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Deceleration area and fetal academia

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ABSTRACT

Aims: To compare the predictive ability for neonatal acidemia of individual components of intrapartum cardiotocography (CTG) described by National Institute of Child Health and Human Development (NICHD) system and deceleration area.

Design: Case-control study.

Setting: Spanish tertiary obstetrical hospital.

Population: CTG patterns of 102 acidemic fetus (umbilical arterial cord gas pH≤7.10, base deficit (BD)>8) and 102 non-acidemic controls (umbilical arterial cord gas pH>7.10).

Methods: Two reviewers blind to clinical and outcome data analysed the last thirty minutes before delivery of 204 fetal heart rate (FHR) tracings, extracting those features defined by NICHD and certain measures of FHR decelerations, including deceleration area, not considered by this system.

Outcome measures: The primary outcome was the predictive ability of NICHD features and non-NICHD deceleration measures for fetal acidemia. The secondary outcome was the impact of deceleration area in the last thirty minutes of labor on gasometry components (pH, BD and lactate).

Results: Minimal variability (area under the curve [AUC] 0.74), total number of late (AUC:0.75) and prolonged decelerations (0.77) were the three NICHD features with the greatest predictive ability for fetal acidemia in the last thirty minutes of labor. Total deceleration area demonstrated the highest discrimination power (AUC: 0.83) of all the analysed elements. For each cm^2 the area increases in the last thirty minutes of labor, pH decreases 0.08 units, BD increases 0.272 mEq/L and lactate 0.183 mEq/L.

Conclusions: Total deceleration area showed the greatest predictive ability for fetal acidemia and its measure could help to estimate intrapartum fetal acid-base status.

Keywords: Cardiotocography, deceleration area, neonatal acidemia, fetal heart rate decelerations, fetal buffer system.

Abbreviations: Cardiotocography (CTG), fetal heart rate (FHR), National Institute of Child Health and Human Development (NICHD), electronic fetal monitoring (EFM), base deficit (BD), odds ratio (OR), confidence interval (CI), area under the curve (AUC).

Keywords: Cardiotocography, deceleration area, neonatal academia, fetal heart rate decelerations, fetal buffer system

INTRODUCTION

Despite the ubiquity of intrapartum cardiotocography (CTG) the validity of the relationship between various fetal heart rate (FHR) patterns and fetal acidemia has yet to be established [1]. In the last forty years the obstetric community has focused its efforts on trying to reach a standardised approach in the management of FHR patterns developing a diversity of classification systems, but the utility of them is still debated [2-5]. In this context, the current 3-tier system proposed in 2008 by the National Institute of Child Health and Human Development (NICHD) seems not to be an exception [6]. These systems have been established around two main pillars: deceleration morphology and its temporal relation to contraction. Recent studies have highlighted the importance of researching new elements of CTG and tools to ameliorate the predictive ability for fetal acidemia, exploring those features that can evaluate both quantity and severity of periodic patterns [7]. Among them, deceleration area stands out as an objective measure of abnormal periodic decelerative patterns. Following this trend, we conducted a study in which we compared the relation of individual components of the CTG recognised by NICHD and non-NICHD measures of FHR decelerations before delivery with fetal acidemia.

MATERIAL AND METHODS

This is a retrospective case-control study of all neonates born at a tertiary referral hospital in Zaragoza, Spain, with neonatal acidemia, defined as an umbilical arterial cord gas of 7.10 or less and a base deficit in blood (BD) > 8 mmol/L during a one year period from September 1, 2012, to August 31, 2013. Neonates in the control group were matched to each neonate in the case group in a one-to-one fashion using subsequent delivery matched by gestational age. Women were included if they carried a singleton term gestation, in cephalic presentation, with no known fetal anomalies. Women that experienced an unpredictable/sentinel event, such as cord prolapsed, uterine rupture or shoulder dystocia, were excluded. The study was conducted following the STARD statement for diagnostic accuracy studies [8].

Our maternity policy is one of universal electronic fetal monitoring (EFM) during labor, which is stored electronically, and universal arterial umbilical cord gas pH at delivery, performing a paired cord acid–base analysis on neonates with an arterial umbilical cord gas ≤ 7.10 or on high-risk deliveries where antenatal complications are identified. The cord is doubled clamped immediately after delivery and both the artery and vein are sampled in preheparinised labeled syringes and processed within 10 minutes in a GEM Premier 3000 (Instrumentation Laboratory, 180 Hartwell Road Bedford, MA 01730 United States). Routine calibrations are run every six hours. In low-risk deliveries with non-acidemic neonates only the artery is sampled.

The primary target of the study was 30 minutes of EFM immediately prior to delivery, interpreted by two obstetricians blind to clinical and outcome data. Each reviewer assessed the last thirty minutes of FHR patterns using the NICHD 3-tier classification system and definitions. Individual features as baseline, variability, accelerations and

NICHD category were determined based on the most non-reassuring portion of the tracings. The total number of decelerations and number of late, variable, early and prolonged decelerations were gathered. Non-NICHD features, as duration and depth of each deceleration, number of decelerations lasting more than sixty seconds and number of severe decelerations (nadir of ≤ 60 bpm) were collected. Deceleration area was calculated as half depth times width of each deceleration. Total deceleration area was obtained as the sum of the area within all decelerations in the last thirty minutes of labor, as a measure of both quantity and severity. Time from last monitored minute and delivery was taken into account, selecting only those patients with at least ten minutes of monitored labor within the thirty minutes before delivery. Patients with insufficient EFM were excluded.

We calculated κ statistics to assess the interobserver reliability in classifying categorical FHR parameters as baseline, variability and category. Predefined criteria for agreement were: poor (0.0–0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), and excellent (0.81–1.0). We calculated the Pearson correlation coefficient to assess the interobserver reliability in classifying continuous EFM parameters such as number of FHR decelerations and deceleration area.

Detailed maternal and pregnancy data were also extracted reviewing paper medical records, including: medical and obstetric history, pregnancy course and complications, medication exposure, labor course, delivery and neonatal outcomes.

Baseline characteristics were compared between acidemic and non-acidemic groups. Continuous variables were compared using the paired student t-test after assessing the normality of the data. For categorical data, Odds Ratios (OR) and their 95% confidence intervals (CI) were developed. Comparison was performed using chi-square tests or Fisher's exact test when appropriate. The significance level was set at $p < 0.05$.

Validity of FHR features that demonstrated statistical significance was calculated, extracting its sensitivity, specificity and predictive values for acidemia.

Multivariable logistic regression models were used to compare the risk to have an acidemic fetus in the presence of each FHR feature in the last thirty minutes of labor. Variables significant at a p value of <.10 in bivariate analyses were used, as other variables historically associated with acidemia. Backward step-wise logistic regression was used to develop the final models. Receiver-operator curves were constructed from the final logistic regression models for the 7 EFM features with the highest magnitude of association with acidemia and were compared by area under the curve (AUC).

Optimal cut-off value of deceleration area for predicting neonatal acidemia was determined by the maximal Youden index on the ROC curve, extracting its sensitivity and specificity.

By a linear regression we estimated the influence of total deceleration area in the last thirty minutes of labor in fetal umbilical arterial cord gas parameters (pH, lactate and base deficit).

All statistical analyses were performed using SPSS statistics for Windows version 19.0.

The study was approved by the Clinical Research Ethics Committee of Aragon (Zaragoza, Spain) (02/2016).

RESULTS

Of the 4002 women who delivered in our institution during the period studied, 3490 met inclusion criteria. Of those, 121 (3.3%) birthed an acidemic infant. Six of them were excluded for insufficient EFM, four for not having a validated umbilical pH and nine for having suffered an unpredictable/sentinel event, leaving 102 acidemic cases that were compared with 102 non-acidemic controls (Figure 1).

Women who delivered infants with acidemia were more likely to be nulliparous, have an induced labor, presence of meconium and maternal fever. They were also more likely to deliver by operative vaginal delivery or cesarean compared with women delivering non-acidemic infants (Table 1). Among women who delivered by cesarean section, 15.6% of acidemic fetus and 5.8% of non-acidemic fetus had less than 15 minutes of monitored labor in the last 30 minutes before delivery.

Correlation among reviewers ranged from fair (κ: 0.39) to substantial (κ: 0.76) for categorical FHR parameters. The Pearson correlation coefficient for continuous variables ranged from 0.84 for total deceleration area to 0.54 for number of early decelerations (Table 2).

Category II tracings were statistically significant associated with acidemia (OR: 7.73, 95% CI: 2.57-23.24), but after adjusting for nulliparity, induction of labor, presence of meconium and fetal gender this association did not remain significant. In the last thirty minutes of labor, 96% of acidemic fetus and 75% of non acidemic fetus exhibited a FHR pattern belonging to this category. Category III tracings were too infrequent to estimate association (Table 3).

Compared to normal baseline, tachycardia was not significantly associated with acidemia. Bradycardia was hardly observed -impeding risk estimation. Compared with moderate variability, minimal variability demonstrated statistical association with neonatal acidemia (OR_a: 2.90, 95% CI: 1.30-6.45). Marked variability was not significantly associated with acidemia, absent variability occurred rarely in the acidemic group and not at all in those fetuses without acidemia, dismissing risk estimation. The presence of accelerations (OR_a: 0.22, 95% CI: 0.11-0.44) showed statistical protection from neonatal acidemia (Table 3).

Number of variable decelerations and prolonged decelerations was larger in the acidemic group, although variable decelerations did not show a significant relation with acidemia. Number of late and early decelerations presented statistically significant differences between both groups (Table 3).

When assessing the FHR characteristics non-identified by NICHD, total deceleration area was significantly greater in those infants with acidemia at birth. Total number of decelerations, number of severe decelerations and number of decelerations lasting more than sixty seconds in the thirty minutes prior to delivery were also larger in those infants with acidemia at birth (Table 4). Mean deceleration area was significantly higher in category II tracings, compared to category III in both acidemic and non-acidemic infants (Table 4).

Validity of NICHD features that demonstrated statistical significance was calculated. The sensitivity of these elements vary in a range from 1.9% to 96% and their specificity from 12% to 87%. The element that performed better was category II with 96% sensitivity and 24% specificity (Table 5).

To compare those FHR features recognised and non-recognised by NICHD system that demonstrated statistical significant association with neonatal acidemia in the last thirty minutes of labor, predictive models were built and compared by AUC of the receiver-operator curve, adjusting for nulliparity, induction of labor, presence of meconium and fetal male gender. Total deceleration area was the FHR feature with the highest discrimination ability between cases and controls, with an AUC of 0.83 (95% CI: 0.78-0.89), compared to decelerations lasting more than 60 seconds (AUC: 0.81; 95% CI: 0.75-0.87), severe decelerations (> 60bpm) (AUC: 0.78; 95% CI: 0.72-0.85), prolonged decelerations (AUC: 0.77; 95% CI: 0.70-0.83), total number of decelerations (AUC: 0.75; 95% CI: 0.68-0.82), late decelerations (AUC: 0.75; 95% CI: 0.68-0.81) and minimal variability (AUC: 0.74; 95% CI: 0.68-0.81) (Figure 2).

The optimal cut off value for predicting neonatal acidemia for total deceleration area was 8.37 cm^2 in the last thirty minutes of labor. This point has 71.6% sensitivity and 71% specificity. When selecting category II tracings, the optimal cut-off value for deceleration area was 11.68 cm^2 with 59.2% sensitivity and 80.0% specificity for acidemia.

By a linear regression the impact of deceleration area in each parameter of fetal gasometry was determined. Thus, for each cm^2 the area increases in the last thirty minutes of labor, pH decreases 0.008 units (95% CI: 0.010 - 0.006), base deficit increases 0.272 mEq/L (95% CI: 0.350 - 0.209) and lactate 0.183 mEq/L (95% CI: 0.143 - 0.222).

DISCUSSION

The results of this study identified total deceleration area in the last thirty minutes of labor as the FHR feature with the strongest association and ability prediction for neonatal acidemia. This element captures quantitatively both temporal and dose impact of periodic features, including total number of decelerations, decelerations lasting more than 60 seconds and decelerations with more than 60 bpm below the baseline, since it is the result of the interaction of all them.

The optimal cut-off point of this test showed the highest validity of the studied FHR features. Total deceleration area analysis within the three categories system revealed that category II tracings exhibit an area value markedly larger than category III tracings, both in acidemic and non-acidemic infants.

In addition, deceleration area allowed the calculation of the level of consumption of fetal buffer system in the last thirty minutes of labor.

The main strength of this study was the retrospective interpretation of FHR patterns made by two obstetricians, blind to clinical and outcome data. This study has limitations. Due to the low acidemia incidence, we designed a case-control study with a smaller sample size than previous studies that may affect the generalizability of our results [7-9], however the number of women finally included was able to demonstrate statistically significant differences and we were able to adjust for confounding factors to refine the association between FHR features and acidemia. Although there have been real breakthroughs in computer CTG analyses, total deceleration area was calculated manually, and this procedure may have underestimated area value. However, it makes this study easily reproducible in comparison with other studies that used specific software applications [9-10]. Lastly, we analysed the last 30 minutes of EFM before labor as the period that would influence more the acid-base status at birth. Nevertheless, FHR tracings should be assessed on a continuum, and our obtained results are not applicable to earlier periods of labor. In addition, women who underwent an operative or cesarean delivery may have a non-monitored window of 10-20 minutes; in our study this circumstance affected 15.6% of women who delivered an acidemic fetus, conditioning the accuracy of our results. The true optimal cut-off value for deceleration area may probably be higher.

In 1971 Tipton and Shelley [11] demonstrated the inverse correlation between deceleration area, umbilical pH and Apgar score at one minute. Beguin et al. [12] found a positive correlation between deceleration area concordant with contraction and fetal scalp pH values. Strachan et al. [9] performed a computerised analysis of 679 tracings finding a significant association between fetal bradycardia, deceleration area and deceleration area after a contraction. However, none of their receiver-operator curve analyses demonstrated features with clinically useful efficiency (AUC: 0.53-0.62).

Tranquilli et al. [10] demonstrated an association between area of fetal bradycardia and acidemia in 33 fetuses. The threshold value of deceleration area indicative of acidemia was 12.72 cm^2 ($r = -0.76$, $p < 0.02$), establishing also a correlation between deceleration area and timing of acidemia. We obtained a similar cut-off value for category II patterns.

Hamilton et al. [13] hypothesised that frequency of variable decelerations and certain characteristics such as depth and duration could discriminate between acidemic and non-acidemic infants. They reported that only variable decelerations with a depth below 60 bpm for more than 60 seconds were discriminatory for metabolic acidemia, according to our findings. However, the absolute AUC values in this study were relatively low (0.58 - 0.63), probably because they extracted a very long EFM period of which only the last part contributed to the acidemic state at birth.

Cahill et al. [7] published the first study in a large unselected cohort analyzing 5388 tracings. They found that deceleration area presented the best predictive ability for acidemia, both in the last thirty and in the last ten minutes before delivery. The results of the present study agree with those described by Cahill (AUC: 0.83), although predictive models were constructed with different adjusting variables (nulliparity, fever, prolonged first stage and obesity).

Graham et al. [14] studied the diagnostic accuracy of certain elements of the CTG in the last hour before delivery of neonates with encephalopathy treated with whole-body hypothermia in a case-control study. He concluded that the measure of total deceleration area in the last hour of labor was significantly increased in encephalopathic fetuses but its sensitivity and specificity was too low for being clinically useful (AUC: 0.68). Nevertheless in this study sentinel events occurred in one third of the cases (n=13), therefore it is probable that CTG patterns prior to the sentinel event were normal, and subsequent to it, the minutes of analysable tracing were scant. As CTG patterns from neonates who have suffered a sentinel event can be poor predictive of its acid-base status at birth, we excluded this cases. On the other hand, they did not specify if the monitoring of the cases was initially normal, presenting afterwards a decelerative period, or if it was anomalous since the beginning, typical of fetus who had suffered neurological injuries before labor begins.

NICHD consensus panel in 2008 [4] proposed a uniform nomenclature system in which FHR patterns were classified in three categories, based in the presence or absence of well-defined elements. However, more than 80% of the fetuses exhibit patterns during labor that fall into category II [15], according to our findings of 85.6% tracings within this category. The utility of this system is under question due to the amplitude of the category II and the limited consensus about its management [16]. In fact, a new 3-tier classification system has been recently proposed by the FIGO Intrapartum Fetal Monitoring Expert Consensus Panel [17], but its superiority still has to be probed. A recent study assessed the diagnostic accuracy of the 5-tier system proposed by Parer and Ikeda with the FIGO 3-tier system in the detection of neonatal acidemia, concluding that both systems were comparable in acidemia detection (AUC: 0.62 vs 0.63) [18].

Certain elements of FHR described by NICHD, are strongly associated with neonatal acidemia, among which minimal or undetectable variability seems to be the most consistent predictor of newborn acidemia [19], coinciding with our results. Nevertheless, a healthy fetus with a normal variability (category I), will not switch to one with reduced or absent variability in an acidemic context (category III) without the input of a decelerative period (category II) [20]. For some investigators, it is irrelevant whether decelerations are morphologically 'early', 'late' or 'variable' in the production of acidemia. What will condition that a certain decelerative pattern leads to an acidemic status will be the depth, duration and frequency of decelerations [20-22]. Thus, deceleration area is a reasonable element in acidemia prediction. On one hand, is a quantitative measure of abnormal patterns of FHR, on the other hand, it allows to eliminate the subjective component, responsible of the intra and interobserver variability in tracings interpretation and the complexity of its classification.

Category II patterns identify fetuses that may potentially be in some degree of jeopardy but are either not acidemic, or have not yet developed a degree of hypoxia or acidemia that would result in neonatal encephalopathy [23]. Deceleration area can be a good predictor of acidemia just in those fetuses *in risk* of neurological deterioration. Once the damage has been produced, the fetuses will show absence of decelerations and in case there is still a residual hypoxia these decelerations are typically shallow and low in amplitude [20, 24]. In fact, the two cases that presented a category III pattern in our study, both with a pH < 6.90, showed a deceleration area significantly lesser than those fetus whose tracings belonged to category II, because these fetuses would exhibit a lower myocardial response ability.

Deceleration area allowed the calculation of the level of consumption of fetal buffer system in the last thirty minutes of labor. Ross et al. [25] hypothesised that variable deceleration severity was highly correlated with fetal lactate and base deficit accumulation. They studied the responses of seven near-term ovine fetuses to a series of graded umbilical cord occlusions, concluding that ovine fetuses could tolerate repetitive mild and moderate variable decelerations with minimal change in buffer system. In contrast, repetitive severe variable decelerations resulted in significant base deficit increases (0.54 ± 0.09 mEq/l), dependent on frequency. This severity and frequency was quantified in our study by deceleration area. To date, no relation between deceleration area and specific consumption of fetal buffer system has been reported.

Finally, although the threshold pH for adverse neurological outcomes is 7.10, most of acidemic babies will be discharged in absence of neurological symptoms [26]. Only 5.8% of neonates with an umbilical arterial pH $\leq$ 7.10 presented in our study short-term neurological morbidity, however, we still do not know much about long-term prognosis. Odd et al. determined that infants who were resuscitated had increased risk of a low intelligence quotient score, even if they remained healthy during the neonatal period [27].

The results of this study mark deceleration area as a feature with a big predictive ability for neonatal acidemia, which deserves to be construed with more interest. More studies are needed to search new FHR features that could ameliorate the interpretation, management and predictive ability of CTG. In the light of the results of this study, we decided to design in collaboration with a biomedical engineering group a computer application to calculate deceleration area in real time, and based on it, estimate the acid-base intrapartum fetal status. The results of this application still have to be validated, but could represent a new horizon in CTG interpretation.

DISCLOSURE OF INTERESTS

The authors have no conflict of interests to disclose

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Figure 1. Flow chart of patient recruitment

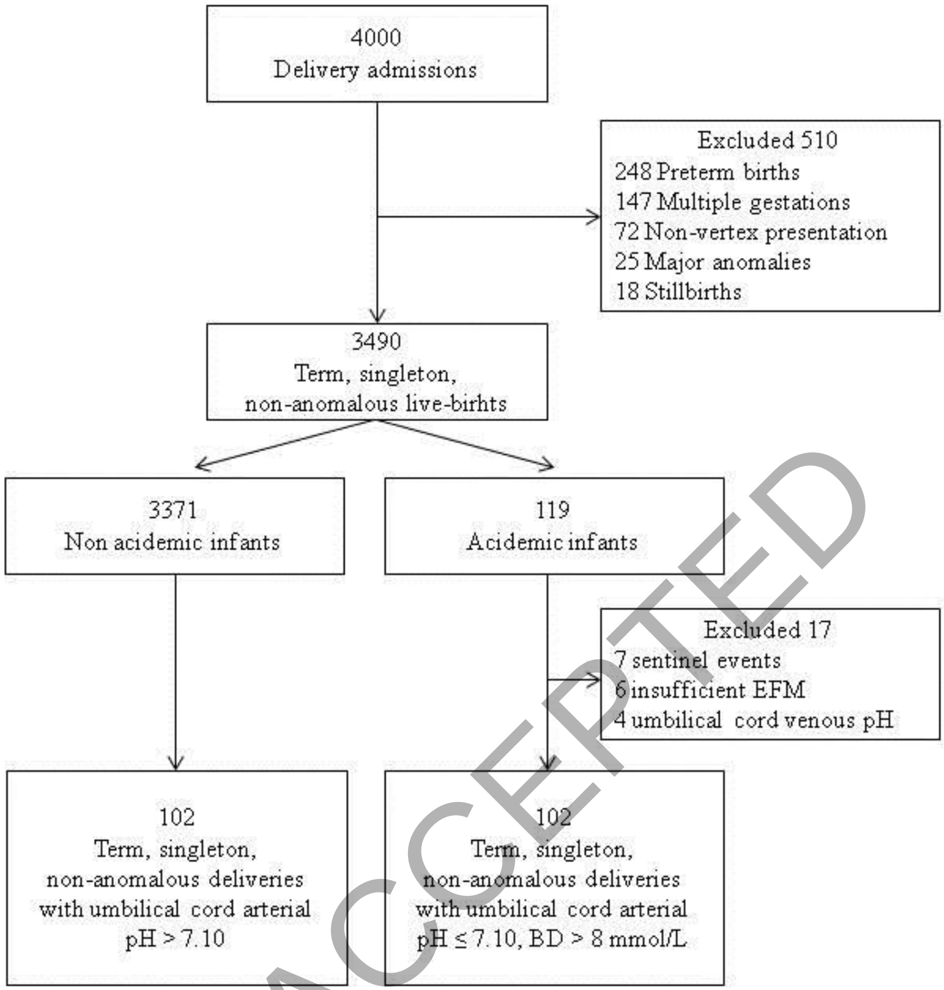
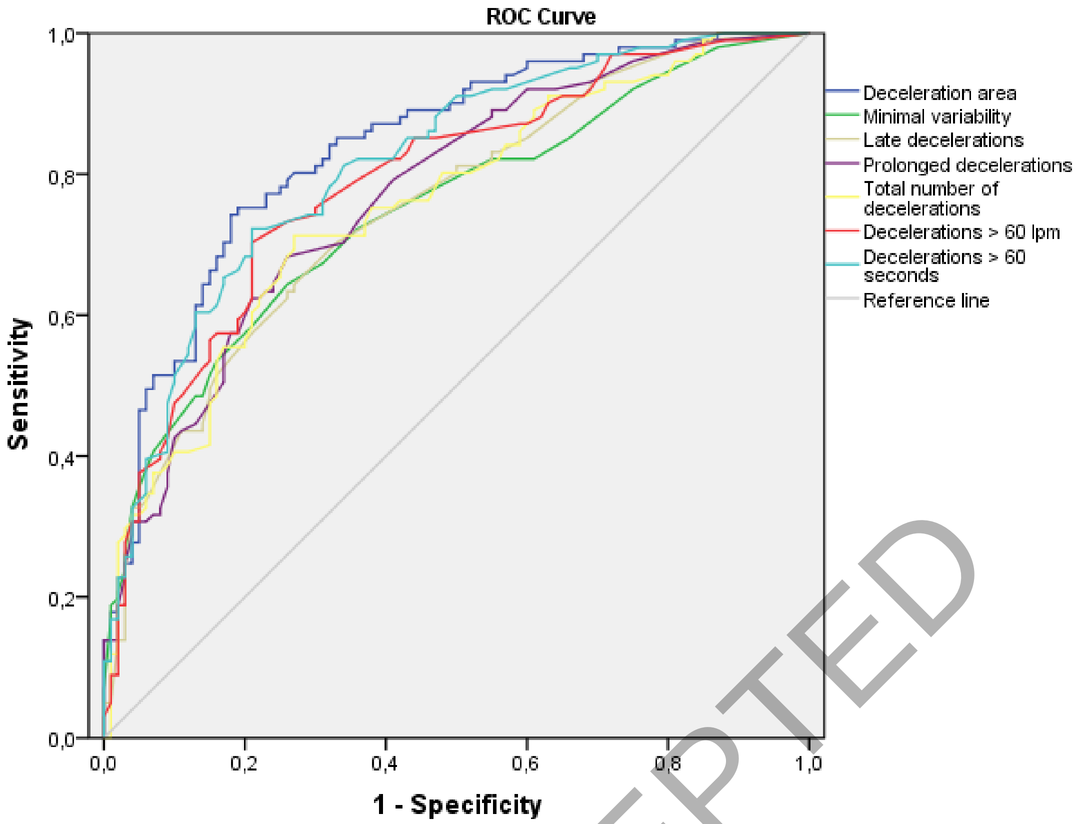


Figure 2. Predictive ability for fetal acidemia in the last thirty minutes of labor of FHR features



All models are adjusted for nulliparity, induction of labor, presence of meconium and fetal male gender.

Table 1. Maternal, intrapartum and neonatal variables

	Acidemia N= 102	No acidemia N = 102	p
Maternal age, y	32.30 (± 5.04)	30.92 (± 6.17)	0.082
Gestational age, d	279.48 (± 8.37)	278.60 (± 6.85)	0.073
Maternal race			0.714
Caucasian	87 (85.3)	85 (83.3)	
African	3 (2.9)	2 (1.9)	
Asian	12 (11.8)	13 (12.7)	
Nulliparity	77 (75.5)	58 (56.8)	0.008
Prior low transverse cesarean section	9 (8.8)	7 (6.8)	0.631
Preeclampsia	7 (6.8)	0	0.140
Gestational diabetes	10 (9.8)	12 (11.7)	0.616
Pregestational diabetes	3 (2.9)	0	0.246
Regional anesthesia	101 (99)	96 (94.1)	0.167
Induction of labor	43 (42.2)	24 (23.5)	0.006
Presence of meconium	39 (38.2)	15 (14.7)	<0.001
Maternal fever	24 (23.5)	12 (11.7)	0.032
Vaginal delivery	37 (36.3)	75 (73.5)	<0.001
Operative vaginal delivery	37 (36.3)	19 (18.6)	0.006
Cesarean delivery	28 (27.4)	8 (7.8)	<0.001
Birthweight, g	3292 (± 401)	3114 (± 529)	0.740
Fetal gender			0.005
Male	67 (65.6)	48 (47.0)	
Female	35 (34.3)	54 (52.9)	
Cord pH	7.04 (± 0.06)	7.26 (± 0.06)	<0.001
pH ≤ 7.00	21	0	
pH > 7.00 and ≤ 7.05	18	0	
pH > 7.05 and ≤ 7.10	63	0	
Base deficit	10.52 (± 3.87)	3.91 (± 2.80)	<0.001
Neurological morbidity	6 (5.8)	0	-

Table 2. Correlation among reviewers in assessing fetal heart rate parameters in the last thirty minutes of labor

Fetal heart rate parameter	Kappa correlation	Pearson correlation
Category	0.76	
Category I	0.70	
Category II	0.66	
Category III	0.39	
Baseline	0.91	
Variability	0.61	
Number of decelerations		0.84
Early decelerations		0.54
Variable decelerations		0.65
Late decelerations		0.60
Total deceleration area		0.84

Table 3. Fetal heart rate characteristics identified by NICHD and its association with fetal acidemia in the last thirty minutes of labor

	Acidemia N = 102	No acidemia N = 102	Unadjusted OR CI 95%	Adjusted[a] OR CI 95%	p
Normal baseline	74 (72.5)	90 (88.2)	Referent	-	-
Tachycardia baseline	23 (22.5)	12 (11.7)	1.91 (0.82-4.45)	-	0.134
Bradycardia baseline	5 (4.9)	0	-	-	-
Moderate variability	62 (60.7)	83 (81.3)	Referent	-	-
Absent variability	2 (1.9)	0	-	-	-
Marked variability	9 (8.8)	4 (3.9)	2.06 (0.55-7.75)	-	0.282
Minimal variability	29 (28.4)	13 (12.7)	2.53 (1.22-5.24)	2.90 (1.30-6.45)	0.009
Presence of accelerations	20 (19.6)	54 (52.9)	0.20 (0.11-0.38)	0.22 (0.11-0.44)	<0.001
Number of variable decelerations	4 [0-17]	3 [0-19]	-	-	0.157
Number of late decelerations	0 [0-12]	0 [0-10]	-	-	0.009
Number of early decelerations	0 [0-13]	0 [0-8]	-	-	0.005
Number of prolonged decelerations	1 [0-6]	0 [0-5]	-	-	<0.001
Category I	2 (1.9)	25 (24.5)	Referent	-	-

Category II	98 (96.0)	77 (75.5)	7.73 (2.57-23.24)	-	-
Category III	2 (1.9)	0	-	-	-

Data are expressed as n (%), median [interquartile range]

**: Adjusted for nulliparity, induction of labor, presence of meconium and fetal male gender*

Table 4. Fetal heart rate characteristics non identified by NICHD and its association with fetal acidemia in the last thirty minutes of labor

	Acidemia N = 102	No acidemia N = 102	Unadjusted OR CI 95%	Adjusted* OR CI 95%	p
Total number of decelerations	7 [0-17]	5 [0-19]	-	-	<0.001
Number of severe decelerations (> 60 bpm)	2 [0-9]	0 [0-10]	-	-	<0.001
Periodic severe decelerations (> 60 bpm)	17 (16.7)	5 (4.9)	3.80 (1.34-10.74)	4.08 (1.34-12.42)	0.013
Number of decelerations > 60 seconds	4 [0-11]	1 [0-10]	-	-	<0.001
Periodic decelerations > 60 seconds	28 (27.4)	9 (8.8)	3.82 (1.70-8.61)	3.80 (1.57-9.19)	0.003
Total deceleration area	12.82 [0 - 33.89]	4.98 [0 - 28.05]	-	-	<0.001
Category I area	0 [0]	0.12 [0 - 13.5]	-	-	0.195
Category II area	13.17 [1.17 - 33.99]	5.62 [0 - 28.05]	-	-	<0.001
Category III area	3.36 [2.54 - 4.18]	0 [0]	-	-	-

Data are expressed as n (%) and median [interquartile range]

**: Adjusted for nulliparity, induction of labor, presence of meconium and fetal male gender*

Table 5. Validity of NICHD features associated with neonatal acidemia in the last thirty minutes of labor

	Sensitivity	Specificity	PPV	PNV
Category I	1.9%	75%	7.4%	42.8%
Category II	96%	24%	56%	86%
Category III	1.9%	100%	100%	50%
Baseline normal	72.5%	12%	45.6%	30%
Moderate variability	60.7%	17%	42.7%	29.8%
Minimal variability	28.4%	87%	69.0%	54.3%
Presence of accelerations	19.6%	46%	27%	39.7%