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Electronic Fetal Monitoring Patterns Associated with Respiratory Morbidity in Term Neonates

Lucy Liu, MD¹, Methodius G. Tuuli, MD, MPH¹, Kimberly A. Roehl Ms., MPH¹, Anthony O. Odibo, MD, MSCE¹, George A. Macones, MD, MSCE¹, and Alison G. Cahill, MD, MSCI¹

¹Department of Obstetrics and Gynecology, Washington University School of Medicine, Campus Box 8064, 660 S Euclid Avenue, St. Louis, MO 63110

STRUCTURED ABSTRACT

Objective—To identify electronic fetal monitoring patterns associated with neonatal respiratory morbidity.

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

Results—Of 4,736 neonates, 175 (3.4%) experienced respiratory morbidity. Most electronic fetal monitoring patterns were Category II (96.6%, n=4575). Baseline tachycardia (aOR 2.9, 95%CI 1.9–4.4) as well as marked variability (aOR 2.7, 95%CI 1.5–5.0) and prolonged decelerations (aOR 2.7, 95%CI 1.5–5.0) were significantly associated 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 non-anomalous term infants. Tachycardia, marked variability, or prolonged decelerations prior to delivery can assist providers in anticipating the potential need for neonatal respiratory support.

Keywords

Electronic fetal monitoring; neonatal respiratory morbidity; term neonates

Corresponding Author: Lucy Liu, MD, Department of Obstetrics and Gynecology, Washington University School of Medicine, Campus Box 8064, 660 S Euclid Avenue, St. Louis, MO 63110 liul@wudosis.wustl.edu, 314-294-4963 (pager), 651-303-6829 (cell).

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INTRODUCTION

Respiratory morbidity is estimated to occur in 6.0–8.8% of early term (37–38 weeks) and 2.1–4.7% of term (39 weeks and after) 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 mortality.³ Secondary complications may include persistent pulmonary hypertension of the neonate, severe hypoxic respiratory failure, bronchopulmonary dysplasia, pneumothorax and neurological complications.^{3–6} Infants may require treatment with nitric oxide, mechanical ventilation, or extracorporeal membrane oxygenation and may subsequently develop adverse outcomes due to invasive procedures. Despite its significance, we lack tools to identify which infants born after 37 weeks 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 non-anomalous 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 over 8000 consecutive term, vertex, non-anomalous singleton pregnancies during labor at Washington University in St. Louis; this study included the first 5000 subjects as a representative sample. Neonates with less than 10 minutes of EFM in the 30 minutes prior to delivery, less than 37 weeks gestational age, and those with a post-natal 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 formally trained in EFM pattern recognition were blinded to the antepartum and neonatal clinical data and extracted EFM patterns in the 2 hours prior to 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 (NICHD) three-tiered category system between infants with respiratory morbidity and healthy infants without morbidities.⁸ Maternal and neonatal demographic data were also obtained including obstetric and gynecologic history, type of labor, types of augmentation used, mode of delivery, maternal complications, use of regional anesthesia, and neonatal birth weight.

In this study, we examined the EFM patterns in the 30 minutes prior to delivery. EFM was performed using internal or external monitoring as clinically indicated. The primary

outcome was neonatal respiratory morbidity, defined as either any oxygen requirement at or after 6 hours of life or any mechanical ventilation in the first 24 hours. Because cesarean and fever are both risk factors for increased neonatal respiratory morbidity, two secondary analyses were performed excluding those patients that underwent cesarean and those with fever. Since 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 to those without morbidity.

Baseline characteristics of women who delivered infants with and without respiratory morbidity were compared. Student's *t* test and Mann-Whitney *U* test were used for continuous variables and χ^2 and Fisher's 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, adjusting for maternal fever, parity, pregestational diabetes mellitus, prior cesarean, and preeclampsia, was tested with the Hosmer-Lemeshow goodness-of-fit test. We included all subjects meeting inclusion criteria during the study period and no a priori sample size estimation was performed. All analyses were performed using STATA 10 special edition and SAS 9.2 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Of 4,736 neonates meeting inclusion criteria, 175 (3.7%) experienced respiratory morbidity and 4561 (96.3%) did not (Table 1). Most EFM patterns were category II (96.6%, n=4575) during the 30 minutes prior to delivery. Maternal age, gestational age at delivery, labor type, birth weight, percentage of maternal black race, percentage of gestational diabetes, and use of regional anesthesia, foley bulb, and oxytocin were not significantly different between the groups. As expected, neonates with respiratory morbidity were less likely to deliver vaginally and more likely to deliver by a cesarean. Preeclampsia, pregestational diabetes, nulliparity, prior cesarean, higher body mass index, prostaglandin use, and maternal fever were significantly more likely among women delivering an infant with respiratory morbidity.

Neonates experiencing respiratory morbidity were significantly more likely to ever have had baseline tachycardia (adjusted OR [aOR] 2.9, 95% confidence interval [CI] 1.9–4.4) or marked variability (aOR 2.7, 95% CI 1.5–5.0) on EFM tracings in the 30 minutes prior to delivery compared to healthy neonates (Table 2). Prolonged decelerations (aOR 1.7, 95% CI 1.3–2.4) were also significantly more likely in neonates with respiratory morbidity. The associations remained significant after adjusting for fever, parity, pregestational diabetes, prior cesarean, preeclampsia, and labor type. However, the presence of early (aOR 0.4, 95% CI 0.1–1.1), variable (aOR 0.8, 95% CI 0.5–1.1), or late (aOR 0.8, 95% CI 0.6–1.1) decelerations were not independently associated with term neonatal respiratory morbidity. Similarly, baseline bradycardia (aOR 0.5, 95% CI 0.1–3.4) and ever (aOR 1.3, 95% CI 0.9–

1.8), mostly (aOR 1.1, 95% CI 0.8–1.6), and always (aOR 1.2, 95% CI 0.8–1.7) absent or minimal variability were not independently associated with respiratory morbidity in the term neonate. Moderate variability throughout the final 30 minutes prior to delivery and the presence of accelerations were both associated with a decreased likelihood of respiratory morbidity in the term neonate (aOR 0.7, 95%CI 0.5–0.9 and aOR 0.6, 95%CI 0.4–0.9, respectively).

The secondary analyses excluding women who underwent cesarean delivery (Table 3) and excluding women who experienced maternal fever (Table 4) revealed consistent findings with baseline tachycardia, marked variability, and prolonged decelerations significantly more likely to precede the delivery of a neonate experiencing respiratory morbidity. Analysis including only neonates who were mechanically ventilated showed an independent association of baseline tachycardia and prolonged decelerations with term neonatal respiratory morbidity but not for marked variability (Table 5). In all three secondary analyses, baseline bradycardia, absent or minimal variability, and early, variable, and late decelerations were not associated with neonatal respiratory morbidity with the exception of variable decelerations when excluding women who underwent cesarean delivery.

COMMENT

This study of over 4700 term neonates demonstrated that baseline tachycardia, marked variability, and prolonged decelerations 30 minutes prior to delivery was associated with a two-fold increase in the risk of respiratory morbidity. Presence of persistent moderate variability and/or accelerations in the 30 minutes prior to delivery made respiratory morbidity significantly less likely. We found no association between baseline bradycardia, early, variable, or late decelerations, and absent or minimal variability with term neonatal respiratory morbidity. These associations remained true when cesarean deliveries and women with intrapartum fever were excluded, and when analysis was limited to neonates requiring mechanical ventilation.

We defined respiratory morbidity as any oxygen requirement at or after 6 hours of life or any mechanical ventilation in the first 24 hours. Specifically, a transient need for respiratory support was not considered respiratory morbidity, which demonstrates the clinical significance of our outcome measure. Given the previous reports of the severe complications associated with respiratory morbidity including admission to the neonatal intensive care unit, iatrogenic injury secondary to invasive procedures, progression to bronchopulmonary dysplasia or pulmonary hypertension, and even death⁴, we have further support for the clinical significance of our findings.

A previous study has identified risk factors for respiratory morbidity in the term neonate including early term, elective and emergency cesarean, meconium-stained amniotic fluid, placental abruption, and a 1-minute APGAR score of less than 3.³ It has been further demonstrated that neonates may still be at risk for respiratory morbidity after documented fetal lung maturity prior to 39 weeks.^{9,10} Bates et al. performed a retrospective cohort study of women delivering after positive fetal lung maturity testing. They found that even after confirmed fetal lung maturity, early delivery at 36 to 38 weeks was associated with an

increased risk of respiratory distress syndrome when compared to delivery at 39 to 40 weeks.¹⁰ In the absence of many risk factors for neonatal respiratory morbidity and without many intrapartum predictors, the provider is restricted in one's assessment of the need for additional support in the delivery room and is unable to take advantage of this opportunity to prevent adverse outcomes. Few studies have evaluated the impact of resuscitative efforts in term neonates in improving outcomes and preventing additional complications.¹¹ Previous studies in preterm neonates have shown benefit in early resuscitative measures such as continuous positive airway pressure.^{12,13} We believe earlier intervention for term neonates with respiratory morbidities may similarly benefit although future studies are needed to determine this.

Since most occurrences of respiratory morbidity in the term neonate are unpredictable, EFM may be instrumental in anticipating the need for additional respiratory support. Few studies have evaluated the characteristics of EFM that are associated with an increased risk for neonatal respiratory morbidity in the term neonate. Counter-intuitively, one study found a decreased incidence of respiratory disease when infants had baseline bradycardia, late and severe variable decelerations, and reduced variability.¹⁴ However, this study had a small sample size of 157 term infants and only studied neonates delivered by cesarean, limiting the generalizability of these findings. In a prospective cohort study of severe respiratory disorders, Gouyon et al. examined 14,813 neonates with gestational age 37–38 weeks and 50,187 neonates with gestational age 39–41 weeks and found that abnormal cardiotocography was independently associated with severe respiratory disorders in term neonates with gestational age 39–41 weeks.³ However, the characteristics of what constituted abnormal cardiotocography were not described, preventing clinicians from being able to use this data at the bedside. By contrast, our large study demonstrated the specific EFM characteristics that may alert the provider to call for additional assistance.

Because our study involved a large sample size and included vaginal, operative vaginal, and cesarean deliveries, the findings can be applied widely and support the generalizability of our findings. Our institution does not follow a standardized protocol for mechanical ventilation or oxygen weaning and thus, neonatal management is provider dependent. While this may limit the generalizability of our study, this is consistent with daily clinical practice.

Multiple factors also support the validity of our study. Data was collected prospectively in our study, limiting incomplete and inaccurate data collection. EFM patterns were analyzed by obstetric research nurse trained in electronic fetal heart rate monitoring interpretation according to NICHD criteria and blinded to clinical outcomes. The nurses underwent formal inter- and intraobserver reliability testing.¹⁵ As a result, we were able to limit inter- and intraobserver variability and still maintain generalizability since daily practice involves human interpretation of EFM data. Finally, by defining our outcome measures based on need for respiratory interventions, we avoided differences in clinical diagnosis by different neonatologists.

Certain limitations must be considered when evaluating our results. After consultation with our pediatric colleagues, we chose outcome measures of respiratory morbidity that are of clinical significance, oxygen supplementation for 6 hours or more and any mechanical

ventilation in the first 24 hours. Although we do not have data on long-term respiratory morbidities associated with the specific findings on EFM tracings, the short term measures of respiratory morbidity are common reasons to require higher order nursery admissions. In addition, Ramadan et al. evaluated the longer-term outcomes of term non-anomalous infants requiring ventilation in the first 24 hours after birth.¹⁶ Of the 43 infants requiring mechanical ventilation in the first 24 hours after birth, 26% had an adverse outcome, which included 6 deaths and 5 infants with severe neurodisability at 2 years. Therefore, we believe our findings are clinically important.

As with all cohort studies, confounding is a concern. We used appropriate statistical techniques to adjust for confounders, but there is the possibility of residual confounding by unmeasured factors. Lastly, EFM data was only studied from the 30 minutes preceding delivery. However, we believe that the 30 minutes immediately prior to delivery is a critical period which may indicate potential complications. Future studies are needed to assess if EFM characteristics greater than 30 minutes before delivery confer an increased risk of respiratory morbidity.

In conclusion, results of this large cohort study show that features of category II tracings on EFM are associated with increased respiratory morbidity in the term neonate. Baseline tachycardia, marked variability, and prolonged decelerations 30 minutes prior to delivery was associated with a two-fold increased risk of neonatal respiratory morbidity. These intrapartum markers may help guide the clinician to anticipate and prepare for additional neonatal resuscitation measures in otherwise low risk deliveries.

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REFERENCES

1. Hansen AK, Wisborg K, Uldbjerg N, Henriksen TB. Risk of respiratory morbidity in term infants delivered by elective caesarean section: cohort study. *BMJ*. 2008; 336:85–87. [PubMed: 18077440]
2. Gharvey K, Coletta J, Lizarraga L, Murphy E, Ananth CV, Gyamfi-Bannerman C. Neonatal respiratory morbidity in the early term delivery. *Am J Obstet Gynecol*. 2012; 207:292.e1–292.e4. [PubMed: 22902075]
3. Gouyon JB, Ribakovsky C, Ferdynus C, Quantin C, Sagot P, Gouyon B. Burgundy Perinatal Network. Severe respiratory disorders in term neonates. *Paediatr Perinat Epidemiol*. 2008; 22:22–30. [PubMed: 18173781]
4. Morrison JJ, Rennie JM, Milton PJ. Neonatal respiratory morbidity and mode of delivery at term: influence of timing of elective caesarean section. *Br J Obstet Gynaecol*. 1995; 102:101–106. [PubMed: 7756199]
5. Heritage CK, Cunningham MD. Association of elective repeat cesarean delivery and persistent pulmonary hypertension of the newborn. *Am J Obstet Gynecol*. 1985; 152:627–629. [PubMed: 4025421]
6. Keszler M, Carbone MT, Cox C, Schumacher RE. Severe respiratory failure after elective repeat cesarean delivery: a potentially preventable condition leading to extracorporeal membrane oxygenation. *Pediatrics*. 1992; 89:670–672. [PubMed: 1557250]

7. Alkiaat A, Hutchinson M, Jacques A, Sharp MJ, Dickinson JE. Evaluation of the frequency and obstetric risk factors associated with term neonatal admissions to special care units. *Aust N Z J Obstet Gynaecol.* 2013; 53:277–282. [PubMed: 23731095]
8. Macones GA, Hankins GD, Spong CY, Hauth J, Moore T. The 2008 National Institute of Child Health and Human Development workshop report on electronic fetal monitoring: update on definitions, interpretation, and research guidelines. *Obstet Gynecol.* 2008; 112:661–666. [PubMed: 18757666]
9. Kamath BD, Marcotte MP, DeFranco EA. Neonatal morbidity after documented fetal lung maturity in late preterm and early term infants. *Am J Obstet Gynecol.* 2011; 204:518.e1–518.e8. [PubMed: 21752754]
10. Bates E, Rouse DJ, Mann ML, Chapman V, Carlo WA, Tita AT. Neonatal outcomes after demonstrated fetal lung maturity before 39 weeks of gestation. *Obstet Gynecol.* 2010; 116:1288–1295. [PubMed: 21099593]
11. Chowdhury O, Wedderburn CJ, Lee S, Hannam S, Greenough A. Respiratory support practices in infants born at term in the United Kingdom. *Eur J Pediatr.* 2012; 171:1633–1638. [PubMed: 22821075]
12. SUPPORT Study Group. Early CPAP versus Surfactant in Extremely Preterm Infants. *N Engl J Med.* 2010; 362:1970–1979. [PubMed: 20472939]
13. Dunn MS, Kaempf J, de Klerk A, et al. Randomized Trial Comparing 3 Approaches to the Initial Respiratory Management of Preterm Neonates. *Pediatrics.* 2011; 128:e1069–e1076. [PubMed: 22025591]
14. Wennergren M, Krantz M, Hjalmarson O, Karlsson K. Fetal heart rate pattern and risk for respiratory disturbance in full-term neonates. *Obstet Gynecol.* 1986; 68:49–53. [PubMed: 3725259]
15. Cahill AG, Roehl KA, Odibo AO, Macones GA. Association and prediction of neonatal acidemia. *Am J Obstet Gynecol.* 2012; 207:206.e1–206.e8. [PubMed: 22939728]
16. Ramadan G, Paul N, Morton M, Peacock JL, Greenough A. Outcome of ventilated infants born at term without major congenital abnormalities. *Eur J Pediatr.* 2012; 171:331–336. [PubMed: 21833494]

Table 1

Baseline characteristics of study subjects

	Respiratory Morbidity (n=175)	No Respiratory Morbidity (n=4561)	p
Maternal age (years), mean (SD)	24.9 (6.4)	25.6 (5.9)	0.13
Advance maternal age	5.7%	8.5%	0.19
Gestational age at delivery (weeks), mean (SD)	38.9 (1.3)	38.9 (1.2)	0.55
Maternal black race	66.3%	65.0%	0.72
Body mass index (BMI), mean (SD)	33.0 (7.1)	31.9 (7.3)	0.05
Preeclampsia	16.0%	9.4%	<0.01
Gestational diabetes	3.4%	2.7%	0.48
Pregestational diabetes	4.0%	0.9%	<0.01
Nulliparous	57.4%	40.2%	<0.01
Prior cesarean	16.0%	8.4%	<0.01
Labor type Spontaneous Augmented Induction	25.1% 24.6% 50.3%	30.0% 26.8% 43.2%	0.16
Regional anesthesia	89.1%	89.5%	0.90
Prostaglandin	24.0%	17.2%	0.02
Foley bulb	12.0%	9.1%	0.18
Oxytocin	66.9%	65.9%	0.79
Birth weight (g), mean (SD)	3260 (548)	3238 (453)	0.53
Birth weight > 4000g	6.3%	5.0%	0.48
Vaginal delivery	50.3%	80.1%	<0.01
Operative vaginal delivery	6.9%	5.3%	0.39
Cesarean	42.9%	14.6%	<0.01
Maternal fever	16.6%	1.3%	<0.01

SD Standard deviation

Table 2

EFM characteristics in the 30 minutes prior to delivery

	Respiratory Morbidity	No Respiratory Morbidity	Relative Risk (95% CI)	Adjusted OR (95% CI)
Baseline³				
Ever bradycardia <110 bpm	0.7%	1.9%	0.37 (0.05–2.63)	0.5 (0.1–3.4) ²
Ever baseline <120 bpm	8.2%	13.4%	0.59 (0.33–1.06)	0.7 (0.4–1.3) ²
Ever tachycardia >160 bpm	29.0%	7.6%	4.46 (3.20–6.23)	2.9 (1.9–4.4) ¹
Variability³				
Ever absent or minimal	62.0%	53.9%	1.38 (1.01–1.89)	1.3 (0.9–1.8) ¹
Mostly absent or minimal	43.2%	38.9%	1.19 (0.87–1.63)	1.1 (0.8–1.6) ¹
Always absent or minimal	34.8%	28.9%	1.30 (0.94–1.80)	1.2 (0.8–1.7) ¹
Mostly moderate	47.1%	56.3%	0.70 (0.51–0.95)	0.7 (0.5–1.0) ¹
Always moderate	33.6%	43.7%	0.66 (0.48–0.92)	0.7 (0.5–0.9) ¹
Ever marked	8.7%	3.2%	2.69 (1.56–4.64)	2.7 (1.5–5.0) ¹
Accelerations				
Accels present	22.2%	33.6%	0.57 (0.39–0.84)	0.6 (0.4–0.9) ¹
Number of accels, median (IQ range)	2 (1–3)	2 (1–3)		
Decelerations				
Decels present	78.2%	86.1%	0.60 (0.42–0.85)	0.8 (0.5–1.2) ¹
Number of decels, median (IQ range)	8 (3–10)	6 (3–9)		
Early decels	2.4%	6.7%	0.34 (0.13–0.92)	0.4 (0.1–1.1) ¹
Variable decels	71.2%	80.7%	0.61 (0.44–0.84)	0.8 (0.5–1.1) ¹
Late decels	41.8%	50.1%	0.72 (0.54–0.98)	0.8 (0.6–1.1) ¹
Prolonged decels	45.9%	33.7%	1.64 (1.22–2.20)	1.7 (1.3–2.4) ¹

¹ Adjusted for fever, parity, pregestational DM, prior c-section, preeclampsia² Adjusted for fever, parity, pregestational DM, prior c-section, preeclampsia, labor type IQ interquartile range³ "Always" was defined as presence of the characteristic during the entire 30-minute period before delivery. "Ever" and "Mostly" refer to the presence of the EFM characteristic during any 10-minute segment and presence of the EFM characteristic for any 15-minute segment or longer, respectively, in the 30-minute period before delivery.

Table 3

EFM characteristics in the 30 minutes prior to delivery – No cesarean deliveries

	Respiratory Morbidity (n=100)	No Respiratory Morbidity (n=3894)	Relative Risk (95% CI)	Adjusted OR^I (95% CI)
Ever ² baseline tachycardia >160 bpm	27.1%	6.8%	4.7 (3.1–7.3)	3.0 (1.8–5.1)
Always ² moderate variability	35.0%	43.7%	0.7 (0.5–1.0)	0.7 (0.5–1.1)
Ever ² marked variability	9.2%	3.2%	2.9 (1.5–5.6)	2.7 (1.3–5.7)
Accelerations present	27.6%	34.5%	0.7 (0.5–1.1)	0.8 (0.5–1.2)
Variable decelerations	95.9%	87.5%	3.3 (1.2–8.9)	3.4 (1.2–9.5)
Prolonged decelerations	52.0%	35.7%	1.9 (1.3–2.8)	1.8 (1.2–2.8)

^I Adjusted for fever, parity, pregestational DM, prior c-section, preeclampsia

² "Always" was defined as presence of the characteristic during the entire 30-minute period before delivery. "Ever" refers to the presence of the EFM characteristic during any 10-minute segment in the 30-minute period before delivery

Table 4

EFM characteristics in the 30 minutes prior to delivery – No maternal fever

	Respiratory Morbidity (n=146)	No Respiratory Morbidity (n=4501)	Relative Risk (95% CI)	Adjusted OR^I (95% CI)
Ever ² baseline tachycardia >160 bpm	21.6%	7.2%	3.3 (2.2–5.0)	2.9 (1.9–4.6)
Always ² moderate variability	35.9%	43.7%	0.7 (0.5–1.0)	0.7 (0.5–1.0)
Ever ² marked variability	10.3%	3.2%	3.3 (1.9–5.7)	3.1 (1.7–5.7)
Accelerations present	23.2%	33.7%	0.6 (0.4–0.9)	0.6 (0.4–0.9)
Prolonged decelerations	48.2%	33.8%	1.8 (1.3–2.5)	1.8 (1.3–2.5)

IQ interquartile range

^I Adjusted for fever, parity, pregestational DM, prior c-section, preeclampsia²"Always" was defined as presence of the characteristic during the entire 30-minute period before delivery. "Ever" refers to the presence of the EFM characteristic during any 10-minute segment in the 30-minute period before delivery.

Table 5

EFM characteristics in the 30 minutes prior to delivery – Mechanical Ventilation

	Mechanical Ventilation (n=44)	No Respiratory Morbidity (n=4561)	Relative Risk (95% CI)	Adjusted OR ^I (95% CI)
Ever ² baseline tachycardia >160 bpm	22.5%	7.6%	3.5 (1.7–7.2)	3.1 (1.4–6.7)
Always ² moderate variability	36.6%	43.7%	0.7 (0.4–1.4)	0.8 (0.4–1.4)
Ever ² marked variability	7.5%	3.2%	2.4 (0.7–7.7)	2.2 (0.7–7.2)
Accelerations present	15.0%	33.6%	0.4 (0.1–0.8)	0.4 (0.2–0.9)
Prolonged decelerations	55.8%	33.7%	2.5 (1.4–4.5)	2.6 (1.4–4.7)

^I Adjusted for fever, parity, pregestational DM, prior c-section, preeclampsia

² "Always" was defined as presence of the characteristic during the entire 30-minute period before delivery. "Ever" refers to the presence of the EFM characteristic during any 10-minute segment in the 30-minute period before delivery.