OBSTETRICS

Early preterm preeclampsia outcomes by intended mode of delivery

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BACKGROUND: The optimal route of delivery in early-onset preeclampsia before 34 weeks is debated because many clinicians are reluctant to proceed with induction for perceived high risk of failure.

OBJECTIVE: Our objective was to investigate labor induction success rates and compare maternal and neonatal outcomes by intended mode of delivery in women with early preterm preeclampsia.

STUDY DESIGN: We identified 914 singleton pregnancies with preeclampsia in the Consortium on Safe Labor study for analysis who delivered between 24 0/7 and 33 6/7 weeks. We excluded fetal anomalies, antepartum stillbirth, or spontaneous preterm labor. Maternal and neonatal outcomes were compared between women undergoing induction of labor (n = 460) and planned cesarean delivery (n = 454) and women with successful induction of labor (n = 214) and unsuccessful induction of labor (n = 246). We calculated relative risks and 95% confidence intervals to determine outcomes by Poisson regression model with propensity score adjustment. The calculation of propensity scores considered covariates such as maternal age, gestational age, parity, body mass index, tobacco use, diabetes mellitus, chronic hypertension, hospital type and site, birthweight, history of cesarean delivery, malpresentation/breech, simplified Bishop score, insurance, marital status, and steroid use.

RESULTS: Among the 460 women with induction (50%), 47% of deliveries were vaginal. By gestational age, 24 to 27 6/7, 28 to 31 6/7, and 32 to 33 6/7, the induction of labor success rates were 38% (12 of 32), 39% (70 of 180), and 54% (132 of 248), respectively. Induction of labor compared with planned cesarean delivery was less likely to be associated with placental abruption (adjusted relative risk, 0.33; 95% confidence interval, 0.16–0.67), wound infection or separation (adjusted relative risk, 0.23; 95% confidence interval, 0.06–0.85), and neonatal asphyxia (0.12; 95% confidence interval, 0.02–0.78). Women with vaginal delivery compared with those with failed induction of labor had decreased maternal morbidity (adjusted relative risk, 0.27; 95% confidence interval, 0.09–0.82) and no difference in neonatal outcomes.

CONCLUSION: About half of women with preterm preeclampsia who attempted an induction had a successful vaginal delivery. The rate of successful vaginal delivery increases with gestational age. Successful induction has the benefit of preventing maternal and fetal comorbidities associated with previous cesarean deliveries in subsequent pregnancies. While overall rates of a composite of serious maternal and neonatal morbidity/mortality did not differ between induction of labor and planned cesarean delivery groups, women with failed induction of labor had increased maternal morbidity highlighting the complex route of delivery counseling required in this high-risk population of women.

Key words: early preterm preeclampsia, outcomes early preterm preeclampsia, preterm mode of delivery, preterm preeclampsia

There is no consensus on the optimal mode of delivery for women with preeclampsia with severe features, superimposed preeclampsia (SIPE), eclampsia, and the syndrome of hemolysis, elevated liver enzymes and low platelets (HELLP) in the early preterm period (24 0/7 through 33 6/7 weeks). No randomized control trials have investigated this topic.[1] Few retrospective studies have investigated rates of labor inductions and neonatal outcomes, by mode of delivery, in early preterm pregnancies complicated by preeclampsia.[2–5]

Only two studies have evaluated neonatal outcomes by intended mode of delivery in women with early preterm preeclampsia, but both were single-center studies and lacked enough numbers to study rare neonatal outcomes, making it difficult to apply these conclusions to the broader population.[2,4] In addition, these studies focused only on neonatal outcomes, so little is known about maternal outcomes.

Early preterm delivery often is recommended in women with preeclampsia with severe features to decrease the risk of maternal mortality and morbidity.[6,7] The Task Force on Hypertension from the American College of Obstetrics and Gynecology states that "the mode of delivery should be determined by fetal gestational age, fetal presentation, cervical status, and maternal and fetal conditions"[8] and does not provide guidelines regarding the optimal mode of delivery for the benefit of maternal health. Clear guidelines are lacking regarding mode of delivery to minimize maternal and fetal risks.

The objective of this study was to investigate induction of labor success rates by gestational age and Bishop score and compare maternal and neonatal outcomes by intended mode of delivery before 34 weeks in women with preeclampsia with severe features, SIPE, eclampsia, or HELLP syndrome.

Materials and Methods

This was a secondary analysis of deidentified data from the Consortium on Safe Labor (CSL), which was conducted between 2002 and 2008. CSL was a retrospective cohort study of 228,562

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AJOG at a Glance

Why was this study conducted?

Many clinicians are reluctant to proceed with induction for perceived high risk of failure in early-onset preeclampsia.

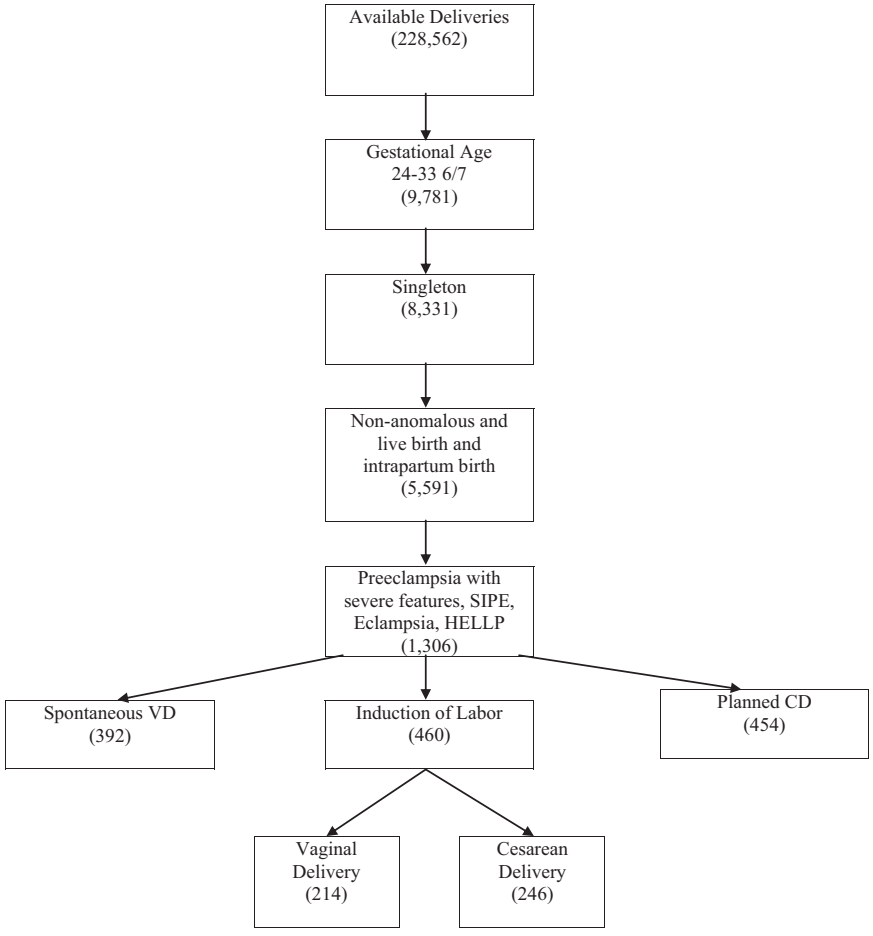
Key findings

Induction of labor (IOL) for preeclampsia before 34 weeks is successful in almost half of women. Women who underwent IOL had no difference in the composite maternal outcome but did have decreased placental abruption and wound separation compared with women undergoing planned cesarean delivery. Women with successful IOL had decreased maternal morbidity and no difference in neonatal outcomes compared with women with failed IOL.

What does this add to what is known?

These date provide information on outcomes that were previously understudied. Women with IOL and vaginal delivery have less maternal and neonatal morbidity compared with women with planned cesarean delivery and failed IOL.

FIGURE
Selection diagram



CD, cesarean delivery; *HELLP*, syndrome of hemolysis, elevated liver enzymes, and low platelets; *VD*, vaginal delivery.

Coviello et al. Preterm preeclampsia outcomes. Am J Obstet Gynecol 2019.

deliveries at 23 weeks or greater from 12 US clinical centers.[9] Data were extracted from the electronic medical record, including maternal characteristics, maternal antenatal medical history, labor and delivery outcomes, postpartum outcomes, and neonatal outcomes.

The data were mapped to predefined categories at the data-coordinating center. All participating institutions in the original study received institutional review board approval, and the current study was deemed exempt by the MedStar Health Research Institute's Institutional Review Board on Aug. 23, 2016.

We identified 1306 singleton pregnancies in the CSL with preeclampsia with severe features, SIPE, or HELLP syndrome who required delivery between 24 0/7 and 33 6/7 weeks (Figure). Pregnancies complicated by fetal anomalies, antepartum stillbirth, or spontaneous preterm labor were excluded, resulting in 914 eligible deliveries.

Maternal demographics, clinical characteristics, outcomes, and neonatal outcomes were identified from the medical record or *International Classification of Disease*, ninth revision, codes. Maternal demographics and clinical characteristics included maternal age, parity, race, prepregnancy body mass index (BMI), tobacco use, pregestational or gestational diabetes mellitus, chronic hypertension, systemic lupus erythematous, heart disease, renal disease, a history of prior cesarean delivery (CD), gestational age at delivery, fetal growth restriction, neonatal sex, oligohydramnios, disseminated intravascular coagulopathy (DIC), modified Bishop score,[10] birthweight, and CD indication.

Maternal and neonatal outcomes were compared between induction of labor (IOL; n = 460) and planned cesarean delivery (pCD; n = 454). A second analysis was performed to compare maternal and neonatal outcomes between successful IOL (vaginal delivery [VD], n = 214) and failed IOL (CD, n = 246). Unsuccessful IOL was defined as the decision to proceed to cesarean delivery after induction was started for a variety of indications.

TABLE 1
Maternal demographics

Variables	Induction (n = 460)	Planned CD (n = 454)	*P* value
Mom age, y[a]	26.6 (6.6)	29.8 (6.7)	< .01
Nulliparous	282 (61.3)	179 (39.4)	< .01
Race			.57
White	124 (27.0)	136 (30.0)	
Black	204 (44.3)	181 (39.9)	
Hispanic	81 (17.6)	83 (18.3)	
Others/unknown	51 (11.1)	54 (11.9)	
BMI at admission, kg/m^2 (n = 374; n = 352)			< .01
<25	40 (10.7)	37 (10.5)	
25.0–29.9	117 (31.3)	71 (20.2)	
30.0–34.9	99 (26.5)	109 (31.0)	
35.0–39.9	49 (13.1)	71 (20.2)	
≥40	69 (18.4)	64 (18.2)	
Tobacco use	39 (8.5)	40 (8.8)	.86
Diabetes			.08
No diabetes	399 (86.7)	369 (81.3)	
Pregestational diabetes	38 (8.3)	51 (11.2)	
Gestational diabetes	23 (5.0)	34 (7.5)	
Chronic hypertension	201 (43.7)	242 (53.3)	< .01
Systemic lupus erythematous	4 (0.9)	4 (0.9)	> .99[b]
Heart disease	9 (2.0)	13 (2.9)	.37
Renal disease	14 (3.0)	19 (4.2)	.36
History of CD	15 (3.3)	190 (41.9)	< .01
Gestational age, wks[a]	31.4 (2.1)	30.2 (2.5)	< .01
Fetal growth restriction	47 (10.2)	79 (17.4)	< .01
Neonatal gender (n = 460; n = 450)[c]			.19
Female	242 (52.6)	256 (56.9)	
Male	218 (47.4)	194 (43.1)	
Oligohydramnios	39 (8.5)	50 (11.0)	.20
DIC	0 (0)	0 (0)	—
Modified Bishop score (n = 280; n = 43)[c]			.03
0	87 (31.1)	21 (48.8)	
1–2	96 (34.3)	16 (37.2)	
3–4	63 (22.5)	5 (11.6)	
≥5	34 (12.1)	1 (2.33)	
Birthweight[a]	1611.5 (496.1)	1387.7 (557.6)	< .01
CD	246 (53.5)	454 (100)	< .01[b]

Coviello et al. Preterm preeclampsia outcomes. Am J Obstet Gynecol 2019. *(continued)*

Maternal outcomes included a maternal composite of maternal death, maternal intensive care unit admission, DIC, wound separation or infection, postpartum thrombosis or embolism, hysterectomy, and postpartum blood transfusion. Other maternal outcomes included maternal death, intensive care unit admission, DIC, placental abruption, chorioamnionitis, wound infection or separation, postpartum thrombosis or embolism, postpartum hemorrhage, postpartum blood product transfusion, postpartum fever, postpartum endometritis, and hysterectomy.

Neonatal outcomes included a composite outcome of death, asphyxia, and grade III/IV intraventricular hemorrhage (IVH). Other neonatal outcomes included neonatal death, neonatal intensive care unit admission, asphyxia, respiratory distress syndrome, transient tachypnea of the newborn, pneumonia, birth injury, grade III/IV IVH necrotizing enterocolitis (NEC), ventilation use, neonatal sepsis, and 5 minute Apgar score <7.

Descriptive statistics were calculated for all study variables. χ^2 test, Fisher exact test, or Wilcoxon rank-sum test was performed. A value of $P < .05$ was considered significant. Adjusted relative risks (aRRs) and 95% confidence intervals (CIs) for maternal and neonatal outcomes were calculated using Poisson regression with propensity score adjustment.[11]

We calculated the propensity scores for the intended routes and IOL outcomes, respectively, using multivariable logistic regressions with the consideration of maternal age, gestational age, parity, race, body mass index, tobacco use, diabetes mellitus, chronic hypertension, hospital type, hospital site, birthweight, a history of cesarean delivery, malpresentation/breech, simplified Bishop score, insurance, marital status, and steroid use. All statistical analyses were performed using SAS 9.4 (SAS Institute Inc, Cary, NC).

Results

The demographics of the women are described in Table 1. There were 460

TABLE 1
Maternal demographics *(continued)*

Variables	Induction (n = 460)	Planned CD (n = 454)	*P* value
CD indication			
Elective CD	37 (15.0)	30 (6.6)	< .01[b]
Failed induction of labor	27 (11.0)	0 (0)	< .01[b]
Failed forceps delivery	1 (0.4)	0 (0)	.35[b]
Failed VBAC	0 (0)	0 (0)	—
Failure to progress	46 (18.7)	0 (0)	< .01[b]
Nonreassuring fetal heart tracing	113 (45.9)	87 (19.2)	< .01[b]
HIV or herpes, contraindicated to VD	0 (0)	1 (0.2)	> .99[b]
Hypertensive disease	66 (26.8)	212 (46.7)	< .01[b]
Previous uterine scar	3 (1.2)	75 (16.5)	< .01[b]
Breech/malpresentation	5 (2.0)	53 (11.7)	< .01[b]
Other indication	30 (12.2)	90 (19.8)	.01[b]

The table presents the frequency and column percentage for each category unless indicated.

BMI, body mass index; *CD*, cesarean delivery; *DIC*, disseminated intravascular coagulopathy; *VBAC*, vaginal birth after cesarean; *VD*, vaginal delivery.

[a] Mean (SD); Student *t* test for statistical testing; [b] Fisher exact test; [c] There are missing observations for this calculation. Values in parentheses indicate the samples in the calculation.

Coviello et al. Preterm preeclampsia outcomes. Am J Obstet Gynecol 2019.

women with preeclampsia in the induction of labor group (50%) and 454 in the planned CD group (50%). Women with IOL were younger, more likely to be nulliparous, and presented at a later gestational age. Women with pCD were more likely to have a BMI >35 kg/m^2, chronic hypertension, prior CD, fetal growth restriction, or chronic hypertension ($P < .01$ for all comparisons). There was no statistically significant difference in tobacco use, systemic lupus erythematous, heart disease, renal disease, or oligohydramnios.

The IOL success rate was 47% (Table 2), with respective success rates increasing by gestational age category, 24 to 27 6/7, 28 to 31 6/7, and 32 to 33 6/7 of 38% (12 of 32), 39% (70 of 180), and 54% (132 of 248), respectively. CD was indicated in women with failed IOL for nonreassuring fetal heart tracing (46%), failed induction of labor or failure to progress (29%), and hypertensive disease (27%). The modified Bishop score was available in 160 women with successful VD and in 120 with failed IOL (CD).

For women with IOL, a more favorable modified Bishop score was associated with a higher rate of vaginal delivery. Successful VD occurred in 39% of women with a modified Bishop score value of zero, 56% with a modified Bishop score value of 1−2, 67% with a modified Bishop score value of 3−4, and 88% with a modified Bishop score value of ≥5 (Table 3).

Table 4 presents the maternal outcomes by intended mode of delivery. IOL was less likely to be associated with placental abruption (aRR, 0.33; 95% CI, 0.16-0.67), wound infection or separation (aRR, 0.23; 95% CI, 0.06-0.85) and neonatal asphyxia (aRR, 0.12; 95% CI, 0.02-0.78). One maternal death occurred in the pCD group for which no specific details were available. Statistically significant differences were not observed comparing IOL with pCD for maternal composite, chorioamnionitis, postpartum thrombosis or embolism, postpartum hemorrhage, postpartum blood product transfusion, postpartum fever, or postpartum endometritis.

When comparing maternal outcomes among women with IOL by actual mode of delivery (Table 5), VD was associated with a decreased risk of maternal composite compared with failed IOL (aRR, 0.27; 95% CI, 0.09−0.82). No cases of DIC occurred and 1 hysterectomy was reported in the group of women with successful IOL. There was no statistically significant difference between the successful IOL (VD) group and the failed IOL (CD) group regarding maternal death, placental abruption, chorioamnionitis, wound infection or separation, postpartum thrombosis or embolism, postpartum hemorrhage or blood product transfusion, or postpartum fever or postpartum endometritis.

Table 6 presents the neonatal outcomes by intended mode of delivery. The composite neonatal outcome was not statistically different between the induction and planned CD groups. Infants

TABLE 2
Induction of labor success rates by gestational age

Gestational age	Induction of labor, n	Vaginal delivery, n	Cesarean delivery, n	Labor induction success rates, %[a]
24−27 6/7	32	12	20	38
28−31 6/7	180	70	110	39
32−33 6/7	248	132	116	53
24−33 6/7	460	214	246	47

[a] Labor induction success rates were calculated by dividing the number of vaginal deliveries by the number of women undergoing labor induction.

Coviello et al. Preterm preeclampsia outcomes. Am J Obstet Gynecol 2019.

TABLE 3
Modified Bishop score by induction outcome

Variables	VD (n = 214)	CD (n = 246)	*P* value
Induction outcome			
Modified Bishop score (n = 160, n = 120)[a]			< .01
0	34 (39.1)	53 (60.9)	
1–2	54 (56.3)	42 (43.7)	
3–4	42 (66.7)	21 (33.3)	
≥5	30 (88.2)	4 (11.8)	

The table presents the frequency with row percentages for each category.

CD, cesarean delivery; *VD*, vaginal delivery.

[a] There are missing observations for this calculation. Values in parentheses indicate the samples in the calculation.

Coviello et al. Preterm preeclampsia outcomes. Am J Obstet Gynecol 2019.

delivered from women with IOL were less likely to have neonatal asphyxia (aRR, 0.12; 95% CI, 0.02–0.78) compared with those delivered by pCD. No statistically significant differences were seen for neonatal death, neonatal intensive care unit admission, respiratory distress syndrome, transient tachypnea of the newborn, pneumonia, NEC, ventilation use, birth injury, or 5 minute Apgar <7 comparing IOL and pCD. When comparing neonatal outcomes among women with IOL by actual route of delivery (Table 7), neonatal outcomes did not differ by route of delivery.

Comment

The optimal mode of delivery in women with early-onset preeclampsia in terms of maternal and neonatal morbidity and mortality is unknown. In our study, IOL was successful in 46% of the women with preeclampsia between 24 and 33 6/7 weeks and in more than one third of women between 24 and 31 6/7 weeks. Successful IOL was associated with a more favorable modified Bishop score; however, more than half of the women with an unfavorable modified Bishop score (1–2), had a VD.

Women who underwent IOL had no difference in the composite maternal outcome but did have decreased placental abruption and wound separation compared with women undergoing planned CD. However, women with

TABLE 4
Maternal outcomes for intended mode of delivery

Variables	Induction (n = 460)	Planned CD (reference) (n = 454)	cRR (95% CI)	aRR (95% CI)
composite outcome (237, 161)[a,b]	22 (9.3)	20 (12.4)	0.75 (0.41–1.37)	0.84 (0.31-2.30)
Maternal death (n = 348; n = 284)[a]	0 (0)	1 (0.4)	—	—
Maternal ICU admission (n = 400; n = 366)[a]	29 (7.3)	6 (1.6)	4.42 (1.84–10.65)	1.92 (0.54–6.78)
DIC	0 (0)	0 (0)	—	—
Placental abruption	25 (5.4)	37 (8.1)	0.67 (0.40–1.11)	0.33 (0.16–0.67)
Chorioamnionitis	8 (1.7)	9 (2.0)	0.88 (0.34–2.27)	1.26 (0.30–5.34)
Wound infection or separation	6 (1.3)	11 (2.4)	0.54 (0.20–1.45)	0.23 (0.06–0.85)
Postpartum thrombosis or embolism	4 (0.9)	2 (0.4)	1.97 (0.36–10.78)	3.15 (0.28–35.85)
Postpartum hemorrhage	28 (6.1)	18 (4.0)	1.53 (0.85–2.77)	1.51 (0.61–3.73)
Postpartum blood transfusion (n = 247; n = 194)[a]	16 (6.5)	12 (6.2)	1.05 (0.50–2.21)	0.86 (0.26–2.86)
Postpartum fever	19 (4.1)	26 (5.7)	0.72 (0.40–1.30)	0.59 (0.24–1.42)
Postpartum endometritis	7 (1.5)	11 (2.4)	0.63 (0.24–1.62)	0.68 (0.16–2.80)
Hysterectomy	1 (0.2)	0 (0)	—	—

Covariates included in the propensity score model include maternal age, gestational age, parity, race, body mass index, history of tobacco use, diabetes mellitus, chronic hypertension, type of hospital, site, birthweight, history of cesarean delivery, malpresentation/breech, simplified Bishop score, insurance, marital status, and administration of steroids.

aRR, adjusted relative risk; *CD*, cesarean delivery; *CI*, confidence interval; *cRR*, crude relative risk; *DIC*, disseminated intravascular coagulopathy; *ICU*, intensive care unit.

[a] There are missing observations for this calculation. Values in parentheses indicate the samples in the calculation; [b] Composite outcome includes maternal death, maternal ICU admission, DIC, wound separation or infection, postpartum thrombosis or embolism, hysterectomy, and postpartum blood transfusion.

Coviello et al. Preterm preeclampsia outcomes. Am J Obstet Gynecol 2019.

TABLE 5
Maternal outcomes by route of delivery

Variables	VD (n = 214)	CD (reference) (n = 246)	cRR (95% CI) VD to CD	aRR (95% CI) VD to CD
Composite outcome (115, 122)[a,b]	5 (4.4)	17 (13.9)	0.31 (0.11–0.84)	0.27 (0.09-0.82)
Maternal death (n = 170; n = 178)[a]	0 (0)	0 (0)	—	—
Maternal ICU admission (n = 184, n = 216)	23 (12.5)	6 (2.8)	4.5 (1.83–11.05)	0.96 (0.33–2.77)
DIC	0 (0)	0 (0)	—	—
Placental abruption	10 (4.7)	15 (6.1)	0.77 (0.34–1.70)	0.63 (0.22–1.78)
Chorioamnionitis	1 (0.5)	7 (2.8)	0.16 (0.02–1.33)	0.27 (0.02–3.24)
Wound infection or separation	0 (0)	6 (2.4)	—	—
Postpartum thrombosis or embolism	1 (0.5)	3 (1.2)	0.38 (0.04–3.68)	0.77 (0.04–13.98)
Postpartum hemorrhage	20 (9.3)	8 (3.3)	2.87 (1.26–6.52)	1.97 (0.66–5.93)
Postpartum blood transfusion (n = 119; n = 128)[a]	5 (4.2)	11 (8.6)	0.49 (0.17–1.41)	0.33 (0.10–1.10)
Postpartum fever	8 (3.7)	11 (4.5)	0.84 (0.34–2.08)	0.84 (0.24–2.85)
Postpartum endometritis	1 (0.5)	6 (2.4)	0.20 (0.02–1.59)	0.30 (0.02–3.76)
Hysterectomy	1 (0.5)	0 (0)	—	—

Covariates included in the propensity score model include: maternal age, gestational age, parity, race, body mass index, history of tobacco use, diabetes mellitus, chronic hypertension, type of hospital, site, birthweight, history of cesarean delivery, malpresentation/breech, simplified Bishop score, insurance, marital status, and administration of steroids.

aRR, adjusted relative risk; *CD*, cesarean delivery; *CI*, confidence interval; *cRR*, crude relative risk; *DIC*, disseminated intravascular coagulopathy; *ICU*, intensive care unit; *VD*, vaginal delivery.

[a] There are missing observations for this calculation. Values in parentheses indicate the samples in the calculation; [b] Composite outcome includes maternal death, maternal ICU admission, DIC, wound separation or infection, postpartum thrombosis or embolism, hysterectomy, and postpartum blood transfusion.

Coviello et al. Preterm preeclampsia outcomes. Am J Obstet Gynecol 2019.

failed IOL resulting in CD had higher rates of the maternal composite morbidity than women who had a successful vaginal delivery. Infants of women with IOL compared with pCD had lower rates of neonatal asphyxia, while women with attempted IOL, regardless of route of delivery, had no difference in neonatal outcomes.

The IOL success rate in our study is consistent with those reported in previous studies of pregnancies complicated by early preterm preeclampsia.[4,5] Nassar et al[5] found a 48% success rate of IOL in women with preeclampsia eligible for IOL between 24 and less than 34 weeks (70 of 145). Blackwell et al[4] studied 215 women with preeclampsia before 34 weeks who underwent IOL with a successful vaginal delivery rate of 46% and demonstrated that successful IOL was associated with increasing gestational age. Similarly, Alanis et al[2] evaluated the success of IOL related to gestation age in 491 women with preeclampsia between 24 and 34 weeks who underwent IOL or elective CD. These authors found a lower IOL success rate between 24 and 27 6/7 weeks, 7% (1 of 15), compared with our 38% success rate in the same gestational age cohort.

Our findings and those of Alanis et al[2] were similar in describing success rates related to increasing gestational age. Our data differ in that we found higher success rates for IOL at earlier gestational ages among women between 24 and 27 6/7 and 28 to 31 6/7 weeks. Our population differs in that our study included women from 12 centers throughout the United States, whereas the population described by Alanis et al[2] was limited to women who delivered at a single university center. The current findings may be more representative of major medical centers throughout the country that practice attempting IOL at earlier gestational ages.

The increased risk of wound infection or separation in women with planned CD could be attributed to increased rates of BMI >35 kg/m^2 compared with women with IOL. Although we were unable to determine the association in this cohort, this relationship has been established in previous studies.[12–14] One study showed that women with a BMI >35 kg/m^2 had 3.7 times the risk of wound infection compared with women with a BMI 18.5–25 kg/m^2.[12] Additional studies have suggested that preeclampsia and diabetes increase the risk of wound infection or separation, both prevalent in women with planned CD in the current study.[13,14]

The current study is consistent with previous studies that show no increase in serious neonatal morbidity among women with preterm preeclampsia and induction of labor.[2,4] Both Blackwell et al[4] (n = 215) and Alanis et al[2] (n = 491) found that attempted mode of

TABLE 6
Neonatal outcomes for intended mode of delivery

Variables	Induction (n = 460)	Planned CD (reference) (n = 454)	cRR (95% CI)	aRR (95% CI)
Composite outcome[a]	16 (3.5)	35 (7.7)	0.45 (0.25–0.82)	0.93 (0.38–2.29)
Neonatal death	10 (2.2)	24 (5.3)	0.41 (0.20–0.86)	2.15 (0.78–5.92)
NICU admission	402 (87.4)	403 (88.8)	0.98 (0.86–1.13)	0.99 (0.80–1.22)
Asphyxia	2 (0.4)	12 (2.6)	0.16 (0.04–0.73)	0.12 (0.02–0.78)
RDS	140 (30.4)	169 (37.2)	0.82 (0.65–1.02)	0.83 (0.59–1.17)
TTN	65 (14.1)	58 (12.8)	1.11 (0.78–1.57)	0.82 (0.48–1.39)
Pneumonia	6 (1.3)	7 (1.5)	0.85 (0.28–2.52)	1.10 (0.21–5.74)
Birth injury	8 (1.7)	3 (0.7)	2.63 (0.70–9.92)	1.87 (0.22–15.74)
IVH Grades III and IV	6 (1.3)	2 (0.4)	2.96 (0.60–14.67)	7.57 (0.91–62.80)
NEC	2 (0.4)	6 (1.3)	0.33 (0.07–1.63)	0.82 (0.08–8.14)
Ventilation use (n = 460; n = 453)[b]	126 (27.4)	192 (42.4)	0.65 (0.52–0.81)	0.84 (0.59–1.18)
Neonatal sepsis	67 (14.6)	50 (11.0)	1.32 (0.92–1.91)	1.23 (0.71–2.14)
Apgar <7 (n = 450; n = 452)[b,c]	47 (10.4)	62 (13.7)	0.76 (0.52–1.11)	0.91 (0.51–1.63)

Covariates included in the propensity score model include: maternal age, gestational age, parity, race, body mass index, history of tobacco use, diabetes mellitus, chronic hypertension, type of hospital, site, birth weight, history of cesarean delivery, malpresentation/breech, simplified bishop score, insurance and marital status and administration of steroids.

CD, cesarean delivery; *CI*, confidence interval; *cRR*, crude relative risk; *IVH*, intraventrical hemorrhage; *NEC*, necrotizing enterocolitis; *NICU*, neonatal intensive care unit; *RDS*, respiratory distress syndrome; *TTN*, transient tachypnea of the newborn.

[a] Composite outcome: death, asphyxia, and grades III/IV IVH; [b] There are missing observations for this calculation. Values in parentheses indicate the samples in the calculation; [c] Five minute Apgar.

Coviello et al. Preterm preeclampsia outcomes. Am J Obstet Gynecol 2019.

delivery was not associated with neonatal morbidity in women with IOL. Blackwell et al[4] investigated only a composite neonatal outcome major morbidity, which was restricted to grade III/IV IVH, NEC, bronchopulmonary dysplasia, early-onset seizures, and neonatal death. Neither study included asphyxia as a neonatal outcome.

Neonates born to women with vaginal delivery are typically exposed to hormonal and physiological stress, accelerating fetal lung maturation, compared with neonates born to women with prelabor CD.[15] This could account for a decreased risk of neonatal asphyxia in women with IOL. Unique to our study, neonatal outcomes were compared between those with successful IOL (VD) and failed IOL (CD) and showed no statically significant differences.

This study does have limitations. The Consortium on Safe Labor did not collect the etiology for the single maternal death in the study. It may be that the underlying hypertensive disease or morbidities associated with hypertension were associated with maternal death rather than the attempted mode of delivery.

It is also unclear why women with planned CD had a higher risk of placental abruption compared with women with IOL. Women with signs of placental abruption, including heavy vaginal bleeding and fetal distress, may be more likely to have a CD rather than offered an induction of labor. While we were able to investigate a number of individual morbidities, the numbers for some of the outcomes were small, and we may not have had power to detect differences that varied by intended and actual mode of delivery.

The strengths of the study include a robust cohort, with 914 deliveries from multiple medical centers compared with previous studies[2,4,5] and examination of both maternal and neonatal outcomes in the same cohort of women. This study further highlights the increased IOL success rates in women delivering at early preterm gestations compared with the previous studies.[2,4]

The decision of which route of delivery to pursue is particularly complex in women undergoing early preterm delivery for preeclampsia. We found a higher success rate for vaginal delivery after IOL than previous studies with the same population of women that is gestational age dependent. Furthermore, successful IOL has the benefit of preventing maternal and fetal comorbidities associated with previous CD in subsequent pregnancies without compromising neonatal morbidity or mortality. The overall rates of a composite of serious maternal and neonatal morbidity/mortality did not differ between IOL and planned CD groups. However, there were individual outcomes that differed between groups,

TABLE 7
Neonatal outcomes by route of delivery

Variables	VD (n = 214)	CD (reference) (n = 246)	cRR (95% CI) VD to CD	aRR (95% CI) VD to CD
Composite outcome[a]	6 (2.8)	10 (4.1)	0.69 (0.25–1.90)	2.49 (0.63–9.82)
Neonatal death	2 (0.9)	8 (3.3)	0.29 (0.06–1.35)	1.11 (0.16–2.81)
NICU admission	183 (85.5)	219 (89.0)	0.96 (0.79–1.17)	0.96 (0.74–1.25)
Asphyxia	1 (0.5)	1 (0.4)	1.15 (0.07–18.38)	5.64 (0.17–182.05)
RDS	63 (29.4)	77 (31.3)	0.94 (0.67–1.31)	1.00 (0.64–1.57)
TTN	31 (14.5)	34 (13.8)	1.05 (0.64–1.70)	0.73 (0.38–1.39)
Pneumonia	4 (1.9)	2 (0.8)	2.30 (0.42–12.55)	7.19 (0.89–57.77)
Birth injury	6 (2.8)	2 (0.8)	3.45 (0.70–17.09)	4.01 (0.54–29.61)
IVH grades III and IV	3 (1.4)	3 (1.2)	1.15 (0.23–5.70)	5.05 (0.53–47.89)
NEC	2 (0.9)	0 (0)	—	—
Ventilation use	46 (21.5)	80 (32.5)	0.66 (0.46–0.95)	1.11 (0.68–1.80)
Neonatal sepsis	35 (16.4)	32 (13.0)	1.26 (0.78–2.03)	1.69 (0.89–3.21)
Apgar <7 (n = 207; n = 243)[b,c]	17 (8.2)	30 (12.3)	0.96 (0.81–1.15)	0.97 (0.77–1.24)

Covariates included in the propensity score model include maternal age, gestational age, parity, race, body mass index, history of tobacco use, diabetes mellitus, chronic hypertension, type of hospital, site, birthweight, history of cesarean delivery, malpresentation/breech, simplified Bishop score, insurance, marital status, and administration of steroids.

CD, cesarean delivery; *CI*, confidence interval; *cRR*, crude relative risk; *IVH*, intraventrical hemorrhage; *NEC*, necrotizing enterocolitis; *NICU*, neonatal intensive care unit; *RDS*, respiratory distress syndrome; *TTN*, transient tachypnea of the newborn; *VD*, vaginal delivery.

[a] Composite outcome: death, asphyxia, and grades III/IV IVH; [b] Five minute Apgar; [c] There are missing observations for this calculation. Values in parentheses indicate the samples in the calculation.

Coviello et al. Preterm preeclampsia outcomes. Am J Obstet Gynecol 2019.

highlighting the complex route of delivery counseling required in this high-risk population of women. Providers should discuss the maternal and neonatal benefits and risks to both IOL and planned CD and longer-term reproductive outcomes with women as part of the shared decision-making process to determine the best individualized route of delivery. ■

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