Published in final edited form as:

J Matern Fetal Neonatal Med. 2012 July ; 25(7): 1055–1058. doi:10.3109/14767058.2011.614975.

A modified fetal heart rate tracing interpretation system for prediction of cesarean section

William T. Schnettler^{1,2,3}, Jennifer Rogers³, Rachel E. Barber¹, and Michele R. Hacker^{1,2}

¹Department of Obstetrics and Gynecology, Beth Israel Deaconess Medical Center, Boston, MA, USA

²Harvard Medical School, Boston, MA, USA

³Department of Obstetrics and Gynecology, Aultman Hospital, Canton, OH, USA

Abstract

Objective—To investigate whether a modified version of the 2008 National Institute of Child Health and Human Development (NICHD) interpretation system upon admission decreases cesarean delivery risk.

Methods—This retrospective cohort study ascribed a modified category to the first 30 min of fetal heart rate (FHR) tracings in labor. Category I was divided into two subsets (Ia and Ib) by the presence of accelerations. Category II was divided into four subsets (IIa–IId) based on baseline FHR, variability, response to stimulation and decelerations. Log-binomial regression was used to calculate risk ratios (RR) and 95% confidence intervals (CI).

Results—A category was ascribed to 910 women. Most FHR tracings were Category Ia (65.8%), Ib (7.7%), IIb (11.8%) and IIc (14.0%). Category Ib tracings (fewer than two accelerations) were 2.26 (95% CI: 1.13–4.52) times more likely to result in cesarean delivery for abnormal FHR tracing than Category Ia tracings. A similar increase in risk was seen when comparing Category IIb and Category IIc with Category Ia.

Conclusion—Application of a modified version of the 2008 NICHD FHR interpretation system to the initial 30 min of labor can identify women at increased risk of cesarean delivery for abnormal FHR tracing.

Keywords

Three-tiered cardiotocography scheme; abnormal tracing

Introduction

Continuous electronic fetal heart rate (FHR) monitoring in labor has become standard of care on labor and delivery units worldwide, despite a lack of proven benefit or recommendation from the United States Preventive Services Task Force [1]. Evidence suggests that the current use of FHR monitoring has failed to decrease the incidence of perinatal mortality or cerebral palsy [2–7]. The Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD), American Congress of Obstetricians and Gynecologists (ACOG) and the Society for Maternal-Fetal Medicine convened in 2008 to

develop a consensus interpretation system and standardize the nomenclature. The resulting system comprises three categories of FHR patterns based on several parameters, such as baseline FHR, variability, accelerations and decelerations [8]. One criticism of this classification system has been the extreme heterogeneity within the intermediate Category II – those tracings that are neither clearly normal nor markedly abnormal [8].

It is well accepted that the categorization of a FHR tracing evaluates a fetus at a single moment in time and that clinical circumstances often change throughout the course of labor. However, emphasis has been placed upon the importance of the first 30 min of FHR following admission and its prognostic value for fetal status throughout labor [9]. Whether the categorization of this initial tracing, particularly those that are deemed Category II can predict the development of fetal distress is unknown. The objective of this study was to assess whether the classification of the initial 30 min of FHR tracing after presentation is associated with subsequent cesarean delivery for abnormal FHR tracing and if further stratification of FHR tracings based on presence of accelerations, baseline heart rate, variability, response to stimulation and presence of decelerations influenced this relationship.

Methods

Study population

This was a retrospective cohort study of deliveries at Aultman Hospital from 1 January 2008 through 1 December 2008. The study was approved by the Aultman Hospital Human Ethics Review Board. Eligible women included all singleton pregnancies beyond 31 completed weeks of gestation, for which at least 30 min of FHR tracing at admission was available and were delivered following spontaneous or induced labor. This gestational age cutoff was chosen based on the uniformity of FHR criteria used in clinical practice for determination of fetal wellbeing beyond 32 weeks. Exclusion criteria included induction of labor for suspected fetal compromise, known potentially lethal fetal anomalies and cesarean delivery for indications other than concern for fetal well being. Cesarean deliveries for dystocia were excluded, because we hypothesized that they are a unique subset that have a distinct pathophysiologic association with abnormal FHR tracing. We also excluded deliveries within 60 min of admission given it was unlikely that, within that brief time period, there was time to obtain a 30-min FHR tracing that was then used to guide the decision to perform a cesarean delivery.

Interpretation of FHR tracings

The Philips OB TraceVue electronic cardiotocography system was used to record computerized FHR tracing analysis (at 3 cm/min) upon admission and continuously throughout labor. These FHR tracings were stored in electronic format on a secured internal server. Two authors (WTS and JR), who were blinded to the delivery outcome, reviewed the first 30 min of continuous FHR tracings following admission and assigned a category to each pregnancy. Both authors were chief residents in obstetrics and gynecology at the time they reviewed and categorized the tracings.

Categories I, II and III were assigned according to the 2008 NICHD three-tier interpretation system [8]. The further stratification of these categories is outlined in Table I. Category I was divided by the presence of accelerations, while Category II was stratified based on the examples published in the NICHD report [8]. Two authors (WTS and JR) jointly reviewed individual tracings without characteristics for clear categorization to reach consensus on a single category assignment. No tracing met criteria for multiple categories. This study does not include Category III tracings. Such tracings would have prompted immediate

intervention and thus would not have allowed adequate separation between admission tracing (test) and delivery (outcome) – a requisite for investigating the predictive value.

Data analysis

We used SAS 9.2 (SAS institute Inc., Cary, NC, USA) for data analysis. All tests were two-sided, and p -values <0.05 were considered statistically significant. The two authors who interpreted the tracings did not review the medical records to abstract demographic information and outcome data; these data were obtained by a research assistant. The indication for mode of delivery was abstracted from the operative report. The primary outcome was cesarean delivery for abnormal FHR tracing. Data are presented as mean and standard deviation (SD) or proportion. Comparisons were made using the chi-square test or one-way analysis of variance, as appropriate. We used log-binomial regression to calculate risk ratios (RR) and 95% confidence intervals (CI).

Results

There were 2340 deliveries at Aultman Hospital from 1 January 2008 through 1 December 2008. A total of 916 women met the inclusion criteria, and 910 (98.7%) had FHR tracings that were of high-enough quality to be categorized using the modified interpretation system described. The remaining six women were excluded from the analysis based on poor signal quality of the tracing.

Baseline participant characteristics are presented in Table II. The study population was comprised of predominantly white, non-diabetic, and non-smoking women with an average body mass index (BMI) that was 31.0 ± 5.7 at the first prenatal visit. The mean gestational age was 39.3 ± 1.3 weeks and more than three-quarters of the women were nulliparous or primiparous. There were no significant differences in the baseline characteristics of women with Category I tracings compared to women with Category II tracings. Similarly, no differences were seen after stratifying further using the modified interpretation system (data not presented).

As expected, all of the admission FHR tracings were Category I (73.5%) or Category II (26.5%) (Table III). The majority of admission tracings met the criteria for Category Ia (65.8%), while 7.7% met Category Ib. Among Category II tracings, 0.77% met Category IIa, 11.8% met Category IIb and 14.0% met Category IId. There were no tracings in Category IIc. Among the 837 vaginal deliveries, there were 58 (6.9%) operative vaginal deliveries, and only 1 (1.7%) of the operative vaginal deliveries was performed for an abnormal FHR tracing.

The incidence and risk of cesarean delivery for abnormal FHR tracing are shown in Table III. Based on the three-tier interpretation system of admission FHR tracings, the risk of cesarean delivery for abnormal FHR tracing was nearly twice as high for Category II tracings compared with Category I tracings on admission (RR: 1.94; 95% CI: 1.24–3.01). The modified interpretation system revealed that within Category I there was a significantly increased risk of cesarean delivery for an abnormal FHR tracing among patients with fewer than two accelerations during the first 30 min of monitoring – Category Ib tracings were 2.26 (95% CI: 1.13–4.52) times as likely to result in a cesarean delivery than Category Ia tracings. A similar increase in risk was seen when comparing Category IIb and Category IId with Category Ia. Within Category II, the RR for cesarean delivery for abnormal FHR tracing in Category IIb compared with IId was 1.35 (95% CI: 0.69–2.65).

Discussion

Our findings support the prognostic utility of the 2008 NICHD three-tier interpretation system applied to the admission FHR tracing, as well as further refinement of the system to account for heterogeneity of risk within the tiers. Not only did admission FHR tracings in Category II carry nearly twice the risk for cesarean delivery as those in Category I, but we also found heterogeneity of risk within the lowest risk category and evidence for potential heterogeneity in Category II. Specifically, within Category I, the risk of cesarean for abnormal FHR tracing was more than twice as high in the absence of at least two accelerations (Category Ib) than when two or more accelerations were present (Category Ia) in the first 30 min of monitoring following admission. Admission tracings characterized by abnormal variability, and thus in Category IIb, demonstrated a slightly increased risk (RR: 1.35), albeit not significant, of progression to cesarean delivery compared with tracings with decelerations (Category IIc). Given the potential heterogeneity of risk within the broad categories, modifying the three-tier interpretation system to incorporate subcategories based on objective criteria may more accurately identify the at-risk population.

Since its inception in the 1970s, the goal of electronic FHR monitoring has been to identify women at risk for delivering an asphyxiated fetus, but most studies have demonstrated that it has poor sensitivity and positive predictive value. The highest estimate of sensitivity for either intrapartum mortality or cerebral palsy approaches 60% [10]. However, these outcomes are rare (e.g. 50 fetal deaths per 100,000 pregnancies) such that the positive predictive value of an abnormal FHR tracing approaches 0% [11]. Preselecting fetuses at higher risk for asphyxia in labor potentially increases the incidence in the screened population and consequently the test's positive predictive value. In this regard, national practice guidelines support the limited use of continuous FHR monitoring for "the labor of women with high-risk conditions" [2]. Our findings support the routine evaluation of the initial 30 min of FHR tracing as an independent predictive measure of fetal intolerance of labor.

Coupled with the low sensitivity and predictive values, the lack of clear and objective definitions to categorize FHR tracings has limited the utility of FHR monitoring as an effective screening tool. A uniform definition of the tracing characteristics that denote "reassurance" is necessary and was the stated goal of the 2008 NICHD interpretation system [12]. However, one criticism to this system has been the broad inclusion criteria for each of the three categories. Our modification of this interpretation system further stratifies these categories based on individual objective tracing characteristics and provides evidence supporting the specific FHR tracing characteristics that provide reassurance or cause for concern. Thus, when the initial 30 min of FHR tracing fails to demonstrate adequate accelerations or appropriate "moderate" variability, clinicians should consider utilizing continuous monitoring and have a more heightened awareness of fetal status.

There are several limitations to this study that warrant mention. First, while the overall sample size was substantial, there were very few tracings that met criteria for Category IIa and none in Category IIc. If a spectrum of risk exists within Category II, we were unable to demonstrate that given our limited sample size. A second limitation lies in the outcome determination. Although the authors were blinded to the outcome when they classified each FHR tracing, the outcome was determined by each patient's physician with knowledge of the FHR tracing. It is possible that the treating physician's choice of cesarean delivery and documenting abnormal FHR tracing as the indication was influenced by physician fatigue or labor abnormalities. Retrospective review of the FHR tracing fails to provide the complete clinical picture leading to the physician's decision for cesarean delivery. While there is a set of criteria to define "reassuring," the "non-reassuring" designation spans the breadth of

clinical circumstance. Multiple factors subtly influence the clinician's decision-making process, and we did not independently confirm the indication of abnormal FHR tracing.

A third limitation is that exposure misclassification might have occurred, because most FHR tracings were evaluated and categorized by a single author. However, the categories were based on objective criteria and the two authors reached consensus in all cases where the tracing lacked clear characteristics for categorization. Furthermore, because the authors were blinded to the outcome, any misclassification would be nondifferential and would serve to bias results toward the null.

Continuous FHR monitoring occurs in nearly all pregnancies in the United States despite the lack of supportive evidence and is associated with an increase in the incidence of cesarean delivery [3,5]. Efforts to improve the utility of FHR tracing as a screening tool should focus on improving its sensitivity, decreasing inter- and intra-observer variability, and specifying the clinical circumstances for its continuous use. More robust evidence to support the safety of the intermittent monitoring approach may prompt a shift in clinical practice away from the nonselective use of continuous electronic fetal monitoring. This will allow for the application of the continuous approach to fetuses lacking reassurance on the admission tracing and at higher risk for morbidity or mortality.

Acknowledgments

Declaration of Interest: This work was conducted with support from Harvard Catalyst, The Harvard Clinical and Translational Science Center (NIH Award #UL1 RR 025758 and financial contributions from Harvard University and its affiliated academic health care centers).

References

1. US Preventive Services Task Force. Intrapartum Electronic Fetal Monitoring. 2005 Mar 7.
2. ACOG Practice Bulletin No. 106: Intrapartum fetal heart rate monitoring: nomenclature, interpretation, and general management principles. *Obstet Gynecol.* 2009; 114:192–202. [PubMed: 19546798]
3. Alfirevic Z, Devane D, Gyte GM. Continuous cardiotocography (CTG) as a form of electronic fetal monitoring (EFM) for fetal assessment during labour. *Cochrane Database Syst Rev.* 2006; 3:CD006066. [PubMed: 16856111]
4. Freeman RK. Problems with intrapartum fetal heart rate monitoring interpretation and patient management. *Obstet Gynecol.* 2002; 100:813–826. [PubMed: 12383554]
5. Graham EM, Petersen SM, Christo DK, Fox HE. Intrapartum electronic fetal heart rate monitoring and the prevention of perinatal brain injury. *Obstet Gynecol.* 2006; 108:656–666. [PubMed: 16946228]
6. Larma JD, Silva AM, Holcroft CJ, Thompson RE, Donohue PK, Graham EM. Intrapartum electronic fetal heart rate monitoring and the identification of metabolic acidosis and hypoxic-ischemic encephalopathy. *Am J Obstet Gynecol.* 2007; 197:301.e1–301.e8. [PubMed: 17826429]
7. Chauhan SP, Klausner CK, Woodring TC, Sanderson M, Magann EF, Morrison JC. Intrapartum nonreassuring fetal heart rate tracing and prediction of adverse outcomes: interobserver variability. *Am J Obstet Gynecol.* 2008; 199:623.e1–623.e5. [PubMed: 18667185]
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. Elimian A, Lawlor P, Figueroa R, Wiencek V, Garry D, Quirk JG. Intrapartum assessment of fetal well-being: any role for a fetal admission test? *J Matern Fetal Neonatal Med.* 2003; 13:408–413. [PubMed: 12962267]

10. Grimes DA, Peipert JF. Electronic fetal monitoring as a public health screening program: the arithmetic of failure. *Obstet Gynecol.* 2010; 116:1397–1400. [PubMed: 21099609]
11. Walsh CA, McMenamin MB, Foley ME, Daly SF, Robson MS, Geary MP. Trends in intrapartum fetal death 1979–2003. *Am J Obstet Gynecol.* 2008; 198:47.e1–47.e7. [PubMed: 17905174]
12. American Congress of Obstetricians and Gynecologists. Management of Intrapartum Fetal Heart Rate Tracings. Washington D.C.: 2010 Nov.. Report No.: Practice Bulletin No. 116

Table I

Modified NICHD three-tier FHR interpretation system.*

Category	Characteristics
Ia	<p>All of the following criteria are met:</p> <ul style="list-style-type: none"> • Baseline heart rate of 110–160 beats per minute (bpm) • Late or variable decelerations absent • Early decelerations either present or absent • Two accelerations ($>15 \text{ bpm} \times 15 \text{ s}$)
Ib	All the above criteria are met with the exception of two accelerations present
IIa	Category II FHR tracings fail to meet criteria for Category I or III
IIa	Baseline heart rate $<110 \text{ bpm}$ or $>160 \text{ bpm}$, but variability is present
IIb	<p>Any of the following criteria are met:</p> <ul style="list-style-type: none"> • Minimal baseline variability ($<5 \text{ bpm}$) • Absent baseline variability without recurrent decelerations • Marked baseline variability ($>25 \text{ bpm}$)
IIc	Absence of induced accelerations after fetal stimulation
IId	<p>Any of the following criteria are met:</p> <ul style="list-style-type: none"> • Recurrent variable decelerations accompanied by minimal or moderate baseline variability • Prolonged deceleration $>2 \text{ min}$ but $<10 \text{ min}$ • Recurrent late decelerations with moderate baseline variability • Variable decelerations with other characteristics, such as slow return to baseline, “overshoots,” or “shoulders”
III	<p>Either of the following criteria are met:</p> <ul style="list-style-type: none"> • Absent baseline FHR variability and any of the following: <ul style="list-style-type: none"> ○ Recurrent late decelerations ○ Recurrent variable decelerations ○ Bradycardia-Sinusoidal pattern

Note:

* Based on the 2008 NICHD Workshop Report on Electronic Fetal Monitoring.

Table II

Baseline participant characteristics.

Characteristic	All women (<i>n</i> = 910)	Category I (<i>n</i> = 669)	Category I (<i>n</i> = 669)	<i>p</i> [*]
Maternal age (years) – mean ± SD	26.3 ± 5.6	26.2 ± 5.6	26.2 ± 5.6	0.87
BMI at first prenatal visit (kg/m ²) – mean ± SD	31.0 ± 5.7	30.9 ± 5.7	30.9 ± 5.7	0.64
Gestational age (weeks) – mean ± SD	39.3 ± 1.3	39.3 ± 1.3	39.4 ± 1.4	0.18
Parity – <i>n</i> (%)				
0	407 (44.7)	300 (44.8)	107 (44.4)	0.89
1	284 (31.2)	206 (30.8)	78 (32.4)	
2	219 (24.1)	163 (24.4)	56 (23.2)	
Race/Ethnicity – <i>n</i> (%)				
White	743 (81.7)	548 (81.9)	195 (81.0)	0.92
African American	81 (8.9)	58 (8.7)	23 (9.5)	
Unknown	86 (9.5)	63 (9.4)	23 (9.5)	
Smoker – <i>n</i> (%)				0.82
Yes	201 (22.1)	149 (22.3)	52 (21.6)	
No	709 (77.9)	520 (77.7)	189 (78.4)	
Diabetes mellitus – <i>n</i> (%)				0.38
Pre-gestational	4 (0.4)	2 (0.3)	2 (0.8)	
Gestational	30 (3.3)	20 (3.0)	10 (4.2)	
None	876 (96.3)	647 (96.7)	229 (95.0)	

Notes:

^{*} Comparison is between Categories I and II; BMI = body mass index; SD = standard deviation.

Table III

Incidence and risk of cesarean delivery for abnormal FHR tracing by admission category.

FHR tracing category	<i>n</i> (%)	Vaginal delivery <i>n</i> (%)	Cesarean delivery for abnormal FHR tracing <i>n</i> (%)	RR (95% CI)
Three-tier interpretation				
Category I	669 (73.5)	626 (93.6)	43 (6.4)	Reference
Category II	241 (26.5)	211 (87.6)	30 (12.4)	1.9 (1.2–3.0)
Modified interpretation				
Ia	599 (65.8)	565 (94.3)	34 (5.7)	Reference
Ib	70 (7.7)	61 (87.1)	9 (12.9)	2.2 (1.1–4.5)
IIa	7 (0.77)	7 (100.0)	0 (0.0)	— [*]
IIb	107 (11.8)	91 (85.1)	16 (14.9)	2.6 (1.5–4.6)
IIc	127 (14.0)	113 (89.0)	14 (11.0)	1.9 (1.1–3.5)

Notes: Vaginal delivery includes both operative vaginal and vaginal delivery;

^{*} RR could not be estimated due to the lack of cesareans for abnormal FHR in Category IIa.