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Morbidity and mortality associated with mode of delivery for breech periviable deliveries

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Abstract

Objective—To estimate the odds of morbidity and mortality associated with cesarean compared to vaginal delivery for breech fetuses delivered from 23 to 24 6/7 weeks gestational age (GA).

Study Design—Retrospective cohort study of state-level maternal and infant hospital discharge data linked to vital statistics for breech deliveries occurring between 23 and 24 6/7 weeks gestation in California, Missouri and Pennsylvania from 2000–2009 (N=1854). Analyses were stratified by GA (23–23 6/7 vs. 24–24 6/7).

Results—Cesarean was performed for 46% (335) and 77% (856) of 23- and 24-week breech fetuses. In multivariable analyses, overall survival was greater for cesarean-born neonates (AOR=3.98 95% CI=2.24, 7.06; AOR=2.91, 95% CI=1.76, 4.81). When delivered for non-emergent indications, cesarean-born survivors were more than twice as likely to experience 'Major Morbidity' (IVH, BPD, NEC, asphyxia composite) (AOR 2.83, 95% CI=1.37, 5.84; AOR=2.07, 95% CI=1.11, 3.86 at 23 and 24 weeks). Among intubated neonates, despite a short-term survival advantage, there was no difference in survival to >6-month corrected age (AOR=1.77, 95% CI =0.83, 3.74; AOR=1.50, 95% CI=0.81, 2.76). There was no difference in survival for intubated

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23-week neonates delivered by cesarean for non-emergent indications, nor cesarean-born neonates weighing <500g.

Conclusion—Cesarean increased overall survival and major morbidity for breech periviable neonates. However, among intubated neonates, despite a short-term survival advantage, there was no difference in 6-month survival. Also, cesarean did not increase survival for neonates weighing <500g. Patients and providers should explicitly discuss the trade-offs related to neonatal mortality and morbidity, maternal morbidity, and implications for future pregnancies.

Keywords

periviable birth; breech presentation; mode of delivery; birth outcomes

Introduction

With technological gains in neonatal intensive care capabilities, the threshold to provide antenatal interventions to improve survival has decreased to earlier gestational ages. Even in the face of rising periviable cesarean rates,[1, 2] the optimal mode of delivery for breech periviable neonates remains controversial, and it remains unclear whether cesarean delivery in the periviable period actually improves neonatal outcomes.[2] In light of the known increase in maternal morbidity and implications for future pregnancies associated with classical cesarean,[3] it is critically important that we have ample evidence to guide mode of delivery decisions at periviable gestational ages (GA). If cesarean does not confer substantial benefits to neonates, it is difficult to justify the added morbidity to mothers.

Many studies consider neonatal mortality and morbidity but often do not report outcomes by mode of delivery,[4, 5] and those studies that do examine mode of delivery often describe only mortality without morbidity-related outcomes.[2, 6–15] Furthermore, no randomized control trials of adequate size have compared planned vaginal delivery with planned cesarean for periviable neonates. Therefore, the literature leaves obstetricians ill-equipped to provide evidence-based recommendations and counseling to patients for periviable mode of delivery decisions.

The purpose of this study is to fill this gap in current knowledge by describing neonatal morbidity and mortality by mode of delivery for breech periviable fetuses. To do so, we aim to estimate the odds of neonatal morbidity and mortality associated with cesarean compared to vaginal delivery of breech fetuses delivered between 23 and 24 6/7 weeks GA.

Materials and Methods

Study Design and Population

We conducted a retrospective cohort study, analyzing state-level maternal and infant hospital discharge data, linked to birth and death certificate data, for California, Missouri, and Pennsylvania from 2000–2009. The Institutional Review Board (IRB) of the departments of health in California, Missouri, and Pennsylvania, and the Children's Hospital of Philadelphia approved this study. The data were input by the departments of health for each respective state; then cleaned and validated using sources including birth certificates and maternal and infant hospital data, with strong concordance (e.g. mode of delivery is over 99.5% concordant). The records were created by linking birth certificate data with maternal hospital discharge records and newborn hospital discharge data records, or death certificate data in the event of a fetal demise. Records were linked using previously described methods.[16] With these techniques, more than 98% of birth and death certificates are matched to maternal and newborn hospital records.[17] These data have been utilized extensively in our and others' publications.[18–21]

Live singleton births and 'in-hospital' fetal deaths occurring between 23 and 24 6/7 weeks of reported gestational age were included in the analysis. Because periviable births that are not resuscitated at the time of the delivery may potentially be classified as a fetal death,[22] it was important that fetal deaths not be excluded entirely from the analysis. We sought to distinguish these types of fetal deaths from fetal deaths that occurred out of the hospital or as intrauterine demises. Such deaths were designated as 'outpatient' or 'intrauterine' fetal deaths using criteria described by Phibbs et al. in previous work[22] and excluded from the analysis. (See Appendix A) Fetal anomalies were also excluded.

Variable Selection and Data Analysis

The primary predictor of interest was cesarean section (ICD 669.7x and 74.x), which had to be documented in the maternal or the infant record. Ultimately, documentation from the maternal record is reflected in all but 28 of the 8157 cases (99.0%). Breech neonates were identified by the following ICD-9 codes: 652.2, 652.20, 652.21, 652.23, and 763.0. Mortality-related outcomes of interest included: 'Overall survival' (defined as 6-month corrected age among intubated and non-intubated neonates) and survival to >24 hours, >1 week, and >6-month corrected age among neonates for whom intubation was performed or attempted (designated by ICD-9 codes 96.01, 96.02, 96.03, 96.04, 96.05 and CPT code 31500). Morbidity outcomes included: respiratory distress syndrome (RDS), bronchopulmonary dysplasia (BPD), grade III/IV intraventricular hemorrhage (IVH), necrotizing enterocolitis (NEC), retinopathy of prematurity (ROP), and asphyxia. Also included were composite outcome measures of 'Major Morbidity' designated as BPD, grade III/IV IVH, NEC, or asphyxia and a 'Composite' for death or asphyxia. ICD-9 codes used for specific diagnoses are listed in Appendix B. Maternal sociodemographic characteristics were also considered, including age in three categories (<18, 18–35, >35); race or ethnicity, designated in four categories (White, Black, Hispanic and Other); parity in four categories (0, 1, 2, 3 or more), education in two categories (<high school education or ≥high school education), median ZIP code income (<$20,000, $20,000–$40,000, $40,000–60,000, > $60,000) to approximate household income, and insurance payer (Fee For Service (FFS), Health Maintenance Organization (HMO), Federally Insured, Uninsured, and Other). In an effort to control for potential confounding factors, sociodemographic characteristics (insurance, race, and age) associated with mode of delivery were included as covariates in the final models. Likewise, maternal comorbidities, pregnancy complications, and delivery indications were also included in the full model, specifically: preexisting diabetes (DM), gestational diabetes (GDM), chronic hypertension (cHTN), pregnancy induced hypertension (PIH), preterm labor, preterm premature rupture of membranes (PPROM), placental abruption, repeat cesarean, placenta previa, and chorioamnionitis. ICD-9 codes used for specific diagnoses are listed in Appendix B. Finally, year of delivery was included because the incidence of cesarean increased over time in our cohort.

We conducted all analyses using SAS 9.2. Descriptive statistics were calculated using chi-squared tests and Fisher's exact test as appropriate. Logistic regression was performed for multivariable analyses, which included potential modifying factors such as sociodemographic factors, maternal comorbidities, pregnancy complications, and delivery indications in the model. Delivery hospital was also included as a fixed effect to account for potential clustering of outcomes at the level of the delivery hospital. We initially examined the relationship between mode of delivery and mortality and morbidity in the overall cohort. Separate analyses were conducted which excluded 'emergent indications,' designated as fetal distress, PIH, previa, and abruption. We reasoned that these indications typically require immediate delivery and may also be associated with poorer outcomes regardless of mode of delivery. We also examined survival over 3 time periods among the subset of neonates that were intubated. Finally, we constructed separate models to evaluate the potential interaction between cesarean delivery and birthweight in relationship to morbidity and mortality. Statistical tests were considered significant at α=.05, adjusted for multiple comparisons using the Bonferroni correction.

Results

Study Population

Our study population was comprised of 8157 maternal/infant observations. Among these, we identified 1854 (22.9%) breech deliveries that comprised our final study cohort. Table 1 provides overall baseline sociodemographic and clinical characteristics for the mother and infant pairs, stratified by GA and mode of delivery. 77.9% of mothers were age 18–35. 21.6% of the women were Black, 32.8% Hispanic, and 34.4% White. Approximately 27.6% of women had less than a high school education, and 50.0% were federally insured. Overall, 45.5% and 76.6% of women delivering 23- and 24- week breech neonates were delivered by cesarean.

Women who were delivered by cesarean differed significantly from women who were not delivered by cesarean across parity, insurer, and educational categories (p<.01 for each). Mode of delivery also differed based on maternal comorbidities. Compared to women who delivered vaginally, women delivered by cesarean were more likely to have PIH (7.89% vs. 1.66%, p=<.01) and a prior cesarean delivery (16.04% vs. 8.90%; p<.01); and less likely to have birth weight of <=500g (10.41% vs. 22.51%; p <.01).

Absolute Incidence and Adjusted Odds of Overall Survival by Mode of Delivery

Table 2 presents the absolute incidence and adjusted odds of 'overall survival' (includes all intubated and non-intubated neonates) for 23- and 24-week breech neonates in our study population, stratified by mode of delivery. Among the entire cohort of neonates delivered by cesarean at 23 weeks, the incidence of overall survival for cesarean-born neonates was 52.2% (175/335) compared to 22.9% (94/402) for vaginally-born neonates. Survival among this group was statistically significantly higher (AOR 3.98, 95% CI=2.24, 7.06) for those delivered by cesarean as compared to those who had a vaginal delivery in multivariable analyses. At 24 weeks, the overall survival among neonates delivered by cesarean was 65.0% (556/856), compared to a survival of 41.0% (107/261) for vaginally delivered neonates. In multivariable analysis, at 24 weeks, breech neonates delivered by cesarean, when compared to vaginal delivery, experienced greater survival in the overall cohort (AOR 2.91, 95% CI=1.76, 4.81). These associations remained statistically significant even after excluding emergent indications.

Morbidity among Survivors by Mode of Delivery and Gestational Age (GA)

Table 3 presents neonatal morbidity among intubated and non-intubated survivors, comparing cesarean and vaginal delivery by delivery indication and GA. Among intubated and non-intubated 23-week cesarean-born neonates who survived beyond 6-month corrected age, no differences were found in morbidity outcomes by mode of delivery. However, among those delivered for non-emergent indications, cesarean-born neonates were significantly more likely to experience each of the following: sepsis (AOR 3.62, 95% CI=1.78, 7.40), NEC (AOR 7.90, 95% CI=1.03, 60.57), and RDS (AOR 6.84, 95% CI=3.20, 14.63). Moreover, 'Major Morbidity', defined as BPD, IVH, NEC or asphyxia, was nearly 3 times as high for neonates delivered via cesarean for non-emergent indications compared to those delivered vaginally (AOR 2.83, 95% CI=1.37, 5.84).

Similar findings were noted among 24-week breech presenting neonates. Among intubated and non-intubated neonates delivered for all indications, no significant differences in morbidity were identified. However, 24-week cesarean-born neonates delivered for non-emergent indications were more likely to experience BPD (AOR 2.09, 95% CI=1.05, 4.16), sepsis (AOR 2.06, 95% CI=1.11, 3.84), RDS (AOR 4.11, 95% CI=2.03, 8.32), and ROP (AOR 4.49, 95% CI=1.86, 10.82). Likewise, 'Major Morbidity' was twice as high among 24-week breech neonates delivered by non-emergent cesarean (AOR 2.07, 95% CI=1.11, 3.86) compared to those delivered vaginally.

Survival over Time among Intubated Neonates by Mode of Delivery

Table 4 presents the adjusted odds of surviving for >24 hours, >1 week, and >6 months corrected age by mode of delivery and indication for 23- and 24-week neonates who were intubated. Among intubated neonates, we found that cesarean-born 23-week neonates were significantly more likely to survive for 1 week (AOR 2.22, 95% CI=1.01, 4.87), but there was no difference in the likelihood of surviving 24 hours (AOR 1.44, 95% CI=0.46, 4.47) or to 6-month corrected age (AOR 1.77, 95% CI=0.83, 3.74) based on mode of delivery. Furthermore, when we limited the analysis to non-emergent indications for cesarean, there was no difference in survival at any time interval based on mode of delivery.

Findings differed for 24-week neonates. At 24 weeks, intubated breech neonates delivered by cesarean, when compared to vaginal delivery, experienced greater survival at the 24 hour and 1 week intervals; however, no difference was observed in likelihood of survival to 6-month corrected age (AOR=1.81, 95% CI=0.72, 4.54). These associations remained even after excluding emergent indications.

Additional Analyses

In the analysis that adjusted for the effect of clustering at the level of the delivery hospital, our results remained largely unchanged. Table 5 reveals the results of an analysis performed to evaluate the potential interaction between cesarean delivery and birth weight in relationship to morbidity and mortality. This analysis showed no difference in mortality for cesarean-born neonates weighing <500g (AOR=0.46 95% CI=0.12, 1.79). Separate analyses were also performed to evaluate the cesarean rate over time. The prevalence of cesarean delivery increased over time. However, the association between mode of delivery and neonatal morbidity and mortality did not change over the time frame of this study.

Comment

We set out to estimate the odds of morbidity and mortality associated with cesarean compared to vaginal delivery for breech periviable fetuses. Our findings demonstrate a survival advantage with cesarean delivery among the entire cohort of intubated and non-intubated 23- and 24-week breech neonates. However, the odds of major neonatal morbidity among survivors were increased with cesarean performed for non-emergent indications. Furthermore, among the subset of intubated neonates, while the odds of short-term survival increased for 23- and 24-week neonates delivered by cesarean, their survival was no different beyond 6-month corrected age. Moreover, those intubated 23-week neonates delivered by cesarean for non-emergent indications were no more likely to survive at any time interval than those delivered by vaginal delivery. Finally, cesarean did not confer a survival benefit to neonates weighing <500g.

Other studies have reported a survival benefit for periviable neonates delivered by cesarean. Reddy et al. recently studied neonatal outcomes by attempted mode of delivery in a cohort of 24–32 week neonates.[15] Among 388 breech presenting 24–28 week deliveries, attempted vaginal delivery was associated with a higher rate of mortality (25.2% vs. 13.2%). Unfortunately, it was difficult to interpret the relevance of these findings for periviable neonates because 24-week deliveries were grouped with deliveries up to 28 weeks, and 23-week deliveries were not included. Malloy et al. studied vital statistics from more than 120000 22–31 week neonates and reported a survival advantage among 22–25 week neonates delivered by cesarean (61.5% compared to 37.8%). This survival advantage was primarily attributable to a greater survival in the first 24 hours of life.[6] In our initial analysis of the entire cohort of intubated and non-intubated breech neonates, we too found a survival advantage for cesarean-born neonates. However, for intubated neonates, this survival advantage was short-lived. For example, while cesarean-born 23-week breech neonates were more likely to survive from 24 hours to 1 week, they were no more likely to survive to 6-month corrected age. Moreover, this short-term survival advantage likely reflects confounding by indication for delivery, because when we excluded non-emergent indications for cesarean, there was no longer a statistically significant association between mode of delivery and survival at any time interval for 23-week breech neonates.

Bottoms et al. previously reported that an obstetrician’s willingness to perform periviable cesarean more than tripled the odds of survival while doubling neonatal morbidity.[24] Similarly, we found that morbidity was greater among cesarean-born 23- and 24-week neonates compared to vaginally-born neonates, but only when cesarean was performed for non-emergent indications. We were concerned that our results may be biased if obstetricians were more likely to deliver 'sick' or distressed babies by cesarean, resulting in greater morbidity among cesarean survivors. However, after excluding distressed and emergent deliveries, we noted greater, rather than attenuated, morbidity among the cesarean cohort. This may suggest that physician and fetal factors matter less in emergent decision-making; whereas, in non-emergent circumstances, physician judgments about survivability and/or parental preferences for intubation have a greater influence on clinical decision-making and outcomes. We sought to attend to this possible source of bias by calculating survival in a cohort of intubated neonates, and, indeed, we found that this attenuated the initially observed relationship between cesarean and survival.

There are limitations to the conclusions we can draw from these findings. Due to the limitations of the data set, we are unable to determine if the patterns of cesarean observed reflect institutional practice, maternal preference, or physician guidance. When we controlled for hospital as a fixed effect, there were no major differences in the overall findings. This suggests that institutional practice may not be a driving factor. Another limitation of the study is that we identified our predictor and outcome variables by ICD-9 codes, not primary chart abstraction. This limits our ability to distinguish planned cesarean from unplanned cesarean and creates the risk for misclassification. However, this method allows for a large, population-based cohort that is needed to study these relatively rare events. The large cohort also allowed for stratified analysis to specifically focus on the association of cesarean and outcomes for breech presenting 23- and 24-week pregnancies. Finally, other unmeasured confounders, such as the administration of antenatal corticosteroids, may play a significant role in decision-making and actually account for the associations that we observed.

In closing, our study provides a more nuanced understanding of factors that may explain previous reports that cesarean confers a survival advantage for periviable neonates. In particular, our findings suggest that, for intubated 23- and 24-week breech neonates delivered by cesarean, this survival advantage is shortlived. Furthermore, we find no survival advantage for 23-week neonates when cesarean is performed for non-emergent indications. Additionally, we find that this short-term survival advantage can come at the expense of significant morbidity. In particular, we observed increased morbidity among intubated and non-intubated neonates delivered by cesarean for non-emergent indications. These findings have important clinical implications, particularly for the care of 23-week breech presenting fetuses. What parents consider to be a meaningful absolute difference in survival may not be consistent with what physicians designate as 'clinically significant' difference; and this may vary from parent to parent. Likewise, with survival time – some parents may find added days to weeks of survival to be meaningful; while others find it painstaking. These 'quality vs. quantity' of life determinations are best made with and by parents. Furthermore, as providers, we contend with numerous uncertainties—both in regards to where any given child will fall in the potential spectrum of disability, and what impact a classical cesarean will have on future reproductive outcomes for the mother. With such uncertainties, and poor prognostic capabilities available, these clinical deliberations clearly call for shared decision-making to occur between patients and providers. Together, patients and providers must consider and explicitly discuss the inherent trade-offs related to neonatal mortality and morbidity, maternal morbidity, and implications for future pregnancies.

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Appendix A

'Outpatient' or 'intrauterine' fetal deaths were designated by the following ICD9 CM codes using criteria described by Phibbs et. al. in previous work.[22] Fetal deaths with these diagnoses were excluded from the analysis:

Papyraceous fetus (ICD9 CM 646.01)

Intrauterine death (ICD9 CM 656.40, -41, or -43)

Decreased fetal movement (ICD9 CM 655.71)

Cord entanglement with compression (ICD9 CM 663.20)

Cord entanglement without compression (ICD9 CM 663.31)

Ruptured uterus before delivery (ICD9 CM 665.01)

Insertion of laminaria (ICD9 CM 69.93)

Hysterotomy to terminate pregnancy (ICD9 CM 74.91)

Appendix B

The following ICD9 CM codes were used to designate maternal and fetal characteristics included as covariates in the models:

Preexisting Diabetes Mellitus (ICD9 CM 250.xx, 648.0x, 357.2, 362.0, 362.01, 362.02, 366.41)

Gestational Diabetes (ICD9 CM 648.8x)

Chronic Hypertension (ICD9 CM 642.0x, 642.1x, 642.2x)

Pregnancy Induced Hypertension (ICD9 CM 642.4x, 642.5x, 642.7x)

Preterm Labor (ICD9 CM 644.0x, 644.2x)

Preterm Premature Rupture of Membranes (ICD9 CM 658.1x, 658.2x)

Placental Abruption (ICD9 CM 641.2x)

Repeat Cesarean (ICD9 CM 654.2x and Birth Certificate Indicator)

Placenta Previa (ICD9 CM 641.0x, 641.1x)

Chorioamnionitis (ICD9 CM 646.6x, 658.4x, 659.2x, 659.3x)

Asphyxia (ICD9 CM 738.9, 768.1, 768.3, 768.4, 768.5, 768.6, 768.7, 768.70, 768.71, 768.72, 768.73)

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Table 1

Baseline Maternal Characteristics among Breech Presentations by Gestational Age and Mode of Delivery

	All N=1,854				23 Weeks Breech N=737			24 Weeks Breech N=1,117		
Maternal Characteristic	**Overall N=1854**	**Vaginal N=663 (35.8)**	**Cesarean N=1191 (64.2)**	***p****	**Vaginal N=402 (54.6)**	**Cesarean N=335 (45.5)**	***p***	**Vaginal N=261 (23.4)**	**Cesarean N=856 (76.6)**	***p***
Age (y)				0.36			0.42			0.45
Younger than 18	119 (6.4)	47 (7.1)	72 (6.0)		29 (7.2)	17 (5.1)		18 (6.9)	55 (6.4)	
18–35	1444 (77.9)	521 (78.6)	923 (77.5)		312 (77.6)	261 (77.9)		209 (80.1)	662 (77.3)	
Older than 35	291 (15.7)	95 (14.3)	196 (16.5)		61 (15.2)	57 (17.0)		34 (13.0)	139 (16.2)	
Parity				<0.01			<0.01			0.06
0	23 (1.2)	14 (2.11)	9 (0.8)		9 (2.2)	1 (0.30)		5 (1.9)	8 (0.9)	
1	581 (31.3)	232 (35.0)	349 (29.3)		139 (34.6)	93 (27.8)		93 (35.6)	256 (29.9)	
2	295 (15.9)	111 (16.7)	184 (15.5)		67 (16.7)	58 (17.3)		44 (16.9)	126 (14.7)	
3 or more	333 (18.0)	92 (13.9)	241 (20.2)		60 (14.9)	86 (25.7)		32 (12.3)	155 (18.1)	
Missing	622 (33.5)	214 (32.3)	408 (34.3)		127 (31.6)	97 (29.0)		87 (33.3)	311 (36.3)	
Race or ethnicity				0.50			0.29			0.12
White	638 (34.4)	219 (33.0)	419 (35.2)		137 (34.1)	107 (31.9)		82 (31.4)	312 (36.5)	
African American	400 (21.6)	150 (22.6)	250 (21.0)		87 (21.6)	68 (20.3)		63 (24.1)	182 (21.3)	
Hispanic	608 (32.8)	212 (32.0)	396 (33.3)		127 (31.6)	127 (37.9)		85 (32.6)	269 (31.4)	
Other	177 (9.6)	72 (10.9)	105 (8.8)		42 (10.5)	30 (9.0)		30 (11.5)	75 (8.8)	
Missing	31 (1.7)	10 (1.5)	21 (1.8)		9 (2.2)	3 (0.9)		1 (0.4)	18 (2.1)	
Insurance				<0.01			0.09			0.46
Fee for service	115 (6.2)	41 (6.2)	74 (6.2)		26 (6.5)	17 (5.1)		15 (5.8)	57 (6.7)	
Health maintenance organization	728 (39.3)	275 (41.5)	453 (38.0)		169 (42.0)	128 (38.2)		106 (40.6)	325 (38.0)	
Federal	926 (50.0)	315 (47.5)	611 (51.3)		185 (46.0)	177 (52.8)		130 (49.8)	434 (50.7)	
Other	21 (1.1)	4 (0.6)	17 (1.4)		2 (0.5)	2 (0.6)		2 (0.8)	15 (1.8)	
Uninsured	14 (0.8)	11 (1.7)	3 (0.3)		8 (2.0)	0		3 (1.2)	3 (0.4)	
Missing	50 (2.7)	17 (2.6)	33 (2.8)		12 (3.0)	11 (3.3)		5 (1.9)	22 (2.6)	

	All N=1,854				23 Weeks Breech N=737			24 Weeks Breech N=1,117		
Maternal Characteristic	**Overall N=1854**	**Vaginal N=663 (35.8)**	**Cesarean N=1191 (64.2)**	***p*** *	**Vaginal N=402 (54.6)**	**Cesarean N=335 (45.5)**	***p***	**Vaginal N=261 (23.4)**	**Cesarean N=856 (76.6)**	***p***
Education				<0.01			0.14			<0.01
At least a high school graduate	1268 (68.4)	467 (70.4)	801 (67.3)		278 (69.2)	218 (65.1)		189 (72.4)	583 (68.1)	
Did not complete high school	511 (27.6)	157 (23.7)	354 (29.7)		100 (24.9)	103 (30.8)		57 (21.8)	251 (29.3)	
Missing	75 (4.1)	39 (5.9)	36 (3.0)		24 (6.0)	14 (4.2)		15 (5.8)	22 (2.6)	
Annual income				0.79			0.41			0.25
Less than $20,000	20 (1.1)	8 (1.1)	12 (1.0)		1 (0.3)	3 (0.9)		7 (2.7)	9 (1.1)	
$20,000.01–40,000	938 (50.6)	329 (49.6)	609 (51.1)		204 (50.8)	172 (51.3)		125 (47.9)	437 (51.1)	
$40,000.01–60,000	646 (34.8)	228 (34.4)	418 (35.1)		134 (33.3)	120 (35.8)		94 (36.0)	298 (34.8)	
Greater than $60,000	228 (12.3)	89 (13.4)	139 11.7)		59 (14.7)	36 (10.8)		30 (11.5)	103 (12.0)	
Missing	22 (1.2)	9 (1.4)	13 (1.1)		4 (1.0)	4 (1.2)		5 (1.9)	9 (1.1)	
Maternal comorbidities										
Pre-existing DM	20 (1.1)	7 (1.1)	13 (1.01	0.94	5 (1.2)	2 (0.6)	0.46	2 (0.8)	11 (1.3)	0.74
GDM	48 (2.6)	17 (2.6)	31 (2.6)	0.96	7 (1.7)	10 (3.0)	0.26	10 (3.8)	21 (2.5)	0.24
Chronic hypertension	41 (2.2)	11 (1.7)	30 (2.5)	0.23	6 (1.5)	6 (1.8)	0.75	5 (1.9)	24 (2.8)	0.43
PIH	105 (5.7)	11 (1.7)	94 (7.9)	<0.01	6 (1.5)	21 (6.3)	<0.01	5 (1.9)	73 (8.5)	<0.01
Diagnosis or indication										
Preterm labor	1635 (88.2)	594 (89.6)	1,041 (87.4)	0.16	355 (88.3)	295 (88.1)	0.92	239 (91.6)	746 (87.2)	0.05
PPROM	644 (34.7)	224 (33.8)	420 (35.3)	0.52	139 (34.6)	110 (32.8)	0.62	85 (32.6)	310 (63.2)	0.28
Chorioamnionitis	105 (5.7)	170 (25.6)	342 (28.7)	0.16	103 (25.6)	91 (27.2)	0.63	67 (25.7)	251 (29.3)	0.25
Previous Cesarean	512 (27.6)	59 (8.9)	191 (16.0)	<0.01	33 (8.2)	64 (19.1)	<0.01	26 (10.0)	127 (14.8	0.05
Placenta Previa	53 (2.9)	12 (1.8)	41 (3.4)	0.04	8 (2.0)	9 (2.7)	0.53	4 (1.5)	32 (3.7)	0.07
Delivery outcomes										
Sex				0.29			0.48			0.09
Male	1015 (54.7)	352 (53.1)	663 (55.7)		218 (54.2)	173 (51.6)		134 (51.3)	490 (57.2)	
Female	839 (45.3)	311 (46.9)	528 (44.3)		184 (45.8)	162 (48.4)		127 (48.7)	366 (42.8)	
Birth weight ≤ 500g	273 (14.7)	149 (22.5)	124 (10.4)	<0.01	111 (27.7)	40 (11.9)	<0.01	38 (14.6)	84 (9.8)	0.03

*Cesarean vs. vaginal delivery

†Percentages may not sum to 100 due to rounding.

Table 2

Absolute Incidence and Adjusted Odds of Survival among Intubated and Non-intubated Breech Neonates by GA and Mode of Delivery

	All Indications					
	23 Weeks GA			24 Weeks GA		
	Vaginal [n/N (%)]	Cesarean [n/N (%)]	AOR (95% CI)*†‡	Vaginal [n/N (%)]	Cesarean [n/N (%)]	AOR (95% CI)*†‡
Overall Survival§	92/402 (22.9)	175/335 (52.2)	3.98 (2.24, 7.06)	107/261 (41.0)	556/856 (65.0)	2.91 (1.76,4.81)

*Corrected for multiple comparisons using the Bonferroni method (α=0.001563).

†Adjusted for insurance, maternal race, maternal age, chronic hypertension, diabetes, gestational diabetes, chorioamnionitis, pregnancy induced hypertension, preterm labor, premature rupture of membranes, placenta previa, placental abruption, previous Cesarean, and year.

‡Cesarean vs. vaginal delivery

§Survival to 6 months corrected age among intubated and non-intubated breech neonates.

Table 3

Neonatal Morbidity among Intubated and Non-intubated Survivors Comparing Mode of Delivery by Delivery Indication and GA

	All Indications		Excluding Emergent Indications	
	23 Weeks GA	24 Weeks GA	23 Weeks GA	24 Weeks GA
	AOR (95% CI)*,†,‡	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Asphyxia	0.47 (0.01, 38.85)	4.51 (0.11, 181.57)	0.87 (0.08, 9.15)	1.01 (0.18, 5.76)
BPD	0.87 (0.33, 2.32)	0.80 (0.38, 1.66)	2.28 (0.98, 5.31)	2.09 (1.05, 4.16)//
Bacterial Sepsis	1.01 (0.37, 2.74)	1.13 (0.53, 2.41)	3.62 (1.78, 7.40)//	2.06 (1.11, 3.84)//
IVH Grades III/IV	0.75 (0.14, 3.89)	0.78 (0.26, 2.29)	2.67 (0.87, 8.23)	1.39 (0.51, 3.83)
NEC	4.04 (0.36, 45.30)	1.32 (0.36, 4.79)	7.90 (1.03, 60.57)//	1.67 (0.53, 5.30)
RDS	2.01 (0.56, 7.27)	0.66 (0.22, 1.94)	6.84 (3.20, 14.63)//	4.11 (2.03, 8.32)//
ROP	1.17 (0.40, 3.42)	1.57 (0.71, 3.49)	2.25 (0.91, 5.52)	4.49 (1.86,10.82)//
Major Morbidity§	0.83 (0.32, 2.20)	0.78 (0.37, 1.65)	2.83 (1.37, 5.84)//	2.07 (1.11, 3.86)//
Composite§	0.47 (0.01, 38.85)	4.51 (0.11, 181.57)	0.25 (0.12, 0.50)//	0.27 (0.14, 0.50)//

*Corrected for multiple comparisons using the Bonferroni method (α=0.001389).

†Adjusted for insurance, maternal race, maternal age, chronic hypertension, diabetes, gestational diabetes, chorioamnionitis, pregnancy induced hypertension, preterm labor, premature rupture of membranes, placenta previa, placental abruption, previous Cesarean, and year.

‡Cesarean vs. vaginal delivery

§Major Morbidity includes BPD, IVH, NEC, or asphyxia; Composite includes death or asphyxia

//Significant at α=0.001389

Table 4

Survival over Time among Intubated Breech Neonates by Delivery Indication, GA, and Mode of Delivery

	All Indications						Excluding Emergent Indications					
	23 Weeks GA			24 Weeks GA			23 Weeks GA			24 Weeks GA		
	Vaginal n/N (%)	Cesarean n/N (%)	AOR (95% CI)*†‡	Vaginal n/N (%)	Cesarean n/N (%)	AOR (95% CI)*†‡	Vaginal n/N (%)	Cesarean n/N (%)	AOR (95% CI)*†‡	Vaginal n/N (%)	Cesarean n/N (%)	AOR (95% CI)*†‡
Survival >24h	130/149 (87.3)	237/262 (90.5)	1.44 (0.46, 4.47)	138/161 (85.7)	653/696 (93.8)	2.44 (0.94, 6.33)	103/120 (85.8)	137/151 (90.7)	2.40 (0.57, 10.14)	103/123 (83.7)	329/349 (94.3)	3.30 (1.02, 10.72)
Survival >1wk	84/149 (56.4)	187/262 (71.4)	2.22 (1.01, 4.87)	114/161 (70.8)	579/696 (83.2)	2.07 (1.04, 4.11)	69/120 (57.5)	102/151 (67.6)	2.12 (0.80, 5.64)	85/123 (69.1)	299/349 (85.7)	2.38 (1.01, 5.61)
Survival >6mos	60/149 (40.3)	139/262 (53.1)	1.77 (0.83, 3.74)	94/161 (58.4)	467/696 (67.1)	1.50 (0.81, 2.76)	48/120 (40..0)	77/151 (51.0)	1.81 (0.72, 4.54)	68/123 (55.3)	249/349 (71.4)	1.87 (0.88, 3.96)

* Corrected for multiple comparisons using the Bonferroni method (α=0.001389).

† Adjusted for insurance, maternal race, maternal age, chronic hypertension, diabetes, gestational diabetes, chorioamnionitis, pregnancy induced hypertension, preterm labor, premature rupture of membranes, placenta previa, placental abruption, previous Cesarean, and year.

‡ Cesarean vs. vaginal delivery

Table 5

Adjusted Odds of Neonatal Mortality and Morbidity Comparing Cesarean and Vaginal Delivery by Birth Weight (BW)

	All Indications				Excluding Emergent Indications			
	BW <500 g	**BW 500–749 g**	**BW 750–999 g**	**BW >=1000 g**	**BW <500 g**	**BW 500–749 g**	**BW 750–999 g**	**BW >=1000 g**
	AOR (95% CI)* [†,‡]	***AOR (95% CI)***	***AOR (95% CI)***	***AOR (95% CI)***	***AOR (95% CI)***	***AOR (95% CI)***	***AOR (95% CI)***	***AOR (95% CI)***
Neonatal Death >6 months	0.46 (0.12, 1.79)	0.28 (0.17, 0.45)[//]	0.59 (0.18, 1.89)	0.02 (0,1.43)	25.91 (0.07,9107.46)	2.26 (1.28,3.99)[//]	3.19 (0.73,14)	0.74 (0,125.20)
Asphyxia	2.09E8 (0, 8.93E40)	1.50 (0.35, 6.38)	0.63 (0.04, 9.95)		111.69 (0,1.27E86)	1.23 (0.22,6.93)	0.22 (0,15.18)	
BPD	3.88 (0.49, 30.54)	2.18 (1.30, 3.67)[//]	2.33 (0.63, 8.67)	0.60 (0, 84.34)	3.34E32 (0,2.89E87)	2.07 (1.10, 3.90)[//]	4.15 (0.72, 23.91)	2.35 (0, 2445.47)
Bacterial Sepsis	18.30 (2.78, 120.69)[//]	2.54 (1.59, 4.06)[//]	1.90 (0.57, 6.38)	2.25 (0.09,57.65)	16.10 (0.92,281.91)	2.43 (1.38,4.27)[//]	1.93 (0.42,8.83)	3.18 (0.03, 378.73)
IVH III/IV	9.05E4 (0, 4.57E12)	1.54 (0.78, 3.04)	2.31 (0.35,15.10)	0 (0, 2.36E111)	120.55 (0,2.18E62)	1.50 (0.64, 3.53)	1.36 (0.13,13.93)	0.081 (0,4.90E71)
NEC	199.31 (0, 1.17E7)	1.77 (0.66, 4.73)	12.79 (0.32,505.15)	12.19 (0,9.28E32)	15215.77 (0,3.35E75)	2.04 (0.60, 6.94)	13.78 (0.27,714.81)	356.51 (0,1.20E291)
RDS	7.97 (2.16,29.48)[//]	6.38 (3.69, 11.05)[//]	2.65 (0.68,10.35)	1.03 (0.05,19.73)	7.44 (0.77,72.24)	8.26 (4.06, 16.89)[//]	3.02 (0.49,18.61)	0.93 (0.01,188.82)
ROP	11.76 (0.75, 183.75)	2.84 (1.56, 5.17)[//]	1.64 (0.48,5.62)	0.75 (0.01,39.90)	3434.58 (0,8.27E24)	3.43 (1.65, 7.14)[//]	2.83 (0.57,14.02)	0 (0,1.33E19)
Major Morbidity[§]	5.96 (0.91, 38.94)	2.25 (1.41, 3.59)[//]	2.44 (0.76,7.81)	0.46 (0.01,27.13)	25.91 (0.07,9107.46)	2.26 (1.28,3.99)[//]	3.19 (0.73, 14.0)	0.74 (0.00,125.20)
Composite[§]	0.44 (0.11, 1.69)	0.30 (0.18, 0.48)[//]	0.54 (0.17,1.74)	0.03 (0,1.68)	0.21 (0.01,3.12)	0.28 (0.16,0.50)[//]	0.32 (0.07,1.47)	0.03 (0,3.71)

[*] Corrected for multiple comparisons using the Bonferroni method (α=0.000641025).

[†] Adjusted for insurance, maternal race, maternal age, chronic hypertension, diabetes, gestational diabetes, chorioamnionitis, pregnancy induced hypertension, preterm labor, premature rupture of membranes, placenta previa, placental abruption, previous Cesarean, and year.

[‡] Cesarean vs. vaginal delivery

[§] Major morbidity includes BPD, IVH, NEC, or asphyxia; Composite includes death or asphyxia

[//] Significant at α=0.000641025