Non-reassuring fetal heart rate patterns in association with umbilical artery acidosis

ABSTRACT
Objective: The main purpose of the study was to evaluate the clinical outcomes of fetuses who had intrapartum non-reassuring fetal heart rate tracings.

Material and Methods: Patients who underwent cesarean section as an emergency operation due to non-reassuring fetal heart rate patterns were included in the study. All FHR paper traces were reevaluated by an expert obstetrician, blinded to the neonatal outcomes, based on the guidelines of the NICHD workshop. Patients were placed into five groups considering the variability and accompanying deceleration type. Clinical outcomes, Apgar scores, and umbilical artery blood parameters were evaluated.

Results: The study consisted of 84 patients; Group 1, normal variability with late decelerations (n=32); Group 2, normal variability with variable decelerations (n=16); Group 3, decreased variability (n=10); Group 4, decreased variability with late decelerations (n=14); Group 5, decreased variability with variable decelerations (n=12). Groups with decreased variability and decelerations (groups 4 and 5) had higher rates of NICU admission than the groups with normal variability with decelerations (groups 1 and 2) (p<0.05). In the decreased variability with late decelerations group (Group 4), umbilical artery blood pH and ABE were significantly lower while lactate levels were higher than in groups 1, 2, and 3 (p<0.001). Among all patients, inverse correlations were shown between umbilical artery blood lactate and pH (r=-0.734, p<0.001), and also between lactate and ABE (r=-0.581, p<0.001). For the prediction of umbilical artery blood pH<7.1 and/or ABE<-12, the optimal umbilical artery blood lactate cut-off level is 7 mmol/L with a sensitivity of 88.9% and specificity of 89.3%.

Conclusion: Decreased variability in non-reassuring intrapartum fetal heart rate patterns should be considered as important as decelerations. In the evaluation of intrapartum fetal asphyxia, lactate appears to be as good a marker as pH and ABE.

Keywords: Fetal heart rate, fetal hypoxia, nonreassuring fetal status, lactate, umbilical cord blood.
INTRODUCTION
During labor, transient but recurrent interruptions in fetal oxygenation may occur due to regular uterine contractions. It is well tolerated by many fetuses, but in some, metabolic changes due to decreased oxygenation are reflected in fetal heart rate (FHR) tracings. Detection of fetal heart rate changes that may be associated with decreased fetal oxygenation is aimed with continuous intrapartum fetal heart rate monitoring.\[1\] Although its effects on fetal death or long-term neurological outcomes are controversial, continuous intrapartum FHR monitoring is recommended in patients with high-risk conditions (e.g., growth-restricted fetuses, hypertensive disorders, type 1 diabetes mellitus).\[2\] Algorithms have been developed to identify FHR patterns that are normal, that require more attention, and that are abnormal which requires immediate delivery of the fetus.\[3,4\] Although normal results seem reliable in determining fetal well-being, intrapartum FHR monitoring is associated with increased cesarean rates due to high false positive rates.\[5\] One of the most common indications for primary cesarean delivery is non-reassuring FHR patterns.

The Apgar score provides a universally accepted, easily applicable method for revealing the status of the newborn just after birth. Although lower Apgar scores are associated with higher neonatal mortality and morbidity, it is not recommended as a prognostic tool.\[6,7\] Umbilical artery blood sampling provides more objective information in demonstrating fetal status at birth. An umbilical artery pH below 7.0 is defined as fetal metabolic acidemia.\[8\] It is also suggested that the umbilical artery pH < 7.10 and ABE < -12 mmol/L threshold to identify fetuses with non-reassuring heart rate patterns that may benefit from intervention before pathological fetal acidosis and fetal damage develop.\[9-15\] Lactate concentration is also useful in demonstrating tissue hypoxia as a result of anaerobic metabolism.\[16\]

The main purpose of our study was to assess the relationship between intrapartum nonreassuring fetal heart rate tracings and early neonatal clinical findings. Secondly, to investigate the importance of umbilical artery blood lactate in the evaluation of fetal status.

MATERIAL AND METHODS
This prospective observational study was carried out at Istanbul Medeniyet University Göztepe Training and Research Hospital, Türkiye, from February 2015 through January 2016. Ethical approval was obtained from the local ethics committee, and the study was conducted in accordance with the Declaration of Helsinki. Patients who were admitted to the delivery room due to the onset of labor gave informed consent. All patients in the delivery room were monitored with external cardiotocography (CTG) continuously, and FHR paper tracings were obtained for later evaluation. Eighty-four patients who underwent cesarean section as an emergency operation due to non-reassuring FHR patterns were included in the study. The selection criteria were beyond the 34th gestational weeks of pregnancy with singleton, cephalic presentation fetuses. Patients with medical disorders that might affect the fetal acid-base status, such as cardiopulmonary disease, chronic renal failure, or poorly controlled diabetes mellitus, were excluded. Pregnancies with known fetal anomalies, growth-retracted fetuses, and multiple gestations were also not included in the study. All operations were performed under general anesthesia, and premedication protocols were identical in all patients.

Comen Fetal Monitor Star 500F or Sunray SRF 618B was used as external cardiotocography to record electronic fetal heart rate tracings. The time between the last recorded non-reassuring FHR tracing and the time of cesarean section was no more than 30 minutes. All FHR paper tracings were reevaluated by an expert obstetrician, blinded to the neonatal outcomes, based on the guidelines of the NICHD workshop.\[9,10\] We combined tracings with absent and minimal variability and labeled them as decreased variability. Variable and late deceleration definitions of the NICHD workshop were also complied with. All FHR tracings were grouped into five according to the variability and deceleration parameters: group 1, normal variability with recurrent late decelerations; group 2, normal variability with recurrent variable decelerations; group 3, decreased variability with no decelerations; group 4, decreased variability with recurrent late decelerations; and group 5, decreased variability with recurrent variable decelerations.

Immediately after delivery, the umbilical cord was double clamped and arterial blood samples were collected in a plastic syringe washed with heparin solution. Blood samples were analyzed for pH, actual base excess (ABE), and lactate within 15 minutes of delivery using a Radiometer Copenhagen ABL 510 Blood Gas System.

The study data were analyzed using IBM SPSS Statistics version 21.0 (IBM Corporation, Armonk, New York, United States). Data were presented as mean±SD and categorical parameters were presented as frequencies with group proportions. Fisher’s exact test was used for pairwise group comparisons of categorical variables. For numerical variables with a normal distribution, the One-Way ANOVA test was used, and the Kruskal-Wallis test was used for variables without a normal distribution to compare more than two independent FHR pattern-based groups. Tukey and Tamhane’s T2 tests were used for post-hoc analysis for variables with normal and non-normal distributions respectively. A receiver operating characteristic (ROC) analysis was performed to assess the best cut-off level of umbilical artery blood lactate which predicts the fetuses who may benefit from intervention. To evaluate the relationship between quantitative variables, Spearman’s rank correlation was used. Differences were interpreted as statistically significant at p<0.05.

RESULTS
The study consisted of 84 participants; Group 1, Normal Variability with Late Decelerations (n=32); Group 2, Normal Variability with Variable Decelerations (n=16); Group 3, Decreased Variability (n=10); Group 4, Decreased Variability with Late Decelerations (n=14); Group 5, Decreased Variability with Variable Decelerations (n=12).

Table 1 shows the clinical characteristics of the five FHR pattern groups. The groups were similar in terms of age, gravida, parity, gestational age at delivery, and birth weights (p>0.05). When we compared groups according to the APGAR scores; in the Decreased Variability with Late Decelerations group (group 4), both 1- and 5-minute APGAR scores were lower than in groups 1 and 2 (p<0.05). First and fifth minute APGAR scores were similar in decreased variability groups (groups 3, 4, and 5) irrespective of accompanying decelerations (p>0.05). The Decreased Variability with Late Decelerations group (group 4) had the highest rates of meconium-stained amniotic fluid contamination (50%).
fluid among the groups (p<0.001). Groups which showed decreased variability with decelerations (groups 4 and 5) had higher rates of NICU admission than the groups that had normal variability with decelerations (groups 1 and 2) (p<0.05).

Group comparisons of the umbilical artery acid-base parameters are shown in Table 2. In group 4 (decreased variability with late decelerations), significantly lower umbilical artery blood pH and ABE levels and higher lactate concentration were observed than in groups 1, 2, and 3 (p<0.001). Significantly lower actual base excess was observed in group 5 (decreased variability with variable decelerations) than in groups 1, 2, and 3 (p<0.001). Group 5 also had higher levels of umbilical artery blood lactate concentrations compared to the groups with normal variability (groups 1 and 2) (p<0.001).

The relationship between Apgar scores and umbilical artery acid-base parameters is given in Table 3. pH and ABE were positively correlated with 1- and 5-minute Apgar scores (p<0.05), while lactate levels had a stronger negative correlation with 1- and 5-minute Apgar scores (p<0.05). The relationship between umbilical artery blood lactate concentrations and Apgar scores was significant (p<0.05).
tate and pH - ABE is shown in Figures 1 and 2. Spearman’s correlation showed a significant inverse correlation between lactate and pH ($r=-0.734$, $p<0.001$). There was also a moderate inverse correlation between lactate and ABE ($r=-0.581$, $p<0.001$).

Among 84 patients, there was only 1 newborn whose umbilical artery blood pH <7.0. Nine patients had umbilical artery blood pH <7.1 and/or ABE <12. The ROC curve analysis was also performed to determine the best cut-off value of the umbilical artery blood lactate concentration to predict these nine fetuses (Fig. 3). The optimal umbilical artery blood lactate cut-off level of 7 mmol/L, above which the sensitivity and specificity were 88.9% and 89.3%, respectively. The area under the curve (AUC) was 0.915±0.056 (95% CI 0.805–1.00).

**DISCUSSION**

Intrapartum fetal heart rate monitoring aims to identify fetuses with intrapartum acidosis and prevent fetal death through timely intervention. The secondary purpose is to prevent fetal neurological damage.

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<th>Table 3: Correlations between 1st and 5th minute Apgar scores and umbilical artery blood pH, actual base excess and lactate (n=84)</th>
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$r$: Spearman’s correlation coefficient.
Despite all these definitions, the positive predictive value (PPV) of intrapartum electronic fetal monitoring for acidosis is quite low. According to the current literature, neonatal acidemia was reported between 12–30% in patients with non-reassuring intrapartum fetal heart rate tracings.\[20,21\] In our study, the PPV of intrapartum FHR monitoring for fetal acidosis was lower than the values reported in the literature (11% for pH <7.1). This was interpreted as “obstetricians in Türkiye are not guaranteed by the laws, and there may be increased malpractice concerns, so they may act hastily in the cesarean section decision.”

In addition, the presence of inter- and intraobserver variations in the evaluation of the traces is a situation that limits the reliability of the method. Nevertheless, its negative predictivity of 99% serves as a guide for the clinician for fetal well-being.\[22\]

Relatively small sample size and not evaluating interobserver and intraobserver variability in the assessment of fetal heart rate tracings were the main limitations of the study. Nonetheless, it provides useful information for the assessment of fetal well-being with continuous intrapartum electronic monitoring. Further large-scale studies are recommended, especially for the routine use of umbilical artery lactate concentration to identify intrapartum fetal acidosis.

CONCLUSION

Due to the high false-positive rates of intrapartum fetal heart rate monitoring for adverse neonatal outcomes, we recommend careful interpretation. Decreased variability in non-reassuring intrapartum fetal heart rate patterns should be considered as important as decelerations. In the evaluation of intrapartum fetal asphyxia, umbilical artery blood lactate appears to be as good a marker as pH and ABE.

REFERENCES


