OBSTETRICS

Electronic fetal monitoring patterns associated with respiratory morbidity in term neonates

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OBJECTIVE: The purpose of this study was to identify electronic fetal monitoring patterns that are associated with neonatal respiratory morbidity.

STUDY DESIGN: In an on-going prospective cohort study of >8000 consecutive term, vertex, nonanomalous singleton pregnancies during labor, we performed this analysis within the first 5000 women as a representative sample. Electronic fetal monitoring patterns in the 30 minutes preceding delivery were extracted by trained obstetrics research nurses, who were blinded to clinical data, using the National Institute of Child Health and Human Development system; the data were compared between those with respiratory morbidity and healthy infants (no morbidities). The primary outcome was *neonatal respiratory morbidity*, which was defined as either oxygen requirement at ≥6 hours of life or any mechanical ventilation in the first 24 hours. Multivariable logistic regression was used to adjust for confounders.

RESULTS: Of 4736 neonates, 175 (3.4%) experienced respiratory morbidity. Most electronic fetal monitoring patterns were category II (96.6%; n = 4575). Baseline tachycardia (adjusted odds ratio [aOR], 2.9; 95% confidence interval [CI], 1.9–4.4), marked variability (aOR, 2.7; 95% CI, 1.5–5.0), and prolonged decelerations (aOR,2.7; 95% CI, 1.5–5.0) were associated significantly with an increased likelihood of term neonatal respiratory morbidity. Accelerations and persistent moderate variability were both significantly associated with a decreased likelihood of respiratory morbidity.

CONCLUSION: Specific features of category II electronic fetal monitoring patterns make respiratory morbidity more likely in nonanomalous term infants. Tachycardia, marked variability, or prolonged decelerations before delivery can assist providers in anticipating the potential need for neonatal respiratory support.

Key words: electronic fetal monitoring, neonatal respiratory morbidity, term neonate

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Respiratory morbidity is estimated to occur in 6.0-8.8% of early term (37-38 weeks of gestation) and 2.1-4.7% of term (≥39 weeks of gestation) infants.[1,2] However, despite being relatively rare, it remains the most common morbidity among these infants and has the potential to cause significant morbidity and even death.[3] Secondary complications may include persistent pulmonary hypertension of the neonate, severe hypoxic respiratory failure, bronchopulmonary dysplasia, pneumothorax, and neurologic complications.[3-6] Infants may require treatment with nitric oxide, mechanical ventilation, or extracorporeal membrane oxygenation and subsequently may experience adverse outcomes because of invasive procedures. Despite its significance, we lack the tools to identify which infants born after 37 weeks of gestation are at risk for respiratory morbidity and may benefit from additional neonatal support at delivery.

Currently, there are few intrapartum risk factors for neonatal respiratory morbidity in nonanomalous term infants.[3,7] Given the ubiquitous use of intrapartum electronic fetal monitoring (EFM) and that the most common significant morbidity in these term infants is respiratory, we sought to determine which characteristics of EFM were associated with an increase in neonatal respiratory morbidity. Specifically, we assessed the association between fetal bradycardia or tachycardia, absent, minimal, moderate, or marked variability, presence of accelerations, and presence of early, variable, late, or prolonged decelerations, and neonatal respiratory morbidity.

Materials and Methods

We conducted this study within an on-going prospective cohort study of >8000 consecutive term, vertex, nonanomalous singleton pregnancies during labor at Washington University in St. Louis, MO;

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TABLE 1
Baseline characteristics of study subjects

Characteristic	Respiratory morbidity (n = 175)	No respiratory morbidity (n = 4561)	*P* value
Maternal age, y[a]	24.9 ± 6.4	25.6 ± 5.9	.13
Advanced maternal age, %	5.7	8.5	.19
Gestational age at delivery, wk[a]	38.9 ± 1.3	38.9 ± 1.2	.55
Maternal black race, %	66.3	65.0	.72
Body mass index, kg/m^2[a]	33.0 ± 7.1	31.9 ± 7.3	.05
Preeclampsia, %	16.0	9.4	< .01
Gestational diabetes mellitus, %	3.4	2.7	.48
Pregestational diabetes mellitus, %	4.0	0.9	< .01
Nulliparous, %	57.4	40.2	< .01
Previous cesarean delivery, %	16.0	8.4	< .01
Labor type, %			.16
Spontaneous	25.1	30.0	
Augmented	24.6	26.8	
Induction	50.3	43.2	
Regional anesthesia, %	89.1	89.5	.90
Prostaglandin, %	24.0	17.2	.02
Foley bulb, %	12.0	9.1	.18
Oxytocin, %	66.9	65.9	.79
Birthweight, g[a]	3260 ± 548	3238 ± 453	.53
Birthweight >4000 g, %	6.3	5.0	.48
Vaginal delivery, %	50.3	80.1	< .01
Operative vaginal delivery, %	6.9	5.3	.39
Cesarean delivery, %	42.9	14.6	< .01
Maternal fever, %	16.6	1.3	< .01

[a] Data are given as mean ± SD.

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this study included the first 5000 subjects as a representative sample. Neonates with <10 minutes of EFM in the 30 minutes before delivery, who were <37 weeks gestational age, and who had a postnatal anomaly diagnosis were excluded. The institutional policy is one of universal EFM during labor. The study was conducted after approval from the Washington University School of Medicine Human Research Protection Office (IRB #201107131, approved 12/11/2014).

Obstetric research nurses who had been formally trained in EFM pattern recognition were blinded to the antepartum and neonatal clinical data and extracted EFM patterns in the 2 hours before delivery. These patterns were categorized according to fetal heart rate baseline; variability, presence, and number of accelerations; and presence, number, and type of decelerations. We compared characteristics of EFM patterns using the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development 3-tiered category system between infants with respiratory morbidity and healthy infants without morbidities.[8] Maternal and neonatal demographic data that included obstetric and gynecologic history, type of labor, types of augmentation used, mode of delivery, maternal complications, use of regional anesthesia, and neonatal birthweight were also obtained.

In this study, we examined the EFM patterns in the 30 minutes before delivery. EFM was performed with the use of internal or external monitoring as clinically indicated. The primary outcome was *neonatal respiratory morbidity*, which was defined as either any oxygen requirement at or after 6 hours of life or any mechanical ventilation in the first 24 hours. Because cesarean delivery and fever are both risk factors for increased neonatal respiratory morbidity, 2 secondary analyses were performed that excluded those patients who underwent cesarean delivery and those with fever. Because mechanical ventilation is the most severe acute respiratory morbidity for a term infant, analyses were repeated to estimate which EFM patterns were associated with mechanical ventilation compared with those without morbidity.

Baseline characteristics of women who delivered infants with and without respiratory morbidity were compared. The Student *t* test and Mann-Whitney *U* test were used for continuous variables; χ^2 and Fisher exact tests were used for dichotomous variables as appropriate. Continuous variables were tested for normality with the Shapiro-Francia test. Relative risks of severe respiratory morbidity and 95% confidence intervals were calculated for each of the EFM characteristics. Stratified analyses were performed to identify potentially confounding factors, which were considered in multivariable analyses. Multivariable logistic regression was performed in a backward step-wise fashion to refine estimates of association between EFM characteristics and neonatal respiratory morbidity by controlling for confounding factors. Model fit of the final model (adjustment for maternal fever, parity, pregestational diabetes mellitus, previous cesarean delivery, and preeclampsia) was tested with the Hosmer-Lemeshow goodness-of-fit test. We included all Q2 subjects who met inclusion criteria during the study period; no a priori sample size estimation was performed. All

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