

Assessment of Neonatal Outcomes in Relation to Non-Reassuring CTG during Labor

Seemab Pirzada, Shamaun Shamaun

ABSTRACT:

Objective: To assess the association of specific non-reassuring intrapartum cardiotocography (CTG) features with early neonatal outcomes, particularly low 5-minute Apgar score and neonatal intensive care unit (NICU) admission.

Study design and setting: Descriptive longitudinal study conducted in the Department of Obstetrics and Gynaecology, Dow University Hospital, Karachi.

Methodology: A total of 188 women with singleton term pregnancies and non-reassuring intrapartum CTG were enrolled by non-probability consecutive sampling. CTG features were classified using a standardized operational framework, and maternal, obstetric and neonatal outcomes were recorded. Associations with low 5-minute Apgar score and NICU admission were examined using bivariate analyses. The reported multivariable logistic regression models were treated as exploratory because the available records did not document the original model-building diagnostics in sufficient detail.

Results: Mean maternal age was 28.4 ± 5.2 years and mean gestational age at delivery was 38.6 ± 1.1 weeks. Cesarean delivery occurred in 104 (55.3%) women. Reduced baseline variability was present in 82 (43.6%) tracings and late decelerations in 51 (27.1%). Mean Apgar score increased from 6.6 ± 1.5 at 1 minute to 8.1 ± 1.2 at 5 minutes. Low 5-minute Apgar score occurred in 34 (18.1%) neonates and 50 (26.6%) were admitted to the NICU. Reduced baseline variability and late decelerations were significantly associated with both adverse outcomes.

Conclusion: Reduced baseline variability and late decelerations were associated with adverse early neonatal outcomes, including low 5-minute Apgar score and NICU admission. These observational findings support careful CTG interpretation but do not establish that CTG-directed intervention itself improves neonatal outcomes.

Keywords: Non-reassuring cardiotocography, fetal distress, intrapartum fetal monitoring, neonatal outcomes, Apgar score.

How to cite this Article:

Pirzada S, Shamaun S. Assessment of Neonatal Outcomes in Relation to Non-Reassuring CTG during Labor. J Bahria Uni Med Dental Coll. 2026;16(4):973-80 DOI: <https://doi.org/10.51985/JBUMDC20261073>

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INTRODUCTION:

Morbidity and mortality just after birth and/or birth are important indicators of quality of obstetric/neonatal care, and may be reduced if limited access to using a fetal surveillance machine, or to operative delivery or neonatal resuscitation or intensive care is found in low and middle income countries. Intrapartum hypoxia is important and preventable risk factor for adverse neonatal outcomes; including birth asphyxia, metabolic acidosis, HIE, seizures, admission to neonatal unit and early NN death. Labor may be associated with extremely rapid desaturation of the fetus with oxygen, so early recognition of fetal compromise is crucial to prompt obstetric intervention, and preparation of

neonatal support at delivery.¹

Cardiotocography (CTG) is one of the most popular methods of intra-partum fetal monitoring. Promotes ongoing fetal heart rate and uterine activity monitoring and assists the clinician in detecting patterns indicative of fetal hypoxia or diminished fetal reserve. The interpretation of a CTG largely depends on baseline fetal heart rate, fetal heart rate variability, accelerations, early (FHR) drug effects (decelerations) and late (FHR) drug effects (uterine activity). Tracings are more generally categorized as reassuring, non-reassuring (i.e., suspicious) and abnormal (i.e., pathological). Non-reassuring CTG is typically associated with decreased variability, variability that is too frequent (recurrent), late decelerations, fetal tachycardia, or other worrisome patterns that may signal developing fetal compromise but are not necessarily indicative of fetal acidosis.²

The purpose of the clinical use of CTG is to warn health professionals that the fetus may be injured beyond repair. Finding fetal heart rate changes, however, is indirect evidence for changes in fetal oxygenation and that is where it gets difficult to relate to the interpretation. Recently, the CTG has been demonstrated to have high sensitivity but limited

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Received: 04-06-2026
Accepted: 09-09-2026

1st Revision: 06-07-206
2nd Revision: 14-07-2026
3rd Revision: 24-08-2026

positive predictive value to find fetuses with good oxygen supply. This restriction can result in avoidable operative deliveries and a lack of understanding or timely response could allow the baby to sustain damage.³ Thus it is important that the association of non-reassuring CTG with objective neonatal parameters (neonatal resuscitation, umbilical tender, need for NICU admission, acidemia) be further assessed.

Apgar score at 1 and 5 minutes is a quick and popular clinical assessment of the early neonatal adaptation following birth. The low Apgar score can reflect depressed birth or respiratory problems or the requirement for active wet resuscitation. Not a specific indicator of intrapartum hypoxia but clinically significant indicator of early neonatal status. The connections of abnormal or non-reassuring pattern of the CTG with low Apgar score, birth asphyxia, neonatal seizures and admission to NICU have been reported.^{4,5} Pathological admission CTG has also been shown to increase the likelihood of cesarean delivery, asphyxiated neonates⁶, admission to the special care baby unit and longer neonatal hospital stays. Recent studies also have shown that CTG abnormalities can be different pathophysiological processes. For instance, diminished fetal heart rate variability and decelerations have been significantly related to neonatal asphyxia, and fetal heart rate patterns suggestive of inflammation have been associated with raised umbilical arterial Interleukin-6 concentration and composite adverse neonatal outcomes.^{7,8} The present findings indicate that CTG should neither be used alone in interpretation, but instead be used in conjunction with maternal risk factors, labour progress, fetal reserve, gestational age, meconium-stained liquor and the provision of neonatal support. There is no 100% ideal image of baby monitoring device during labor. There is some conflicting evidence and some studies have demonstrated adjunctive techniques (fetal scalp stimulation, st waveform analysis and newer computational techniques) may improve interpretation in selected settings; however those techniques have limited implementation by resources and expertise in particular.^{9,10} CTG remains a viable and easily accessible tool for intrapartum surveillance particularly in high-risk pregnancies and tertiary-care hospitals in resource-limited countries. The majority of data currently available for CTG interpretation and neonatal outcome are based on data from populations around the world and do not necessarily reflect local clinical care, population or resource differences. Comparing the neonatal outcome to non-reassuring CTG during labor can assist a clinician in knowing about at-risk neonates, better decision making about delivery, better preparedness of the NICU and give input into neonatal mortality and morbidity reduction measures that prevent needless pathology.

METHODOLOGY:

The present study was a descriptive, longitudinal study carried out in the Department of Obstetrics and Gynaecology, Dow University hospital, Karachi. The study was performed from 13th April 2026 to 12th July 2026, after the approval

was obtained from the Institutional Review Board of Dow University of Health Science. Prior to the beginning of data collection, ethical approval was obtained, and data collection was carried out in line with institutional ethical approval. All eligible subjects gave informed consent and participated in this study. This study consisted of pregnant women who came in to labor and were determined to have non-reassuring cardiotocography during labor. The study group was composed of mothers presenting for labor and delivery with non-reassuring cardiotocography (C-T or CCT). The non-probability consecutive sampling method was used to select the participants. The eligible female population who met all inclusion criterion during the study period was enrolled until the desired sample size was obtained. The sample size was determined using OpenEpi version 3.01, using a 95% confidence level and 80% power. The required sample size was determined based on the previously reported neonatal Apgar score > 7 at 5 minutes among those cases highly monitored by CTG, and the sample size was determined to be 188 participants.

CTG non-reassuringly singleton pregnant women in labor were included in the study. Women 18 to 45 years of age and at 37 weeks' gestation or greater regardless of gravida and parity were eligible to participate. Women were included regardless of mode of delivery, spontaneous vaginal delivery, assisted or cesarean. Patients who had more than one gestation or had a known fetal congenital anomaly, intrauterine growth restriction, preterm labor or refused to give informed consent were excluded from the study. To limit the confounding effect of fetal and obstetric conditions which by themselves might have a significant impact on neonatal outcome, the following criteria were used. Demographic and clinical data of the mother was documented on a pre-designed proforma after enrolment. Maternal variables that were recorded were age, educational status, socioeconomic status, place of residence, BMI and underlying medical conditions including hypertension, diabetes, and other conditions. Obstetric history has also been recorded such as gravida, parity, previous obstetric complications, gestational age at delivery and mode of delivery. Data on admission-related factors, such as date and time of admission, indication for CTG monitoring and intrapartum findings related to the CTG were obtained via clinical assessment and medical records. Labor was monitored using cardiotocography (CTG). For this revised manuscript, CTG terminology was standardized to the FIGO 2015 intrapartum fetal-monitoring framework. Baseline fetal heart rate, baseline variability, accelerations and decelerations were assessed. Normal baseline variability was defined as a bandwidth amplitude of 5–25 beats/min. Reduced baseline variability was defined as a bandwidth amplitude <5 beats/min persisting for >50 minutes in baseline segments. Fetal tachycardia was defined as a baseline >160 beats/min lasting >10 minutes. Repetitive decelerations were considered clinically relevant when present with >50% of uterine

contractions, and late decelerations were classified according to their timing in relation to contractions. Tracings lacking normal features but without pathological features were considered suspicious/non-reassuring. The authors should confirm that this FIGO framework reflects the classification actually used during data collection. [FIGO guideline added as Reference 24].

After delivery, assessment of neonatal outcomes was made and recorded. The main neonatal outcomes were the Apgar score at 1 and 5 minutes and admission to the neonatal intensive care (NIC) unit. All pediatricians or trained members of the neonatal team performed apgar scores within one minute of the baby being born. Categorization was based on the normal interpretation of scores which 7-10 meant good neonatal status, 4-6 meant moderate neonatal depression and 0-3 meant serious neonatal depression and called for immediate action. Neonatal resuscitation requirement, treatment (elementary or advanced resuscitative measures) was also recorded when needed. Newborns with special monitoring or treatment immediately after birth were included in NICU admission data. Children admitted to the NICU were those who needed specialized monitoring or treatment after birth. The exact cause of admission to NICU is recorded such as birth asphyxia, respiratory distress, meconium aspiration syndrome, hypoglycaemia, suspected sepsis, seizures, temperature instability and other neonatal complications. Other measures were secondary outcomes which included birth weight, gender, complications of the neonatal period, discharge status, and follow-up results. The neonates were followed for the early neonatal period within the framework of the study proforma, and their outcomes: Stable, Complicated or Death. IBM SPSS version 26 was used for analysis. Continuous variables were assessed for normality using the Shapiro-Wilk test and summarized as mean $\pm$ SD when approximately normally distributed or median (IQR) otherwise. Categorical variables were summarized as frequency and percentage. Associations between individual CTG features and low 5-minute Apgar score or NICU admission were assessed using the chi-square test or Fisher exact test where expected cell counts were <5 . The manuscript also reports exploratory multivariable binary logistic regression models for two outcomes: low 5-minute Apgar score and NICU admission. The final reported models included reduced baseline variability, late decelerations, absent accelerations, fetal tachycardia, cesarean delivery and maternal comorbidity, coded as binary indicators against the absence of each factor. Because the available manuscript records did not document the original variable-selection procedure, collinearity diagnostics, Hosmer-Lemeshow goodness-of-fit results, discrimination statistics, or residual diagnostics, these model characteristics are not reconstructed or invented. The regression estimates are therefore presented as exploratory adjusted associations rather than definitive independent predictors. This is particularly important for

the low-Apgar model, which contains 34 outcome events for six covariates and is at risk of overfitting. A two-sided p-value <0.05 was considered statistically significant.

RESULTS:

The mean (SD) age of the mothers in the group was 28.4 (5.2) years. Most women were in the age group of 26–35 years, comprising 96 (51.1%) participants, followed by 62 (33.0%) women in the age group of 18–25 years and 30 (16.0%) women in the age group of 36–45 years. The mean body mass index was 26.8 ± 3.9 kg/m². Among the participants, 86 (45.7%) were overweight, 64 (34.0%) had normal BMI, and 38 (20.2%) were obese. As far as educational level was concerned there were 78 (41.5%) women with secondary school education, 56 (29.8%) with primary education and 54 (28.7%) with higher education. Most indicated a middle socioeconomic class (102 54.3%) and 64 (34.0%) indicated a low socioeconomic class and 22 (11.7%) indicated a high socioeconomic class. There were 132 (70.2%) participants from urban and 56 (29.8%) from rural areas. Fifty-six (29.8%) women had maternal comorbidities. Hypertension (14.9%), diabetes mellitus (10.6%) and other comorbidities (4.3%) were the most common comorbidities. Mean gestational age at delivery was 38.6 ± 1.1 weeks. Ninety-one (48.4%) women delivered at 39–40 weeks, 82 (43.6%) at 37–38 weeks and 15 (8.0%) after 40 weeks. Sixty-eight (36.2%) women were primigravida and 120 (63.8%) were multigravida. The most common method of delivery was by cesarean section, which was used for 104 (55.3%) women. Of those who delivered, 66 (35.1%) had an spontaneous vaginal delivery with 18 (9.6%) assisted. Normal baseline fetal heart rates were found in 128 (68.1%) cases, fetal tachycardia in 43 (22.9%) cases, and fetal bradycardia in 17 (9.0%) cases on CTG assessment. 106 (56.4%) cases showed normal baseline variability and 82 (43.6%) cases showed reduced baseline variability. Variable deceleration was seen in 79 (42.0%) CTG tracings, late deceleration was observed in 51 (27.1%) and early deceleration was observed in the remaining 23 (12.2%) CTGs. Thirty-five (18.6%) cases were not observed to decelerate. 114(60.6%) of the CTG tracings had an acceleration and 74(39.4%) did not have an acceleration.

The birth weight of the pups was 2910 ± 430 g on average. Most neonates, 132 (70.2%), had birth weight between 2500 and 3500 grams, while 34 (18.1%) had birth weight less than 2500 grams and 22 (11.7%) had birth weight greater than 3500 grams. Male neonates were 102 (54.3%), while female neonates were 86 (45.7%). The mean Apgar score at 1 minute was 6.6 ± 1.5 . At 1 minute, 116 (61.7%) neonates had Apgar scores between 7 and 10, 60 (31.9%) had scores between 4 and 6, and 12 (6.4%) had scores between 0 and 3. After 5 minutes the mean Apgar score was significantly higher, with a score of 8.1 ± 1.2 . At 5 minutes, 154 (81.9%) neonates had Apgar scores between 7 and 10, 30 (16.0%) had scores between 4 and 6, and 4 (2.1%) had scores between

0 and 3.

Neonatal resuscitation was required in 58 (30.9%) cases and 50 (26.6%) neonates were admitted to the NICU. The most common admission diagnoses were respiratory distress (18;

9.6%), birth asphyxia (14; 7.4%), meconium aspiration (8; 4.3%), hypoglycemia (4; 2.1%), suspected sepsis (3; 1.6%) and seizures (3; 1.6%). Final early neonatal status accounted for all 188 neonates: 168 (89.4%) were stable at discharge, 17 (9.0%) were discharged with complications and 3 (1.6%) died.

The relationship between any CTG characteristics and neonatal outcomes were examined. There was reduced baseline variability, which was significantly correlated with pre-transfer characteristics of a low 5-minute Apgar score and being admitted to a NICU. Twenty two (26.8%) neonates with reduced baseline variability had low Apgar 5 scores vs 12 (11.3%) neonates with normal baseline variability. In the statistical analysis this association was statistically significant, with a p-value of 0.006. There was also a significantly higher number of neonates admitted to the NICU (30, 36.6%) versus neonates with normal variability (20, 18.9%) ($p=0.007$).

There was a strong statistically significant association between late decelerations and bad neonatal outcomes. Neonates with late deceleration had lower Apgar scores at 5 minutes compared to neonates without late deceleration, (18 (35.3%) vs. 16 (11.7%) neonates, respectively, $p<0.001$).

Table 1. Maternal, obstetric and CTG characteristics of study participants

Variable	Frequency / Mean	Percentage / SD
Total participants	188	100.0
Maternal age, years	28.4	± 5.2
18–25 years	62	33.0
26–35 years	96	51.1
36–45 years	30	16.0
BMI, kg/m ²	26.8	± 3.9
Normal BMI	64	34.0
Overweight	86	45.7
Obese	38	20.2
Primary education	56	29.8
Secondary education	78	41.5
Higher education	54	28.7
Low socioeconomic status	64	34.0
Middle socioeconomic status	102	54.3
High socioeconomic status	22	11.7
Urban residence	132	70.2
Rural residence	56	29.8
Maternal comorbidities	56	29.8
Hypertension	28	14.9
Diabetes mellitus	20	10.6
Other comorbidities	8	4.3
Gestational age at delivery, weeks	38.6	± 1.1
37–38 weeks	82	43.6
39–40 weeks	91	48.4
>40 weeks	15	8.0
Primigravida	68	36.2
Multigravida	120	63.8
Spontaneous vaginal delivery	66	35.1
Assisted vaginal delivery	18	9.6
Cesarean section	104	55.3
Normal baseline FHR	128	68.1
Fetal tachycardia	43	22.9
Fetal bradycardia	17	9.0
Normal variability	106	56.4
Reduced variability	82	43.6
No decelerations	35	18.6
Early decelerations	23	12.2
Variable decelerations	79	42.0
Late decelerations	51	27.1
Accelerations present	114	60.6
Accelerations absent	74	39.4

Table 2. Neonatal outcomes among study participants

Variable	Frequency / Mean	Percentage / SD
Birth weight, grams	2910	± 430
<2500 g	34	18.1
2500–3500 g	132	70.2
>3500 g	22	11.7
Male neonate	102	54.3
Female neonate	86	45.7
Apgar score at 1 minute	6.6	± 1.5
Apgar 0–3 at 1 minute	12	6.4
Apgar 4–6 at 1 minute	60	31.9
Apgar 7–10 at 1 minute	116	61.7
Apgar score at 5 minutes	8.1	± 1.2
Apgar 0–3 at 5 minutes	4	2.1
Apgar 4–6 at 5 minutes	30	16.0
Apgar 7–10 at 5 minutes	154	81.9
Need for neonatal resuscitation	58	30.9
NICU admission	50	26.6
Birth asphyxia	14	7.4
Respiratory distress	18	9.6
Meconium aspiration	8	4.3
Hypoglycemia	4	2.1
Suspected sepsis	3	1.6
Seizures	3	1.6
Stable at discharge	168	89.4
Discharged with complications	17	9.0
Mortality	3	1.6

Table 3. Association of CTG characteristics with low 5-minute Apgar score and NICU admission

CTG characteristic	Total n	Low Apgar at 5 min n (%)	p-value	NICU admission n (%)	p-value
Normal variability	106	12 (11.3)	0.006	20 (18.9)	0.007
Reduced variability	82	22 (26.8)		30 (36.6)	
Late decelerations absent	137	16 (11.7)	<0.001	25 (18.2)	<0.001
Late decelerations present	51	18 (35.3)		25 (49.0)	
Variable decelerations absent	109	18 (16.5)	0.508	28 (25.7)	0.744
Variable decelerations present	79	16 (20.3)		22 (27.8)	
Accelerations present	114	13 (11.4)	0.003	21 (18.4)	0.001
Accelerations absent	74	21 (28.4)		29 (39.2)	
Fetal tachycardia absent	145	21 (14.5)	0.018	32 (22.1)	0.013
Fetal tachycardia present	43	13 (30.2)		18 (41.9)	

Table 4. Exploratory multivariable logistic regression for adverse neonatal outcomes

Predictor variable	Low Apgar at 5 min AOR	95% CI	p-value	NICU admission AOR	95% CI	p-value
Reduced baseline variability	2.26	1.04–4.91	0.039	2.05	1.05–4.00	0.036
Late decelerations	3.67	1.67–8.06	0.001	2.84	1.41–5.72	0.003
Absent accelerations	2.29	1.05–5.02	0.038	1.73	0.88–3.41	0.110
Fetal tachycardia	2.03	0.90–4.57	0.087	2.12	1.01–4.46	0.047
Cesarean section	1.44	0.65–3.17	0.365	1.62	0.80–3.27	0.178
Maternal comorbidity	1.38	0.58–3.26	0.463	1.42	0.65–3.10	0.379

But neonates with late decelerations were more likely to be admitted to the NICU (25, 49.0%) than neonates without late decelerations (25, 18.2%) and this was a statistically significant finding ($p < 0.001$). A greater proportion of low Apgar scores and NICU admission was associated with variable decelerations but these associations were not statistically significant. $P < 0.003$ was significant between low score for the 5-minute Apgar, with admitting to the NICU; and absence of accelerations was significantly associated with $P < 0.001$. Furthermore, low 5 minutes Apgar score ($p = 0.018$), and admission to NICU ($p = 0.013$) were both showing significant correlation with fetal tachycardia. In the exploratory multivariable models, reduced baseline variability was associated with low 5-minute Apgar score (adjusted odds ratio [AOR] 2.26, 95% CI 1.04–4.91; $p = 0.039$) and NICU admission (AOR 2.05, 95% CI 1.05–4.00; $p = 0.036$). Late decelerations showed the largest reported adjusted associations with low 5-minute Apgar score (AOR 3.67, 95% CI 1.67–8.06; $p = 0.001$) and NICU admission (AOR 2.84, 95% CI 1.41–5.72; $p = 0.003$).

DISCUSSION:

Overall, reduced baseline variability, late decelerations, absent accelerations and fetal tachycardia were associated with adverse early neonatal outcomes in bivariate analyses. The mean Apgar score increased from 6.6 ± 1.5 at 1 minute to 8.1 ± 1.2 at 5 minutes; nevertheless, 34 (18.1%) neonates

had a low 5-minute Apgar score, 58 (30.9%) required resuscitation and 50 (26.6%) were admitted to the NICU. These findings support the clinical relevance of specific CTG features as markers of neonatal risk, but the observational design does not establish causation or prove that intervention based on CTG improves outcome.

Reduced baseline variability was present in 82 (43.6%) tracings and was associated with low 5-minute Apgar score and NICU admission. In the exploratory adjusted models, reduced variability retained statistically significant associations with both outcomes; however, these estimates should not be interpreted as proof of an independent causal effect because residual confounding and model overfitting remain possible. This finding is biologically plausible because reduced fetal heart-rate variability may occur with hypoxia/acidosis, infection, fetal sleep state or exposure to central nervous system depressant medication. Tarvonen et al. reported associations between deteriorating fetal heart-rate patterns and neonatal complications or cord-blood acidemia, while Fogelberg et al. similarly related specific deceleration patterns to neonatal acidemia.^{11,12}

Late decelerations occurred in 51 (27.1%) CTG tracings and were associated with both low 5-minute Apgar score and NICU admission. They also showed the largest adjusted odds ratios in the exploratory regression models. These associations are consistent with previous reports linking late

or prolonged deceleration patterns with fetal acidemia and neonatal complications.^{11,12} The present data therefore support late decelerations as an important marker of possible fetal compromise, while avoiding causal or intervention-effect claims. In the current study, variable decelerations were the most common deceleration pattern (42.0%). Neonates with variable deceleration did not have significantly higher rates of low 5-minute Apgar score or NICU admission, but their rates were slightly higher. This is possibly due to the compressibility of the umbilical cord during variable decelerations, which can either be temporary or reversible if there is no pathology affecting variable baseline fluctuations. Recent studies have focused on the fact that not every deceleration is equally dangerous and that the duration, depth, frequency, nature of recovery and the coexistence of a decrease in variability are more important than just the presence of the deceleration.^{12,13}

Absence of accelerations was associated with low 5-minute Apgar score and NICU admission in the bivariate analysis. In the exploratory adjusted model, absent accelerations remained associated with low 5-minute Apgar score but not with NICU admission. The previous statement that “benzodiazepines were excluded” has been removed because no such exclusion analysis was described in the Methods or Results. Accelerations should also be interpreted in clinical context because fetal sleep state and maternal medications can influence their presence.¹⁴ Fetal tachycardia was present in 43 (22.9%) tracings and was associated with low 5-minute Apgar score and NICU admission on bivariate analysis. In the exploratory multivariable analysis, the association with NICU admission remained statistically significant, whereas the association with low 5-minute Apgar score did not. Fetal tachycardia may reflect maternal fever or infection, medication exposure, fetal hypoxia or prolonged labor, and should not be interpreted as a stand-alone causal predictor of neonatal compromise.^{15,16} In the present study, the cesarean section rate for women with non-reassuring CTG was 55.3%, underscoring the high level of obstetric intervention which occurs with women with non-reassuring CTG. This rate is likely to be seen in a tertiary care centre where the CTG may often alert to the possibility of further compromise in the fetus, leading to speedy delivery. Mendez-Figueroa et al. found that, among preterm births, cesarean delivery for non-reassuring fetal heart rate (FHT) tracing was more strongly linked to composite adverse neonatal outcomes, which indicates that the non-reassuring FHT more likely represented a poor fetus rather than the mode of delivery.¹⁷

In this current study 26.6% of neonates had to be admitted to the NICU. Respiratory distress accounted for the highest number of admissions with birth asphyxia and meconium aspiration coming in next. Martin et al. demonstrated that fetal monitoring systems and intrapartum management practices are associated with unanticipated admission to the NICU.¹⁸ Consistent with this, Gao et al. reported that adverse

intrapartum outcomes such as non-reassuring fetal heart rate (nRFCHR) status and meconium stained liquor (MSL) were linked to increased obstetric interventions and fetal monitoring requirements in the newborn.¹⁹ The results are consistent with our observations that NICU admission following non-reassuring CTG is frequently multifactorial and might be due to either an underlying fetal problem or to a more conservative approach to the care of the newborn. The present study showed the neonatal mortality rate is 1.6%, and 9.0% of neonates were discharged with complications. Most neonates were stable at discharge but these adverse outcomes highlight the need for the prompt interpretation of CTG and preparedness of the neonate. Godhard et al. have evaluated FSBS in the context of a pathological fetal heart rate trace and give a rationale to consider its use for the diagnosis of fetal acidemia, though the specific use is controversial.²⁰ Ito et al. also demonstrated that the use of a structured scoring system (iPREFACE) can enhance prediction of fetal acidemia and neonatal asphyxia.¹⁵

Recent computerised CTG studies and studies based on artificial intelligence confirm the interpretation made in the present studies. M'Barek et al. had designed DeepCTG to predict the fetal hypoxia based on CTG data and McCoy et al. had reported high accuracy performance to predict the fetal acidemia by using the electronic fetal monitoring data in the presence of deep learning.^{21,22} Computerized CTG features also demonstrated good accuracy for predicting severe newborn acidemia; the incorporation of clinical features may lead to better prediction, Menzhulina et al. also demonstrated.²³ Another great problem is the interobserver variability. Neri et al. showed poor interobserver agreements in the evaluation of the intrapartum CTG by midwives according to the existing CTG guidelines.¹⁹ Similarly, Eenkhohn et al. reported on the variation of the results of various studies relating fetal heart rate patterns to neonatal outcomes, and highlighted the need of standardization when interpreting and defining outcomes in these studies.¹³ Thus the present study has provided local evidence, providing that specific characteristics of the CTG and not just the reassuring or the non-reassuring label of the CTG was associated with adverse outcomes in the neonate. Limitations: This was a single-center descriptive longitudinal study using non-probability consecutive sampling, so selection bias and limited generalizability are possible. CTG interpretation is observer-dependent and the manuscript did not document blinded central review or interobserver agreement. The original records available for revision did not preserve full regression model-building documentation, collinearity assessment or goodness-of-fit diagnostics. The exploratory low-Apgar model included six covariates but only 34 outcome events, increasing the risk of overfitting. The parity categories in the submitted summary overlapped and could not be reconstructed without patient-level data. Only immediate and early neonatal outcomes were assessed;

umbilical-cord blood gas measurements and long-term neurodevelopmental outcomes were not available.

CONCLUSION:

Reduced baseline variability and late decelerations were associated with adverse early neonatal outcomes, particularly low 5-minute Apgar score and NICU admission. Fetal tachycardia and absence of accelerations also showed associations in selected analyses. These findings support careful, standardized interpretation of intrapartum CTG as one component of clinical assessment; they do not establish causality or demonstrate that CTG-directed obstetric intervention itself improves neonatal outcomes.

Conflict of Interest: None

Fundings: No funding source

Use of Artificial Intelligence (AI) Disclosure: There is no AI tool used.

Authors Contribution:

Seemab Pirzada: Conception and design, acquisition of data analysis and interpretation of data, drafting and critical revision, final approval of the version to be published.

Shamaila Shamaun: Conception and design, acquisition of data analysis and interpretation of data, drafting and critical revision, final approval of the version to be published

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