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Original Article

Fetal Heart Rate Tracings and Adverse Outcomes among Term Small versus Appropriate for Gestational Age

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ABSTRACT

Objective This study aimed to compare the patterns of fetal heart rate tracings (FHRTs), and outcomes among individuals with small (birth weight [BW] <10% for gestational age [GA]; SGA) versus appropriate (BW at 10–89% for GA; AGA) newborns at term (≥37.0 weeks).

Study Design Our retrospective cohort study included consecutive deliveries over 15 months at a level IV center. FHRTs were reviewed by obstetricians blinded to maternal and neonatal outcomes. The inclusion criteria were non-anomalous singletons, cataloged as SGA or AGA birth weight using Alexander et al's nomogram. In 20-minute segments, the last 120 minutes of tracing were characterized. Rates of cesarean delivery (CD) and composite neonatal adverse outcomes (CNAOs) were compared.

Results Of 5,160 deliveries, 3,029 (58.7%) met the inclusion criteria, and among them, 422 (13.9%) were SGA and 2,607 (86.1%) AGA. There were no differences in FHRT baseline, variability, or accelerations. Compared to AGA, SGA was more likely to have prolonged decelerations (11.8 vs. 8.4%, $p = 0.021$), and recurrent decelerations with ≥50% of contractions (21.3 vs. 16.5%, $p = 0.014$). Overall, the presence of category II FHRT or not was similar between the SGA (91.2%) and AGA (88.5%; $p = 0.097$). Persistent category II FHRT was significantly more common among SGA (37.4%) than AGA (28.1%; aOR = 1.47; 95% CI: 1.47–1.82) newborns. The rate of CD for non-reassuring FHRT was similar among the two groups. CNAO occurred in 1.4% in both SGA and AGA neonates ($p = 0.95$).

Conclusion In our cohort of those with fetal monitoring prior to delivery at ≥37 weeks, persistent category II FHRT at the end of labor was significantly more common in SGA compared to AGA neonates; however, composite neonatal morbidity did not differ between the two groups. Our analysis provides data for shared decision-making that among SGA newborns, abnormalities of FHRT are not linked with adverse outcomes.

Keywords fetal heart rate tracings, small for gestational age, maternal outcomes, neonatal outcomes

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Introduction

Fetal heart rate tracing (FHRT) is the most utilized tool in the United States for assessing intrapartum fetal status. Despite its widespread clinical use, there are notable limitations, such as interobserver variability, a high false-positive rate, and discrepancies in algorithms and interpretations.[1,2]

One of the putative pathophysiologic etiologies for small-for-gestational-age (birth weight [BW] <10% for gestational age [GA]; SGA) neonates is impaired uterine–placental perfusion, which affects fetal oxygenation and growth.[3] Compared to appropriate-for-gestational-age (BW at 10–89% for GA; AGA) newborns, SGA neonates have higher rates of stillbirth, neonatal mortality, and neonatal morbidity, including respiratory distress syndrome, need for mechanical ventilation, necrotizing enterocolitis, and neonatal sepsis.[4] In this context, FHRT monitoring intrapartum serves as a screening tool for assessment of fetal acid–base status.

There are few studies analyzing FHRT and associated adverse neonatal and maternal outcomes for SGA versus AGA.[5–9] Prior studies found FHRT in SGA infants had significantly less accelerations and decreased variability.[7,8] A previous report also found increased variable decelerations and cesarean delivery rate for non-reassuring FHRT with no difference in neonatal outcomes among SGA neonates; however, this study relied on a computerized interpretation of FHRT, which is not routine practice worldwide for FHRT monitoring.[5] Previous publication have also been limited by small sample size (from 24 to 1,896 patients).[6,7]

Therefore, our objective was to determine if FHRT patterns differ among SGA versus AGA neonates and if these differences were associated with increased adverse neonatal outcomes. We hypothesized that category II FHRT would be more prevalent in

Key Points

- There were no differences in FHRT baseline, variability, or accelerations between AGA and SGA.
- SGA was more likely to have prolonged decelerations and recurrent decelerations with ≥50% of contractions.
- Persistent category II FHRT before delivery is significantly more common with SGA than AGA.
- FHRT abnormalities, however, were not associated with CD for non-reassuring FHRT, or adverse outcomes.

SGA infants and have a greater association with adverse neonatal outcomes.

Materials and Methods

This was a pre-planned secondary analysis of a retrospective cohort study of consecutive deliveries performed within a 15-month period (July 2020 to September 2021) at a level IV center. The parent cohort included singleton gestations ≥14 weeks admitted for delivery.[10,11] The current inclusion criteria for this secondary analysis were non-anomalous singletons at ≥37 weeks, with intrapartum FHRT, classified as SGA or AGA by BW using Alexander et al's nomogram.[12] BW was used over estimated fetal weight (EFW) as not all patients had a recorded EFW on admission for delivery.[13] FHRTs were reviewed by obstetricians (four obstetric residents, five maternal–fetal medicine fellows, and three obstetrics attendings), who were blinded to maternal and neonatal outcomes. Large for gestational age newborns (BW ≥90% for gestational age) were excluded.

In 20-minute segments, the last 20 to 120 minutes of available fetal heart tracing prior to delivery were reviewed. The period was measured from the last recorded minute of FHRT, not from time of delivery, thus allowing inclusion of cesarean deliveries who may have had gaps in FHRT during maternal transport. In accordance with the American College of Obstetricians and Gynecologists (ACOG) nomenclature, the following FHRT patterns were characterized: baseline, variability, accelerations, decelerations, tachysystole, sinusoidal pattern, and category allocation.[1] Standardized nomograms and training were provided (by K.A.C. and S.C.P.) to each obstetrician interpreting the FHRT to ensure consistency in data collection. Baseline fetal heart rate was determined by the mean of at least 10 minutes of FHRT, rounded to the nearest five beats per minute (beats per min [bpm]), and categorized as normal or tachycardic. Variability was classified as absent (undetectable), minimal (<5 bpm), moderate (6–25 bpm), or marked (>25 bpm). Decelerations were characterized as late, variable, early, or prolonged by ACOG guidelines and classified further by severity.[1,14] Early decelerations were classified as mild (15 bpm below baseline), moderate (30 bpm below baseline), or severe (45 bpm or more below baseline). Variable decelerations were classified as moderate (30–60 seconds duration with nadir <70–80 bmp), severe (60–120 seconds duration with nadir <80), or mild if neither of the previous criteria were met. Lastly, late decelerations were classified as mild (less than 15 bpm below baseline), moderate (15–45 bpm below baseline), or severe (>45 bpm or more below baseline).[14] Prolonged decelerations were analyzed and reported as absent, mild (decrease from baseline <15 bpm and >30 seconds and <2 minutes), moderate (decrease from baseline <15 bpm and >2 minutes and <6 minutes), or severe (decrease from baseline <15 bpm and >6 minutes). Accelerations were classified as absent, mild (>10 bpm for >10 seconds), moderate (>15 bpm for >15 seconds), or severe (>15 bpm over 2 minutes).[14] In this analysis, we analyzed accelerations as present or absent. ACOG guidelines were used by the reviewer to provide an overall classification of the FHRT segment as category I, II, or III.[1]

Rates of cesarean delivery, composite neonatal and maternal adverse outcomes (CNAO and CMAO), and umbilical arterial pH were compared among SGA and AGA neonates. CNAO included a composite of Apgar score less than 7 at 5 minutes, mechanical ventilation, hypoxic ischemic encephalopathy, neonatal seizure, confirmed sepsis, or neonatal death. CMAO included a composite of estimated or quantitative blood loss ≥1,000 mL, blood transfusion, chorioamnionitis, endometritis, venous thromboembolism, admission to an intensive care unit, or maternal death.

Maternal demographics, intrapartum characteristics, and neonatal and maternal outcomes were manually extracted from the electronic medical records by a trained research team separate from the FHT reviewers and stored in REDCap (Vanderbilt University, Nashville, TN).[15] These researchers were blinded to the FHT tracings, and an obstetrics faculty (R.L.W.) audited 75% of records to ensure accuracy.

Chi-square test or Fisher's exact test were used to compare categorical values, with p-value <0.05 considered significant. R Statistical Software (v4.3; R Core Team 2023) was used for all statistical analyses.[16] Multivariable regression analysis was used to calculate odds ratios (OR) with 95% confidence intervals (CI). Our analysis was adjusted for nulliparity and induction of labor. Other maternal comorbidities, including BMI, insurance, smoking, diabetes, and magnesium sulfate use were investigated for adjustment in multiple analysis of variance and ultimately found not to have a significant model effect. This study was approved by The University of Texas Health Science Center at Houston Institutional Review Board (IRB approval no.: HSC-MS-21-0383). The STROBE guidelines for reporting observational studies in epidemiology were followed throughout the study.[17]

Results

Of 5,160 consecutive deliveries, 3,029 (58.7%) met the inclusion criteria. Among the included cohort, 422 (13.9%) were SGA and 2,607 (86.1%) were AGA (**Fig. 1**).

Compared to AGA, individuals with SGA neonates were more likely to be nulliparous (52.6 vs. 41.5%, $p < 0.001$), self-describe race/ethnicity ($p < 0.001$), and have a BMI <30 kg/m^2 (48.3 vs. 35.2%, $p < 0.001$), and use tobacco ($p = 0.001$). AGA newborns were more likely to have private insurance ($p < 0.001$). The remaining baseline maternal demographics were similar between groups (**Table 1**).

In terms of intrapartum characteristics, SGA neonates were more likely to undergo induction of labor with mechanical dilation using a cervical balloon, and SGA neonates were more likely to have received magnesium sulfate in labor (**Table 2**).

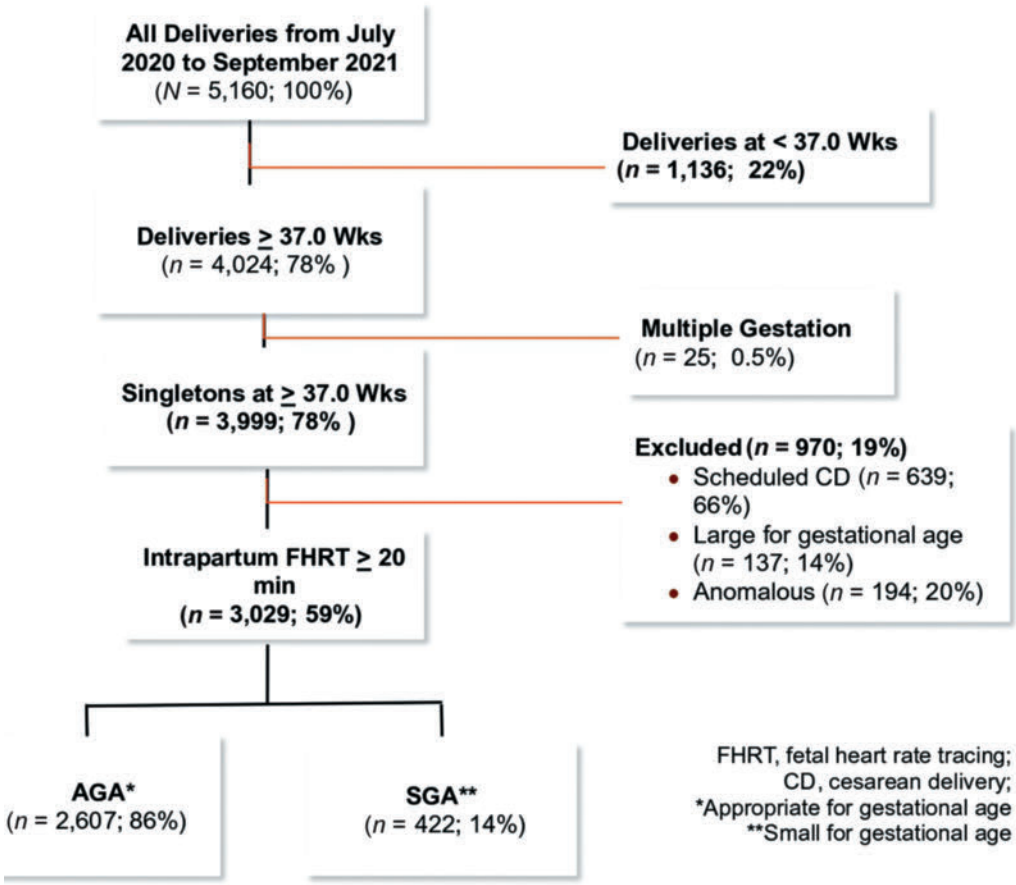

Fig. 1 Flow diagram. CD, cesarean delivery; FHRT, fetal heart rate tracing. *Appropriate for gestational age. **Small for gestational age.

Table 1 Maternal characteristics

	SGA (*n* = 422)	AGA (*n* = 2,607)	*p*-Value
Maternal age (y)			0.145
< 20	29 (6.9%)	145 (5.6%)	
20–34	341 (80.8%)	2055 (78.8%)	
≥35	52 (12.3%)	407 (15.6%)	
Nulliparous	**222 (52.6%)**	**1,081 (41.5%)**	**<0.001**
Race/Ethnicity			**<0.001**
White	71 (16.8%)	612 (23.5%)	
Black/African American	210 (49.8%)	937 (35.9%)	
Hispanic	77 (18.2%)	655 (25.1%)	
Asian	26 (6.2%)	133 (5.1%)	
Others	38 (9%)	270 (10.3%)	
Body mass index ≥30 kg/m^2	218 (51.7%)	1685 (64.8%)	**<0.001**
Private insurance	163 (38.6%)	1166 (44.7%)	**0.019**
Tobacco usage	22 (5.2%)	63 (2.4%)	**0.001**
Hypertensive disorder of pregnancy[a]	145 (34.4%)	867 (33.3%)	0.656
Diabetes mellitus[b]	23 (5.5%)	227 (8.7%)	**0.024**
Hypothyroidism	19.0 (4.5%)	107.0 (4.1%)	0.704
Hyperthyroidism	2.0 (0.5%)	5.0 (0.2%)	0.263

(*Continued*)

Table 1 (*Continued*)

	SGA ($n = 422$)	AGA ($n = 2,607$)	*p*-Value
Anemia Hgb <10 g/dL	51.0 (12.1%)	308.0 (11.8%)	0.873
PE/DVT	1.0 (0.2%)	19.0 (0.7%)	0.247
Asthma	34.0 (8.1%)	197.0 (7.6%)	0.719
Seizure disorder	5.0 (1.2%)	32.0 (1.2%)	0.941
Cardiac disease	5.0 (1.2%)	28.0 (1.1%)	0.839
Kidney disease	0.0 (0.0%)	3.0 (0.1%)	0.486
Major infection (HIV, hepatitis, etc.)	0.0 (0.0%)	18.0 (0.7%)	0.087
Psychiatric disorder	41.0 (9.7%)	194.0 (7.4%)	0.105
COVID-19	19.0 (4.5%)	90.0 (3.5%)	0.283

Abbreviations: COVID-19, coronavirus disease of 2019; HIV, human immunodeficiency virus; PE/DVT, pulmonary embolism or deep venous thromboembolism.
Notes: Data presented as *N* (%).
Using nomogram by Alexander et al,[12] newborns were categorized as SGA (small for gestational age; birth weight <10th percentile for gestational age) or AGA (appropriate for gestational age; birth weight between 10th and 89th percentile for gestational age).
[a]Includes chronic hypertension, pregnancy-induced hypertension without or with severe features.
[b]Includes gestational and pre-gestational diabetes.

Table 2 Intrapartum characteristics

	SGA ($n = 422$)	AGA ($n = 2,607$)	*p*-Value
Gestational age (wk)			**0.004**
37.0–38.6	254 (60.2%)	1349 (51.7%)	
39.0–40.6	165 (39.1%)	1223 (46.9%)	
41.0 or more	3 (0.7%)	35 (1.3%)	
Induction of labor	274(64.9%)	1408 (54%)	**<0.001**
Magnesium use	13 (3.1%)	49 (1.9%)	**0.012**
None	378 (89.6%)	2,435 (93.4%)	
Antepartum	23 (5.5%)	74 (2.8%)	
In labor	13 (3.1%)	49 (1.9%)	
Postpartum	8 (1.9%)	49 (1.9%)	
Neuraxial anesthesia	379 (98.2%)	2,359 (98.3%)	0.929
Amnioinfusion	37 (8.8%)	203 (7.8%)	0.489
Mechanical dilation	115 (27.3%)	508 (19.5%)	**<0.001**
Prostaglandin	71 (16.8%)	401 (15.4%)	0.448
ROM type[a]			0.719
SROM	105 (26.4%)	683 (27.2%)	
AROM	293 (73.6%)	1827 (72.8%)	
Oxytocin	331.0 (78.4%)	1,990.0 (76.4%)	
Chorioamnionitis	12 (2.8%)	118 (4.5%)	0.114

Abbreviations: AROM, artificial rupture of membranes; NR FHRT, non-reassuring fetal heart rate tracing; ROM, rupture of membrane; SROM, spontaneous rupture of membranes; TOLAC, trial of labor after cesarean.
Notes: Data presented as *N* (%).
Using nomogram by Alexander et al,[12] newborns were categorized as SGA (small for gestational age; birth weight <10th percentile for gestational age) or AGA (appropriate for gestational age; birth weight between 10th and 89th percentile for gestational age).
Bolded if significantly different.
P-value calculated excluding missing values.
[a]Data available for 398 SGA and 2,510 AGA newborns.

There were no differences in FHRT baseline, variability, or accelerations (**Table 3**). Compared to AGA, SGA neonates were more likely to have any decelerations (21.3 vs. 16.5%, $p = 0.014$), prolonged decelerations (11.8 vs. 8.4%, $p = 0.021$), or severe variable decelerations with ≥50% of contractions (1.9 vs. 0.7%, $p = 0.011$).

The likelihood of category II FHRT throughout the entire 120 minutes (37.4 vs. 28.1%, $p < 0.001$) and the presence of any severe deceleration (32.5 vs. 27.8%, $p = 0.047$) was significantly more among SGA neonates than AGA (**Table 4**).

CNAO occurred in 1.4% for SGA as well as AGA neonates ($p = 0.95$). Cesarean delivery for non-reassuring FHRT ($p = 0.18$) and umbilical arterial pH < 7 ($p = 0.87$) occurred similarly in the two groups (**Table 5**). After adjustment for nulliparity and induction of labor, AGA was more likely to have cesarean due to arrest with a significant aOR (1.97, 95% CI: 1.31–2.94). CMAO occurred in 6.4% of individuals with SGA and 7.6% of those with AGA neonates ($p = 0.37$).

Discussion

In our cohort of over 3,000 term parturients, in the last 20 to 120 minutes prior to delivery, SGA neonates were more likely to exhibit abnormalities on FHRT, but not more likely to experience

Table 3 Individual patterns of fetal heart rate tracing

	SGA ($n = 422$)	AGA ($n = 2,607$)	*p*-Value	OR (95% CI)	OR (95% CI)[a]
Tachycardia[a]	8 (1.9%)	70 (2.7%)	0.342		
Bradycardia	1 (0.2%)	1 (0.05%)	0.141		
Variability					
Absent	1 (0.2%)	1 (0%)	0.141		
Minimal	45 (10.7%)	235 (9%)	0.278		
Moderate	325 (77.0%)	2053 (78.7%)	0.421		
Marked	3 (0.7%)	5 (0.2%)	0.054		
Accelerations	239 (56.6%)	1,525 (58.5%)	0.472		
Decelerations					
Any[b]	90 (21.3%)	429 (16.5%)	**0.014**	**1.37 (1.07–1.78)**	**1.27 (0.98–1.64)**
Early	6 (1.4%)	35 (1.3%)	0.896		
Mild	3 (0.7%)	17 (0.7%)	0.890		
Moderate	2 (0.5%)	11 (0.4%)	0.880		
Severe	1 (0.2%)	7 (0.3%)	0.907		
Late	30 (7.1%)	150 (5.8%)	0.275		
Mild	19 (4.5%)	107 (4.1%)	0.704		
Moderate	10 (2.4%)	31 (1.2%)	0.052		
Severe	1 (0.2%)	12 (0.5%)	0.515		
Variable	92 (21.8%)	482 (18.5%)	0.107		
Mild	54 (12.8%)	316 (12.1%)	0.694		
Moderate	30 (7.1%)	147 (5.6%)	0.232		
Severe	8 (1.9%)	19 (0.7%)	**0.018**	**2.63 (1.14–6.05)**	**2.34 (1.01–5.43)**
Prolonged	50 (11.8%)	219 (8.4%)	**0.021**	**1.46 (1.06–2.03)**	**1.41 (1.02–1.97)**
Mild	49 (11.6%)	206 (7.9%)	**0.011**	**1.53 (1.10–2.12)**	**1.48 (1.06–2.06)**
Moderate	1 (0.2%)	13 (0.5%)	0.462		
Severe	0	0	NA		

Notes: Data presented as *N* (%).
All patterns of fetal heart rate tracing present >50% of the time in the 20 to 120 minutes segment of labor analyzed.
Using nomogram by Alexander et al,[12] newborns were categorized as SGA (small for gestational age; birth weight <10th percentile for gestational age) or AGA (appropriate for gestational age; birth weight between 10th and 89th percentile for gestational age).
Using the ACOG Practice Bulletins (numbers 106 and 116),[1,24] and Parer JT et al,[14] obstetricians blinded to maternal characteristics and neonatal outcomes interpreted the fetal heart rate tracing.
[a]Adjusted for induction of labor and nulliparity. Other variables investigated for adjustment were body mass index, insurance, smoking, diabetes, magnesium sulfate use, and hypertensive disorders but were found to not have significant model effect.
[b]Any decelerations included a composite of late, variable, or prolonged decelerations.

Table 4 Combination and trends of FHT observations

	SGA ($n = 422$)	AGA ($n = 2,607$)	*p*-Value	OR (95% CI)	aOR[a] (95% CI)
Category I—Always	36 (8.5%)	300 (11.5%)	0.071		
Category II					
Persistent Cat II	158 (37.4%)	732 (28.1%)	**<0.001**	**1.53 (1.23–1.90)**	**1.47 (1.18–1.82)**
Any time Cat II	385 (91.2%)	2,307 (88.5%)	0.097		
Tachycardia	8 (1.9%)	70 (2.7%)	0.342		
With any decelerations[b,c,d]	8 (1.9%)	66 (2.5%)	0.432		
With severe decelerations[c,d]	7 (1.7%)	26 (1%)	0.225		
Moderate variability					
Moderate variability always	276 (65.4%)	1,751 (67.2%)	0.475		
With decelerations[c]	240 (56.9%)	1446 (55.5%)	0.590		
With severe decelerations[c]	91 (21.6%)	492 (18.9%)	0.193		
Moderate variability any time	400 (94.8%)	2,496 (95.7%)	0.374		
With decelerations[c]	354 (83.9%)	2,131 (81.7%)	0.287		
With severe decelerations[c]	129 (30.6%)	702 (26.9%)	0.120		
Moderate variability (>50% time)	325 (77%)	2,053 (78.7%)	0.421		
With decelerations[c]	325 (77%)	1,990 (76.3%)	0.760		
With severe decelerations[c]	123 (29.1%)	659 (25.3%)	0.092		
Accelerations					
Accelerations present always	127 (30.1%)	832 (31.9%)	0.456		
With decelerations[c]	101 (23.9%)	576 (22.1%)	0.400		
With severe decelerations[c]	24 (5.7%)	132 (5.1%)	0.591		
Accelerations present any time	378 (89.6%)	2,426 (93.1%)	0.111		
With decelerations[c]	331 (78.4%)	2,067 (79.3%)	0.690		
With severe decelerations[c]	118 (28%)	652 (25.0%)	0.196		
Accelerations present (>50% time)	239 (56.6%)	1,525 (58.5%)	0.472		
With decelerations[c]	221 (52.4%)	1,342 (51.5%)	0.733		
With severe decelerations[c]	71 (16.8%)	366 (14%)	0.131		
Decelerations					
Any decelerations (any % time)	373 (88.4%)	2,233 (85.7%)	0.133		
Variable and late (>50% time)	23 (5.5%)	96 (3.7%)	0.083		
Variable, Late, Prolonged[b] (>50% time)	6 (1.4%)	24 (0.9%)	0.335		
Severe decelerations (any % time)[d]	137 (32.5%)	724 (27.8%)	**0.047**	**1.25 (1.00–1.56)**	1.18 (0.94–1.47)
Category III—ever (any % time)	3 (0.7%)	22 (0.8%)	0.779		

Notes: Data presented as *N* (%), *p* values are unadjusted.
Using nomogram by Alexander et al,[12] newborns were categorized as SGA (small for gestational age; birth weight <10th percentile for gestational age) or AGA (appropriate for gestational age; birth weight between 10th and 89th percentile for gestational age).
Any decelerations only include a composite of pathologic decelerations (late, variable, prolonged).
Using the ACOG Practice Bulletins (numbers 106 and 116),[1,24] and Parer JT et al,[14] obstetricians blinded to maternal characteristics and neonatal outcomes interpreted the fetal heart rate tracing.
Bolded if significantly different.
[a]Adjusted for IOL, nulliparity. Other variables investigated for adjustment were BMI, insurance, smoking, diabetes, magnesium sulfate use, and hypertensive disorders but were found to not have significant model effect.
[b]All three present during the evaluated time period.
[c]Present any time in the available analyzed epochs in the 2 hours prior to delivery.
[d]Any decelerations–variable, late, or prolonged decelerations.

short-term maternal or neonatal morbidity. Our study is congruent with prior studies reporting a higher incidence of variable decelerations in SGA neonates versus AGA neonates.[5,9] Possible reasons for abnormal FHRT in SGA fetuses include chronic hypoxia or nutrient deprivation, resulting in delayed sympathetic nervous system development.[8,9]

Table 5 Maternal and neonatal outcomes

	SGA ($n = 422$)	AGA ($n = 2,607$)	*p*-Value
Cesarean delivery for arrest	30 (7.1%)	258 (9.9%)	0.07[a]
Cesarean delivery for NR-FRHT	47(11.1%)	237 (9.1%)	0.18
Umbilical arterial pH <7.00[b]	2 (0.9%)	11 (0.8%)	0.87
Composite neonatal adverse outcomes	6 (1.4%)	36 (1.4%)	0.95
Apgar score <7 at 5 min.	3 (0.7%)	20 (0.8%)	0.90
Mechanical ventilation >6 hours	4 (0.9%)	8 (0.3%)	
Neonatal seizure	0 (0%)	2 (0.1%)	
Bronchopulmonary dysplasia	0 (0%)	0 (0%)	
Intraventricular hemorrhage	0 (0%)	0 (0%)	
Necrotizing enterocolitis	0 (0%)	1 (0%)	
Neonatal sepsis	0 (0%)	7 (0.3%)	
Brachial plexus palsy	0 (0%)	4 (0.2%)	
Hypoxic ischemic encephalopathy	1 (0.2%)	3 (0.1%)	
Neonatal death	0 (0%)	0 (0%)	
Composite maternal adverse outcomes	27 (6.4%)	199 (7.6%)	0.37
Estimated blood loss ≥1,000 mL	13 (3.1%)	134 (5.1%)	
Blood transfusion	16 (3.8%)	76 (2.9%)	
Endometritis	4 (0.9%)	21 (0.8%)	
Surgical site infection	1 (0.2%)	7 (0.3%)	
Deep venous thrombosis	0 (0%)	0 (0%)	
Intensive care unit	2 (0.5%)	9 (0.3%)	
Maternal death	0 (0%)	0 (0%)	

Abbreviation: NR-FHRT, non-reassuring fetal heart rate tracing.
Notes: Data presented as *N* (%).
Bolded if significantly different.
Using nomogram by Alexander et al,[12] newborns were categorized as SGA (small for gestational age; birth weight <10th percentile for gestational age) or AGA (appropriate for gestational age; birth weight between 10th and 89th percentile for gestational age).
[a]After adjustment for nulliparity and induction of labor, aOR was significant (1.97, 95% CI: 1.31–2.94).
[b]Obtained in 201 (47.6%) of SGA and 1,227 (47.1%) of AGA.

A prior publication by Chauhan et al has highlighted no difference in composite neonatal adverse outcomes, neonatal seizures, umbilical cord artery pH ≤7.05 or base deficit ≥12 mmol/L, and neonatal encephalopathy in SGA compared to AGA neonates without any maternal/neonatal complications (maternal diabetes, hypertension, placental abnormalities).[5] This differs from outcomes reported in the general population, which includes patients with multiple comorbidities.[3] From our results, SGA neonates were more likely to have received magnesium sulfate in labor, consistent with the higher prevalence of pre-eclampsia with SGA and the underlying etiology of SGA being utero-placental insufficiency.[5]

Some have reported that cesarean delivery rate is higher in SGA,[5,18] whereas our study and others noted no difference.[19] Rather, after adjustment for nulliparity and induction of labor, AGA was more likely to require cesarean delivery due to arrest disorder. This result is postulated to be secondary to elevated birth weight.[20] Like we observed, Rhoades et al noted no difference in vaginal delivery rate between SGA and non-SGA groups, but the most common indication for cesarean was non-reassuring fetal heart tracing.[19]

Since most of the SGA cases are not identified as fetal growth restriction (FGR; estimate of fetal weight <10th percentile for gestational age),[21–23] some may opine that exploration of FHRT abnormality with SGA is neither important nor clinically useful. Such a dismissive opinion would be erroneous for at least six reasons. First, ACOG guidelines on the topic of FHRT[24,25] note that one of the obstetric conditions which predisposes fetuses to adverse outcomes is growth restriction. Thus, characterization and categories of FHRT with SGA provides insight into abnormal FHRT. Second, majority of fetuses with FGR are SGA[18,26] and, therefore, our findings may be applicable to those with FGR. Third, our analysis can help guide clinical decision-making, counseling of patients with SGA and category II FHRT, and potentially decrease unnecessary cesarean deliveries. ACOG strives to reduce primary cesarean rates, and the analysis presented here can provide context for expected FHRT patterns in suspected SGA fetuses with no difference in CNAO and CMAO.[1] Fourth, there is a call to action for improving the antenatal detection of SGA with universal third trimester ultrasound examination among low-risk pregnancies.[27] Indeed there is evidence from intervention trials that

universal third trimester examinations significantly improves the identification of SGA during pregnancy.[28,29] Thus, our findings of this analysis will have greater application as there is an improvement in the identification of SGA newborns. Fifth, if the dictum is that lack of foreknowledge of immediate neonatal outcomes like SGA is unimportant, then it applies to studies and trials on several topics like macrosomia, Apgar scores, shoulder dystocia, and composite neonatal adverse outcomes.[30–36] Sixth, our findings are nidus for investigation to understand the putative pathophysiology of decelerations, specifically among SGA neonates, and how in the majority of the cases it is not linked with an increase in adverse neonatal outcomes.

The strengths of our study include our cohort of consecutive deliveries with FHRT interpretation by obstetricians blinded to maternal characteristics and neonatal outcomes. Additionally, this study represents the only large-scale analysis in which the FHRT analysis was conducted by physicians, as opposed to only registered nurses, clinical staff, or computerized technology increasing generalizability in clinical practice.[5–7] Finally, this study encompasses a racially, ethnically, and socioeconomically diverse patient population and a large sample size.

Our study has limitations. An important consideration is the interobserver variability in interpreting FHRT. Although the team followed structured criteria and algorithms when analyzing the FHRT, a degree of subjectivity cannot be avoided. Studies examining the interobserver variability in classifying FHRT described interobserver agreement as "moderate" for categories I and II FHRT and "poor" for category III.[37] Also, we only evaluated the FHRT during the last 20 to 120 minutes preceding delivery, and are unable to comment if longer periods of non-reassuring FHRT are associated with CNAO. We excluded deliveries before 37 weeks ($n = 1{,}136$; 22%); therefore, our findings may not be applicable to preterm births. Our setting at a level IV maternal care center may not be relevant to all delivery settings. Lastly, the umbilical arterial pH was not universally available, so our study was limited to the available data. Lastly, we focused on birth weight $<$10th percentile rather than estimated fetal weight below 10th percentile for gestational age because for the majority of individuals delivered, a sonographic estimated fetal weight within 4 weeks of labor was not available.[13]

Compared to AGA newborns, SGA newborns had a higher rate of decelerations and category II FHRT. However, this was not associated with a significant difference in cesarean delivery for NRFHT, umbilical arterial pH, or composite adverse neonatal or maternal outcomes. These findings may be used to guide the interpretation of FHRT and aid with shared decision-making during labor if SGA is suspected.

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Statements and Additional Information

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