OBSTETRICS

Neonatal mortality by attempted route of delivery in early preterm birth

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OBJECTIVE: We sought to study neonatal outcomes in early preterm births by delivery route.

STUDY DESIGN: Delivery precursors were analyzed in 4352 singleton deliveries, 24 0/7 to 31 6/7 weeks' gestation. In a subset (n = 2906) eligible for a trial of labor, neonatal mortality in attempted vaginal delivery (VD) was compared to planned cesarean delivery stratified by presentation.

RESULTS: Delivery precursors were classified as maternal or fetal conditions (45.7%), preterm premature rupture of membranes (37.7%), and preterm labor (16.6%). For vertex presentation, 79% attempted VD and 84% were successful. There was no difference in neonatal mortality. For breech presentation, at 24 0/7 to 27 6/7 weeks' gestation, 31.7% attempted VD and 27.6% were successful; neonatal mortality was increased (25.2% vs 13.2%, $P = .003$). At 28 0/7 to 31 6/7 weeks' gestation, 30.5% attempted VD and 17.2% were successful; neonatal mortality was increased (6.0% vs 1.5%, $P = .016$).

CONCLUSION: Attempted VD for vertex presentation has a high success rate with no difference in neonatal mortality unlike breech presentation.

Key words: early preterm birth, precursors, route of delivery

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Fifty-four percent of all infant deaths in the United States occur among the 2% of infants born at <32 weeks' gestation.[1] The optimal route of delivery for the early preterm fetus remains controversial. Some observational studies have shown a lower neonatal mortality for planned cesarean delivery (CD) as compared with vaginal delivery (VD) for vertex[2-4] and breech[2,4-9] early preterm pregnancies whereas other studies do not show a difference by route of delivery for vertex[10-12] or breech[13-15] presentation.

★ EDITORS' CHOICE ★

The vertical uterine incision often required for CD at this gestational age increases the risks of hemorrhage, bladder injury, and other complications. There is also an increased risk of uterine rupture, placenta previa, and placenta accreta in subsequent pregnancies.[16,17]

Six trials have attempted to randomize the route of delivery for women in preterm labor (PTL) at high risk for delivery. Recruitment difficulties limited combined enrollment in all of these trials to only 122 women. A metaanalysis of these trials found no statistically significant differences in neonatal outcomes by route of delivery, except for lower cord pH values among infants delivered by CD.[18]

Because randomized trials to answer this question have not proven feasible, a study using recent cohort data to determine the effect of fetal presentation, gestational age, and the intended route of delivery on outcome would be valuable. Therefore, the purpose of this study was to use a contemporary cohort that reflects current obstetric and neonatal clinical practice to identify the precursors of early preterm delivery ≤32 weeks of gestation and to assess the effect of intended route of delivery on neonatal mortality for viable singleton early preterm births, stratified by presentation.

Materials and Methods

The Consortium on Safe Labor (CSL) was a study conducted by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development,

From the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, National Institutes of Health, Bethesda, MD (all authors), and Ministry of Education and Shanghai Key Laboratory of Children's Environmental Health, Xinhua Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, People's Republic of China (Dr Zhang). Institutions in the Consortium are listed in the Acknowledgments.

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TABLE 1
Major anomalies: *ICD-9 codes*

ICD-9 code	Description
740	Anencephalus and similar anomalies
741	Spina bifida
742	Other congenital anomalies of nervous system
745	Bulbus cordis anomalies and anomalies of cardiac septal closure
746	Other congenital anomalies of heart
747	Other congenital anomalies of circulatory system
748	Congenital anomalies of respiratory system
750	Other congenital anomaly of upper alimentary tract
751	Other congenital anomalies of digestive system
753	Congenital anomalies of urinary system
756	Other congenital musculoskeletal anomalies
757.1	Ichthyosis congenita
758	Chromosomal anomalies
759.3-759.8	Other specified anomalies

ICD-9, International Classification of Diseases, Ninth Revision.

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National Institutes of Health, and has been described in detail elsewhere.[19] Briefly, CSL was a retrospective cohort study involving 228,668 deliveries from 2002 through 2008 from 12 clinical centers and 19 hospitals representing 9 American Congress of Obstetricians and Gynecologists districts. All deliveries at ≥23 weeks' gestation were included in the CSL cohort. Women could have >1 pregnancy in the cohort; so to avoid intraperson correlation only the first pregnancy enrolled was included for a total of 208,695 women.

Demographic data; medical history; prenatal, labor, and delivery information; as well as postpartum and neonatal outcomes were extracted from electronic medical records from each institution. Data from the neonatal intensive care unit (NICU) were collected and linked to the newborn record. Maternal and newborn discharge *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes were also collected for each delivery. Data were transferred in electronic format from each site and were mapped to common categories for each predefined variable at the data coordinating center. Data inquiries, cleaning, and logic checking were performed. Validation studies for 4 key outcome diagnoses (cesarean for nonreassuring fetal heart rate tracing, asphyxia, NICU admission for respiratory conditions, and shoulder dystocia) confirmed high level of accuracy. There was >95% concordance with the medical chart for 16/20 variables examined with the lowest concordance of 91.1% for clinical diagnosis of shoulder dystocia.[19] Institutional review board approval was obtained by all participating institutions.

All singleton deliveries occurring between 24 0/7 to 31 6/7 weeks of gestation comprised the cohort for this analysis (n = 5055). The Figure summarizes the study population for analysis. Due to a high percentage of missing data for some neonatal and pregnancy variables, 2 sites were eliminated from further analyses (n = 703), resulting in 4352 pregnancies. We first categorized the possible precursors for preterm delivery. The indications for admission, delivery, and pregnancy complications in the electronic medical record fields were used to classify the precursors to delivery into 3 overall categories: PTL, preterm premature rupture of membranes (PPROM), and indicated delivery. These 3 categories were mutually exclusive, prioritizing PTL then PPROM and then indicated for classification. The conditions leading to an indicated preterm birth included preeclampsia, placental abruption, nonreassuring fetal status, fetal growth restriction, severe maternal medical disease, antepartum stillbirth, and major anomalies; these conditions were not mutually exclusive so multiple indications could be coded for a single pregnancy. For example, a pregnancy complicated by a major anomaly, fetal growth restriction, and nonreassuring fetal status would be counted in each of these 3 categories of indicated early PTB. Major anomalies were defined by ≥1 *ICD-9* codes (Table 1).

Next we investigated neonatal outcomes in pregnancies eligible for attempted VD vs planned CD. Pregnancies with conditions requiring immediate CD, such as fetal distress, placenta previa, and placental abruption, or that were associated with such poor neonatal outcome that route of delivery was unlikely to affect outcome, including antepartum stillbirth and fetal anomalies, were eliminated from further analyses (n = 1446), resulting in 2906 singleton pregnancies. These 2906 singleton nonanomalous pregnancies were then stratified by gestational age blocks: 24 0/7 to 27 6/7 weeks of gestation (n = 1102) and 28 0/7 to 31 6/7 weeks of gestation (n = 1804). These gestational age categories were based on the fact that the highest rates of neonatal mortality and morbidity occur between 24 0/7 and 27 6/7 weeks of gestation. Within each gestational age block, pregnancies were then stratified by vertex or breech presentation (Figure).

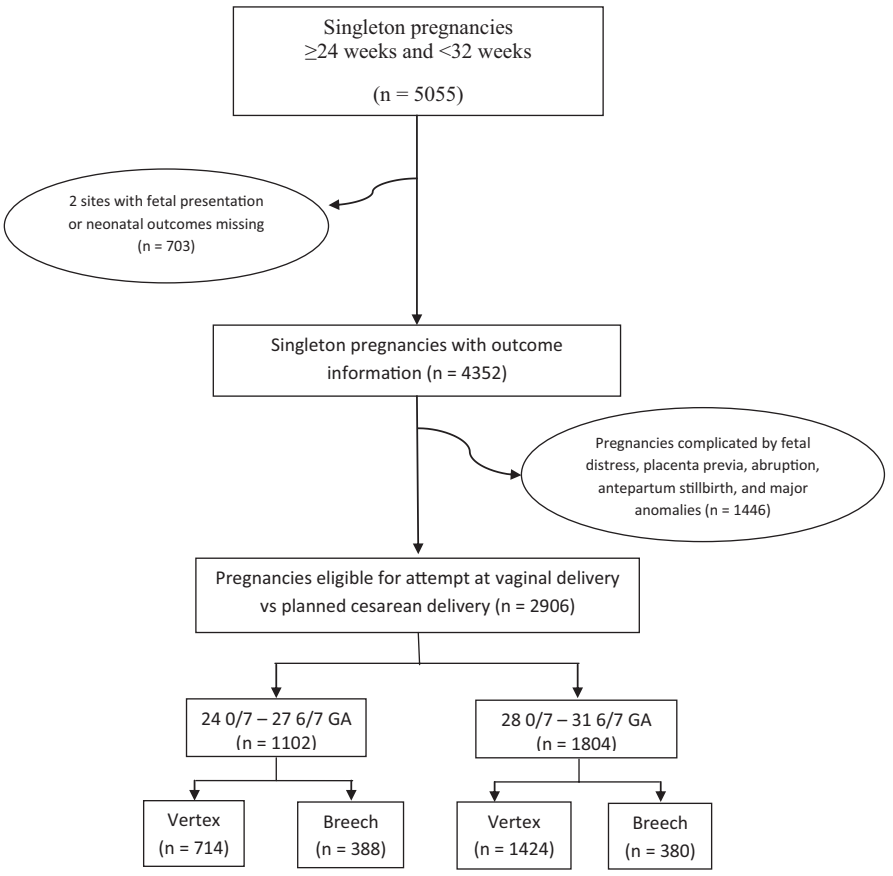
The following maternal characteristics were analyzed: race (white/Asian, black, Hispanic/other); maternal age (continuous variable); marital status (married, not married/unknown); insurance (private, public/self-pay/other/unknown); parity (nulliparas, multiparas); preexisting diabetes; preeclampsia; PTL; PPROM; smoking prior to/during pregnancy; alcohol use prior to/during pregnancy; illicit drug use prior to/during pregnancy; prepregnancy body mass index (BMI) (continuous variable); gestational age week (continuous variable); and birth weight (continuous variable). Antenatal corticosteroid (ACS) use (yes/no) was analyzed in a subset

of pregnancies where this information was reported (n = 1094).

Attempted VD was then compared to planned CD for the following neonatal outcome variables: death (intrapartum death + neonatal death), asphyxia, respiratory distress syndrome, pneumonia, intraventricular hemorrhage (IVH), necrotizing enterocolitis, sepsis, and need for ventilation. The local NICU definitions as recorded in the neonatal medical chart were used. Diagnoses were also supplemented with *ICD-9* codes.

Univariable analysis for all baseline and outcome variables was performed using χ^2 test comparing women undergoing attempted VD and planned CD. Multivariable analysis was then performed calculating adjusted relative risks (RRs) and 95% confidence intervals (CIs) to assess the strength of the relationship between attempted route of delivery stratified by presentation and the occurrence of neonatal mortality or morbidity. Missing values for maternal age (0.2% of cohort) and prepregnancy BMI (27.7% of cohort) were replaced with mean values. For birthweight, 4% of births were missing values and were replaced by the mean value within each gestational age week. To estimate RRs instead of odds ratios and also avoid the convergence pitfall associated with log binomial models, we used Poisson regression with a robust variance estimator as described by Zou[20] and dealt with clustering by site using fixed effects covariates in the model. Statistical analyses were performed using software (SAS, version 9.2; SAS Institute Inc, Cary, NC).

FIGURE
Study cohort description



Flowchart of study cohort.

GA, gestational age.

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RESULTS

To address the precursors of early preterm birth, the entire cohort of 4352 singleton pregnancies at 24 0/7 to 31 6/7 weeks' gestation with complete information on baseline and outcome variables was analyzed. The precursors leading to delivery by gestational age groupings (24-27 and 28-31 weeks' gestation) are presented in Table 2. The distribution of precursors was as follows: maternal or fetal indications (45.7%), PPROM (37.7%), and PTL (16.6%). Preeclampsia and major congenital anomalies were the leading contributors to indicated early preterm births. The distribution of the precursors leading to delivery was relatively similar across the 2 gestational age groupings.

Univariable analyses comparing attempted VD to planned CD for gestational age subgroups stratified by presentation are presented in Tables 3 and 4. At 24 0/7 to 27 6/7 weeks of gestation with a vertex presentation (n = 714), 22.8% underwent planned CD and 77.2% attempted VD. Of those attempting VD, 84.8% had a successful VD. The planned CD pregnancies were more likely to be multiparous, have diabetes, or have preeclampsia and less likely to have PPROM and PTL when compared to the attempted VD group ($P < .05$) (Table 3). Overall neonatal mortality in the group was 14.8% (106/714). When attempted VD was compared to planned CD, there were no differences in neonatal mortality or other neonatal outcomes (Table 4).

At 24 0/7 to 27 6/7 weeks' gestation with a breech presentation, (n = 388), 68.3% underwent planned CD and 31.7% attempted VD. Of those with attempted VD, only 27.6% had a successful VD. By univariable analyses, the planned CD pregnancies were more likely to have preeclampsia and less likely to be complicated by PTL when compared to the attempted VD group ($P < .05$) (Table 3). Overall neonatal mortality in this group was 17.0% (66/388). When compared to planned CD, attempted VD was associated with a higher rate of neonatal mortality (25.2% vs 13.2%, $P = .003$), but a lower rate of neonatal sepsis ($P = .01$) and decreased need for neonatal ventilation ($P = .023$) (Table 4).

At 28 0/7 to 31 6/7 weeks' gestation with a vertex presentation (n = 1424),

TABLE 2
Precursors leading to early preterm delivery

Variable	24-31 wk (n = 4352), n (%)	24-27 wk (n = 1701), n (%)	28-31 wk (n = 2651), n (%)
Preterm labor[a]	721 (16.6)	320 (18.8)	401 (15.1)
PPROM[a]	1641 (37.7)	665 (39.1)	976 (36.8)
Indicated[a]	1990 (45.7)	716 (42.1)	1274 (48.1)
Preeclampsia[b]	627 (14.4)	189 (11.1)	438 (16.5)
Abruption[b]	142 (3.3)	60 (3.5)	82 (3.1)
Nonreassuring fetal status[b]	495 (11.4)	161 (9.5)	334 (12.6)
Fetal growth restriction[b]	157 (3.6)	59 (3.5)	98 (3.7)
Severe maternal medical disease[b]	29 (0.7)	6 (0.4)	23 (0.9)
Fetal death[b]	153 (3.5)	70 (4.1)	83 (3.1)
Major anomalies[b]	648 (14.9)	278 (16.3)	370 (14.0)

PPROM, preterm premature rupture of membranes.

[a] Mutually exclusive categories; [b] "Indicated" subcategories are not mutually exclusive, pregnancy may be included in >1 "indicated" subcategory.

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20.1% underwent planned CD and 79.9% attempted VD. Of those with attempted VD, 84.3% had a successful VD. By univariable analyses, the planned CD pregnancies were more likely to have private insurance, be multiparous, have diabetes, or have preeclampsia and less likely to have PPROM and PTL when compared to the attempted VD group ($P < .05$) (Table 3). Overall neonatal mortality in this group was 2.4% (34/1424). When attempted VD was compared to planned CD, there were no differences in neonatal mortality. Compared to planned CD, attempted VD was associated with lower rates of perinatal asphyxia ($P = .004$), fewer cases of respiratory distress syndrome ($P = .003$), and a reduced need for assisted ventilation ($P = .004$) but higher rates of IVH ($P = .0017$) (Table 4).

At 28 0/7 to 31 6/7 weeks' gestation with a breech presentation (N = 380), 69.5% underwent planned CD and 30.5% attempted VD. Of those with attempted VD, only 17.2% had a successful VD. By univariable analyses, the planned CD pregnancies were more likely to have preeclampsia and less likely to be complicated by PTL when compared to the attempted VD group ($P < .05$) (Table 3). Overall neonatal mortality in this group was 2.9% (11/380). Attempted VD compared to planned CD was associated with increased neonatal mortality (6.0% vs 1.5%, $P = .016$) (Table 4).

Multivariable analyses were then performed examining the previously defined neonatal outcomes as well as a composite outcome of death or asphyxia (Table 5). For vertex presentation at 24 0/7 to 27 6/7 weeks' gestation, there were no differences in individual neonatal outcomes or in the composite outcome between attempted VD and planned CD. However, for breech presentation in this gestational age range, there was a 3-fold increase in mortality with attempted VD (RR, 3.0; 95% CI, 1.8–5.1) and a 2.4-fold increase in the composite outcome of death or asphyxia (RR, 2.4; 95% CI, 1.5–4.0). The differences in the risks of neonatal sepsis and need for ventilation seen on univariable analysis were no longer significant. Vertex presentation with attempted VD at 28 0/7 to 31 6/7 weeks' gestation was not associated with an increased risk of neonatal mortality or with the composite outcome of death or asphyxia, but was associated with an increased risk of IVH (RR, 1.8; 95% CI, 1.1–2.9) when compared to planned CD for vertex presentation in this gestational age range. For breech presentation at this gestational age range, attempted VD was associated with an increased neonatal mortality (RR, 5.1; 95% CI, 1.3–19.9) compared to planned CD (Table 5). Sensitivity analysis was performed by removing the 872 subjects who had missing values for maternal age, prepregnancy BMI, or birthweight. There was no change in the main findings of our study with the sensitivity analysis based on the remaining 2034 subjects with complete information. For vertex presentation, there was no increase in neonatal mortality with attempted VD compared to planned CD. For breech presentation, there remained an increased neonatal mortality rate with attempted VD compared to planned CD (data not shown). Multivariable analyses was then also performed in the subset of 5 sites reporting information on ACS administration (n = 1094). A total of 75.4% (825/1094) reported administering ACS prior to delivery. When ACS use was added to the multivariable model there was essentially no change in the neonatal mortality results for the 24-27 weeks' gestation group. There was no increased risk of neonatal mortality for vertex presentation (RR, 1.34; 95% CI, 0.49–3.64) and there remained an increased risk of neonatal mortality for breech presentation (RR, 4.0; 95% CI, 1.3–12.2) even after accounting for ACS administration. There were too few deaths in 28-31 weeks' gestation (n = 13 deaths) to evaluate the effects of route of delivery stratified by presentation in this subset with information on ACS use. However, there was no longer an increased risk of IVH with attempted VD at 28-31 weeks' gestation in vertex presentation after controlling for ACS administration (RR, 1.57; 95% CI, 0.72–3.40).

COMMENT

Despite the uncertainty of benefit, the use of CD for infants at <32 weeks of gestation has increased over the last 20 years as survival has improved.[21] In this large recent cohort with detailed medical record data, PPROM and indicated deliveries accounted for the majority of early preterm births; preeclampsia was the most common obstetric reason for indicated preterm delivery. This distribution differs from the usually quoted rates of about 30–35% of preterm births being indicated, 40–45% due to spontaneous PTL, and 25–30% due to

TABLE 3
Univariable analysis of baseline factors comparing attempted vaginal delivery and planned cesarean delivery stratified by presentation

	Gestational age: 24-27 wk, n = 1102						Gestational age: 28-31 wk, n = 1804					
	Vertex, n = 714			Breech, n = 388			Vertex, n = 1424			Breech, n = 380		
Variable	Attempted VD, n = 551 (77.2%) n (%)	Planned CD, n = 163 (22.8%) n (%)	*P* value	Attempted VD, n = 123 (31.7%) n (%)	Planned CD, n = 265 (68.3%) n (%)	*P* value	Attempted VD, n = 1138 (79.9%) n (%)	Planned CD, n = 286 (20.1%) n (%)	*P* value	Attempted VD, n = 116 (30.5%) n (%)	Planned CD, n = 264 (69.5%) n (%)	*P* value
Mode of delivery												
CD	84 (15.2)	163 (100)	< .0001	89 (72.4)	265 (100)	< .0001	179 (15.7)	286 (100)	< .0001	96 (82.8)	264 (100)	< .0001
VD	467 (84.8)	0 (0.0)	–	34 (27.6)	0 (0.0)	–	959 (84.3)	0 (0.0)	–	20 (17.2)	0 (0.0)	–
Insurance												
Private	215 (39.0)	65 (39.9)	.8439	57 (46.3)	115 (43.4)	.5869	470 (41.3)	146 (51.0)	.0029	50 (43.1)	123 (46.6)	.5296
Public/self-pay/other/unknown	336 (61.0)	98 (60.1)	–	66 (53.7)	150 (56.6)	–	668 (58.7)	140 (49.0)	–	66 (56.9)	141 (53.4)	–
Maternal race												
White/Asian	140 (25.4)	29 (17.8)	.0705	34 (27.6)	77 (29.1)	.9048	339 (29.8)	68 (23.8)	.0891	51 (44.0)	88 (33.3)	.0710
Black	255 (46.3)	76 (46.6)	–	54 (43.9)	110 (41.5)	–	454 (39.9)	131 (45.8)	–	29 (25.0)	94 (35.6)	–
Hispanic/other	156 (28.3)	58 (35.6)	–	35 (28.5)	78 (29.4)	–	345 (30.3)	87 (30.4)	–	36 (31.0)	82 (31.1)	–
Parity												
0	297 (53.9)	54 (33.1)	< .0001	55 (44.7)	119 (44.9)	.9882	546 (48.0)	100 (35.0)	.0004	40 (34.5)	100 (37.9)	.6004
1/2	188 (34.1)	75 (46.0)	–	52 (42.3)	113 (42.6)	–	432 (38.0)	135 (47.2)	–	57 (49.1)	115 (43.6)	–
≥3	66 (12.0)	34 (20.9)	–	16 (13.0)	33 (12.5)	–	160 (14.1)	51 (17.8)	–	19 (16.4)	49 (18.6)	–
Alcohol/drug use and smoking	90 (16.3)	23 (14.1)	.4944	25 (20.3)	54 (20.4)	.9905	162 (14.2)	34 (11.9)	.3030	14 (12.1)	45 (17.0)	.2174
Diabetes	26 (4.7)	16 (9.8)	.0151	8 (6.5)	15 (5.7)	.7433	83 (7.3)	44 (15.4)	< .0001	10 (8.6)	29 (11.0)	.4843
Preeclampsia	21 (3.8)	42 (25.8)	< .0001	4 (3.3)	42 (15.8)	.0004	106 (9.3)	92 (32.2)	< .0001	5 (4.3)	55 (20.8)	< .0001
PPROM	256 (46.5)	57 (35.0)	.0094	52 (42.3)	127 (47.9)	.2991	569 (50.0)	96 (33.6)	< .0001	40 (34.5)	107 (40.5)	.2650
Preterm labor	157 (28.5)	33 (20.2)	.0363	32 (26.0)	33 (12.5)	.0009	231 (20.3)	30 (10.5)	.0001	34 (29.3)	35 (13.3)	.0002

CD, cesarean delivery; *PPROM*, preterm premature rupture of membranes; *VD*, vaginal delivery.

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TABLE 4

Univariable analysis of neonatal outcomes comparing attempted vaginal delivery and planned cesarean delivery stratified by presentation

Neonatal outcomes	Gestational age: 24-27 wk, n = 1102						Gestational age: 28-31 wk, n = 1804					
	Vertex, n = 714			Breech, n = 388			Vertex, n = 1424			Breech, n = 380		
	Attempted VD, n = 551 n (%)	Planned CD, n = 163 n (%)	*P* value	Attempted VD, n = 123 n (%)	Planned CD, n = 265 n (%)	*P* value	Attempted VD, n = 1138 n (%)	Planned CD, n = 286 n (%)	*P* value	Attempted VD, n = 116 n (%)	Planned CD, n = 264 n (%)	*P* value
Death	84 (15.2)	22 (13.5)	.5814	31 (25.2)	35 (13.2)	.0034	25 (2.2)	9 (3.1)	.3468	7 (6.0)	4 (1.5)	.0155
Asphyxia	18 (3.3)	7 (4.3)	.5306	3 (2.4)	13 (4.9)	.2555	5 (0.4)	6 (2.1)	.0042	3 (2.6)	7 (2.7)	.9708
IVH	133 (24.1)	40 (24.5)	.9162	29 (23.6)	63 (23.8)	.9662	168 (14.8)	22 (7.7)	.0017	7 (6.0)	27 (10.2)	.1873
NEC	55 (10.0)	15 (9.2)	.7688	14 (11.4)	34 (12.8)	.6869	41 (3.6)	13 (4.5)	.4556	8 (6.9)	14 (5.3)	.5402
Pneumonia	85 (15.4)	18 (11.0)	.1617	21 (17.1)	39 (14.7)	.5503	59 (5.2)	16 (5.6)	.7815	11 (9.5)	18 (6.8)	.3676
RDS	430 (78.0)	134 (82.2)	.2511	95 (77.2)	224 (84.5)	.0805	528 (46.4)	161 (56.3)	.0028	78 (67.2)	165 (62.5)	.3754
Sepsis	293 (53.2)	89 (54.6)	.7486	61 (49.6)	168 (63.4)	.0101	354 (31.1)	80 (28.0)	.3032	35 (30.2)	101 (38.3)	.1300
Ventilation	341 (61.9)	108 (66.3)	.3103	74 (60.2)	190 (71.7)	.0234	349 (30.7)	113 (39.5)	.0043	58 (50.0)	123 (46.6)	.5400

CD, cesarean delivery; *IVH*, intraventricular hemorrhage; *NEC*, necrotizing enterocolitis; *RDS*, respiratory distress syndrome; *VD*, vaginal delivery.

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PPROM.[22] This difference likely results from our focus on preterm births <32 weeks' gestation rather than on all preterm birth (<37 weeks' gestation).

In contrast to some previously published reports,[2-4] we found that attempting VD with vertex presentation at 24 0/7 to 27 6/7 weeks of gestation did not significantly affect neonatal mortality. Furthermore, in such situations, >80% of attempted VD were successful. The findings, however, were different at 24 0/7 to 27 6/7 weeks of gestation if the fetal presentation was breech. In this subgroup, the majority of deliveries were by planned CD and the failure rate of attempted VD was high. Planned CD was associated with significantly lower neonatal mortality.

The findings in the deliveries at 28 0/7 to 31 6/7 weeks' gestation also differed by presentation. In this subgroup, if the fetal presentation was vertex, the majority of attempted VD succeeded. There was also no difference in the neonatal mortality rate compared to planned CD. It is important to note that the risk of IVH in the subgroup at 28-31 weeks of gestation in vertex presentation was no longer increased in the attempted VD group after accounting for ACS administration. For breech-presenting fetuses, attempting VD was less successful and planned CD was associated with lower neonatal mortality.

Previous studies examining the effect of route of delivery on neonatal mortality for early preterm births with a vertex presentation have defined route of delivery by actual, not attempted, delivery route. Two studies based on US birth certificate data found that actual CD was associated with decreased neonatal mortality for vertex presentation 500-749 g[2] as well as up to 1300 g.[3] The detailed information available in our study, but not available in birth certificate data, enabled us to account for attempted route of delivery as well as indications for delivery on neonatal mortality. This information is crucial for counseling families about the benefits and risks of attempting VD in this situation. Our results are consistent with the findings of 3 previous studies that analyzed singleton vertex-presenting neonates, <1500 g[10,12] as well as those born at 24-34 weeks of gestation,[11]

which showed no survival advantage for CD.

For breech pregnancies <32 weeks of gestation, planned CD was associated with lower neonatal mortality in our study. This finding has been noted in other studies based on birth certificate data[2,4-9] but not in other, smaller studies that use detailed medical record data from individual institutions.[13-15]

There are numerous strengths to this study. Examining the attempted route of delivery instead of actual route of delivery and controlling for indications leading to early preterm delivery is a major strength over previous studies because this information has direct clinical applications. We were able to control for multiple maternal, demographic, and obstetric covariates such as gestational age that influence neonatal outcome when examining planned delivery route. Some studies are based solely on birthweight and not gestational age, which is a limitation since gestational age is more directly related to neonatal outcome. Other strengths include using a relatively large recent cohort of early preterm deliveries with medical record level data available from multiple hospitals throughout the United States rather than relying upon birth certificate data. Previous studies have been single-center or multicenter trials with relatively small sample sizes and therefore underpowered to demonstrate a difference or accumulated larger numbers by evaluating outcomes over a decade, in which time neonatal intensive care has improved.

The limitations of this study include lack of information regarding ACS administration in the entire cohort. However, recent data demonstrates that 85% of infants <28 weeks of gestation are exposed to antenatal steroids.[23] Information regarding the grade of IVH and necrotizing enterocolitis was not collected. In addition, because the decision on mode of delivery was made by the physician and influenced by local practice, bias may have been introduced in that those with perceived worse outcome potential may have been more likely to be delivered vaginally. Likewise, neonatal outcomes were defined clinically as recorded in the patient's medical records, so criteria for defining these conditions may have varied among hospitals. Misclassification may have occurred in that a planned CD may have been classified as an attempted VD: for example, breech presentation that has progressed through labor quickly and delivers vaginally but would have been a planned CD if the woman was earlier in the course of labor. This misclassification may result in bias in either direction. Lastly, there are limited data on maternal outcomes and long-term neurological and physical disability outcomes of these infants, which is important when evaluating the overall risks and benefits of either route of delivery.

Selecting a route of delivery at <32 weeks' gestation is a difficult clinical decision given the high rate of neonatal mortality and morbidity as well as the maternal risks associated with CD and requires detailed counseling. For vertex-presenting fetuses <32 weeks' gestation, there was no improvement in neonatal mortality with planned CD. For breech-presenting fetuses <32 weeks' gestation, attempting VD was associated with a low success rate and planned CD was associated with lower neonatal mortality rates. Because it is unlikely that a randomized control trial will ever be conducted in the United States,[24] research with prospective data collection is needed to further delineate the short- and long-term benefits and risks of attempted route of delivery in the early preterm gestation. ■

TABLE 5
Multivariable analysis of neonatal outcomes comparing attempted vaginal delivery and planned cesarean delivery stratified by presentation

	Gestational age: 24-27 wk		Gestational age: 28-31 wk	
Outcomes	Vertex RR (95% CI)	Breech RR (95% CI)	Vertex RR (95% CI)	Breech RR (95% CI)
Death	1.31 (0.77–2.24)	3.01 (1.77–5.12)	0.84 (0.36–1.96)	5.06 (1.29–19.90)
Asphyxia	0.86 (0.31–2.41)	0.50 (0.14–1.88)	0.44 (0.11–1.72)	1.29 (0.21–7.74)
RDS	0.94 (0.76–1.17)	0.92 (0.71–1.19)	0.87 (0.72–1.06)	1.01 (0.75–1.35)
Pneumonia	1.21 (0.68–2.17)	1.03 (0.57–1.87)	1.11 (0.60–2.06)	1.49 (0.67–3.28)
IVH	0.77 (0.51–1.14)	0.88 (0.55–1.41)	1.83 (1.14–2.93)	0.48 (0.19–1.17)
NEC	0.90 (0.47–1.73)	0.84 (0.42–1.67)	0.74 (0.37–1.48)	0.67 (0.24–1.90)
Sepsis	1.00 (0.76–1.31)	0.76 (0.56–1.05)	1.15 (0.88–1.50)	0.75 (0.49–1.14)
Ventilation	0.97 (0.76–1.24)	0.88 (0.66–1.17)	0.80 (0.63–1.02)	1.08 (0.77–1.52)
Composite outcome[a]	1.21 (0.75–1.97)	2.44 (1.49–3.99)	0.80 (0.38–1.67)	2.31 (0.81–6.56)

Adjusted for: maternal race, maternal age, parity, insurance, smoking, alcohol, illicit drug use, diabetes (not adjusted for breech models), preterm labor, preterm premature rupture of membranes, preeclampsia, prepregnancy body mass index, gestational age week, birthweight, and site. Numerical variables (maternal age and prepregnancy body mass index) are treated as continuous variables in model and missing are replaced with means. Birthweight missing values are replaced by means within each gestational week.

CI, confidence interval; *IVH,* intraventricular hemorrhage; *NEC,* necrotizing enterocolitis; *RDS,* respiratory distress syndrome; *RR,* relative risk.

[a] Death or asphyxia.

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REFERENCES

1. Mathews TJ, MacDorman MF. Infant mortality statistics from the 2007 period linked birth/infant death data set. Natl Vital Stat Rep 2011;59:1-30.

2. Muhuri PK, Macdorman MF, Menacker F. Method of delivery and neonatal mortality among very low birth weight infants in the United States. Matern Child Health J 2006; 10:47-53.

3. Lee HC, Gould JB. Survival advantage associated with cesarean delivery in very low birth weight vertex neonates. Obstet Gynecol 2006; 107:97-105.

4. Malloy MH. Impact of cesarean section on neonatal mortality rates among very preterm infants in the United States, 2000-2003. Pediatrics 2008;122:285-92.

5. Jonas HA, Khalid N, Schwartz SM. The relationship between cesarean section and neonatal mortality in very-low-birthweight infants born in Washington State, USA. Paediatr Perinat Epidemiol 1999;13:170-89.

6. Jonas HA, Lumley JM. The effect of mode of delivery on neonatal mortality in very low birthweight infants born in Victoria, Australia: cesarean section is associated with increased survival in breech-presenting, but not vertex-presenting, infants. Paediatr Perinat Epidemiol 1997;11:181-99.

7. Kiely JL. Mode of delivery and neonatal death in 17,587 infants presenting by the breech. Br J Obstet Gynaecol 1991;98:898-904.

8. Gravenhorst JB, Schreuder AM, Veen S, et al. Breech delivery in very preterm and very low birthweight infants in The Netherlands. Br J Obstet Gynaecol 1993;100:411-5.

9. Lee KS, Khoshnood B, Sriram S, Hsieh HL, Singh J, Mittendorf R. Relationship of cesarean delivery to lower birth weight-specific neonatal mortality in singleton breech infants in the United States. Obstet Gynecol 1998;92: 769-74.

10. Wylie BJ, Davidson LL, Batra M, Reed SD. Method of delivery and neonatal outcome in very low-birthweight vertex-presenting fetuses. Am J Obstet Gynecol 2008;198:640.e1-7.

11. Riskin A, Riskin-Mashiah S, Lusky A, Reichman B; Israel Neonatal Network. The relationship between delivery mode and mortality in very low birthweight singleton vertex-presenting infants. BJOG 2004;111:1365-71.

12. Durie DE, Sciscione AC, Hoffman MK, Mackley AB, Paul DA. Mode of delivery and outcomes in very low-birth-weight infants in the vertex presentation. Am J Perinatol 2011;28: 195-200.

13. Stohl HE, Szymanski LM, Althaus J. Vaginal breech delivery in very low birth weight (VLBW) neonates: experience of a single center. J Perinat Med 2011;39:379-83.

14. Kayem G, Baumann R, Goffinet F, et al. Early preterm breech delivery: is a policy of planned vaginal delivery associated with increased risk of neonatal death? Am J Obstet Gynecol 2008;198:289.e1-6.

15. Wolf H, Schaap AH, Bruinse HW, Smolders-de Haas H, van Ertbruggen I, Treffers PE. Vaginal delivery compared with cesarean section in early preterm breech delivery: a comparison of long term outcome. Br J Obstet Gynaecol 1999;106:486-91.

16. Greene R, Fitzpatrick C, Turner MJ. What are the maternal implications of a classical cesarean section? J Obstet Gynaecol 1998;18: 345-7.

17. Cesarean delivery and peripartum hysterectomy. In: Cunningham FG, Leveno KJ, eds. Williams obstetrics, 23rd ed. New York: McGraw-Hill Companies Inc; 2010:544-64.

18. Grant A, Glazener CMA. Elective cesarean section versus expectant management for delivery of the small baby. Cochrane Database Syst Rev 2001;2:CD000078, 1-44.

19. Zhang J, Troendle J, Reddy UM, et al, for the Consortium on Safe Labor. Contemporary cesarean delivery practice in the United States. Am J Obstet Gynecol 2010;326.e1-10.

20. Zou G. A modified Poisson regression approach to prospective studies with binary data. Am J Epidemiol 2004;159:702-6.

21. MacDorman MF, Declercq E, Zhang J. Obstetrical intervention and the singleton preterm birth rate in the United States from 1991-2006. Am J Public Health 2010;100:2241-7.

22. Goldenberg RL, Culhane JF, Iams JD, Romero R. Epidemiology and causes of preterm birth. Lancet 2008;371:75-84.

23. Wirtschafter DD, Danielsen BH, Main EK, et al. Promoting antenatal steroid use for fetal maturation: results from the California perinatal quality care collaborative. J Pediatr 2006;148: 606-12.

24. Eller DP, VanDorsten JP. Route of delivery for the breech presentation: a conundrum. Am J Obstet Gynecol 1995;173:393-6.