not shown).

Intraoperative and maternal outcomes by gestational weeks between 28 0/7 and 31 6/7 weeks' gestation are presented in Table 4. Total operative time of both primary and repeat cesarean delivery was longer in classical cesarean delivery group compared with low transverse cesarean delivery ($P<.01$). In women who underwent cesarean delivery between 28 0/7 and 31 6/7 weeks' gestation, skin incision to delivery time of repeat cesarean delivery were longer in classical cesarean delivery group compared to low transverse cesarean delivery even after controlling for confounders ($P=.01$). The rates of composite maternal outcome were 16.7% and 31.9% in low transverse and classical cesarean delivery, respectively. Classical cesarean delivery between 28 0/7 and 31 6/7 weeks' gestation was associated with increased risk of blood transfusion (adjusted OR=2.42; 95%CI=1.06–5.52), endometritis (adjusted OR=3.23; 95%CI=1.02–10.21), Intensive Care Unit admission (adjusted OR=5.05; 95%CI=1.37–18.52), and composite maternal outcome (adjusted OR=1.95; 95%CI=1.10–3.45) compared with low transverse cesarean delivery group.

We then compared maternal outcomes of extreme preterm (between 23 0/7 and 27 6/7 weeks' gestation) with those of later gestation (28 0/7 and 31 6/7 weeks' gestation) among different cesarean delivery types (classical and low transverse cesarean delivery). In the low transverse cesarean delivery group, there were no differences in maternal complications

between extreme preterm gestation and later gestations. In the classical cesarean delivery group, later gestation group had increased risk of Intensive Care Unit admission (adjusted OR=1.07; 95% CI=1.07–24.80) compared with the extreme preterm gestation group (data not shown).

Comment

Principal findings

There was no difference in blood transfusion, endometritis, Intensive Care Unit admission, or composite maternal outcome between classical cesarean and low transverse cesarean at 23 0/7–27 6/7 weeks' gestation, while the risks of these complications increased with classical cesarean compared with low transverse cesarean at 28 0/7 and 31 6/7 weeks' gestation.

Meaning of the findings

Consistent with previous studies, this study demonstrated the rate of classical cesarean delivery declined with increasing gestational age.^{3, 13} However; there is a wide range of reported rates of classical cesarean delivery. The study by Bethune et al¹² in 1997 described a 20% classical cesarean delivery rate at 24 weeks' gestation that declined to less than 5% at 30 weeks' gestation. In their study of 1,562 classical cesarean deliveries, Osmundson et al³ in 2013 reported a classical cesarean delivery rate of 53% between 24 0/7 and 25 6/7 weeks' gestation, declining to 35% at 28 0/7 weeks' gestation, and to below 10% by 32 0/7 weeks' gestation. In our study, the classical cesarean delivery rate steadily declined from 79–84% (23 0/7 to 24 6/7 weeks' gestation) to 12–14% (30 0/7 to 31 6/7 weeks' gestation). The reason for a wide range of reported classical cesarean delivery rates may be due to difference in pregnancy characteristics.³

Prior studies have found increased risks of postpartum hemorrhage and blood transfusion in women undergoing classical cesarean delivery,^{6, 7, 9, 10} although other studies did not find an increased risk.^{4, 8} This conflicting data might be due to different inclusion criteria (term versus preterm). Our study demonstrated an increased risk of blood transfusion in women undergoing classical cesarean delivery between 28 0/7 and 31 6/7 weeks' gestation but not in the earlier gestational ages between 23 0/7 and 27 6/7 weeks' gestation.

There is limited published literature regarding severe complications such as sepsis, ICU admission, and hysterectomy. In a recent Maternal-Fetal Medicine Units (MFMU) Network study of maternal outcomes,¹¹ there was no increased risk of serious maternal complications (hemorrhage, infection, Intensive Care Unit admission, and death) in classical cesarean delivery compared with low transverse cesarean delivery in women who delivered between 23 0/7 and 33 6/7 weeks' gestation. That study did not stratify by gestational age when they evaluated the difference in serious maternal complications between classical cesarean delivery and low transverse cesarean delivery. Because the rates of classical cesarean delivery decline after 28 weeks' gestation,³ our hypothesis was that the lower uterine segment is more likely to be developed after 28 weeks' gestation; therefore, the risks of maternal complications may be higher with vertical incisions made through the relatively thicker uterine segment compared with transverse incisions through the thinner lower uterine

segment after 28 weeks' gestation. In our study, blood transfusion and ICU admission were increased in classical cesarean delivery compared with low transverse cesarean delivery between 28 0/7 and 31 6/7 weeks' gestation, but not between 23 0/7 and 27 6/7 weeks' gestation.

Clinical implications

Our study found no differences in short-term maternal complications in classical cesarean delivery compared with low transverse cesarean delivery between 23 0/7 and 27 6/7 weeks' gestation. In a previous study, classical cesarean delivery was not associated with improved short-term neonatal outcomes compared with low transverse cesarean delivery.¹⁰ In the long-term, it is well known that classical cesarean delivery is associated with an increased risk of uterine rupture and uterine scar dehiscence compared with low transverse cesarean delivery.^{8, 14, 15} Also subsequent pregnancies require cesarean delivery at late preterm or early term due to the risk of scar dehiscence, which raises concern for abnormal placental implantation and neonatal respiratory complications.^{16, 17} However, our study was not able to evaluate the long-term outcomes.

Research implications

We postulate that the thick lower uterine segment in the extreme preterm cesarean delivery (between 23 0/7 and 27 6/7 weeks' gestation) may explain our findings that the risks of classical and low transverse cesarean deliveries are relatively equivalent in the risk of maternal complications. In addition, there may be unknown factors such as lower uterine fibroids and severe adhesions that led to classical cesarean delivery between 28 0/7 and 31 6/7 weeks' gestation. These unknown factors may have contributed to increased maternal complications associated with classical cesarean delivery compared with lower segment cesarean delivery between 28 0/7 and 31 6/7 weeks' gestation.

Strengths and weaknesses

The limitation of this study is its retrospective nature. Although we accounted for multiple confounders, it is possible that we did not control for other conditions of importance such as presence of uterine fibroids and degree of adhesions, which could have influenced maternal outcomes. Our study was conducted in the inner city setting; therefore, our study may not be generalizable. In addition, the smaller sample size of cesarean deliveries between 23 0/7 and 27 6/7 weeks' gestation may be underpowered to show a difference in maternal complications as seen with later gestation with a greater number of cesarean deliveries. The major strength of our study is the detailed high quality data from chart review that allowed us to control for major confounders.

Next step in research

In conclusion, between 23 0/7 and 27 6/7 weeks' gestation the rate of classical cesarean delivery was higher than low transverse cesarean delivery but there was no difference in maternal morbidity.. Almost one in every four women experienced a serious maternal complication regardless of incision type at this early gestational age. However, in later gestation between 28 0/7 and 31 6/7 weeks' gestation, even though the rates of classical

cesarean delivery declined, classical cesarean delivery was associated with higher maternal morbidities. Skin incision to delivery time was longer with classical cesarean delivery indicating that for conditions such as non-reassuring fetal heart rate tracing, performance of low transverse cesarean delivery is preferable if the lower uterine segment is well developed, given the higher maternal morbidity of classical cesarean delivery. Whether classical cesarean delivery decreases the risk of neonatal outcomes such as birth trauma compared with low transverse cesarean delivery is not clear and future research is warranted.

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Figure 1. Uterine incision type by gestational age

Abbreviations: Other (Other cesarean delivery), Low transverse (low transverse cesarean delivery), J + inverted T (J or inverted incision), classical (classical cesarean delivery)

Other cesarean delivery includes low vertical and high transverse uterine incisions.

P < .01 for Classical cesarean delivery (Cochran-Armitage trend test)

Table 1

Demographic data, pregnancy outcome, and indications for cesarean delivery between 23 0/7 and 27 6/7 weeks' gestation.

	LTCD (n=126)	Classical CD (n=221)	Other CD (n=16)	P-value (Classical vs LTCD)	P-value (Other vs LTCD)
Maternal age (yr), mean (SD)	28.4 (6.4)	29.7 (6.5)	31.44 (6.1)	.08	.08
Race/ethnicity					
Non-Hispanic white	22 (17.5)	40 (18.1)	2 (12.5)	.30	1.00
Non-Hispanic black	81 (64.3)	154 (69.7)	11 (68.8)		
Other	23 (18.3)	27 (12.2)	3 (18.8)		
BMI at admission (kg/m ²)	31.3 (7.6)	33.4 (8.4)	33.9 (9.3)	.03	.26
Underweight/Normal	21 (18.0)	33 (16.2)	2 (13.3)	.05	.87
Overweight	35 (29.9)	39 (19.1)	4 (26.7)		
Obese	61 (52.1)	132 (64.7)	9 (60.0)		
Number of prior uterine scar					
No uterine scar	92 (73.0)	169 (76.8)	15 (93.8)	.67	.27
1 – 2	29 (23.0)	45 (20.4)	1 (6.3)		
3 or more	5 (4.0)	6 (2.7)	0 (0.0)		
Birth weight (g), mean (SD)	827.4 (192.7)	724.3 (188.0)	752.2 (216.5)	<.001	.18
Emergent delivery	50 (39.7)	108 (49.1)	10 (62.5)	.09	.08
Skin incision					
Pfannenstiel incision	122 (97.6)	210 (95.5)	16 (100.0)	.39	1.0
Vertical incision	3 (2.4)	10 (4.6)	0 (0.0)		
Presentation					
Breech	60 (47.6)	134 (60.9)	11 (68.8)	.001	.24
Cephalic	60 (47.6)	63 (28.6)	5 (31.3)		
Transverse	6 (4.8)	23 (10.5)	0 (0.0)		
Pregestational diabetes	3 (2.4)	10 (4.5)	1 (6.3)	.39	.38
Gestational diabetes	4 (3.2)	3 (1.4)	1 (6.3)	.26	.45
Chronic hypertension	14 (11.2)	29 (13.1)	2 (12.5)	.60	1.00
Pregnancy associated hypertensive disease	40 (31.8)	56 (25.3)	2 (12.5)	.15	.20
Indications for cesarean delivery					

	LTCD (n=126)	Classical CD (n=221)	Other CD (n=16)	P-value (Classical vs LTCD)	P-value (Other vs LTCD)
Non-cephalic presentation	58 (46.0)	149 (67.4)	11 (68.8)	<.001	.09
Non-reassuring fetal heart tracing	44 (34.9)	87 (39.4)	6 (37.5)	.41	.84
Failure to progress	0 (0.0)	0 (0.0)	0 (0.0)	-	-
Placenta abnormalities	23 (18.3)	31 (14.0)	3 (18.8)	.30	1.00
Intrauterine growth restriction	18 (14.3)	34 (15.4)	0 (0.0)	.78	.22
Preeclampsia with severe features	35 (27.8)	42 (19.0)	3 (18.8)	.06	.56
Cord prolapse	7 (5.6)	9 (4.1)	1 (6.3)	.53	1.00
HIV/active HSV	2 (1.6)	2 (0.9)	0 (0.0)	.62	1.00
Chorioamnionitis	18 (14.3)	25 (11.3)	5 (31.3)	.42	.14
Fetal anomaly	0 (0.0)	0 (0.0)	0 (0.0)	-	-

Abbreviations: Cesarean delivery (CD), Low transverse CD (LTCD), classical CD (CCD), Human immunodeficiency virus (HIV), active herpes simplex virus (HSV), Standard deviation (SD), Body mass index (BMI), gram (g)

Number shown as n (%) unless otherwise specified.

J or inverted T incisions were included in classical CD. Other CD includes low vertical and high transverse uterine incisions.

Pregnancy related hypertensive disease includes gestational hypertension, preeclampsia, and HELLP syndrome. Placenta abnormalities include placenta previa and placenta abruption.

Bolded values are statistically significant at $P < .05$

Demographic data, pregnancy outcome, and indications for cesarean delivery between 28 0/7 and 31 6/7 weeks' gestation.

Table 2

	LTCD (n=426)	Classical CD (n=91)	Other CD (n=22)	P-value (Classical vs LTCD)	P-value (Other vs LTCD)
Maternal age (yr), mean (SD)	29.8 (6.8)	29.2 (7.0)	32.8 (5.2)	.45	.04
Race/ethnicity					
Non-Hispanic white	126 (29.6)	17 (18.7)	3 (13.6)		
Non-Hispanic black	224 (52.6)	59 (64.8)	14 (63.6)	.07	.27
Other	76 (17.8)	15 (16.5)	5 (22.7)		
BMI at admission (kg/m ²)	31.3 (7.0)	32.5 (8.3)	31.3 (6.2)	.17	1.00
Underweight/Normal	74 (19.1)	17 (20.7)	3 (14.3)		
Overweight	124 (32.0)	19 (23.2)	4 (19.1)	.28	.27
Obese	189 (48.8)	46 (56.1)	14 (66.7)		
Number of prior uterine scar					
No uterine scar	324 (76.2)	60 (65.9)	11 (50.0)		
1 – 2	87 (20.5)	27 (29.7)	11 (50.0)	.122	<.01
3 or more	14 (3.3)	4 (4.4)	0 (0.00)		
Birth weight (g), mean (SD)	1341.9 (323.2)	1213.9 (319.3)	1440.9 (602.1)	<.01	.19
Emergent delivery	126 (29.6)	37 (41.1)	5 (22.7)	.03	.49
Skin incision					
Pfannenstiel incision	419 (98.4)	82 (90.1)	22 (100.0%)	<.001	1.00
Vertical incision	7 (1.6)	9 (9.9)	0 (0.0)		
Presentation					
Breech	139 (32.7)	49 (53.9)	8 (36.4)		
Cephalic	265 (62.4)	35 (38.5)	11 (50.0)	<.001	.17
Transverse	21 (4.9)	7 (7.7)	3 (13.6)		
Pregestational diabetes	14 (3.3)	5 (5.5)	1 (4.6)	.35	.54
Gestational diabetes	22 (5.2)	3 (3.3)	0 (0.0)	.60	.62
Chronic hypertension	57 (13.4)	21 (23.1)	4 (18.2)	.02	.52
Pregnancy associated hypertensive disease	189 (44.4)	31 (34.1)	8 (36.4)	.07	.46
Indications for cesarean delivery					

	LTCD (n=426)	Classical CD (n=91)	Other CD (n=22)	P-value (Classical vs LTCD)	P-value (Other vs LTCD)
Non-cephalic presentation	153 (35.9)	53 (58.2)	10 (45.5)	<.0001	.36
Non-reassuring fetal heart tracing	181 (42.5)	30 (33.0)	8 (36.4)	.09	.57
Failure to progress	16 (3.8)	2 (2.2)	1 (4.6)	.75	.58
Placenta abnormalities	63 (14.8)	15 (16.5)	5 (22.7)	.68	.36
Intrauterine growth restriction	70 (16.4)	18 (19.8)	6 (27.3)	.44	.24
Preeclampsia with severe features	164 (38.5)	25 (27.5)	8 (36.4)	.05	.84
Cord prolapse	6 (1.4)	3 (3.3)	0 (0.0)	.20	1.00
HIV/active HSV	7 (1.6)	2 (2.2)	0 (0.0)	.66	1.00
Chorioamnionitis	33 (7.8)	7 (7.7)	1 (4.6)	.99	1.00
Fetal anomaly	9 (2.1)	2 (2.2)	0 (0.0)	1.00	1.00

Abbreviations: Cesarean delivery (CD), Low transverse CD (LTCD), classical CD (CCD), Human immunodeficiency virus (HIV), active herpes simplex virus (HSV), Standard deviation (SD), Body mass index (BMI), gram (g)

Number shown as n (%) unless otherwise specified.

J or inverted T incisions were included in classical CD. Other CD includes low vertical and high transverse uterine incisions.

Pregnancy related hypertensive disease includes gestational hypertension, preeclampsia, and HELLP syndrome. Placenta abnormalities include placenta previa and placenta abruption.

Bolded values are statistically significant at $P < .05$

Table 3
Intraoperative and maternal outcomes by gestational weeks between 23 0/7 and 27 6/7 weeks' gestation.

	Low transverse cesarean (n=125)	Classical cesarean (n=221)	Unadjusted P-value or Odds ratio (95%CI)	Adjusted P-value or Odds ratio (95%CI) [†]
Intraoperative outcomes				
Primary cesarean				
Skin Incision-delivery (min)	6 (2, 13)	6 (2, 14)	.33	.57
Total operative time (min)	46 (29, 63)	52 (35, 76)	<.01	<.01
Repeat cesarean				
Incision-delivery (min)	10 (3, 17)	12 (3.5, 27)	.18	.07
Total operative time (min)	45.5 (31.5, 65.5)	66.5 (46, 97)	<.01	<.01
All cesarean delivery				
Estimated blood loss (ml)	723.6 ± 365.8	739.1 ± 354.7	.87	.28
Maternal outcomes				
Postpartum hemorrhage	7 (5.6)	18 (8.1)	1.51 (0.61–3.72)	2.01 (0.64–6.26)
Blood transfusion	15 (11.9)	22 (10.0)	0.82 (0.41–1.64)	0.95 (0.40–2.21)
Endometritis	7 (5.6)	22 (10.0)	1.88 (0.78–4.53)	1.55 (0.56–4.30)
Sepsis	3 (2.4)	7 (3.2)	1.35 (0.34–5.31)	0.42 (0.08–2.28)
Wound infection	4 (3.2)	5 (2.3)	0.71 (0.19–2.68)	0.54 (0.13–2.25)
Respiratory complications [*]	2 (1.6)	3 (1.4)	0.85 (0.14–5.18)	Not available
Intensive care unit admission	4 (3.2)	4 (1.8)	0.57 (0.14–2.30)	0.85 (0.13–5.63)
Composite maternal outcome	29 (23.0)	52 (23.6)	1.04 (0.62–1.74)	1.03 (0.56–1.87)
Duration of hospital stay after delivery (days)	4 (3, 5)	3.5 (3, 5)	.96	.90

Numbers shown as median (10th, 90th percentile), n (%) and mean ± standard deviation.

Abbreviations: Confidence interval (CI)

Low transverse cesarean as a reference.

J or inverted T incisions were included in classical cesarean.

Women could have multiple morbidities. For example, if a woman had hemorrhage and required intensive care unit admission; the woman was counted in the individual analyses for both hemorrhage and intensive care unit admission outcomes.

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* Respiratory complications included pulmonary edema, acute respiratory distress syndrome, and congestive heart failure.

[†] Adjusted P-value or Odds ratio comparing classical cesarean and low transverse cesarean (reference). Controlling for maternal age, race/ethnicity, gestational age, preterm premature rupture of membrane, preterm labor, hypertension, any diabetes, emergent delivery, skin incision, number of previous uterine scar, placenta abnormalities, and body mass index on admission.

Bolded values are statistically significant.

Table 4

Intraoperative and maternal outcomes by gestational weeks between 28 0/7 and 31 6/7 weeks' gestation.

	Low transverse cesarean (n=427)	Classical cesarean (n=91)	Unadjusted P-value or Odds ratio	Adjusted P-value or Odds ratio (95%CI) [†]
Intraoperative outcomes				
Primary cesarean				
Skin Incision-delivery (min)	8 (2, 15)	8 (2, 14)	.85	.32
Total operative time (min)	41 (26, 59)	52 (34, 90)	<.01	<.01
Repeat cesarean				
Incision-delivery (min)	10 (3, 18)	13 (4, 29)	<.01	.01
Total operative time (min)	44 (33, 74)	69 (52, 106)	<.01	<.01
All cesarean delivery				
Estimated blood loss (ml)	696.6 ± 307.3	781.3 ± 338.6	<.01	.23
Maternal outcomes				
Postpartum hemorrhage	33 (7.8)	11 (12.1)	1.66 (0.80–3.42)	1.17 (0.46–2.97)
Blood transfusion	26 (6.1)	14 (15.4)	2.80 (1.40–5.60)	2.42 (1.06–5.52)
Endometritis	12 (2.8)	6 (6.6)	2.44 (0.89–6.67)	3.23 (1.02–10.21)
Sepsis	3 (0.7)	2 (2.2)	3.17 (0.52–19.24)	3.11 (0.39–24.90)
Wound infection	14 (3.3)	4 (4.4)	1.35 (0.44–4.21)	0.89 (0.23–3.38)
Respiratory complications [*]	4 (0.9)	2 (2.2)	2.37 (0.43–13.15)	Not available
Intensive care unit admission	9 (2.1)	6 (6.6)	3.27 (1.13–9.43)	5.05 (1.37–18.52)
Composite maternal outcome	71 (16.7)	29 (31.9)	2.34 (1.41–3.89)	1.95 (1.10–3.45)
Duration of hospital stay after delivery (days)	4 (3, 5)	3.5 (2.5, 6)	.87	.71

Numbers shown as median (10th, 90th percentile), n (%) and mean ± standard deviation.

Low transverse CD as a reference.

J or inverted T incisions were included in classical CD.

Women could have multiple morbidities. For example, if a woman had hemorrhage and required intensive care unit admission; the woman was counted in the individual analyses for both hemorrhage and intensive care unit admission outcomes.

^{*} Respiratory complications included pulmonary edema, acute respiratory distress syndrome, and congestive heart failure.

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Adjusted P-value or Odds ratio comparing classical cesarean and low transverse cesarean (reference). Controlling for maternal age, race/ethnicity, gestational age, preterm premature rupture of membrane, preterm labor, hypertension, any diabetes, emergent delivery, skin incision, number of previous uterine scar, placenta abnormalities, and body mass index on admission.

Bolded values are statistically significant.