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Does Time of Delivery Influence the Risk of Neonatal Morbidity?

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Abstract

Objective—To examine whether time of delivery influences the risk of neonatal morbidity among women with singleton pregnancies.

Study Design—Secondary analysis of data from the Maternal Fetal Medicine Units Network Factor V Leiden Mutation study. We categorized time of delivery as day (07:00–16:59), evening (17:00–23:59), and overnight (midnight–06:59). Severe neonatal morbidity was defined by at least one of the following: respiratory distress syndrome, transient tachypnea of the newborn, sepsis, seizures, neonatal intensive care admission, or a 5-minute APGAR ≤ 3 . We calculated frequencies of severe neonatal morbidity by time of delivery. Multivariate analysis was performed to determine whether time of delivery was independently associated with severe neonatal morbidity.

Results—Among 4,087 women, 1,917 (46.9%) delivered during the day, 1,140 (27.9%) delivered in the evening, and 1,030 (25.2%) delivered overnight. We observed no significant differences in the rates of neonatal morbidity between delivery time periods (day: 12.3%; evening: 12.8%; overnight: 12.6%; $p = 0.9$). No significant association was observed between time of delivery and neonatal morbidity after adjustment for maternal, obstetric, and peripartum factors.

Conclusion—Our findings suggest that time of delivery is not associated with severe neonatal morbidity.

Keywords

delivery, obstetric; time; morbidity; infant, newborn

Over the past 20 years, induction of labor and cesarean delivery have both become increasingly prevalent.^{1,2} These increases have resulted in a higher proportion of deliveries occurring during daylight hours.^{2,3} Although deliveries during daytime hours may be

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Conflict of Interest

The authors report no conflict of interest.

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preferable to obstetric care providers, it is uncertain whether neonatal outcomes are influenced by the time of delivery.

The potential influence of time of delivery on neonatal outcomes has important clinical relevance. Variation in the rates of neonatal morbidity according to time of delivery may raise questions about the type and quality of obstetrical, anesthetic, and neonatal care provided out-of-hours. Several observational studies have investigated whether an association exists between time of delivery and neonatal morbidity, yet findings from these studies are relatively inconsistent. Several studies reported that neonatal outcomes were not influenced by time of delivery.⁴⁻⁷ However, the majority of these studies sourced data from single obstetric centers; thus, the generalizability of these findings is uncertain. In contrast, data from population-wide studies indicate that the risk of neonatal death is increased for deliveries in the evening or at night.^{8,9} Rates of neonatal morbidity were not reported in these studies. Given these findings, population-level data are needed to determine whether the risk of neonatal morbidity is increased for out-of-hours deliveries.

Using a multicenter clinical registry, the aim of this retrospective cohort study was to examine whether time of delivery influences the risk of severe neonatal morbidity. We also performed stratified analyses to determine the influence of time of delivery on neonatal morbidity according to mode of delivery and gestational age at delivery.

Methods

We performed a secondary analysis of the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development Maternal-Fetal Medicine Units (MFMU) Network Factor V Leiden (FVL) study, which has been previously described.¹⁰ Briefly, the original study was a prospective observational study to determine the risk of pregnancy-related thromboembolism among potential carriers of the FVL mutation; no patients received anticoagulation. Study participants were pregnant women who were enrolled at no less than 14 weeks of gestational age by last menstrual period. For the original study, women were excluded if they had the following conditions: prior, current, or planned anticoagulation; previous or current thromboembolism; antiphospholipid syndrome; known FVL mutation; multiple gestation; known fetal demise; or planned termination or uncertain dates by last menstrual period. The FVL dataset was selected for our study, as the characteristics of the FVL study cohort were deemed to be generalizable to a normal delivery population with singleton pregnancies. The study was performed between April 2000 and August 2001 at 13 U.S. obstetric centers. The final FVL dataset comprised data from 4,903 pregnancies from an unselected population of patients seeking prenatal care at participating centers. The use of the FVL study data for secondary analysis was approved by the Stanford University Institutional Review Board.

For our analysis, we excluded women who had missing data for the time of delivery, mode of delivery, and gestational age at delivery. We excluded women with multiple gestations; women who delivered before 24 weeks' gestational age; and women with pregnancies affected by a major congenital malformation, small for gestational age (SGA) (classified as less than 10th centile for birth weight), stillbirth, miscarriage, and termination of pregnancy.

We categorized time of delivery into three time periods: 07:00 to 16:59 (day); 17:00 to 23:59 (evening); and midnight to 06:59 (overnight). These time periods were selected based on prior literature,^{4,9} and the authors' opinions of typical times for changes of physicians' shifts. Our primary outcome was defined by the presence of at least one of the following severe neonatal morbidities: respiratory distress syndrome, transient tachypnea of the newborn, necrotizing enterocolitis, sepsis, seizures, neonatal intensive care unit (NICU) admission, or a 5-minute APGAR score ≤ 3 . These outcomes were selected based on literature review^{5-7,11,12} and clinical plausibility.

Statistical Analyses

Chi-squared or Fisher exact tests were used to assess differences in maternal characteristics and rates of severe neonatal morbidity according to the time period for delivery. We calculated gestational age-adjusted frequencies for neonatal morbidity for each time period for delivery. To examine the influence of time of delivery on severe neonatal morbidity, we performed multivariate logistic regression, adjusting for the following potential confounders: maternal age, years of schooling, race/ethnicity, obesity, parity, gestational age at delivery, gestational diabetes, hypertensive disease of pregnancy, placental abruption, and mode of delivery (classified as vaginal delivery, prelabor cesarean delivery, or cesarean delivery after labor or induction). Adjusted odds ratios (aOR) and 95% confidence intervals (95% CIs) were calculated. In our secondary analyses, we performed multivariate logistic regression to investigate whether time of delivery influences neonatal outcomes stratified by mode of delivery. Statistical analyses were performed using SAS 9.3 (SAS Institute Inc., Cary, NC) and STATA version 12 (Statacorp, College Station, TX) with $p < 0.05$ considered as statistically significant.

Results

For our study cohort, we excluded women with missing data for the following variables: time of delivery ($n = 205$), mode of delivery ($n = 208$), gestational age at delivery ($n = 17$), and SGA ($n = 283$). Women who delivered infants with a major congenital malformation ($n = 74$) and SGA ($n = 420$) were also excluded. We also excluded women with the following conditions: multiple gestation ($n = 29$); delivery before 24 weeks' gestational age ($n = 271$); and women who underwent the following procedures: terminations ($n = 8$), ante-partum or intrapartum stillbirths ($n = 58$), and elective abortions ($n = 36$). After accounting for 846 women with at least one criterion for exclusion, our study cohort comprised 4,057 women. In our cohort, 1,905 (47%) women delivered during the day, 1,129 (27.8%) women delivered in the evening, and 1,023 (25.2%) women delivered overnight (Fig. 1). Baseline characteristics for the cohort are reported in Table 1. Women who were younger than 20 years, African American race, and other race (Asian, Native American) were more likely to deliver overnight. Compared with those who underwent prelabor cesarean delivery, women who had a vaginal delivery or cesarean delivery after labor or induction were more likely to deliver in the evening or overnight.

For our primary outcome, the unadjusted rates of severe neonatal morbidity were similar for all delivery time periods: day = 11.9%; evening = 11.6%; overnight = 12.1%; $p = 0.93$

(Table 2). For each individual neonatal morbidity, we observed no statistically significant between-group differences in the unadjusted rate of respiratory distress syndrome, transient tachypnea of the newborn, sepsis, seizures, NICU admission, or 5-minute APGAR score <3 (Table 2).

We calculated rates of neonatal morbidity for infants delivered at the following gestational ages: 24 to 27⁺⁶ weeks, 28 to 31⁺⁶ weeks, 32 to 36⁺⁶ weeks, 37 to 40⁺⁶ weeks, 41 to 41⁺⁶ weeks, and 42 weeks or more (Table 2). We observed no significant between-group differences in rates of severe neonatal morbidity for each gestational age category. The overall rates of severe neonatal morbidity after adjusting for these gestational age categories were 12.5% = day; 10.9% = evening, and 11.4% = overnight.

In our multivariate analyses, we adjusted for several potential confounders. Compared with daytime deliveries, the adjusted odds of severe neonatal morbidity were not significantly increased for deliveries occurring in the evening (aOR = 0.90; 95% CI = 0.7–1.2) or overnight (aOR = 1.06; 95% CI = 0.8–1.4) (Table 3). In our stratified analyses, these findings were similar for women who underwent cesarean delivery and vaginal delivery (Table 3).

Discussion

In this retrospective cohort study, we sourced clinical data from a large U.S. registry of 13 different obstetric centers. We did not identify a significant association between severe neonatal morbidity and time of delivery. In our stratified analyses, time of delivery did not influence the likelihood of severe neonatal morbidity, after stratifying by gestational age at delivery or by mode of delivery.

The association between time of delivery and neonatal morbidity has been the focus of several observational studies.^{4-7,13,14} However, there is substantial between-study heterogeneity. Across these studies, variability existed in the definitions for neonatal morbidity, the classification of delivery time periods (“regular” hours vs. out-of-hours), and the selection of confounders in regression models. Key methodologic differences between these studies are presented in Table 4. Nonetheless, our findings are congruent with the main findings of several studies. In a study of term pregnancies at a large U.S. obstetric center, Caughey et al observed no differences in rates of neonatal morbidity or mortality between infants born to women who delivered during the daytime (7 AM to 6 PM), evening (6 PM to midnight), or at night (midnight to 7 AM).⁶ At a single center in the United Kingdom, Woodhead and Lindow observed no differences in rates of NICU admission or neonatal resuscitation of infants born between midnight and 07:59 AM, 8 AM, and 3:59 PM, versus 4 PM to 11:59 PM.¹⁴ At a single obstetric center in Greece, Kalogiannidis et al did not observe significant differences in rates of neonatal morbidity of term babies born between 11 PM and 7 AM versus 7 AM to 11 PM.⁷ In a multicenter U.S. study, Bailit et al observed that neonatal ICU admissions were slightly increased at night for infants born by cesarean delivery between 11 PM and 7 AM compared with 3 PM and 11 PM as well as 7 AM and 3 PM (20.9% vs. 19.1% and 19.3%, respectively).¹³ However, no other differences were observed for other neonatal morbidities according to time of delivery.

It has been previously assumed that the risk of neonatal morbidity increases at night. Night-shift work is characterized by increased fatigue and decreased attention, relative to daytime work.¹⁵⁻¹⁷ Previous studies have shown that sleep deprivation can result in impaired psychomotor performance and clinical performance.^{15,17-19} Fewer in-house physicians and more limited resident supervision by attending physicians may occur out-of-hours.²⁰ In-house or immediate availability of obstetric and anesthesia specialists during the evening and night hours may also vary between different hospitals.²⁰ Despite these concerns, we did not find any association between neonatal morbidity and out-of-hours delivery, even after adjustment for a large set of prespecified potential confounding variables. Given that the confidence intervals for evening and overnight delivery in each model overlapped the null, it is unlikely that we have missed a major confounder that would likely or plausibly impact neonatal morbidity in a substantial fashion.

In our study, the reasons for the observed lack of association between time of delivery and neonatal morbidity are unclear. Hospitals in the MFMU network were tertiary care obstetric centers. Therefore, it is possible that many of these centers had 24 hour in-house availability of obstetricians, anesthesiologists, and neonatologists. This may have reduced variability in the quality of care and subsequent rates of neonatal morbidity over a 24-hour period.

The main strengths of our study are that we utilized prospectively collected maternal, obstetric, and neonatal data on over 4,000 pregnancies. The majority of prior studies report data from single obstetric centers. In contrast, multiple centers contributed data to the FVL dataset; therefore, our findings are more generalizable. Our study has a number of limitations. Data collection for the FVL study was performed between 2000 and 2001; therefore, our findings may be not reflective of contemporary obstetric practice. Current recommendations from the American College of Obstetricians and Gynecologists are that non-medically indicated births should not occur before 39 weeks' gestational age.²¹ Therefore, future studies are needed to determine whether this change in obstetrical practice has influenced rates of neonatal morbidity. Owing to a lack of available data, we were unable to determine whether patients had an elective or nonelective cesarean delivery. Therefore, our study is prone to confounding, as elective cesarean deliveries predominantly occur during the day. Nonetheless, we were able to determine whether women underwent prelabor cesarean delivery versus cesarean delivery after a trial of labor or induction. As the majority of women who underwent prelabor cesarean delivery were delivered during the daytime period (268 women [77%]), it is possible that many of these women underwent elective cesarean delivery. Furthermore, in some cases, the risk of neonatal morbidity may be worse following elective cesarean delivery. For example, data from several studies suggest that the risk of respiratory morbidity for infants born before 39 weeks' gestation is higher after elective cesarean delivery compared with vaginal delivery.^{22,23} Only a minority of patients in our cohort delivered before 37 weeks' gestation; therefore, larger studies are needed to determine whether time of delivery influences neonatal morbidity for infants delivered preterm. As the obstetric centers in the MFMU network are tertiary care centers, it is uncertain whether these outcomes would be similar in non-tertiary community hospitals where staffing practices and availability may differ. Finally, hospitals in the FVL dataset were deidentified; therefore, hospital-specific rates of neonatal morbidity could not be ascertained.

In conclusion, we found no differences in rates of neonatal morbidity among singleton term deliveries according to the time period of delivery. Our findings may help reassure patients and providers that infants delivered out-of-hours are no more likely to incur neonatal morbidity compared with those born during daylight hours. As we sourced population-wide data from the MFMU network, future population-wide studies are needed to validate our findings and to determine whether time of delivery influences neonatal outcomes for women who deliver at nonteaching community hospitals.

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Fig. 1.
Flow diagram of study participants. FVL, Factor V Leiden.

Table 1

Patient and labor characteristics by time of delivery

Patient characteristics	Day: 07:00–16:59 (N = 1,905)	Evening: 17:00–23:59 (N = 1,129)	Night: midnight to 06:59 (N = 1,023)	p-Value
Maternal age (y)				0.03
< 20	255 (13.4%)	186 (16.5%)	168 (16.4%)	
20–34	1,524 (80%)	856 (75.8%)	794 (77.6%)	
35	126 (6.6%)	87 (7.7%)	61 (6%)	
Race/Ethnicity				<0.001
African American	621 (32.6%)	393 (34.8%)	384 (37.5%)	
Caucasian	660 (49.4%)	394 (34.9%)	283 (27.7%)	
Hispanic	592 (31.1%)	317 (28.1%)	323 (31.6%)	
Other	32 (1.7%)	25 (2.2%)	33 (3.2%)	
Years of schooling:				0.72
< 5	28 (1.5%)	12 (1.1%)	16 (1.6%)	
5–9	361 (19.1%)	207 (26.8%)	204 (20.2%)	
10	1,497 (79.4%)	885 (80.2%)	788 (78.2%)	
Parity	1 (0–2)	1 (0–2)	1 (0–2)	0.86
BMI (kg/m ²)				0.15
< 30	1,409 (74%)	836 (74%)	725 (70.9%)	
30	471 (24.7%)	280 (24.8%)	276 (27%)	
Missing	25 (1.3%)	13 (1.2%)	22 (2.1%)	
Placental abruption	5 (0.3%)	8 (0.8%)	5 (0.4%)	0.007
GDM	81 (4.3%)	42 (3.7%)	49 (4.8%)	0.47
Preeclampsia, HELLP syndrome or eclampsia	49 (2.6%)	34 (3%)	22 (2.1%)	0.45
Mode of delivery ^a				<0.001
Vaginal	1,426 (74.9%)	907 (80.3%)	853 (83.4%)	
Prelabor Cesarean	268 (14.1%)	61 (5.4%)	18 (1.7%)	
Cesarean after labor or induction	210 (11%)	161 (14.3%)	152 (14.9%)	
Gestational age at delivery (wk)	39 (38–40)	39 (38–40)	40 (38–41)	0.09

Abbreviations: BMI, body mass index; GDM, gestational diabetes.

Note: Data presented as *n* (%), median (interquartile range).^aLabor data missing for one patient for a daytime delivery.

Table 2

Neonatal outcomes by time of delivery

Individual neonatal morbidities	Day: 07:00–16:59 (N = 1,905)	Evening: 17:00–23:59 (N = 1,129)	Night: midnight-06:59 (N = 1,023)	p-Value
Respiratory distress syndrome	64 (3.3%)	35 (3.1%)	34 (3.3%)	0.92
Transient tachypnea of the newborn	56 (2.9%)	35 (3.1%)	30 (2.9%)	0.96
Necrotizing enterocolitis	5 (0.3%)	3 (0.3%)	2 (0.2%)	1.0
Sepsis	98 (5.1%)	72 (6.3%)	63 (6.1%)	0.30
Seizures	1 (0.1%)	4 (0.4%)	1 (0.1%)	0.11
Neonatal intensive care admission	230 (12%)	132 (11.6%)	125 (12.2%)	0.92
5-min APGAR $\geq 3^a$	3 (0.2%)	3 (0.3%)	2 (0.2%)	0.19
Severe neonatal morbidity (composite)				
Full cohort	226 (11.9%)	131 (11.6%)	124 (12.1%)	0.93
Gestational age at delivery (wk) b :				
24–27 $^{+6}$	9/10 (90%)	11/12 (91.7%)	2/2 (100%)	1.0
28–31 $^{+6}$	15/15 (100%)	10/12 (83.3%)	11/12 (91.7%)	0.27
32–36 $^{+6}$	51/148 (34.5%)	31/116 (26.7%)	34/102 (33.3%)	0.37
37–40 $^{+6}$	118/1,487 (7.9%)	63/843 (7.5%)	60/742 (8.1%)	0.89
41–41 $^{+6}$	24/186 (12.9%)	14/105 (13.3%)	14/128 (10.9%)	0.83
42	9/59 (15.3%)	2/41 (4.9%)	3/37 (8.1%)	0.26

Note: Data presented as *n* (%).

^a APGAR scores not reported for three women who delivered between 07:00 and 16:59, nine women between 17:00 and 23:59, and six women between midnight and 06:59.

^b Numerator = number of infants with severe neonatal morbidity; denominator = number of infants delivered within each gestational age category according to time of delivery.

Table 3

Adjusted odds ratios for neonatal morbidity according to time of delivery

	Evening aOR (95% CI)	Overnight aOR (95% CI)
Neonatal morbidity—all deliveries ^a	0.90 (0.70–1.18)	1.06 (0.81–1.39)
Neonatal morbidity—all vaginal deliveries ^b	0.92 (0.67–1.28)	1.06 (0.78–1.47)
Neonatal morbidity—all cesarean deliveries ^c	0.89 (0.56–1.40)	1.07 (0.65–1.78)

Abbreviation: aOR, adjusted odds ratio.

Reference group = daytime for time of delivery.

^a Adjusted for maternal age; years of schooling; race/ethnicity; obesity; parity; gestational age at delivery; gestational diabetes; hypertensive disease of pregnancy; placental abruption; and mode of delivery.

^b Adjusted for maternal age; years of schooling; race/ethnicity; obesity; parity; gestational age at delivery; gestational diabetes; type of labor (spontaneous; induced; or spontaneous, augmented); hypertensive disease of pregnancy; and placental abruption.

^c Adjusted for maternal age; years of schooling; race/ethnicity; obesity; parity; gestational age at delivery; gestational diabetes; type of labor prior to cesarean delivery (no labor; spontaneous; induced; or spontaneous, augmented); hypertensive disease of pregnancy; and placental abruption.

Table 4

Data from studies examining time of delivery and neonatal outcomes

Author	Study location	N	Definition of morbidity	Time periods for delivery	Confounders in regression models	Main finding
Bell et al ⁴	17 tertiary care centers; United States	11,137 (only VLBW infants were studied)	NEC, sepsis, BPD, IVH, PVL, ROP	Day: 8 AM–5 PM Evening: 5:01 PM–11:59 PM Night: midnight–7:59 AM	Mode of delivery, birthweight, gestational age, race	ROP requiring operative intervention rates lower for infants born at night
Butler et al ⁵	Single obstetric center; Ireland	597	NICU admission, fetal acidosis, neonatal trauma	Day: 8 AM–7:59 PM Night: 8 PM–7:59 AM	Maternal age, BMI, race, comorbidities, infant gender, birthweight, head circumference	No difference in adverse perinatal outcomes
Caughey et al ⁶	Single obstetric center; United States	34,424	5-min APGAR < 7, BE < 12, pH < 7, NICU admission, neonatal trauma, MAS, neonatal death	Day: 7 AM–6 PM Evening: 6 PM–midnight Night: midnight–7 AM	Maternal age, ethnicity, education, mode of delivery, labor length, anesthesia, birthweight, induction vs. spontaneous	No difference in neonatal morbidity or mortality
Kalogiannidis et al ⁷	Single obstetric center; Greece	3,055	Mean APGAR, meningitis, intrapartum fever, NICU admit, emergency intubation	Day: 7 AM–11 PM Night 1: 11 PM–3 AM Night 2: 3 AM–7 AM	Maternal age, ethnicity, parity, infant gender, gestational age, birthweight, mode of delivery, anesthesia, indication for CS or assisted delivery	Rates of emergent CS and NICU admissions greater during 11 PM–3 AM hours
Lee et al ⁸	17 tertiary care centers; Canada	5,192	Neonatal death within 7 d of NICU admission	Day: 8 AM–5 PM Night: 5 PM–8 AM	Infant gender, gestational age, APGAR, mode of delivery, administered steroids	The risk-adjusted early neonatal mortality rates of inborn infants 24–32 weeks of gestation were higher for infants admitted to NICU at night
Pasupathy et al ⁹	Scottish maternity hospitals; Scotland	1,039,560	Neonatal death in the first 4 wk of life following live birth	Day: 9 AM–5 PM (M–F) Out of hours: 5 PM–9 AM or weekend	Birth year, maternal age, parity, socioeconomic status, gender, gestational age, birthweight, onset of labor	Delivering an infant outside the normal day hours was associated with an increased risk of neonatal death at term
Bailit et al ¹³	13 tertiary care centers; United States	18,939	pH < 7, BE < 12, brachial plexus injury/trauma, NICU admission, seizure,	Day: 7 AM–3 PM Evening: 3 PM–11 PM Night: 11 PM–7 AM	Maternal age, race, insurance, maternal comorbidities, prenatal care	NICU admission rate higher at night

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Author	Study location	N	Definition of morbidity	Time periods for delivery	Confounders in regression models	Main finding
Woodhead and Lindow ¹⁴	Single obstetric center, United Kingdom	14,426	infant death Stillbirth, need for resuscitation, NICU admission, Apgar score	Day: 8 AM–3:59 PM Evening: 4 PM–11:59 PM Night: midnight–7:59 AM	N/A	No significant difference in need for neonatal resuscitation or NICU admissions

Abbreviations: BE, base excess; BMI, body mass index; BPD, bronchopulmonary dysplasia; CS, cesarean section; IVH, intraventricular hemorrhage; NEC, necrotizing enterocolitis; NICU, neonatal intensive care unit; PVL, periventricular leukomalacia; ROP, retinopathy of prematurity; VLBW, very low birth weight.