Published in final edited form as:
Obstet Gynecol. 2012 September ; 120(3): 560–564. doi:10.1097/AOG.0b013e318265b16c.

Mode of Delivery and Neonatal Outcomes in Preterm, Small-for-Gestational-Age Newborns

Erika F. Werner, MD, MS, **David A. Savitz, PhD**, **Teresa M. Janevic, PhD**, **Robert M. Ehsanipoor, MD**, **Stephen F. Thung, MD**, **Edmund F. Funai, MD**, and **Heather S. Lipkind, MD, MS**

Departments of Gynecology and Obstetrics, Johns Hopkins University School of Medicine, Baltimore, Maryland, and The Ohio State University, Columbus, Ohio; the Departments of Epidemiology and Obstetrics and Gynecology, Brown University, Providence, Rhode Island; the Department of Epidemiology, University of Medicine and Dentistry of New Jersey School of Public Health, Piscataway, New Jersey; and the Department of Obstetrics, Gynecology & Reproductive Sciences, Yale University School of Medicine, New Haven, Connecticut

Abstract

Objective—To compare neonatal outcomes by method of delivery in preterm (34 weeks of gestation or prior), small-for-gestational-age (SGA) newborns in a large diverse cohort.

Methods—Birth data for 1995–2003 from New York City were linked to hospital discharge data. Data were limited to singleton, liveborn, vertex neonates delivered between 25 and 34 weeks of gestation. Births complicated by known congenital anomalies and birth weight less than 500 g were excluded. Small for gestational age was used as a surrogate for intrauterine growth restriction. Associations between method of delivery and neonatal morbidities were estimated using logistic regression.

Results—Two thousand eight hundred eighty-five SGA neonates meeting study criteria were identified; 42.1% were delivered vaginally, and 57.9% were delivered by cesarean. There was no significant difference in intraventricular hemorrhage, subdural hemorrhage, seizure, or sepsis between the cesarean delivery and vaginal delivery groups. Cesarean delivery compared with vaginal delivery was associated with increased odds of respiratory distress syndrome. The increased odds persisted after controlling for maternal age, parity, ethnicity, education, primary payer, prepregnancy weight, gestational age at delivery, diabetes, and hypertension.

Conclusion—Cesarean delivery was not associated with improved neonatal outcomes in preterm SGA newborns and was associated with an increased risk of respiratory distress syndrome.

Level of Evidence: II

The cesarean delivery rate has risen dramatically over the past two decades, but it is particularly elevated in preterm deliveries. As of 2005, more than half of the neonates born before 34 weeks of gestation in the United States were delivered by cesarean delivery.[1] When the indication for preterm delivery is growth restriction, it is unclear whether cesarean delivery improves neonatal outcomes. Two previous studies have suggested that when

Corresponding author: Erika F. Werner, MD, MS, Department of Gynecology and Obstetrics, Division of Maternal Fetal Medicine, Johns Hopkins University School of Medicine, 600 North Wolfe Street, Phipps 228, Baltimore, MD 21287;ewerner4@jhmi.edu.

Presented at the Society of Maternal-Fetal Medicine annual meeting in February 6–11, 2012, Dallas, Texas

Financial Disclosure: The authors did not report any potential conflicts of interest.

intrauterine growth restriction is present or the neonate is small for gestational age (SGA), vaginal delivery is associated with increased odds of neonatal mortality.[2,3] Many studies have examined the outcomes of very-low-birth-weight neonates (less than 1,500 g) comparing cesarean delivery with vaginal delivery and yielded conflicting results with regard to both the odds of intraventricular hemorrhage and neonatal death.[2,4–7] However, these studies do not address differences in outcome when the newborn is not only a low birth weight but also SGA.

The relative rarity of preterm deliveries in the SGA population has drastically limited prospective randomized studies. In fact, attempted randomized controlled trials have been halted prematurely as a result of recruitment difficulties[8] forcing clinicians to rely on limited cohort studies to guide clinical practice. Given the increased risk of morbidity and mortality[9–11] for SGA newborns and the relative impossibility of a conclusive randomized controlled trial, we sought to examine the association between route of delivery and neonatal outcomes, particularly neonatal death, intraventricular hemorrhage, and respiratory distress syndrome, in a large, diverse cohort of pre term, SGA newborns.

Materials and Methods

Data on singleton live births from 1995 to 2003 (N=1,025,903) were obtained using a data set linking birth certificate information from the New York City Department of Health and Mental Hygiene to hospital discharge data from the Statewide Planning and Research Cooperative System. The Statewide Planning and Research Cooperative System data include both the maternal and neonatal records. Our study population was limited to women delivering vertex-presenting, singleton neonates between 25 and 34 6/7 weeks of gestation (n=31,135). Newborns with con genital anomalies and those with birth weights less than 500 g were excluded. Newborns delivered by vacuum or forceps were excluded given the possibility that operative deliveries may independently in crease morbidity or mortality for the preterm neonate. Of the 23,144 neonates meeting these inclusion and exclusion criteria, we identified 2,885 who met the definition for SGA at the time of their delivery (Fig. 1). Small for gestational age was defined as less than the 10th percentile of birth weight for gestational age based on sex-specific U.S. standard birth weights and was used as a surrogate for intrauterine growth restriction.[12] Mode of delivery was determined both by birth certificate information and procedural codes in the Statewide Planning and Research Cooperative System database. Given the wide range of gestational ages, we also did a subanalysis in which we limited the study population to those with a gestational age less than 30 weeks (n=359).

Although operative deliveries were initially excluded, because health care providers cannot anticipate the need for operative delivery at the initial mode of delivery decision point, we performed an additional analysis in which all operative deliveries were included. The study population in this analysis was 2,927.

The outcomes of interest in this study included neonatal death before discharge, neonatal respiratory distress syndrome, sepsis, intraventricular hemorrhage, seizure, subdural hemorrhage, or 5-minute Apgar score less than 7. Neonatal death was determined by discharge data included in the Statewide Planning and Research Cooperative System data set. Neonatal morbidities including respiratory distress syndrome, sepsis, intraventricular hemorrhage, seizure, and subdural hemorrhage were ascertained using International Classification of Diseases, Ninth Revision codes from the newborn's hospitalization record. Neonatal seizure was defined by the presence of this complication in either the Statewide Planning and Research Cooperative System or the birth certificate data because seizure is

also identified on the birth certificate. Five-minute Apgar scores were obtained from birth certificate data.

Maternal characteristics were obtained from birth records and the Statewide Planning and Research Cooperative System database and were examined as covariates and potential confounders based on previous literature. Maternal characteristics derived from birth certificates included age, parity, race and ethnicity, level of education, insurance status, and prepregnancy weight. Prepregnancy weight was used as a surrogate for body mass index because the mother's height was not available.[13,14] We used categorical variables for maternal age. The categories chosen were selected because advanced maternal age and teenage pregnancy are associated with increased risk for some complications.

Pregnancy and medical complications used as covariates included diabetes, hypertension, and gestational age of delivery based on the clinical estimate reported on the birth certificate. Pregnancies complicated by diabetes and gestational diabetes were determined by a previously described algorithm that used information from both the hospital discharge and birth data.[15] We combined diabetes and gestational diabetes because both are associated with fetal weight abnormalities and neonatal morbidity.[16] Presence of maternal hypertension included preeclampsia, hyper tension with onset during pregnancy, and pre-existing hypertension because all can be associated with impaired fetal growth.[17–19]

We estimated univariable associations between delivery mode and neonatal outcomes using the χ^2 statistic. Logistic regression was used to determine the odds of each neonatal morbidity and neonatal mortality for cesarean delivery compared with vaginal delivery adjusting for potential confounders as de scribed previously. Covariates were considered for inclusion in the multivariable model if the univariable χ^2 $P<.05$.

All potential confounders were found to be significant based on this criterion and thus included. Analyses were conducted using SAS 9.2. This study was approved by the Yale University Human Investigations Committee.

Results

Of the 2,885 neonates meeting the study criteria, 1,214 (42.1%) were delivered vaginally and 1,671 (57.9%) were delivered by cesarean. Baseline characteristics for those delivered vaginally and by cesarean are presented in Table 1. All maternal and pregnancy characteristics differed significantly between comparison groups ($P<.05$). Women who underwent cesarean delivery were older, heavier, better educated, more likely to be white, and more often had diabetes or hypertension. As occurred nationally,[1] the rate of cesarean delivery rose in SGA newborns born at or before 34 weeks of gestation over the time course of the study. In 1995, 50% were delivered by cesarean compared with 61% in 2003.

Table 2 presents the incidence and unadjusted and adjusted odds of neonatal complications including in-hospital neonatal mortality with cesarean delivery compared with vaginal delivery. Neonates born by cesarean delivery had a higher incidence of respiratory distress syndrome and 5-minute Apgar score less than 7 compared with those delivered vaginally (odds ratio [OR] 1.49, 95% confidence interval [CI] 1.25–1.76 and OR 1.42, 95% CI 1.07–1.87, respectively). After adjusting for maternal age, race, parity, education, insurance status, prepregnancy weight, diabetes, hypertension, and gestational age at delivery, cesarean delivery continued to be associated with increased odds of respiratory distress syndrome compared with vaginal delivery (adjusted OR 1.32, 95% CI 1.07–1.63) and tended to be associated with slightly elevated risks for all outcomes except intraventricular hemorrhage and neonatal death after adjustment. When we limited the population to those neonates who delivered before 30 weeks of gestation, the association of cesarean delivery

and increased respiratory distress syndrome dissipated with an adjusted OR of 0.92 (95% CI 0.46–1.83). The additional analysis in which forceps and vacuum deliveries were included did not significantly alter any of the results.

Discussion

This study's finding that cesarean delivery is associated with more respiratory distress syndrome high lights the uncertainty of the premise that cesarean deliveries provide a benefit for all SGA preterm neonates. Cesarean deliveries are associated with an increase in short- and long-term risks for the mother, including infection, hemorrhage, and future surgical complications resulting from scarring.[20] Additionally, cesarean deliveries are more costly to the health care system.[21,22] These risks and costs may be justified if cesarean delivery improves neonatal outcomes. How ever, in this retrospective cohort, cesarean delivery compared with vaginal delivery was not associated with any statistically significant benefit for preterm, SGA neonates.

This study's findings are consistent with several large prospective cohorts performed outside of the United States.[6,7] However, these results differ from a large national retrospective study showing that cesarean delivery was associated with decreased odds of mortality within 28 days of life in SGA vertex neonates born before 31 weeks of gestation.[3] It is possible that our study, which defined neonatal mortality any time before hospital discharge, captured later neonatal deaths, occurring after 28 days of life, because many premature newborns are hospitalized for months. This study's findings also differ from Wylie et al[2] who found that cesarean delivery was associated with decreased odds of neonatal morality in singleton, liveborn neonates weighing less than 1,500 g if growth restriction was present. However, only 261 neonates in this study had growth restriction, 31 of whom were delivered vaginally. Interestingly Wylie et al's larger study population (growth restricted and nongrowth-restricted) showed a trend toward decreased odds of respiratory distress syndrome with vaginal delivery compared with cesarean delivery. An association between cesarean delivery and an increased odds of respiratory morbidity has been demonstrated in late preterm and term neonates.[23,24]

This study has several strengths. New York City provides an ideal study population because the cohort is socially, racially, and economically diverse. This study also focuses on multiple outcomes in preterm, SGA neonates, instead of limiting our cohort by birth weight, in a database that combines birth certificate data and hospital discharge information. This pairing of analyzed variables has been shown to significantly improve the quality of the data.[25] Compared with prior studies, this study is more complete given the relatively large sample size for a rare condition and the variety of outcomes measured.

Because the study is a retrospective, nonrandomized cohort study, there are limitations. We were not able to adjust for delivery indication or separate spontaneous preterm birth from indicated preterm birth. Thus, it is possible that some of the cesarean deliveries occurred in patients in whom more urgent delivery was needed and who would have fared worse had they delivered vaginally. It is also conceivable that some of the cesarean deliveries were the result of a failed trial of induction or that cesarean delivery was used when the health care provider felt delivery was more urgent. Additionally, our database did not contain information on steroid administration and ante natal steroids are known to reduce intraventricular hemorrhage[3] and respiratory distress syndrome.[26] Although accuracy improves when birth certificate variables are combined with hospitalization information, misclassification of gestational age and mode of delivery as well as underreporting of neonatal poor outcomes may have occurred in some cases.[27] We used obstetric and clinical

estimates of gestational age because several studies have suggested that this pro vides a good approximation of dating.[9]

Despite the limitations of this study, it highlights the need for further research evaluating the effects of the rising cesarean delivery rate in these vulnerable preterm, SGA neonates. There is no doubt that, in addition to mode of delivery and birth weight, gestational age affects long-term respiratory function, but this study suggests that, like with full-term newborns,[23] vaginal delivery (and probably labor in general) pro vides neonates with an early respiratory advantage compared with cesarean delivery.

References

1. Menacker, F.; Hamilton, BE. [Retrieved April 9, 2012] Recent trends in cesarean delivery in the United States; 2010. p. 1-8.Available at: www.ncbi.nlm.nih.gov/pubmed/20334736
2. 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:e1–7. [PubMed: 18313634]
3. Lee HC, Gould JB. Survival rates and mode of delivery for vertex preterm neonates according to small- or appropriate-for-gestational-age status. Pediatrics. 2006; 118:e1836–44. [PubMed: 17142505]
4. Ment LR, Oh W, Ehrenkranz RA, Philip AG, Duncan CC, Makuch RW. Antenatal steroids, delivery mode, and intraventricular hemorrhage in preterm infants. Am J Obstet Gynecol. 1995; 172:795–800. [PubMed: 7892866]
5. Deulofeut R, Sola A, Lee B, Buchter S, Rahman M, Rogido M. The impact of vaginal delivery in premature infants weighing less than 1,251 grams. Obstet Gynecol. 2005; 105:525–31. [PubMed: 15738019]
6. Riskin A, Riskin-Mashiah S, Bader D, Kugelman A, Lerner-Geva L, Boyko V, et al. Delivery mode and severe intraventricular hemorrhage in single, very low birth weight, vertex infants. Obstet Gynecol. 2008; 112:21–8. [PubMed: 18591303]
7. 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. [PubMed: 15663120]
8. Grant A, Glazener CM. Elective caesarean section versus expectant management for delivery of the small baby. The Cochrane Database of Systematic Reviews 2001, Issue 2 Art No: CD000078. 10.1002/14651858.CD000078
9. Ananth CV. Menstrual versus clinical estimate of gestational age dating in the united states: temporal trends and variability in indices of perinatal outcomes. Paediatr Perinat Epidemiol. 2007; 21(suppl):22–30. [PubMed: 17803615]
10. Bernstein IM, Horbar JD, Badger GJ, Ohlsson A, Golan A. Morbidity and mortality among very-low-birth-weight neonates with intrauterine growth restriction. Am J Obstet Gynecol. 2000; 182:198–206. [PubMed: 10649179]
11. Bardin C, Piuze G, Papageorgiou A. Outcome at 5 years of age of SGA and AGA infants born less than 28 weeks of gestation. Semin Perinatol. 2004; 28:288–94. [PubMed: 15565789]
12. Oken E, Kleinman KP, Rich-Edwards J, Gillman MW. A nearly continuous measure of birth weight for gestational age using a United States national reference. BMC Pediatr. 2003; 3:6. [PubMed: 12848901]
13. Rosenberg TJ, Garbers S, Lipkind H, Chiasson MA. Maternal obesity and diabetes as risk factors for adverse pregnancy outcomes: differences among 4 racial/ethnic groups. Am J Public Health. 2005; 95:1545–51. [PubMed: 16118366]
14. Rosenberg TJ, Garbers S, Chavkin W, Chiasson MA. Prepregnancy weight and adverse perinatal outcomes in an ethnically diverse population. Obstet Gynecol. 2003; 102:1022–7. [PubMed: 14672480]
15. Savitz DA, Janevic TM, Engel SM, Kaufman JS, Herring AH. Ethnicity and gestational diabetes in New York City, 1995–2003. BJOG. 2008; 115:969–78. [PubMed: 18651880]

16. Aljohani N, Rempel BM, Ludwig S, Morris M, Cheang M, Murray R, et al. Impact of diabetes on maternal-fetal outcomes in Manitoba: relationship with ethnic and environmental factors. Clin Invest Med. 2008; 31:E338–45. [PubMed: 19032903]

17. Gilbert WM, Young AL, Danielsen B. Pregnancy outcomes in women with chronic hypertension: a population-based study. J Reprod Med. 2007; 52:1046–51. [PubMed: 18161404]

18. Sibai BM, Koch MA, Freire S, Pinto e Silva JL, Rudge MV, Martins-Costa S, et al. The impact of prior preeclampsia on the risk of superimposed preeclampsia and other adverse pregnancy outcomes in patients with chronic hypertension. Am J Obstet Gynecol. 2011; 204(345):e1–6.

19. Tuuli MG, Rampersad R, Stamilio D, Macones G, Odibo AO. Perinatal outcomes in women with preeclampsia and superim posed preeclampsia: do they differ? Am J Obstet Gynecol. 2011; 204(508):e1–7. [PubMed: 21419381]

20. Lydon-Rochelle M, Holt VL, Martin DP, Easterling TR. Association between method of delivery and maternal rehospitalization. JAMA. 2000; 283:2411–6. [PubMed: 10815084]

21. Allen VM, O'Connell CM, Baskett TF. Cumulative economic implications of initial method of delivery. Obstet Gynecol. 2006; 108:549–55. [PubMed: 16946214]

22. Declercq E, Barger M, Cabral HJ, Evans SR, Kotelchuck M, Simon C, et al. Maternal outcomes associated with planned primary cesarean births compared with planned vaginal births. Obstet Gynecol. 2007; 109:669–77. [PubMed: 17329519]

23. Hansen AK, Wisborg K, Uldbjerg N, Henriksen TB. Risk of respiratory morbidity in term infants delivered by elective caesarean section: cohort study. BMJ. 2008; 336:85–7. [PubMed: 18077440]

24. Malloy MH. Impact of cesarean section on intermediate and late preterm births: United States, 2000–2003. Birth. 2009; 36:26–33. [PubMed: 19278380]

25. Lydon-Rochelle M, Holt VL, Cárdenas V, Nelson JC, Easterling TR, Gardella C, et al. The reporting of pre-existing maternal medical conditions and complications of pregnancy on birth certificates and in hospital discharge data. Am J Obstet Gynecol. 2005; 193:125–34. [PubMed: 16021070]

26. Papageorgiou AN, Desgranges MF, Masson M, Colle E, Shatz R, Gelfand MM. The antenatal use of betamethasone in the prevention of respiratory distress syndrome: a controlled double-blind study. Pediatrics. 1979; 63:73–9. [PubMed: 375172]

27. Vinikoor LC, Messer LC, Laraia BA, Kaufman JS. Reliability of variables on the North Carolina birth certificate: a comparison with directly queried values from a cohort study. Paediatr Perinat Epidemiol. 2010; 24:102–12. [PubMed: 20078836]

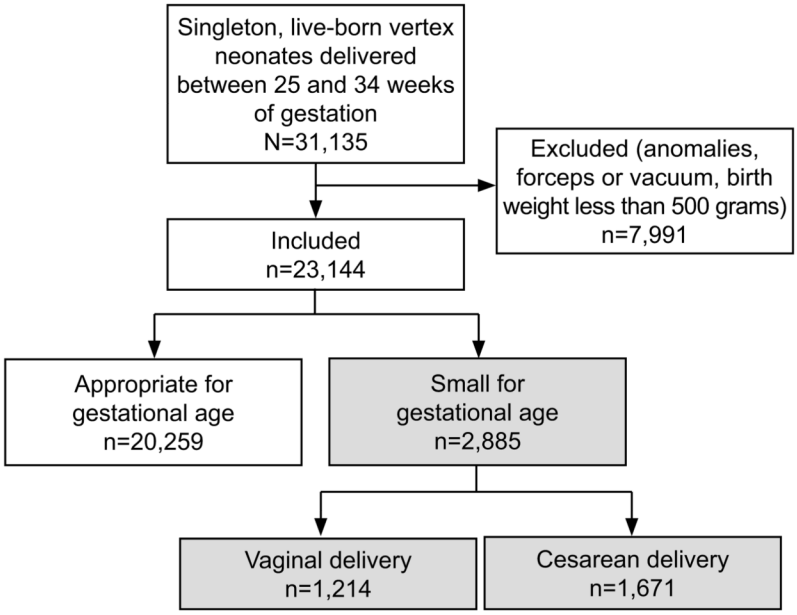

Fig. 1.
Study population flowchart. Shading indicates small-for-gestational-age neonates.

Table 1

Sociodemographic Characteristics by Delivery Mode in Singleton Live Births, New York City, 1995–2003 (n=2,885)

	Vaginal Delivery (n=1,214)	Cesarean Delivery (n=1,671)	*P*
Maternal age (y)			<.001
Younger than 20	13.4	6.8	
20–34 *	67.1	5.0	
35 or older	19.4	28.2	
Parity			
None	49.1	52.5	.017
1	24.7	21.6	
2	11.5	13.6	
3 or more	14.7	12.3	
Gestational age at delivery (wk)			
Before 26	0.6	0.4	<.001
26–28	1.7	2.0	
28–30	2.2	8.0	
30–32	6.2	16.8	
After 32	89.3	72.8	
Mother's ethnicity			.001
White, non-Hispanic	11.5	17.4	
Black, non-Hispanic	45.4	43.0	
Hispanic	35.8	32.3	
Asian and Pacific Islander	6.7	6.7	
Other	0.6	0.6	
Maternal education			<.001
High school or less	70.7	56.1	
More than high school	29.3	43.9	
Primary Payer			<.001
Medicaid	64.6	52.2	
HMO	9.0	12.9	
Third party	20.0	31.6	
Self-pay	6.4	3.3	
Prepregnancy weight (lb)			<.001
99 or less	5.6	3.3	
100–149	65.5	54.7	
150–199	22.6	32.7	
200 or more	6.3	9.3	
Diabetes †	6.3	10.7	<.001
Hypertensive disorders ‡	32.9	64.8	<.001

HMO, health maintenance organization.

Data are % unless otherwise specified.

[*] Includes women in their 34th year.

[†] Includes pregestational and gestational diabetes.

[‡] Includes chronic hypertension and preeclampsia.

Table 2
Neonatal Outcomes for Cesarean Delivery Compared With Vaginal Delivery

	Vaginal Delivery	Cesarean Delivery	Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)*
Respiratory distress	280 (23.1)	515 (30.8)	1.5 (1.3–1.8)	1.3 (1.1–1.6)
Sepsis	37 (3.1)	63 (3.8)	1.3 (0.8–1.9)	1.2 (0.8–2.0)
Intraventricular hemorrhage	63 (5.2)	91 (5.5)	1.1 (0.8–1.5)	0.9 (0.6–1.4)
Subdural hemorrhage	5 (0.4)	18 (1.1)	2.6 (1.0–7.1)	1.9 (0.6–6.2)
Seizures	8 (0.7)	18 (1.1)	1.6 (0.7–3.8)	1.3 (0.5–3.4)
5-min Apgar less than 7	82 (6.8)	156 (9.4)	1.4 (1.1–1.9)	1.4 (1.0–2.0)
Neonatal death	47 (4.3)	58 (3.9)	0.9 (0.6–1.3)	0.7 (0.4–1.1)

CI, confidence interval.

Data are n (%) unless otherwise specified.

*Adjusted for maternal age, parity, ethnicity, education, primary payer, prepregnancy weight, gestational age at delivery, diabetes, and hypertension.