Association Between Intrapartum Cardiotocogram and Early Neonatal Outcomes in a Tertiary Hospital in Thailand

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Background: *Intrapartum electronic fetal monitoring (EFM) has widely been used to monitor mothers in labor who are at risk in clinical practice. There is little evidence to describe the association between EFM categories based on the newly proposed National Institute of Child Health and Human Development (NICHD) 2008 criteria and neonatal outcomes.*
Objective: *To investigate the association between intrapartum cardiotocogram categories based on the NICHD 2008 and early neonatal outcomes.*
Material and Method: *Intrapartum EFM tracings of 120 singleton pregnant women of equal or more than week gestation were evaluated according to NICHD 2008 guidelines. Neonatal outcomes included Apgar scores at 1 and 5 minutes, umbilical cord blood pH, and neonatal intensive care unit (NICU) admission. The association between EFM and neonatal outcomes was analyzed using logistic regression.*
Results: *Among the 120 mothers, 83 (69.2%) had EFM tracings classified as Category I and 37 (30.8%) as Category II. Compared to EFM Category I, Category II had a 5-fold higher risk of having 1-minute Apgar score of <9 (adjusted odds ratio (OR) 4.96, 95% CI 1.03 to 24.00, p = 0.046) and 38-folds higher risk of having neonatal acidosis (adjusted OR 37.88, 7.33 to 195.90, p<0.001). Variable deceleration was associated with a 6-fold increased risk of having 1-minute Apgar score of <9 (OR 6.26, 1.23 to 31.80, p = 0.027). The presence of minimal variability and variable deceleration increased the risk of having neonatal acidosis by 16 and 8 times (OR 15.89, 3.42 to 73.80, p<0.001 and 7.84, 1.45 to 42.48, p = 0.017, respectively).*
Conclusion: *EFM category II according to NICHD 2008 classification was associated with higher risk of having low Apgar score at 1 minute and neonatal acidosis than EFM category I.*

Keywords: *Electronic fetal monitoring, Early neonatal outcome, Intrapartum cardiotocogram, Neonatal acidosis*

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Cardiotocogram or electronic fetal monitoring (EFM) has been introduced into clinical practice as a tool to monitor mothers in labor who are at risk of perinatal asphyxia and neonatal acidosis for more than 30 years. It has been widely used by obstetric care teams including nurses, midwifes, medical practitioners, and obstetricians because this method is non-invasive, easily done, and available in most settings and hospitals.

Data from a meta-analysis[1] showed that continuous EFM during labor halved the risk of neonatal seizures, although it did not reduce perinatal mortality and the incidence of cerebral palsy. It is also showed that use of intrapartum continuous EFM was associated with an increase in cesarean sections and instrumental vaginal births. Previous studies[2-4] suggested that some particular EFM findings were associated with various neonatal outcomes such as Apgar score, umbilical cord blood pH and neonatal intensive care unit (NICU) admission. However, most of these studies were conducted in western populations and few in Asian populations.

Attempts to classify EFM tracings have been made over the last decades. In 2000, Dellinger et al[5] developed a simple classification system for interpreting fetal heart rate tracings and found that it helped predict

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various neonatal outcomes. In 2008, the National Institute of Child Health Development (NICHD) introduced new criteria for evaluating EFM and divided the EFM abnormalities into three categories[6]. However, few studies have documented the burden of EFM abnormality categories according to these newly proposed criteria[7], and little evidence exists to describe the association between EFM categories based on the criteria and neonatal outcomes. The present study was aimed to evaluate clinical utility of the NICHD 2008 criteria and investigate the association between the EFM categories and neonatal outcomes in a regional hospital in Thailand.

Material and Method

Pregnant women with a gestational age of equal or greater than 32 weeks who presented between March and August 2014 with true labor at the labor room of Sanpasitthiprasong Hospital, a referral regional hospital in Ubon Ratchathani, were asked to participate in the present study. Pregnant women with multiple pregnancy, fetal anomalies or aneuploidy, no data or poor quality intrapartum EFM, and those who were delivered by elective cesarean section were excluded. One hundred twenty pregnant women participated in the present study. All participants signed an informed consent. This study was approved by the Sanpasitthiprasong Hospital Ethical Committee.

Demographic data and obstetric history were obtained from medical records. EFMs of eligible pregnant women were recorded within 1 hour before delivery. EFM tracing was evaluated by an author (SA) and confirmed by an obstetrician (PW) who specialized in maternal fetal medicine. EFM tracing was divided into three categories based on the NICHD 2008 criteria[6]. Neonatal outcomes included Apgar score at 1 and 5 minute, umbilical cord blood pH, and neonatal intensive care unit (NICU) admission. Apgar score was evaluated by experienced midwives, medical internists, pediatrician, and obstetrician. All subjects had immediately cord clamping after delivery, with the cord being double clamped at a minimum length of 10 cm when the placenta was still in situ. The cord blood was obtained from umbilical artery and analyzed within 15 minutes. Neonatal acidosis was defined as cord blood pH of less than 7.25, the lower limit of cord blood pH associated with favorable neurological outcomes, as previously reported by Yeh et al[8]. Data on NICU admission were obtained from medical records.

The sample size calculation was based upon the question about the association between EFM abnormality and Apgar score. A study by Dellinger[5] suggested that EFM abnormality was associated with a 5-fold increased risk of low Apgar scores at 1 minute (adjusted relative risk 5.02, 95% CI 3.11 to 8.12). With 80% power and 95% confidence, 120 pregnant women were needed to answer the question, assuming 25% non-responders.

Statistical analysis

SPSS version 11.5 (SPSS Inc, Chicago, IL, USA) was used for statistical analysis. Demographic and obstetric data including EFM tracings were summarized using descriptive statistics: percentage, mean (standard deviation, SD) and median (interquartile range, IQR). Chi-squared test, unpaired t-test and Mann-Whitney U test were used to compare variables across the NICHD 2008 EFM category for categorical, normally and non-normally distributed continuous variables respectively. The association between EFM category and neonatal outcomes was examined using univariate and multivariate logistic regression. Variables associated with the outcomes at the *p*-value of less than 0.2 in univariate analyses were included in multivariable logistic regression models. In addition, the association between EFM characteristics and umbilical cord blood pH was analyzed using multiple linear regression. A *p*-value of <0.05 was considered statistically significant.

Results

Characteristics of study population

During the study periods, a total of 136 mothers delivered at Sanpasitthiprasong Hospital were approached. After excluding pregnant women with multiple gestations, fetal anomalies or aneuploidy, no data or poor quality intrapartum EFM and those delivered by elective cesarean section; 120 pregnant women remained eligible for the present analyses. Participants' demographic and obstetric data were shown in Table 1. The mean age (SD) of participants was 24.6 (6.0) years. Most participants completed secondary school (77.5%) and worked in household (36.7%). The mean gestational age (SD) was 38.6 (1.5) weeks, with the median gravidity and parity of 2 (IQR 1, 2) and 0 (0, 1) respectively. The majority of the pregnant women received hospital antenatal care, with approximately 10 visits during pregnancy. EFM tracings showed 'variable deceleration' in 17 pregnant women (14%). Among 120 participants, 83 (69.2%) and 37 (30.8%) had EFM categories I and II, while none of the participants had EFM Category III according to the

Table 1. Demographic characteristics and obstetric data by EFM category (n = 120)

Characteristic[+]	Total (n = 120)	Category I (n = 83)	Category II (n = 37)	*p*-value[++]
Maternal age, years	24.58 (5.95)	23.90 (5.65)	26.08 (6.38)	0.079
Gestational age, weeks	38.6 (1.5)	38.7 (1.4)	38.6 (1.5)	0.762
Gravidity	2 (1, 2)	2 (1, 2)	1 (1,2)	0.126
Parity	0 (0, 1)	1 (0, 1)	0 (0, 1)	0.227
Antenatal care location				1.821
Sanpasitthiprasong Hospital	53 (44.2%)	42 (50.6%)	11 (30.6%)	
Community hospital	65 (54.2%)	40 (48.2%)	25 (69.4%)	
No antenatal care	1 (0.8%)	1 (1.2%)	0 (0.0%)	
Number of antenatal care	9.77 (2.56)	10.07 (2.53)	9.09 (2.54)	0.590
EFM characteristics				
FHR baseline	139.9 (10.3)	139.5 (9.7)	140.8 (11.6)	0.573
Minimal variability	23 (19.2%)	0	23 (62.2%)	<0.001
Any acceleration	64 (53.3%)	59 (71.1%)	5 (13.5%)	<0.001
Any early deceleration	4 (3.3%)	1 (1.2%)	3 (8.1%)	0.520
Any variable deceleration	17 (14.2%)	0	17 (45.9%)	<0.001

EFM = electronic fetal monitoring; FHR= fetal heart rate

[+] Data are presented as number (%), mean (SD) and median (interquatile range) for categorical, normally and non-normally distributed variables respectively.

[++] Comparison across groups using Chi-square test, t-test and Man-Whitney-U test for categorical, normally and non-normally distributed variables respectively.

NICHD 2008 guideline. Mothers with EFM Categories I and II were comparable regarding their age, occupation, education, gravidity, parity, place of antenatal care, number of antenatal care, and obstetric complications. However, those with EFM Category II were more likely to have rupture of membrane before labor onset than those with EFM Category I (21.6% vs. 8.4%, $p = 0.044$). EFM patterns 'minimal variability', 'any early deceleration' and 'any variable deceleration' were observed in 23 (19.2%), 4 (3.3%) and 17 (14.2%) participants respectively, with significantly lower percentages of early deceleration in Category II (Table 1).

Delivery and neonatal outcomes

Outcomes of delivery were shown in Table 2. Most mothers gave birth by vaginal delivery (66.7%), followed by Cesarean delivery (24.2%), vacuum extraction (8.3%) and forceps extraction (0.8%). Mothers with EFM Category II were more likely to undertake operative delivery (i.e. Cesarean delivery, vacuum, and forceps extraction), compared to those with EFM Category I (51.4% vs. 25.3%, $p = 0.005$). The most frequent indication for operative delivery was fetal distress (12 out of 40 operative deliveries (30.0%)). There were 17 participants (14.8%) who had meconium-stained amniotic fluid, with a higher percentage in those with EFM Category II than Category I (26.5% vs. 9.9%, $p = 0.008$). Only three patients (2.5%) had Apgar score at 1 minute of less than 7, and this was observed more frequently in Category II (8.1% vs. 0% in Categories II and I respectively, $p = 0.028$). Only five infants required intensive care in NICU. There were no significant differences in birthweight, placental weight, proportions of infants with Apgar score at 5 minute of less than 7, and NICU admission between the two groups. There was no perinatal death and no infant with Apgar score at 5 minute of less than 7. In a sensitivity analysis using Apgar score at 1 minute of less than 9 (median Apgar score in the present study population) to represent low Apgar score, a higher proportion of infants delivered from mothers with EFM Category II had low Apgar score at 1 min than those with Category I (21.6% vs. 3.6%, $p = 0.005$). The median umbilical cord blood pH was 7.30, with lower cord blood pH in participants with EFM Category II than I (7.25 vs. 7.31 respectively, $p<0.001$). Infants with EFM Category II were more likely to develop neonatal acidosis than the Category I (45.9% vs. 2.4%, $p<0.001$). Additionally, there was no significant difference in the prevalence of

Table 2. Delivery and neonatal outcomes by EFM category (n = 120)

Characteristics[+]	Total (n = 120)	Category I (n = 83)	Category II (n = 37)	*p*-value[++]
Route of delivery				0.016
Normal delivery	80 (66.7%)	62 (74.7%)	18 (48.6%)	
Cesarean delivery	29 (24.2%)	17 (20.5%)	12 (32.4%)	
Forceps extraction	1 (0.8%)	0 (0.0%)	1 (2.7%)	
Vacuum extraction	10 (8.3%)	4 (4.8%)	6 (16.2%)	
Fetal distress as indication for operative delivery (n = 40)	12 (30.0%)	0 (0.0%)	12 (63.2%)	0.001
Birthweight, gram	3,031.1 (449.1)	3,079.0 (392.1)	2,923.1 (546.9)	0.123
Meconium-stained amniotic fluid*	17 (14.8%)	8 (9.9%)	9 (26.5%)	0.022
Placental weight, gram	524.2 (51.9)	526.5 (51.9)	518.9 (51.8)	0.461
Apgar score at 1 minute <7	3 (2.5%)	0 (0.0%)	3 (8.1%)	0.028
Apgar score at 5 minute <7	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
NICU admission	5 (4.2%)	2 (2.4%)	3 (8.1%)	0.149
Cord blood pH	7.30 (7.26, 7.33)	7.31 (7.29, 7.34)	7.25 (7.23,7.28)	<0.001
Neonatal acidosis	19 (15.8%)	2 (2.4%)	17 (45.9%)	<0.001

NICU = neonatal intensive care unit

[+] Data are presented as number (%), mean (SD) and median (interquatile range) for categorical, normally and non-normally distributed variables respectively.

[++] Comparison across groups using Chi-square test, t-test and Man-Whitney-U test for categorical, normally and non-normally distributed variables respectively.

* Data available for meconium stained amniotic fluid in 115 cases

category II pattern between term and preterm groups (30.6% vs. 33.3%, $p = 0.843$).

Factors associated with early neonatal outcomes

No factor was significantly associated with a low Apgar score of less than 7 at 1 minute. As the Apgar scores were not normally distributed, we did an additional analysis using Apgar score of less than 9 (median Apgar) to represent a low Apgar score. Factors that were associated with a low Apgar of less than 9 at 1 minute in multivariate logistic regression included gestational age and EFM category (Table 3). The risk of having a low Apgar score of less than 9 at 1 minute was reduced by 44% for every one week increase in gestational age, after adjusting for maternal age, gestational age, education, diabetes in pregnancy and operative delivery (adjusted odds ratio (OR) 0.56, 95% CI 0.32 to 1.00, $p = 0.049$). Compared to participants with EFM Category I, those with EFM Category II had an almost 5-fold higher risk of having a low Apgar score of less than 9 at 1 minutes (adjusted OR 4.96, 95% CI 1.03 to 24.00, $p = 0.046$).

EFM category was independently associated with the risk of neonatal acidosis (Table 3). After adjustment for age, education, and the presence of meconium-stained amniotic fluid, EFM Category II was associated with a 38-fold higher risk of neonatal acidosis than category I (adjusted OR 37.88, 95% CI 7.33 to 195.90, $p<0.001$). No other factors were independently associated with neonatal acidosis.

As the numbers of infants who had Apgar score at 5 minute of less than 7 and those with NICU admission were very small (0 and 5 infants respectively), we did not perform logistic regression to investigate the association between EFM category and the two outcomes.

Associations between EFM characteristics and neonatal outcomes

The associations of various EFM characteristics, i.e. baseline FHR, the presence of minimal variability, acceleration, and variable deceleration with neonatal outcomes were presented in Table 4. All types of EFM characteristics were associated with an increased risk of having a low Apgar score of less than 9 at 1 minute in univariate analyses. After adjusting for maternal age, and gestational age, the presence of any variable deceleration increased the risk of having a low Apgar score at 1 minute by 6 folds (OR 6.26, 95% CI 1.23 to 31.80, $p = 0.027$). After

Table 3. Factors associated with Apgar score at 1 minute <9 and neonatal acidosis in logistic regression

Factors	Crude odds ratio (95% CI)	*p*-value	Adjusted odds ratio (95% CI)	*p*-value
Factors associated with Apgar score at 1 minute <9[+]				
Maternal age, for every 1 year older	1.19 (1.06 to 1.32)	0.002	1.09 (0.96 to 1.24)	0.192
Gestational age, for every 1 week older	0.70 (0.46 to 1.08)	0.111	0.56 (0.32 to 1.00)	0.049
Highest education	0.26 (0.09 to 0.82)	0.022	0.34 (0.08 to 1.42)	0.139
Diabetes mellitus in pregnancy	4.97 (0.83 to 29.60)	0.078	1.94 (0.16 to 23.95)	0.606
Operative delivery	11.32 (2.31 to 55.39)	0.003	2.05 (0.97 to 4.30)	0.059
Category (category II vs. category I)	7.36 (1.83 to 29.63)	0.005	4.96 (1.03 to 24.00)	0.046
Factors associated with neonatal acidosis[++]				
Maternal age, for every 1 year older	1.07 (0.99 to 1.16)	0.081	1.03 (0.92 to 1.15)	0.666
Highest education	0.50 (0.20 to 1.28)	0.150	0.45 (0.11 to 1.78)	0.253
Meconium stained amniotic fluid	2.43 (1.27 to 4.66)	0.007	1.44 (0.63 to 3.29)	0.385
Category (category II vs. category I)	34.43 (7.35 to 161.34)	<0.001	37.88 (7.33 to 195.90)	<0.001

[+] Adjusted for all variables in the table; [++] Adjusted for all variables in the table

Table 4. The association of EFM characteristics with Apgar score at 1 minute of <9 and neonatal acidosis in logistic regression

EFM characteristics	Crude odds ratio (95% CI)	*p*-value	Adjusted odds ratio (95% CI)	*p*-value
EFM characteristics affecting Apgar score at 1 minute <9[+]				
FHR baseline	1.08 (1.01 to 1.16)	0.028	1.06 (0.98 to 1.15)	0.155
Minimal variability	4.21 (1.16 to 15.31)	0.029	2.60 (0.53 to 12.68)	0.237
Any acceleration	5.94 (1.23 to 28.77)	0.027	0.30 (0.05 to 1.98)	0.212
Any variable deceleration	10.69 (2.80 to 40.85)	0.001	6.26 (1.23 to 31.80)	0.027
EFM characteristics affecting neonatal acidosis[++]				
Minimal variability	14.03 (4.56 to 43.11)	<0.001	15.89 (3.42 to 73.80)	<0.001
Any acceleration	0.18 (0.06 to 0.59)	0.004	0.62 (0.12 to 3.24)	0.573
Any variable deceleration	7.43 (2.38 to 23.23)	0.001	7.84 (1.45 to 42.48)	0.017
Any late deceleration	2.85 (0.48 to 16.81)	0.247	0.45 (0.05 to 4.56)	0.501

[+] Adjusted for maternal age, gestational age and other variables in the table.
[++] Adjusted for maternal age, meconium stained amniotic fluid and other variables in the table.

adjustment for maternal age, education and meconium-stained amniotic fluid, the presence of minimal variability and any variable deceleration significantly increased the risk of neonatal acidosis by 16 and 8 times (OR 15.89, 95% CI 3.42 to 73.80, $p<0.001$ and 7.84, 95% CI 1.45 to 42.48, $p = 0.017$, respectively). However, further adjustment for EFM category turned the associations non-significant.

A number of EFM characteristics predicted cord blood pH. EFM characteristics that were associated with cord blood pH in multiple linear regression included the presence of minimal variability, any late deceleration, and any variable deceleration, with β coefficients of -0.054 (95% CI -0.074, -0.034), -0.038, (-0.073, -0.003) and -0.030 (-0.052, -0.008), respectively. Therefore, the equation for computing cord blood pH as the function of these EFM characteristics is shown below:

Cord blood pH = 7.277 to 0.054 (minimal variability) -0.038 (late deceleration) -0.030 (variable deceleration).

When values of minimal variability, late and

variable deceleration were coded as follows: presence = 1 and absence = 0.

Discussion

The present study examined the use of EFM category according to the NICHD 2008 classification and described the association between the EFM category and various neonatal outcomes. Approximately one-third of pregnant women had EFM Category II according to the NICHD 2008 classification, and EFM category was independently associated with the risk of having a low Apgar score of less than 9 at 1 minutes and neonatal acidosis in pregnant women who gave births at this regional hospital. We also found that certain EFM characteristics could be used to predict the level of cord blood pH.

Although EFM is widely used for intrapartum fetal monitoring, there is still uncertainty over its values in the prediction of fetal well-being[6]. Neurological impairment such as hypoxic ischemic encephalopathy (HIE) and cerebral palsy (CP) is an uneventful perinatal outcome resulting from intrapartum asphyxia that is associated with low Apgar score and neonatal acidosis. Therefore, the evidence that EFM category was associated with low Apgar score and neonatal acidosis might probably be beneficial in prediction and prevention of HIE and CP. In the study by Sameshima et al[9], the investigators used the NICHD 1997 guidelines for interpretation of EFM and found the association of non-reassuring FHR pattern with fetal acidemia, albeit high false positive and low sensitivity for predicting fetal acidemia. There are some ancillary tests currently available to ensure fetal well-being in those with non-reassuring EFM. When non-reassuring FHR tracing persists and neither spontaneous nor stimulated accelerations are present, a scalp blood sample for the determination of pH or lactate should be considered to confirm poor fetal well-being[10]. In our setting where these ancillary tests were not available, mothers with EFM Category II were likely to proceed to Cesarean section and instrumental vaginal delivery before the fetus deteriorated.

The management of EFM category II remains a debatable issue. Previous studies showed that EFM category II were commonly found (84.1% at some points of labor)[7], and the management of mothers with EFM Category II has somewhat varied. Therefore, standard approach to treatment of these patients is needed. Recently, Clark et al had proposed a management algorithm, comprised of assessing detailed characteristics of EFM (such as variability and significant deceleration), careful monitoring in less severe cases, and reassessing as the labor progresses[11]. This is supported by our findings which emphasize the importance of using EFM characteristics to early predict deleterious neonatal outcomes.

Previous studies suggested that the presence of meconium-stained amniotic fluid was independently associated with an increased risk of composite morbidity[12]. In the present study, the presence of meconium-stained amniotic fluid seemed to increase the risk of neonatal acidosis, although this was not statistical significant.

Severe EFM categories are believed be more commonly observed in preterm than term labors. A study by Chan et al found that suspicious cardiotocograms and a low cord blood pH of below 7.15 were more common in the preterm than in term groups[13]. However, our study suggested that EFM Category II was similarly observed in the two groups, and that gestational age was not independently associated with umbilical cord blood pH levels and neonatal acidosis. One explanation might be different criteria used for interpreting EFM categories in Chan's study and our own (RCOG 2001 and NICHD 2008 respectively). It might also be explained by that a higher proportion of mothers enrolled in Chan's study were high-risk groups than in the present study (35% vs. 10% preterm labors).

The present study supports previous studies[14] suggesting that more suspicious EFM category was associated with an increased risk of detrimental neonatal outcomes, compared to a less suspicious EFM category. Similar to our findings, Maso et al observed lower cord blood pH in term low-risk pregnant women with a suspicious EFM category than those with normal category. However, the authors used different criteria for EFM interpretation and different definition of neonatal acidemia (an umbilical blood pH of less than 7.2) from the present study, and the authors did not account for confounders. Using NICHD 2008 criteria of interpretation of EFM, Jackson et al[7] found that women who had EFM category II for more than 50% in the last 2 hour of labor associated with having 1-minute Apgar score less than 7 and NICU admission. However, the present study cannot demonstrate such correlation because we recorded EFM for only 20 minutes once in a laboring patient, we did not continuous record EFM throughout labor. Therefore, most of our patients were delivered before they spent longer time in category II as in the previous study. Using the ACOG 2010 guideline for EFM interpretation,

Soncini et al[15] demonstrated that mean cord blood pH and neonatal acidosis were significantly correlated with worsening EFM categories respectively. It is also suggested that using more subdividing system such as 5-tier system of assessing fetal heart rate tracings may increase sensitivity in determination of neonatal acidosis[16]. The present study further suggests that EFM category may be a better overall predictor for certain neonatal outcomes, such as neonatal acidosis, than individual EFM characteristics. Our study also suggests that, in addition to EFM categories, some particular EFM characteristics should be considered to enhance the prediction of neonatal outcomes.

The present study was the first to use the NICHD 2008 for categorizing EFM and examined the associations between the EFM category and various early neonatal outcomes. It was also the first to develop a cord blood pH prediction equation as a function of EFM characteristics. Cord blood pH was measured in all subjects using standard procedures and NICU admission was confirmed by medical records review. Hence, the possibility of assessment bias was believed to be minimal. However, the present study has some limitations. As sample size calculation was based on the association between EFM category and Apgar score, it is possible that our study was under-power to detect the association between EFM category and other outcomes. Apgar scores and meconium-stained amniotic fluid were assessed by different medical and nursing staff. This might have resulted in misclassification of the above outcomes and might have altered their association with EFM. However, these medical and nursing staffs were systematically trained for assessing such outcomes, so the misclassification was likely to be modest. Participants enrolled in the present study were generally low risk mothers. Therefore, the generalizability to high risk groups may be limited.

Conclusion

EFM category II according to NICHD 2008 classification was associated with higher risk of having low Apgar score at 1 minute and neonatal acidosis than EFM category I. This EFM classification may be used for management of pregnant women in labor, with potentials to help improve neonatal outcomes in resource-constrained care settings.

What is already known on this topic?

Electronic fetal monitoring (EFM) helps predict various neonatal outcomes. The new EFM category was proposed by the National Institute of Child Health Development (NICHD) in 2008. However, little evidence exists to describe the association between EFM categories based on the criteria and neonatal outcomes.

What this study adds?

The EFM category II according to NICHD 2008 in low risk pregnancy is prevalent. The EFM category was strongly associated with early neonatal outcomes. Our study is the first to develop cord blood pH prediction equation as a function of EFM characteristics.

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Potential conflicts of interest

None.

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ความสัมพันธ์ระหว่างผลการบันทึกอัตราการเต้นหัวใจของทารกในครรภ์ระยะคลอดกับผลลัพธ์ของทารกในช่วงแรกเกิด

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ภูมิหลัง: การบันทึกอัตราการเต้นหัวใจของทารกในครรภ์ระยะคลอดถูกนำมาใช้อย่างกว้างขวางในการติดตามเฝ้าระวังทารกในครรภ์ที่มีความเสี่ยงสูง ในเวชปฏิบัติมีการศึกษาน้อยมากที่ศึกษาความสัมพันธ์ระหว่างผลลัพธ์ของทารกในช่วงแรกเกิดกับเกณฑ์ใหม่ในการแปลผลอัตราการเต้นหัวใจทารกในครรภ์ในปี พ.ศ. 2551

วัตถุประสงค์: เพื่อศึกษาหาความสัมพันธ์ระหว่างผลการบันทึกอัตราการเต้นหัวใจของทารกในครรภ์ระยะคลอดกับผลลัพธ์ของทารกในช่วงแรกเกิด

วัสดุและวิธีการ: ผู้นิพนธ์ทำการบันทึกอัตราการเต้นหัวใจทารกในครรภ์ระยะคลอด (Electronic fetal monitoring; EFM) ของสตรีตั้งครรภ์อายุครรภ์ตั้งแต่ 32 สัปดาห์ขึ้นไปโดยแปลผลตาม National Institute of Child Health and Human Development (NICHD) 2008 guideline และศึกษาความสัมพันธ์ของ category ของ EFM ต่อผลลัพธ์ของทารกหลังคลอดคือ Apgar score ที่ 1 นาที และ 5 นาที การนอนรักษาในตึกผู้ป่วยหนักทารกแรกเกิดและค่าความเป็นกรดของเลือดโดยใช้ logistic regression

ผลการศึกษา: จากข้อมูลสตรีตั้งครรภ์ทั้งหมด 120 คนแบ่งเป็น EFM category I จำนวน 83 คน (69.2%) และ EFM category II จำนวน 37 คน (30.8%) พบว่าทารกที่มี EFM category II มีโอกาสที่จะมี Apgar score ที่ 1 นาทีมีค่าน้อยกว่า 9 เมื่อเทียบกับ category I เพิ่มขึ้น 5 เท่า (adjusted odds ratio 4.96; 95% CI 1.03-24.00, p = 0.046) และมีโอกาสเกิดภาวะเลือดเป็นกรด (neonatal acidosis) เพิ่มขึ้น 38 เท่า เมื่อเทียบกับ category I (adjusted odds ratio 37.88; 95% CI 7.33 ถึง 195.90, p<0.001) เมื่อพิจารณารูปแบบต่างๆ ของผล EFM พบว่าการมี variable deceleration ที่ทำให้ทารกมีโอกาส Apgar score ที่ 1 นาทีน้อยกว่า 9 เพิ่มขึ้น 6 เท่า (adjusted odds ratio 6.26, 95% CI 1.23 ถึง 31.80, p = 0.027) และยังพบว่า minimal variability และ variable deceleration เพิ่มโอกาสการเกิดภาวะเลือดเป็นกรดเพิ่มขึ้น 16 และ 8 เท่า อย่างมีนัยสำคัญ (adjusted odds ratio 15.89; 95% CI 3.42 ถึง 73.80, p<0.001 และ adjusted odds ratio 7.84; 95% CI 1.45 ถึง 42.48, p = 0.017 ตามลำดับ) เมื่อเทียบกับกลุ่มที่ไม่มีลักษณะดังกล่าว

สรุป: EFM category II ตาม NICHD 2008 guideline สัมพันธ์กับความเสี่ยงที่เพิ่มขึ้นที่จะมี Apgar score ต่ำกว่า 9 ที่ 1 นาที และภาวะเลือดเป็นกรดเมื่อเปรียบเทียบกับ EFM category I