Published in final edited form as:

Am J Obstet Gynecol. 2014 December ; 211(6): 644.e1–644.e8. doi:10.1016/j.ajog.2014.06.033.

Interpreting Category II Fetal Heart Rate Tracings: Does Meconium Matter?

Heather A. FREY, MD^a, Methodius G. TUULI, MD, MPH^a, Anthony L. SHANKS, MD^a, George A. MACONES, MS, MSCE^a, and Alison G. CAHILL, MD, MSCl^a

^aDepartment of Obstetrics and Gynecology, Washington University in St. Louis, Campus Box 8064, 660 S. Euclid Ave., St. Louis, Missouri 63110

Abstract

OBJECTIVE—Category II fetal heart rate (FHR) tracings are considered indeterminate, thus improved risk stratification of category II FHR tracings is needed. We estimated whether the presence of meconium increased the risk of adverse neonatal outcomes.

STUDY DESIGN—This study was conducted within a prospective cohort of 5000 women with singleton pregnancies admitted in labor at term. Pregnancies with category II FHR in the 60 minutes prior to delivery were included. FHR data were extracted by trained nurses blinded to clinical outcome. The exposure was presence of meconium. The primary outcome was a composite neonatal morbidity defined as 1 of the following: neonatal death, neurologic morbidity, respiratory morbidity, hypotension requiring treatment, and sepsis. Secondary outcomes were nursery admission, cord pH, 5-minute Apgar score, and components of the composite. Logistic regression was used to adjust for confounders.

RESULTS—Of the 3,257 women with category II FHR tracings, 693 (21.3%) had meconium and 2,564 (78.7%) did not. Meconium was associated with higher risk of the composite morbidity (aOR 2.49, 95% CI 1.78-3.48) and increased risks of the secondary outcomes. The associations remained significant when infants with meconium aspiration syndrome were excluded. Thick meconium was significantly associated with the composite morbidity.

CONCLUSIONS—The presence of meconium is associated with an increased risk of neonatal morbidity in women with category II FHR pattern. This clinical factor may assist clinicians in managing category II FHR patterns in labor.

© 2014 Mosby, Inc. All rights reserved.

Corresponding Author: Heather Frey, MD Department of Obstetrics and Gynecology, Washington University in St. Louis Campus Box 8064, 660 S. Euclid Ave., St. Louis, Missouri 63110 Phone: 314-362-7300 Fax: 314-747-1429 FreyH@wudosis.wustl.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Disclosure: The authors report no conflict of interest.

Presentation: Poster presentation, 34th Annual Meeting of the Society of Maternal Fetal Medicine, New Orleans, Louisiana. February 3-8, 2013.

Keywords

Electronic fetal monitoring; fetal heart rate; meconium

Introduction

Category II FHR tracings^{1,2} are commonly encountered during labor.³ Problems with interpretation of the category II FHR tracing, in part, stem from the diversity of FHR patterns that are included in this group. Additionally, the association between category II FHR tracings and fetal status and neonatal outcomes is poorly defined. One study found that increasing duration of FHR tracing classified as category II prior to delivery was associated with increased incidence of low five-minute Apgar score and NICU admission.³ But, the vast majority of fetuses with a category II FHR tracing will have normal outcomes after delivery.⁴

It has been suggested that other clinical factors should be considered in the evaluation and management of category II FHR tracings in order to improve the predictive ability of electronic fetal monitoring (EFM) for acidosis and outcomes.³ Meconium stained amniotic fluid is found in 12% of all deliveries.⁵ Multiple studies have reported that meconium is associated with adverse neonatal outcomes including fetal acidemia, low Apgar scores, and need for neonatal resuscitation.⁶⁻⁹ Furthermore, the risk of neonatal morbidity in the setting of both meconium and an abnormal FHR tracing may exceed the risk associated with either factor independently.¹⁰⁻¹² We performed this study among women at term with a category II intrapartum fetal heart rate tracing to estimate whether the presence of meconium increased the risk of adverse neonatal outcomes.

Materials and Methods

This observational study was conducted among the first 5000 women enrolled in a prospective cohort study of over 8000 women. The purpose of the parent cohort, which includes all consecutive term singleton pregnancies in labor, is to examine the relationship between intrapartum EFM and perinatal outcomes. The Washington University in St. Louis Human Research Protection Office approved the study.

Trained research staff collected detailed data from participants' medical records. Gestational age was calculated based on the woman's first ultrasound examination in the pregnancy and last menstrual period.¹³ A woman was considered to have diabetes for the purpose of this analysis if she had a diagnosis of pregestational or gestational diabetes based on the National Diabetes Data Group criteria,¹⁴ while hypertension in pregnancy included chronic hypertension, gestational hypertension or preeclampsia. Labor management information was also recorded including oxytocin administration, epidural use, and mode of delivery. Chorioamnionitis was defined based on a clinical diagnosis of maternal intrapartum temperature $>38.0^{\circ}\text{C}$ associated with maternal or fetal tachycardia, fundal tenderness, or purulent amniotic fluid.¹⁵ The infant was considered small-for-gestational age if the birthweight was $<10^{\text{th}}$ percentile based on the Alexander growth reference.¹⁶ Meconium information obtained from the medical record included its presence and classification as

determined by the obstetric nurse and primary obstetric care provider. “Thin” or “thick” meconium was documented based on subjective evaluation of meconium color and consistency. Neonatal outcome data abstracted from the medical record of the infant included umbilical cord arterial gas analyses, Apgar score at five minutes, nursery admission, and medical complications diagnosed during the postnatal hospital admission.

The obstetric research nurses were formally trained to systematically review EFM patterns using the NICHD criteria,¹ blind to all clinical data. Participants were included in this study if they had a category II FHR tracing during the hour prior to delivery. This was defined as a category II FHR tracing for 40 of the 60 minutes prior to delivery. Forty minutes was selected as the duration to represent a predominately category II FHR tracing because each tracing was analyzed in 10 minute increments in this study. Women with any 10 minute FHR pattern in the hour prior to delivery defined as category III were excluded, as were women whose FHR tracing prior to delivery was category II for <40 of the final 60 minutes. Additional exclusion criteria included unknown meconium status, multiple gestation, major fetal anomaly, scheduled non-labor cesarean, and gestational age <37 weeks.

The primary outcome of the study was composite neonatal morbidity, defined as one or more of the following: infant death prior to hospital discharge, neurologic morbidity, respiratory morbidity, hypotension requiring therapy, and suspected or confirmed neonatal sepsis (Table 1). Each component of the composite morbidity was evaluated separately as a secondary outcome. Other secondary outcomes included higher acuity nursery admission, umbilical artery cord pH <7.1, and Apgar <7 at 5 minutes. Our higher acuity nurseries consist of a neonatal intensive care unit (NICU) (Level IV) and a special care nursery (Level II).

Characteristics of women with a category II FHR tracing were compared based on presence or absence of meconium. Categorical variables were compared using the Chi-square test. Maternal age was compared using the Mann-Whitney U test because this variable was not normally distributed based on the Kolmogorov-Smirnov test. Rates of the primary and secondary outcomes were estimated within groups. Multivariable logistic regression models for the primary and secondary outcomes were developed to adjust for potential confounders. Covariates associated with the presence of meconium in univariable analysis ($p < 0.10$) were included in the initial model and were removed sequentially using a backward step-wise approach based on the likelihood ratio test or >10% change in the adjusted odds ratio (aOR). Covariates considered in the model included nulliparity, gestational age category (37⁰-38⁶ weeks, 39⁰-40⁶ weeks, 41⁰ weeks), chorioamnionitis, maternal obesity (body mass index $\geq 30 \text{ kg/m}^2$), prior cesarean, hypertension, diabetes, and oxytocin use. We performed sensitivity analyses excluding pregnancies complicated by meconium aspiration syndrome and chorioamnionitis. Meconium aspiration syndrome was defined as respiratory distress and transthoracic echocardiographic findings of elevated main pulmonary artery pressures.¹⁷ We also conducted a stratified analysis based on classification of meconium as “thin” or “thick.” We also explored specific features within category II FHR patterns to identify if meconium in the setting of specific features conferred risk.

We estimated the ability of the presence of meconium to predict adverse neonatal outcomes among women with a category II FHR tracing by calculating the sensitivity, specificity, and positive and negative predicted values. Similarly, we assessed the test characteristics of a predictive model that included individual FHR characteristics in our model in addition to meconium.

Tests with $p < 0.05$ were considered statistically significant. All statistical analyses were performed using STATA 10.0 (special edition, Stata-Corp, College Station, TX).

Results

Among the 5000 women admitted at term with a singleton gestation, 3257 women had a category II FHR tracing in the hour prior to delivery. Of the women with the category II FHR tracing, 693 (21.3%) had meconium-stained amniotic fluid, while in 2564 women (78.7%) meconium was absent (Figure 1).

Women with meconium were more likely to be nulliparous and at a more advanced gestational age, but less likely to have been diagnosed with hypertension or diabetes. Chorioamnionitis and operative vaginal delivery were more likely in pregnancies with meconium, while use of oxytocin was less common among women with meconium than those without meconium (Table 2).

Among women with a category II FHR tracing, meconium was associated an increased risk of neonatal morbidity (12.1% vs. 5.3%; aOR 2.49, 95% CI 1.78-3.48). Each component of the composite, except neonatal death, was also more common in pregnancies with meconium-stained amniotic fluid. However because of the rarity of the individual outcomes, only respiratory morbidity and suspected sepsis reached statistical significance. Higher acuity nursery admission, fetal acidemia, and Apgar score <7 at five minutes were also more likely in the presence of meconium (Table 3). When we excluded transient tachypnea of the newborn from our definition of respiratory morbidity, the association between meconium and morbidity remained similar in direction and magnitude (data not presented).

When the eighteen neonates with meconium-aspiration syndrome were excluded, meconium remained associated with the composite morbidity (9.8% vs. 5.3%; aOR 1.7, 95% CI 1.25-2.58), respiratory morbidity (4.9% vs. 2.3%, aOR 2.16, 95% CI 1.37-3.42), and higher acuity nursery admission (10.6% vs. 5.8%; aOR 1.79, 95% CI 1.27-2.53).

Exclusion of pregnancies complicated by chorioamnionitis from the main analysis yielded similar results; the associations between meconium and composite morbidity (9.1% vs. 3.7%, aOR 2.83, 95% CI 2.00-4.01), respiratory morbidity (6.1% vs. 2.0%, aOR 3.66, 95% CI 2.36-5.68), suspected sepsis (6.1% vs. 2.8%, aOR 2.33, 95% CI 1.55-3.51), and higher acuity nursery admission (9.9% vs. 4.2%, aOR 2.70, 1.94-3.76) persisted.

In stratified results by meconium thickness, 53 women without this data were excluded. Higher rates of the composite neonatal morbidity, higher acuity nursery admission, and a composite of either arterial cord pH <7.1 or Apgar score <7 at 5 minutes were found in

pregnancies with *thick* meconium. These outcomes were not increased in pregnancies with *thin* meconium compared to pregnancies without meconium present (Table 4).

We further examined individual FHR characteristics associated with the composite adverse neonatal outcome in our cohort of women with meconium. Tachycardia was more prevalent and accelerations less common in women with the composite neonatal morbidity compared to women without any components of the composite outcome. However after controlling for chorioamnionitis, associations were not statistically significant. Variability and decelerations were not significantly different in those women with and without the composite neonatal morbidity (Table 5). In contrast, presence of meconium was associated with an increased risk of the composite adverse outcome among women with a category II FHR tracing, even in the setting of specific generally favorable fetal heart rate characteristics (Table 6).

The presence of meconium alone was poorly predictive of the composite adverse neonatal outcome, with positive predictive value of 12.1%. However, the negative predictive value was high at 94.7%. Meconium in the setting of a category II FHR tracing with absent accelerations had 84.5% sensitivity, 28.1% specificity and 13.9% positive predictive value for adverse neonatal outcome. Further, the finding of meconium, tachycardia and absent accelerations had 26.2% sensitivity, 91.2% specificity, and 29.3% positive predictive value for the adverse neonatal outcome (Table 7).

Comment

Our results show that meconium is a clinical factor that can be used for risk stratification in women with a category II FHR tracing. The presence of meconium was associated with a composite neonatal morbidity as well as adverse outcomes including higher acuity nursery admission, fetal acidemia, and low Apgar score in non-anomalous, term infants. Meconium remained associated with neonatal morbidity even after controlling for relevant confounders and excluding neonates diagnosed with meconium aspiration syndrome.

An association between meconium-stained amniotic fluid and poor perinatal outcome has been well described in the literature. Meconium has been associated with increased rates of low Apgar scores,⁶⁻⁹ fetal acidemia,⁶⁻⁹ NICU admission,^{7,9} neonatal seizures,^{6,7} and perinatal mortality.^{7,9} Additionally, it has been reported that abnormal FHR tracings in the presence of meconium further increase the risk of adverse neonatal outcome.¹⁰⁻¹² However, most prior studies have approached the study of this relationship from the perspective of evaluating the impact of particular FHR characteristics on neonatal outcome among all women with meconium-stained amniotic fluid. In this study we assessed meconium, rather than the FHR tracing, as the risk-stratifying variable.

The predictive ability of meconium to detect pregnancies at risk for the adverse neonatal outcome among women with a category II FHR tracing was overall poor. However, the negative predictive value was high and the test characteristics improved when specific features of the FHR tracing were taken into account as well. Our results indicated that 29.3% of neonates had the composite outcome adverse outcome if there was evidence meconium, tachycardia and absent accelerations prior to delivery in the setting of category II FHR

tracing. Thus, taking into account the presence of meconium when managing women with a category II FHR tracing may be preferable to considering the FHR category in isolation. Incorporation of meconium into clinical decision rules based on FHR categories should be the focus of future research.

The prospective interpretation of the FHR tracings by obstetric nurses blind to clinical outcome is a major strength of this study. This reduced the risk of bias that is introduced when the interpretation of the FHR tracing is performed by an individual who is actively providing clinical care to the participant. Additionally, the prospective study design minimized the amount of missing data. Our use of sensitivity analysis to exclude neonates with MAS is noteworthy. While multiple other studies have found that meconium is associated with adverse neonatal outcome, it is often unclear whether the morbidity occurs primarily in infants with MAS. The results of this study suggest that this association exists independent of the development of MAS. Furthermore, meconium passage has been previously reported to be associated with higher rates of intraamniotic infection,^{18,19} thus it is conceivable that chorioamnionitis is on the causal pathway linking meconium to neonatal morbidity. To investigate this further, we performed a sensitivity analysis excluding pregnancies complicated by chorioamnionitis and found that the association between meconium and increased risk of adverse neonatal outcome persisted, which suggests an independent association.

The finding that neonatal morbidity was significantly increased when meconium was described as thick but not thin is also remarkable. Thick meconium, in contrast to thin meconium, has been previously described as highly correlated with fetal acidosis.^{6,8,9} This finding may indicate either a dose-response relationship or reflect differing etiologies related to the varying types of meconium.

The use of a composite outcome may be viewed as a limitation of the study. However, use of the composite enabled us to evaluate the effect of meconium on neonatal outcomes which would not be feasible with the individual neonatal morbidity. It is also likely that the presence of meconium is related to several neonatal morbidities, making a composite outcome justifiable. Further, the neonatal outcomes that were considered as part of the composite are more clinically meaningful than more commonly occurring surrogate measures of morbidity such as low Apgar score. Our conclusion that meconium is associated with neonatal morbidity in the setting of a category II FHR tracing is further strengthened by the finding that there were higher rates of the secondary morbidity outcomes among pregnancies complicated by meconium.

We categorized the FHR based on the last 60 minutes of tracing prior to delivery. While the time period most proximal to delivery may have the greatest association with neonatal outcomes, this period of monitoring may not be reflective of the characteristics of the FHR during other time periods in labor. Importantly, this study did not address the clinical application of the findings in the management of category II fetal heart rate tracings. Multiple studies support the hypothesis that meconium passage is stimulated by fetal hypoxia.²⁰⁻²² However it is not clear if it occurs in response to chronic or acute stress. Therefore, it is uncertain whether an intervention based on meconium status would yield

improved neonatal outcomes since it is possible that meconium is a sign of a chronic stress state in which the neonatal consequences are already determined. Additionally, while we demonstrated that there is an association between meconium and adverse neonatal outcome in our study, the neonatal composite morbidity was absent in the majority (87.9%) of pregnancies complicated by meconium. It is possible that in utero passage of meconium may not be a sign of fetal stress in some pregnancies. Further research is required to define the effectiveness of using meconium as a factor to guide clinical care.

Category II FHR tracings often present a clinical challenge to obstetric providers in part because of the variability in neonatal outcomes related to these EFM patterns. Our results suggest that meconium, and specifically thick meconium, is a clinical factor that is associated with neonatal morbidity among pregnancies with a category II FHR tracing. While the overall predictive ability of meconium for adverse neonatal outcomes in this setting is poor, the use of this factor to risk-stratify women may have clinical utility, especially if it improves our current interpretation of EFM. In addition the high negative predictive value suggests that the absence of meconium in the setting of category II tracing can be considered one reassuring feature. In conclusion, we assert that in our attempts to optimize the care of women with a category II FHR tracing, meconium is a factor that should be considered in further risk stratification.

Acknowledgments

Funding: NICHD RO1 HD061619-04 (PI: Dr. Cahill). Dr. Frey is supported by a training grant from the NICHD T32 grant (5 T32 HD055172-05) and this publication was supported by the Washington University CTSA grant (UL1 TR000448).

References

1. American College of Obstetricians Gynecologists. ACOG Practice Bulletin No. 106: Intrapartum fetal heart rate monitoring: nomenclature, interpretation, and general management principles. *Obstet Gynecol.* 2009; 114(1):192–202. [PubMed: 19546798]
2. American College of Obstetricians Gynecologists. Practice bulletin No. 116: Management of intrapartum fetal heart rate tracings. *Obstet Gynecol.* 2010; 116(5):1232–1240. [PubMed: 20966730]
3. Jackson M, Holmgren CM, Esplin MS, Henry E, Varner MW. Frequency of fetal heart rate categories and short-term neonatal outcome. *Obstet Gynecol.* 2011; 118(4):803–808. [PubMed: 21897312]
4. Cahill AG, Roehl KA, Odibo AO, Macones GA. Association and prediction of neonatal acidemia. *American journal of obstetrics and gynecology.* 2012; 207(3):206, e201–208. [PubMed: 22939728]
5. Ahanya SN, Lakshmanan J, Morgan BL, Ross MG. Meconium passage in utero: mechanisms, consequences, and management. *Obstetrical & gynecological survey.* 2005; 60(1):45–56. [PubMed: 15618919]
6. Berkus MD, Langer O, Samueloff A, Xenakis EM, Field NT, Ridgway LE. Meconium-stained amniotic fluid: increased risk for adverse neonatal outcome. *Obstet Gynecol.* 1994; 84(1):115–120. [PubMed: 8008304]
7. Nathan L, Leveno KJ, Carmody TJ 3rd, Kelly MA, Sherman ML. Meconium: a 1990s perspective on an old obstetric hazard. *Obstet Gynecol.* 1994; 83(3):329–332. [PubMed: 8127520]
8. Starks GC. Correlation of meconium-stained amniotic fluid, early intrapartum fetal pH, and Apgar scores as predictors of perinatal outcome. *Obstet Gynecol.* 1980; 56(5):604–609. [PubMed: 7432732]

9. Ziadeh SM, Sunna E. Obstetric and perinatal outcome of pregnancies with term labour and meconium-stained amniotic fluid. *Archives of gynecology and obstetrics*. 2000; 264(2):84–87. [PubMed: 11045329]
10. Meis PJ, Hobel CJ, Ureda JR. Late meconium passage in labor--a sign of fetal distress? *Obstet Gynecol*. 1982; 59(3):332–335. [PubMed: 7078880]
11. Steer PJ, Eigbe F, Lissauer TJ, Beard RW. Interrelationships among abnormal cardiotocograms in labor, meconium staining of the amniotic fluid, arterial cord blood pH, and Apgar scores. *Obstet Gynecol*. 1989; 74(5):715–721. [PubMed: 2812647]
12. Xu H, Mas-Calvet M, Wei SQ, Luo ZC, Fraser WD. Abnormal fetal heart rate tracing patterns in patients with thick meconium staining of the amniotic fluid: association with perinatal outcomes. *American journal of obstetrics and gynecology*. 2009; 200(3):283–e281. [PubMed: 19110226]
13. American College of Obstetricians Gynecologists. ACOG Practice Bulletin No. 101: Ultrasonography in pregnancy. *Obstet Gynecol*. 2009; 113(2 Pt 1):451–461. [PubMed: 19155920]
14. Expert Committee on the D, Classification of Diabetes M. Report of the expert committee on the diagnosis and classification of diabetes mellitus. *Diabetes care*. 2003; 26(Suppl 1):S5–20. [PubMed: 12502614]
15. Tita AT, Andrews WW. Diagnosis and management of clinical chorioamnionitis. *Clinics in perinatology*. 2010; 37(2):339–354. [PubMed: 20569811]
16. Alexander GR, Himes JH, Kaufman RB, Mor J, Kogan M. A United States national reference for fetal growth. *Obstet Gynecol*. 1996; 87(2):163–168. [PubMed: 8559516]
17. Dhillon R. The management of neonatal pulmonary hypertension. *Archives of disease in childhood*. 2012; 97(3):F223–228. [PubMed: 21278430]
18. Piper JM, Newton ER, Berkus MD, Peairs WA. Meconium: a marker for peripartum infection. *Obstet Gynecol*. 1998; 91(5 Pt 1):741–745. [PubMed: 9572222]
19. Romero R, Hanaoka S, Mazor M, et al. Meconium-stained amniotic fluid: a risk factor for microbial invasion of the amniotic cavity. *American journal of obstetrics and gynecology*. 1991; 164(3):859–862. [PubMed: 1900664]
20. Lakshmanan J, Ahanya SN, Rehan V, Oyachi N, Ross MG. Elevated plasma corticotrophin release factor levels and in utero meconium passage. *Pediatric research*. 2007; 61(2):176–179. [PubMed: 17237718]
21. Richey SD, Ramin SM, Bawdon RE, et al. Markers of acute and chronic asphyxia in infants with meconium-stained amniotic fluid. *American journal of obstetrics and gynecology*. 1995; 172(4 Pt 1):1212–1215. [PubMed: 7726258]
22. Walker J. Foetal anoxia; a clinical and laboratory study. *The Journal of obstetrics and gynaecology of the British Empire*. 1954; 61(2):162–180. [PubMed: 13152576]
23. Shankaran S, Laptook AR, Ehrenkranz RA, et al. Whole-body hypothermia for neonates with hypoxic-ischemic encephalopathy. *The New England journal of medicine*. 2005; 353(15):1574–1584. [PubMed: 16221780]
24. Silverman WA, Andersen DH. A controlled clinical trial of effects of water mist on obstructive respiratory signs, death rate and necropsy findings among premature infants. *Pediatrics*. 1956; 17(1):1–10. [PubMed: 13353856]

Condensation

Among women with a category II FHR tracing, meconium is associated with increased risk of neonatal morbidity.

Figure 1.
Flow diagram of study cohort

Table 1

Definitions of neonatal morbidity

Component	Definition
Death	Infant death prior to hospital discharge
Neurologic morbidity	Hypoxic-ischemic encephalopathy, seizures, or use of hypothermic therapy
Hypoxic-ischemic encephalopathy	One or more of the following: umbilical artery arterial pH <7.0, base deficit >−16, need for respiratory support at 10 minutes of life, 5-minute Apgar score <5 <i>and</i> moderate-severe neonatal encephalopathy ²³
Respiratory morbidity	Respiratory distress, transient tachypnea of the newborn, or need for ventilatory support
Respiratory distress	Clinically diagnosed by nasal flaring, subcostal and intercostal retractions, and need for supplemental oxygen to maintain oxygen saturations >95% ²⁴
Transient tachypnea	Neonatal respiratory rate >60/min with or without supplementary oxygen to maintain oxygen saturation >95%
Hypotension requiring therapy	Low blood pressure requiring vasopressor therapy
Suspected or confirmed sepsis	Neonatal symptoms including respiratory distress, temperature instability, apnea, lethargy <i>with or without</i> an abnormal CBC (6-12 hours after birth, with leukopenia or leukocytosis with an immature: total neutrophil ratio (I:T ratio) of >0.2) <i>and/or</i> positive blood culture¹⁵

Table 2

Comparison of characteristics within the cohort of women with category II FHR prior to delivery based on presence or absence of meconium

	Meconium (n=693)	No meconium (n=2564)	p
Median maternal age (IQR)	25 (21-30)	25 (21-30)	0.61
Nulliparity	318 (45.9)	1026 (40.0)	0.01
Gestational age (weeks)			
37 ⁰ -38 ⁶	156 (22.5)	1032 (40.3)	
39 ⁰ -40 ⁶	458 (66.1)	1383 (53.9)	
41 ⁰	79 (11.4)	149 (5.8)	
<i>Race</i>			0.15
Black	463 (67.0)	1659 (64.9)	
White	129 (18.7)	563 (22.0)	
Other	99 (14.3)	335 (13.1)	
Obesity (BMI ≥ 30.0)	401 (57.9)	1384 (54.0)	0.07
Smoking	104 (15.0)	344 (13.4)	0.28
History of cesarean	60 (8.7)	179 (7.0)	0.13
Hypertension	91 (13.1)	483 (18.8)	<0.01
Diabetes	17 (2.5)	106 (4.1)	0.04
Chorioamnionitis	34 (4.9)	56 (2.2)	<0.01
Oxytocin use	410 (59.2)	1805 (70.3)	<0.01
Epidural	627 (90.5)	2341 (91.3)	0.50
SGA infant	93 (13.4)	354 (13.8)	0.79
<i>Mode of delivery</i>			
Spontaneous vaginal delivery	602 (86.9)	2303 (89.8)	0.03
Operative vaginal delivery	65 (9.4)	167 (6.5)	
Cesarean delivery	26 (3.7)	94 (3.7)	

^a IQR, interquartile range

Table 3

Comparison of neonatal outcomes within the cohort of women with category II FHR prior to delivery based on presence or absence of meconium

	Meconium (n=693)	No meconium (n=2564)	aOR	p
Composite morbidity^a	84 (12.1)	135 (5.3)	2.49 (1.78-3.48)	<0.01
<i>Death</i>	0 (0)	2 (0.1)	-	-
<i>Neurologic morbidity</i>	5 (0.7)	8 (0.3)	-	-
<i>Respiratory morbidity^a</i>	48 (6.9)	60 (2.3)	3.22 (2.13-4.85)	<0.01
<i>Hypotension requiring therapy</i>	1 (0.1)	0 (0)	-	-
<i>Suspected sepsis^a</i>	63 (9.1)	114 (4.4)	1.97 (1.34-2.90)	<0.01
Higher acuity nursery admission^a	89 (12.9)	149 (5.8)	2.41 (1.75-3.32)	<0.01
<i>NICU^b</i>	17 (2.5)	21 (0.8)	2.84 (1.48-5.44)	<0.01
<i>Special care nursery^a</i>	72 (10.4)	128 (5.0)	2.10 (1.48-2.98)	<0.01
Arterial cord pH<7.1^b	16 (2.3)	29 (1.1)	1.90 (1.02-3.55)	0.04
Apgar <7 at 5 min^b	27 (3.9)	32 (1.2)	2.76 (1.62-4.86)	<0.01

^a Adjusted for nulliparity, gestational age category, chorioamnionitis

^b Adjusted for nulliparity, chorioamnionitis

Table 4

Comparison of neonatal outcomes within the cohort of women with category II FHR prior to delivery based on presence of *thick* or *thin* meconium

	<i>Thick</i> Meconium (n=384)	aOR (95% CI)	<i>Thin</i> Meconium (n=256)	aOR (95% CI)	No meconium (n=2564)	aOR (95% CI)
Composite morbidity^a	57 (14.8)	3.65 (2.49-5.36)	22 (8.6)	1.33 (0.75-2.37)	135 (5.3)	ref
Higher acuity nursery admission^a	60 (15.6)	3.46 (2.39-4.99)	24 (9.4)	1.39 (0.80-2.39)	149 (5.8)	ref
Arterial cord pH<7.1 or Apgar <7 at 5 min^b	26 (6.9)	3.09 (1.90-5.03)	11 (4.3)	1.77 (0.90-3.48)	55 (2.2)	ref

^a Adjusted for gestational age category, chorioamnionitis

^b Adjusted for chorioamnionitis

Table 5

FHR characteristics 30 minutes prior to delivery associated with the composite adverse outcome in women with meconium and category II FHR prior to delivery

FHR characteristic	Composite neonatal outcome present (n=84)	Composite neonatal outcome absent (n=609)	OR (95% CI)	aOR (95% CI) ^e	p
Accelerations present ^a	13 (15.5)	171 (28.1)	0.47 (0.23-0.88)	0.55 (0.29-1.05)	0.07
Tachycardia ^b	23 (27.4)	67 (11.1)	3.02 (1.67-5.32)	1.49 (0.76-2.92)	0.25
Variability^c					
Always moderate	25 (29.8)	212 (34.8)	ref		
Ever minimal/absent	52 (61.9)	371 (60.9)	1.19 (0.70-2.06)	1.01 (0.58-1.77)	0.96
Ever marked	7 (8.3)	29 (4.8)	2.05 (0.81-5.15)	-	
Ever moderate	51 (60.7)	368 (63.4)	0.89 (0.55-1.47)	0.97 (0.58-1.62)	0.90
Accelerations present ^a OR ever moderate variability ^c	55 (65.5)	426 (70.0)	0.81 (0.49-1.37)	0.96 (0.56-1.65)	0.90
Decelerations^d					
No repetitive decelerations	48 (57.1)	390 (64.0)	ref		
Repetitive late	2 (2.4)	20 (3.3)	0.81 (0.09-3.52)	-	-
Repetitive variable	34 (40.5)	212 (34.8)	1.30 (0.79-2.15)	1.33 (0.79-2.23)	0.28

^a Any acceleration present in the 30 minutes prior to delivery

^b Fetal heart rate >160 bpm in any epoch within the last 30 minutes of delivery

^c Variability was “always moderate” if the amplitude ranged between 6-25 beats per minute during the entire 30 minute period prior to delivery, while “ever” refers to the presence of the specific variability descriptor during any 10 minute segment in the 30 minutes prior to delivery.

^d Decelerations were considered repetitive if they occurred with 50% of contractions.

^e Adjusted for chorioamnionitis

Table 6

Impact of meconium on risk of composite adverse outcome among women with specific FHR characteristics 30 minutes prior to delivery and category II FHR

FHR characteristic	Composite neonatal outcome	aOR (95% CI) ^e	p
Accelerations present^a (N=950)			
Meconium	13/184 (7.1)	1.63 (0.78-3.40)	0.19
No meconium	35/766 (4.6)		
Tachycardia absent^b (N=2922)			
Meconium	61/597 (10.2)	3.20 (2.20-4.66)	<0.01
No meconium	79/2325 (3.4)		
Always moderate variability^c (n=1208)			
Meconium	25/237 (10.5)	2.49 (1.41-4.43)	<0.01
No meconium	45/971 (4.6)		
Ever moderate variability^c (N=2102)			
Meconium	51/437 (11.7)	2.15 (1.42-3.24)	<0.01
No meconium	92/1665 (5.5)		
Accelerations present^a OR ever moderate variability^c (N=2376)			
Meconium	55/481	2.33 (1.57-3.45)	<0.01
No meconium	99/1895		
No repetitive decelerations^d (N=2087)			
Meconium	48/438 (11.0)	2.48 (1.60-3.84)	<0.01
No meconium	71/1649 (4.3)		

^a Any acceleration present in the 30 minutes prior to delivery

^b Fetal heart rate >160 bpm in any epoch within the last 30 minutes of delivery

^c Variability was “always moderate” if the amplitude ranged between 6-25 beats per minute during the entire 30 minute period prior to delivery, while “ever” refers to the presence of the specific variability descriptor during any 10 minute segment in the 30 minutes prior to delivery.

^d Decelerations were considered repetitive if they occurred with 50% of contractions.

^e Adjusted for chorioamnionitis

Table 7

Test characteristics of the presence meconium for the prediction of adverse neonatal outcome in pregnancies with category II FHR tracing

	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Meconium	38.4%	80.0%	12.1%	94.7%
Meconium + tachycardia	27.4%	88.9%	25.6%	89.9%
Meconium + absent accelerations	84.5%	28.1%	13.9%	92.9%
Meconium tachycardia + absent accelerations	26.2%	91.2%	29.3%	89.9%