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Accuracy of intrapartum fetal blood gas analysis by scalp sampling

A retrospective cohort study

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Abstract

Fetal blood gas analysis (FBGA) using scalp blood is commonly used to identify serious fetal distress. However, there is a lack of data regarding its accuracy and reliability. The aim of this study was to determine the positive predictive value (PPV) and negative predictive value (NPV) of FBGA for predicting postpartum acidosis in case of nonreassuring fetal heart rate tracings (NRFHRT). To this end, we conducted a retrospective cohort study of singleton term deliveries with NRFHRT according to Fédération Internationale de Gynécologie et d'Obstétrique and Fisher cardiotocography scores undergoing FBGA in a university hospital. The PPV and NPV of FBGA regarding neonatal acidosis (defined as a pH value $\leq$ 7.15 in arterial or venous umbilical cord blood) and Apgar scores indicating neonatal depression (defined as a 5-min Apgar score $\leq$5) were evaluated. Multivariate analysis was used to determine the influence of cardiotocography variations and the time delay between FBGA and delivery on the accuracy of FBGA. We analyzed 343 deliveries with NRFHRT. In 32 (9%) of these cases, fetal acidosis was confirmed by a postpartum umbilical cord blood pH value $\leq$ 7.15. In 308/343 (90%) cases, FBGA identified NRFHRT as false positive (as confirmed by nonacidotic postpartum pH values) and thus avoided unnecessary interventions such as operative delivery. The overall test accuracy of FBGA was 91%. FBGA accurately predicted postpartum cord blood pH values with a margin of $\pm$0.2 in 319/343 (93%) cases. On the other hand, the false negative rate of FBGA was 8% (29/343). The PPV and NPV of FBGA for predicting postpartum acidosis were 50% and 91%, respectively. The sensitivity was 9% and the specificity was 99%. In a multivariate logistic regression analysis, maternal body mass index (odds ratio [OR] 1.1; 95% confidence interval [CI] 1.01–1.17; P = .029) and cardiotocography variations (OR 0.80; 95% CI 0.66–0.98; P = .029) independently affected the predictive value of FBGA. The PPV of FBGA regarding neonatal depression according to Apgar scores was low with only 17%. We conclude that FBGA may be used in clinical practice to rule out, but not to rule in, neonatal acidosis in parturients with NRFHRT. It can avoid unnecessary interventions such as cesarean section or operative vaginal delivery in up to 90% of cases, but cannot reliably detect fetal acidosis.

Abbreviations: BMI = body mass index, CI = confidence interval, CTG = cardiotocography, FBGA = fetal blood gas analysis, FIGO = Fédération Internationale de Gynécologie et d'Obstétrique, NPV = negative predictive value, NRFHRT = nonreassuring fetal heart rate tracing, OR = odds ratio, PPV = positive predictive value.

Keywords: acidosis, cardiotocography, fetal blood gas analysis, fetal monitoring, fetal scalp sampling

1. Introduction

Fetal blood gas analysis (FBGA) using scalp blood is a commonly used tool to identify a fetus in serious distress.[1,2] It is a second-line intervention for the assessment of fetal wellbeing in parturients with nonreassuring fetal heart rate tracings (NRFHRT) on cardiotocography (CTG) with the goal of reducing unnecessary operative deliveries such as cesarean section, vacuum, and forceps extraction. For example, in a recent survey of 86 Dutch hospitals, 98% used FBGA on a routine basis.[3] The rate of FBGA use, however, strongly varies between hospitals and between countries and the frequency of FBGA use within the population of parturients depends on local practice.[1] It can be estimated that institutions using FBGA on a routine basis will apply this method in 1% to 4% of term deliveries.[4] Typically, FBGA is used in a fetus with NRFHRT suggestive of fetal acidosis. The intention of FBGA is to confirm that the fetus is at risk of intrapartum asphyxia and needs immediate delivery and to overrule false-positive fetal heart rate tracings suggestive of asphyxia (i.e., to identify false-positive CTGs).[1,2] In the latter case, FBGA is a method to reduce the rate of unnecessary operative deliveries (i.e., cesarean sections and vacuum or forceps deliveries).

The pH of fetal capillary scalp blood is usually lower than the pH of umbilical venous blood and similar to umbilical arterial

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blood pH.[5] Acidotic fetal scalp blood pH is therefore thought to herald the beginning of intrauterine fetal hypoxia. Appropriate collection of the capillary blood is important to avoid incorrect and misleading capillary scalp pH values. There is no standardized and validated method of fetal scalp blood collection and preparation for analysis.[6] The commonly used method involves aspiration of individual blood drops of fetal capillary blood into a heparinized glass tube. The main drawbacks of FBGA are its invasive and discontinuous nature, the need for a sufficient volume of fetal blood for analysis with failure rates up to 10%, and the lack of methodological standardization.[2]

High-level evidence regarding FBGA is scarce. For example, Jørgensen and Weber[1] performed a review of the published literature on the topic of FBGA and identified only 1 randomized-controlled trial and 7 controlled studies and 1 large cohort study using data from the Danish National Birth Registry. Based on these data, the authors conclude that the evidence on FBGA is of modest quality and shows inconsistent results. However, FBGA in conjunction with CTG may provide additional information on fetal wellbeing and fetal reserves and may reduce the risk of operative deliveries.[1] Carbonne et al[2] performed another systematic review of the literature and also identified only 1 randomized-controlled FBGA trial. They concluded that moderate direct and indirect evidence suggests that FBGA may reduce the number of unnecessary obstetric interventions associated with the use of continuous CTG.

There is a lack of data regarding the accuracy of FBGA and its concordance with postpartum cord blood pH values and Apgar scores. In addition, the influence of CTG variations and the time delay between FBGA and delivery on the accuracy of FBGA is unclear. Kuehnle et al,[7] for example, assessed the correlation between FBGA-based pH values and umbilical arterial pH values after delivery. They described significant differences in 40 of 83 fetuses with an FBGA pH result <7.20. In a French study of 71 cases, Choserot et al[8] found a good correlation for pH values ($r=0.23$, $P=.03$), base excess ($r=0.49$, $P=.001$), and lactate values ($r=0.52$, $P=.001$) between FBGA samples and umbilical cord blood samples taken immediately after delivery. However, in all of these studies, the positive predictive value (PPV) and the negative predictive value (NPV) of FBGA have not been calculated. In addition, it is unknown in how many percent of cases FBGA was able to correctly identify the false-positive CTG, thus avoiding unnecessary cesarean sections or vaginal operative deliveries.

Therefore, we aimed to assess the PPV and NPV of FBGA in deliveries with NRFHRT. In addition, we wanted to assess the influence of CTG variations and fetal as well as maternal anthropometric parameters on the accuracy of FBGA. For this purpose, we retrospectively correlated FBGA results and delivery outcomes in a cohort study of singleton-term deliveries.

2. Methods

We performed a retrospective cohort study of singleton-term deliveries with NRFHRT undergoing FBGA at the Department of Obstetrics and Gynecology, Ruhr-Universität Bochum, Bochum, Germany. Approval for this study was obtained by the Ruhr-Universität Bochum medical faculty's ethical review board (registration number 15-5304). Data were extracted from patient charts. FBGA was performed as follows: First, the fetal scalp was visualized using a round, conic speculum. The scalp was cleaned from blood and mucus and then incised with a 4-mm blade. Blood was collected in a heparinized glass tube making use of the capillary effect. Subsequently, pH was measured using a GEM Premier 4000 analyzer (Instrumentation Laboratory, Munich, Germany). CTG tracings before FBGA and during the last 30 min before delivery were assessed in all deliveries using the Fédération Internationale de Gynécologie et d'Obstétrique (FIGO) score and Fisher CTG score.[9] The FIGO score takes baseline, variability, and decelerations into consideration qualifying them as "normal," "suspicious," and "pathological." Fisher score includes accelerations and zero-line crossings in addition to baseline, variability, and decelerations. Each feature is scored with 0, 1, or 2 points and is subsequently qualified as "normal" (8–10 points), "questionable" (5–7 points), and "pathological" (0–4 points).

Venous and arterial cord blood samples were obtained from all neonates immediately after delivery of the placenta. Apgar scores were determined at 1, 5, and 10 min postpartum by a midwife. Transfer to the neonatal intensive care unit was initiated at the discretion of the treating obstetrician. Neonatal acidosis was defined for the purpose of this study as a postpartum arterial cord blood value of $\leq$7.15.[10,11] Neonatal depression was defined for the purpose of this study as a 5-min Apgar score of $\leq$5.[12]

Statistical analysis: Data are reported using means and standard deviations for normally distributed data and medians and interquartile ranges for data not meeting this assumption. Accordingly, statistical analysis was performed using parametric (t test) or nonparametric tests (Mann–Whitney U test). To compare rates and proportions, the χ^2 test was used. All P values are 2-tailed and $P<.05$ was considered statistically significant. The PPV and NPV of FBGA derived pH values regarding postpartum acidosis (defined as a pH value $\leq$7.15 in arterial umbilical cord blood) and Apgar scores with pathological Apgar score indicating neonatal depression (defined as a 5-min Apgar score $\leq$5) were evaluated. In a sample size calculation and power analysis, we assumed a rate of 10% of neonatal acidosis in fetuses with NRFHRT based on data in the literature[2] and an accuracy (PPV and NPV) of FBGA of >85%.[1,2] With a sample size of 340, our study has a power of >85% to accurately describe the PPV and NPV of FBGA with a 95% confidence level. Multivariate logistic regression analysis was used to determine the influence of maternal characteristics such as body mass index, CTG variations before FBGA and during the last 30 min before delivery, and time between FBGA and delivery on the PPV and NPV of FBGA. We used the statistical software SigmaPlot 12.5 (Systat Software Inc., San Jose, CA) for statistical analysis.

3. Results

We analyzed 343 deliveries with NRFHRT. Table 1 describes the patient characteristics of the study population. In 32 (9%) of these 343 cases included in this study, fetal acidosis was confirmed by a postpartum cord blood pH value $\leq$7.15. Table 2 compares maternal and fetal/neonatal characteristics between cases with acidosis and nonacidotic cases. Maternal body mass index (BMI) was significantly different between these 2 groups with mothers of acidotic neonates showing a higher median BMI. Also, median CTG scores before FBGA and before delivery were lower among acidotic cases. Table 3 shows the different categories of the FIGO CTG classification and Fisher scores in parturients with NRFHRT before FBGA and before delivery.

In 343, 120, 29, 13, and 2 cases, 1, 2, 3, 4, and 5 FBGAs were performed, respectively. Figure 1 demonstrates box plots of pH values measured during intrapartum FBGA (at 1–5 time points in cases with recurrent FBGAs) and postpartum umbilical cord blood sampling (arterial and venous). In recurrent FBGA

Table 1

Patient characteristics.

Patient characteristics	Values
Number of patients	343
Age, y	27.7 ± 5.4
Para	1.4 ± 0.9; 1 (1–2); range 0–7
Gravida	1.7 ± 1.1; 1 (1–2); range 1–7
Body mass index, kg/m^2 [8]	30.4 ± 5.4; 29.9 (26.9–33.3)
Gestational age, wk	39.4 ± 1.3; 40 (39–40)
Infant weight, g	3371 ± 466; 3330 (3020–3700)
Head circumference, cm	34.9 ± 1.3; 35 (34–36)
Sex (male/female)	196 (57%)/147 (43%)
Operative delivery (yes/no)	159 (46%)/184 (54%)
NICU transfer (yes/no)	32 (9%)/311 (91%)
Tocolysis (yes/no)	182 (53%)/161 (47%)
Regional anesthesia (yes/no)	161 (47%)/182 (53%)
Labor induction (yes/no)	135 (39%)/208 (61%)
Labor augmentation (yes/no)	245 (71%)/98 (29%)
Labor duration, h [8]	8.5 ± 4.9; 8 (5–11)
First stage labor duration, h [84]	7.6 ± 4.5; 7 (4–10)
Expulsion stage duration, min [118]	49 ± 45; 32 (16–70)
pH (arterial) [1]	7.27 ± 0.08; 7.28 (7.23–7.32)
Base excess (arterial; mEq/L) [3]	−5.0 ± 3.4; −4.6 (−6.8 to −2.7)
pH (venous) [14]	7.32 ± 0.07; 7.33 (7.28–7.36)
Apgar: 1 min	8.54 ± 0.87; 9 (8–9); range 3–10
Apgar: 5 min	9.69 ± 0.61; 10 (10–10); range 7–10
Apgar: 10 min	9.95 ± 0.26; 10 (10–10); range 7–10
CTG (before), Fisher score [7]	6.9 ± 1.8; 7 (6–8); range 2–10
CTG (after), Fisher score [25]	6.7 ± 1.9; 7 (6–8); range 1–10
CTG (before), FIGO [7]	
Normal	29 (9%)
Suspicious	95 (28%)
Pathological	211 (63%)
CTG (after), FIGO [25]	
Normal	18 (6%)
Suspicious	61 (19%)
Pathological	239 (75%)
Time between last FBGA and birth, min [24]	78 ± 67; 55 (33–97)

Data are n (%), mean ± standard deviation, or median (interquartile range). Numbers in square brackets indicate the number of missing values.

CTG = cardiotocography, FBGA = fetal blood gas analysis, FIGO = Fédération Internationale de Gynécologie et d'Obstétrique, NICO = neonatal intensive care unit.

samplings, a constant and statistically significant decline of the median pH value is shown (analysis of variance on ranks, $P = .004$). Specifically, the median (mean) pH values of the first, second, third, fourth, and fifth samplings were 7.33 (7.33), 7.32 (7.32), 7.30 (7.30), 7.30 (7.28), and 7.28 (7.28), respectively. Thus, with every additional FBGA sampling a small pH decline with a decrement of 0.01 to 0.02 was observed. Of note, this translated to a statistically significant increase of acidotic neonates (4/179 vs. 14/164; $P = .013$). Figure 2 shows individual line diagrams of pH values measured by FBGA at 1 to 5 time points in cases with recurrent FBGAs, and the difference between the last intrapartum FBGA and the postpartum umbilical cord blood arterial pH, demonstrating that there is a decline of the pH value in most cases.

In 308/343 (90%) cases, FBGA identified NRFHRT as false positive (as confirmed by nonacidotic postpartum pH values) and thus avoided unnecessary interventions such as cesarean section or vaginal operative delivery. The overall test accuracy of FBGA was 91%. FBGA accurately predicted postpartum cord blood pH values with a margin of ±0.2 in 319/343 (93%) cases. The overall correlation was good with $r = 0.405$ ($P < .001$).

On the other hand, the false-negative rate of FBGA was 8% (29/343). Thus, in 8% of cases, FBGA was normal and overruled the NRFHRT, although neonatal acidosis was later found. Thus, the PPV for predicting postpartum acidosis was only 50% as compared with an NPV of FBGA of 91%. The sensitivity and specificity of FBGA regarding neonatal acidosis were 9% and 99%, respectively. FBGA therefore is a diagnostic test with a high predictive value to rule out fetal acidosis, but with a low predictive value to rule in fetal acidosis.

We also looked at the hypothesis that a combination of normal repeated FBGA results and a normalization of the initial CTG pathology rules out an acidotic fetus. However, this was not the case. Table 4 demonstrates that the number of acidotic neonates increased among cases with repeated FBGAs and normalized CTG readings. Specifically the proportion of acidotic neonates was 8.7%, 13.0%, and 17.4% in cases with 1, 2, and 3 FBGAs combined with normal CTG readings, respectively.

In a multivariate logistic regression analysis, maternal BMI (odds ratio [OR] 1.1; 95% confidence interval [CI] 1.01–1.17; $P = .029$) and CTG variations according to Fisher score (OR 0.80; 95% CI 0.66–0.98; $P = .029$), but not time between FBGA and delivery, independently influenced the predictive value of FBGA. Results did not change when we used the FIGO CTG score (Table 5). The PPV of FBGA regarding neonatal depression according to Apgar scores was low with only 17%.

4. Discussion

In this retrospective cohort study, we found that FBGA is a useful tool in clinical practice to rule out, but not to rule in, neonatal acidosis in parturients with NRFHRT. Due to the high false-positive rate of CTG, FBGA can avoid unnecessary interventions such as cesarean section or operative vaginal delivery in up to 90% of cases. However, FBGA is not sensitive enough to reliably detect fetal acidosis with a false-negative rate of 8% and misses the majority of true acidotic fetuses.

The results of our study are in accordance with previously published data in the literature. For example, Jørgensen and Weber recommended FBGA in conjunction with CTG in order to gain additional information on fetal wellbeing and fetal reserves in order to reduce the risk of operative deliveries.[1] We confirmed that FBGA avoided unnecessary operative deliveries in 90% of cases with NRFHRT thus sparing the mother delivery-associated morbidity and an increased risk of long-term sequelae such as perineal pain, dyspareunia, incontinence, and an increased risk of uterine rupture in future pregnancies associated with vaginal operative delivery and cesarean section. This is an important advantage of FBGA, because CTG has a notoriously low specificity and most fetuses with NRFHRT are not acidotic. In our population, for example, only 9% of fetuses with NRFHRT actually had neonatal acidosis. Therefore, second-line diagnostic tests are necessary to identify cases of false-positive NRFHRT. Other second-line diagnostic tools such as computerized CTG interpretation or STEN analysis have not entered clinical routine[13,14] and FBGA is the only commonly used tool in clinical practice to reduce the rate of operative deliveries among parturients with NRFHRT. However, FBGA clearly has drawbacks. First, there is a lack of randomized trials regarding clinical endpoints such as fetal morbidity and mortality and there is a lack of methodological standardization.[1,2] Second, FBGA is not an effective method for identifying acidotic fetuses. Although FBGA can rule out fetal acidosis in most cases, it cannot rule in this condition. In other words, FBGA should only be used to reduce

Table 2

Maternal, fetal, and neonatal characteristics of acidotic versus nonacidotic cases.

Variables	Acidotic (pH≤ 7.15)	Nonacidotic (pH > 7.15)	P*
Number of cases	32 (9%)	311 (91%)	
Mother's BMI, kg/m^2	32.1 (29.4–34.7) [1]	29.8 (26.7–33.1) [7]	.036
Mother's age, y	28.9 ± 4.6	27.5 ± 5.5	.16†
Infant weight, g	3493 ± 569	3358 ± 453	.12†
Infant's sex (male/female)	19 (59%)/13 (41%)	177 (57%)/134 (43%)	.94‡
Gestational age, wk	40 (39–41)	40 (39–40)	.43
Apgar: 1 min	8 (7–9)	9 (8–9)	<.001
Apgar: 5 min	9 (8–10)	10 (10–10)	<.001
Neonatal depression§ (yes/no)	2 (6%)/30 (94%)	2 (1%)/309 (99%)	.051‡
Apgar: 10 min	10 (10–10)	10 (10–10)	<.001
Postpartum arterial pH	7.12 (7.09–7.14)	7.29 (7.24–7.33)	<.001
Postpartum venous pH	7.18 (7.12–7.25)	7.33 (7.29–7.37)	<.001
Base excess, mEq/L	−10.4 (−13.5 to −7.6)	−4.3 (−6.2 to −2.5)	<.001
Number of FBGAs performed	1 (1–2)	1 (1–2)	.21
>1 FBGA (yes/no)	14 (44%)/18 (56%)	106 (34%)/205 (66%)	.37
FBGA pH (first)	7.31 (7.25–7.34)	7.33 (7.31–7.37)	.003
FBGA pH (last)	7.28 (7.21–7.32)	7.33 (7.30–7.37)	<.001
ΔpH FBGA (first): postpartum	0.19 ± 0.08	0.05 ± 0.07	<.001†
ΔpH FBGA (last): postpartum	0.17 ± 0.09	0.04 ± 0.07	<.001†
CTG (before), Fisher score	6 (5–7)	7 (6–8) [7]	.023
CTG (after), Fisher score	6 (4–7) [1]	7 (6–8) [24]	.012
CTG (before), FIGO		[7]	.16‡
Normal	1 (3%)	28 (9%)	
Suspicious	6 (19%)	89 (29%)	
Pathological	25 (78%)	187 (62%)	
CTG (after), FIGO	[1]	[24]	.12‡
Normal	1 (3%)	17 (6%)	
Suspicious	2 (6%)	59 (21%)	
Pathological	28 (91%)	211 (73%)	
Time between last FBGA and delivery, min	44 (22–100) [3]	56 (35–97) [21]	.15

Data are n (%), mean ± standard deviation, or median (interquartile range). Numbers in square brackets indicate the number of missing values.
BMI = body mass index, CTG = cardiotocography, FBGA = fetal blood gas analysis, FIGO = Fédération Internationale de Gynécologie et d'Obstétrique.
* Mann–Whitney *U* test, unless noted otherwise.
† Student *t* test, 2-tailed.
‡ Chi-squared test with Yates correction.
§ Neonatal depression: 5-min Apgar score ≤ 5.

the rate of unnecessary operative deliveries in cases of NRFHRT, but not to identify cases of fetal acidosis. Therefore, based on our results, FBGA should be avoided in parturients with a high suspicion of fetal acidosis such as severely pathological CTGs or parturients at high risk of fetal acidosis such as those with placental insufficiency, infection, or preterm delivery.

We specifically looked at the issue of repeated FBGA samplings and found that pH steadily declined and led to a statistically significant and clinically relevant increase of acidotic neonates (from 2.2% to 8.5% in the group of neonates with multiple FBGA samplings). Based on these results we suggest to avoid repeating FBGA measurements. If the initial FBGA yields a reassuring result, a window of 30 to 45 min can be safely used to postpone the decision of immediate delivery. In case of continuous CTG pathologies, delivery should be achieved within this time window. However, normalization of the CTG

Table 3

Cardiotocography trace interpretation according to FIGO and Fisher score.

Classification FIGO*/Fisher	FIGO	Fisher	Feature	Baseline	Baseline variability	Decelerations	Accelerations	Zero-line crossings
Traces before fetal blood gas analysis (n = 335; missing: 8)								
Normal/normal (8–10)	29 (9%)	133 (40%)	Reassuring	206 (61%)	78 (23%)	162 (48%)	242 (72%)	117 (35%)
Suspicious/questionable (5–7)	95 (28%)	165 (49%)	Nonreassuring	120 (36%)	208 (62%)	128 (38%)	35 (11%)	213 (64%)
Pathological/pathological (≤4)	211 (63%)	37 (11%)	Abnormal	9 (3%)	49 (15%)	45 (14%)	58 (17%)	5 (1%)
Traces after fetal blood gas analysis, before delivery (n = 318; missing: 25)								
Normal/normal (8–10)	18 (6%)	113 (36%)	Reassuring	170 (54%)	62 (20%)	100 (32%)	233 (73%)	144 (45%)
Suspicious/questionable (5–7)	61 (19%)	156 (49%)	Nonreassuring	138 (43%)	211 (66%)	169 (53%)	31 (10%)	170 (54%)
Pathological/pathological (≤4)	239 (75%)	49 (15%)	Abnormal	10 (3%)	45 (14%)	49 (15%)	54 (17%)	4 (1%)

Data are n (%).
* According to Fédération Internationale de Gynécologie et d'Obstétrique (FIGO) 2015 guidelines: normal = all features reassuring; suspicious = 1 nonreassuring feature and 2 reassuring features; pathological = 1 abnormal feature or 2 nonreassuring features.

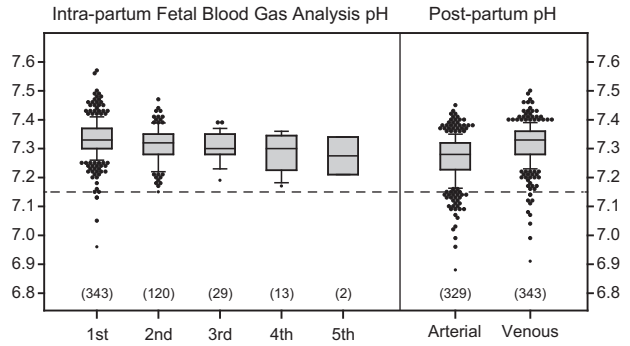

Figure 1. Box plots of pH values measured during intrapartum fetal blood gas analysis (at up to 5 time points) and postpartum umbilical cord blood sampling (arterial and venous). Boundaries of the boxes indicate the 25th/75th percentiles, black lines within the boxes mark the medians. Whiskers indicate the 10th and 90th percentiles. Dots represent individual outliers. Numbers in parentheses indicate the number of data items. The dashed horizontal line indicates the acidotic pH cutoff (7.15).

Table 4

Proportion of acidotic neonates and pathological cardiotocography readings.

Time point*	CTG assessment†		Acidotic/nonacidotic neonates
1st FBGA	Normal/questionable	298 (89.0%)	26 (8.7%)/272 (91.3%)
	Pathological	37 (11.0%)	6 (16.2%)/31 (83.8%)
2nd FBGA	Normal/questionable	100 (87.7%)	13 (13.0%)/87 (87.0%)
	Pathological	14 (12.3%)	1 (7.1%)/13 (92.9%)
3rd FBGA	Normal/questionable	23 (82.1%)	4 (17.4%)/19 (82.6%)
	Pathological	5 (17.9%)	1 (20.0%)/4 (80.0%)

Data are n (%).

CTG = cardiotocography, FBGA = fetal blood gas analysis.

* CTG traces were recorded during 30 min before every FBGA sampling.

† According to Fisher: normal/questionable (score $\geq$ 5), pathological (score $\leq$ 4).

Table 5

Multivariate logistic regression analysis.

	Dependent variable: postpartum acidosis (pH $\leq$ 7.15)	
Independent variables	Odds ratio (95% confidence interval)	*P*
FIGO CTG classification		
Mother's body mass index	1.08 (1.01–1.17)	.031
Time between last FBGA and delivery	1.00 (0.99–1.00)	.21
CTG (after FBGA)	0.38 (0.13–1.14)	.085
Fisher CTG score		
Maternal body mass index	1.08 (1.01–1.17)	.029
Time between last FBGA and delivery	1.00 (0.99–1.00)	.25
CTG (after FBGA)	0.80 (0.66–0.98)	.029

CTG = cardiotocography, FBGA = fetal blood gas analysis, FIGO = Fédération Internationale de Gynécologie et d'Obstétrique.

pathology did not lead to a lower proportion of acidotic neonates. To the contrary, in deliveries with 2 or 3 FBGA samplings, the proportion of acidotic neonates among the cases with normal CTGs increased. Clearly, a normal CTG in combination with repeated normal FBGA does not guarantee a nonacidotic neonate.

Our study adds to the literature on FBGA in providing more details regarding its PPV and NPV as a test for fetal acidosis in parturients with NRFHRT. For example, we found in a multivariate logistic regression analysis, that a high maternal BMI and a higher degree of pathological CTG variations independently and negatively affected the predictive value of FBGA. Thus, we conclude that both women with a high BMI and severe CTG pathologies are not ideal candidates for this diagnostic method and may better be treated with immediate delivery or other second-line diagnostic tests.

In summary, we performed a retrospective cohort study and provide data on the accuracy of FBGA showing that FBGA has a high NPV of 91%, but a poor PPV of 50% making it a good diagnostic method to identify most cases of false-positive NRFHRT suggesting fetal acidosis. However, FBGA is not sensitive enough to reliably detect fetal acidosis and misses the majority of true acidotic fetuses. We recommend that FBGA may be used in obstetric practice as a rule-in test, but every

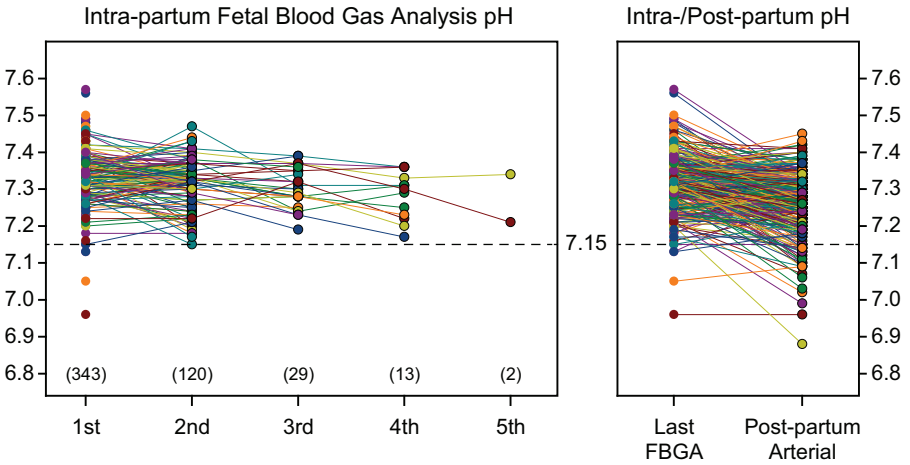

Figure 2. Line diagrams of pH values measured during intrapartum fetal blood gas analysis (FBGA) at up to 5 time points (left panel) and difference between last intrapartum FBGA and postpartum arterial pH (right panel). Colored circles connected by lines depicting longitudinal changes represent the pH values of individual infants measured at the indicated sampling points. Numbers in parentheses indicate the number of data items. The dashed horizontal line indicates the acidotic pH cutoff (7.15).

obstetrician should be aware of the fact that FBGA is a poor rule-in test for fetal acidosis.

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