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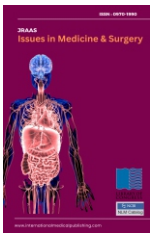

*Research Article*

**Section: Obstetrics & Gynaecology**

# Intrapartum Cardiotocography Monitoring & Its Correlation with Fetomaternal Outcome

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## HIGHLIGHTS

- Abnormal CTG predicts outcomes
- CTG linked cesarean delivery
- CTG predicts birth asphyxia
- Abnormal CTG increases NICU admissions
- Lower cord pH associated CTG

**Key Words:**
Cardiotocography
Intrapartum fetal monitoring
Perinatal outcome
APGAR score
Birth asphyxia

## ABSTRACT

**Introduction:** Intrapartum fetal monitoring with cardiotocography (CTG) is essential for identifying fetal hypoxia and reducing perinatal morbidity and mortality. This study aims to correlate intrapartum CTG patterns with fetomaternal outcomes. **Aims & Objectives:** To identify CTG patterns associated with neonatal respiratory depression and to evaluate the mode of delivery among women with abnormal CTG. **Materials & Methods:** A prospective observational study was conducted on 100 pregnant women at ≥34 weeks of gestation in a tertiary care hospital. CTG patterns were classified as reassuring, suspicious, or pathological according to NICE guidelines. Maternal demographics, labor characteristics, and neonatal outcomes, including APGAR scores, birth asphyxia, NICU admissions, and cord blood pH were recorded and analyzed. **Results:** Pathological and suspicious CTG patterns were observed in 17% and 23% of cases, respectively. Significant associations were found between abnormal CTG and meconium-stained liquor ($p<0.001$), cesarean section ($p<0.001$), and instrumental delivery ($p<0.001$). All cases with reassuring CTG had normal vaginal deliveries without birth asphyxia. Neonatal outcomes, including low APGAR scores at 1 and 5 minutes, birth asphyxia, and NICU admission, were significantly associated with pathological and suspicious CTG patterns ($p<0.001$). Mean cord blood pH was significantly lower in pathological (7.04±0.11) and suspicious (7.01±0.1) groups compared to the reassuring group (7.17±0.1) ($p<0.001$). **Conclusion:** Intrapartum CTG monitoring is a valuable tool for predicting adverse perinatal outcomes. Pathological and suspicious CTG patterns correlate significantly with neonatal respiratory depression, increased cesarean section rates, and NICU admissions.

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## INTRODUCTION

The intrapartum period is a critical phase during which uterine contractions may transiently reduce uteroplacental blood flow, exposing the fetus to physiological stress and potential hypoxia. Continuous fetal surveillance is therefore essential to detect early signs of fetal compromise and facilitate timely intervention. Electronic fetal monitoring using cardiotocography (CTG) has become the most widely used method for intrapartum fetal assessment because it provides continuous information regarding fetal heart rate (FHR) patterns and uterine contractions. CTG enables clinicians to identify abnormalities suggestive of fetal hypoxia or acidosis, allowing appropriate interventions such as maternal repositioning, intravenous fluid administration, oxygen supplementation, discontinuation of uterotonic agents, or expedited delivery when necessary. Consequently, CTG plays a pivotal role in reducing perinatal morbidity and mortality, particularly among high-risk pregnancies [1,2].

Cardiotocography records fetal heart rate and uterine activity simultaneously, allowing interpretation of several important parameters, including baseline fetal heart rate, baseline variability, accelerations, and decelerations. These parameters reflect the functional integrity of the fetal autonomic nervous system and fetal oxygenation status. A normal baseline heart rate ranges between 110 and 160 beats per minute, while moderate baseline variability indicates adequate fetal neurological function and oxygen reserve. Accelerations are reassuring signs of fetal well-being, whereas recurrent late decelerations, prolonged bradycardia, absent variability, or severe variable decelerations may indicate uteroplacental insufficiency and fetal hypoxia. CTG interpretation should therefore consider the overall tracing rather than isolated abnormalities, enabling clinicians to distinguish reassuring from pathological patterns and institute appropriate management [3,4].

Perinatal morbidity and mortality continue to represent significant public health concerns worldwide, particularly in low- and middle-income countries where birth asphyxia remains an important cause of neonatal death and long-term neurological disability. Intrapartum hypoxia contributes substantially to low Apgar scores, neonatal encephalopathy, respiratory depression, metabolic acidosis, and increased neonatal intensive care unit (NICU) admissions. Evidence suggests that timely recognition of fetal distress through effective intrapartum monitoring, coupled with prompt obstetric intervention and neonatal resuscitation, can significantly reduce these adverse outcomes. Although CTG does not perfectly predict fetal compromise, its excellent negative predictive value provides reassurance regarding fetal well-being and assists clinicians in identifying pregnancies requiring closer surveillance and intervention [5,6].

Abnormal CTG patterns significantly influence obstetric decision-making during labour. Persistent pathological tracings frequently prompt intrauterine resuscitative measures and, when abnormalities fail to resolve, operative delivery through cesarean section or assisted vaginal birth. However, continuous CTG monitoring has also been associated with increased operative delivery rates because of its relatively high false-positive rate.

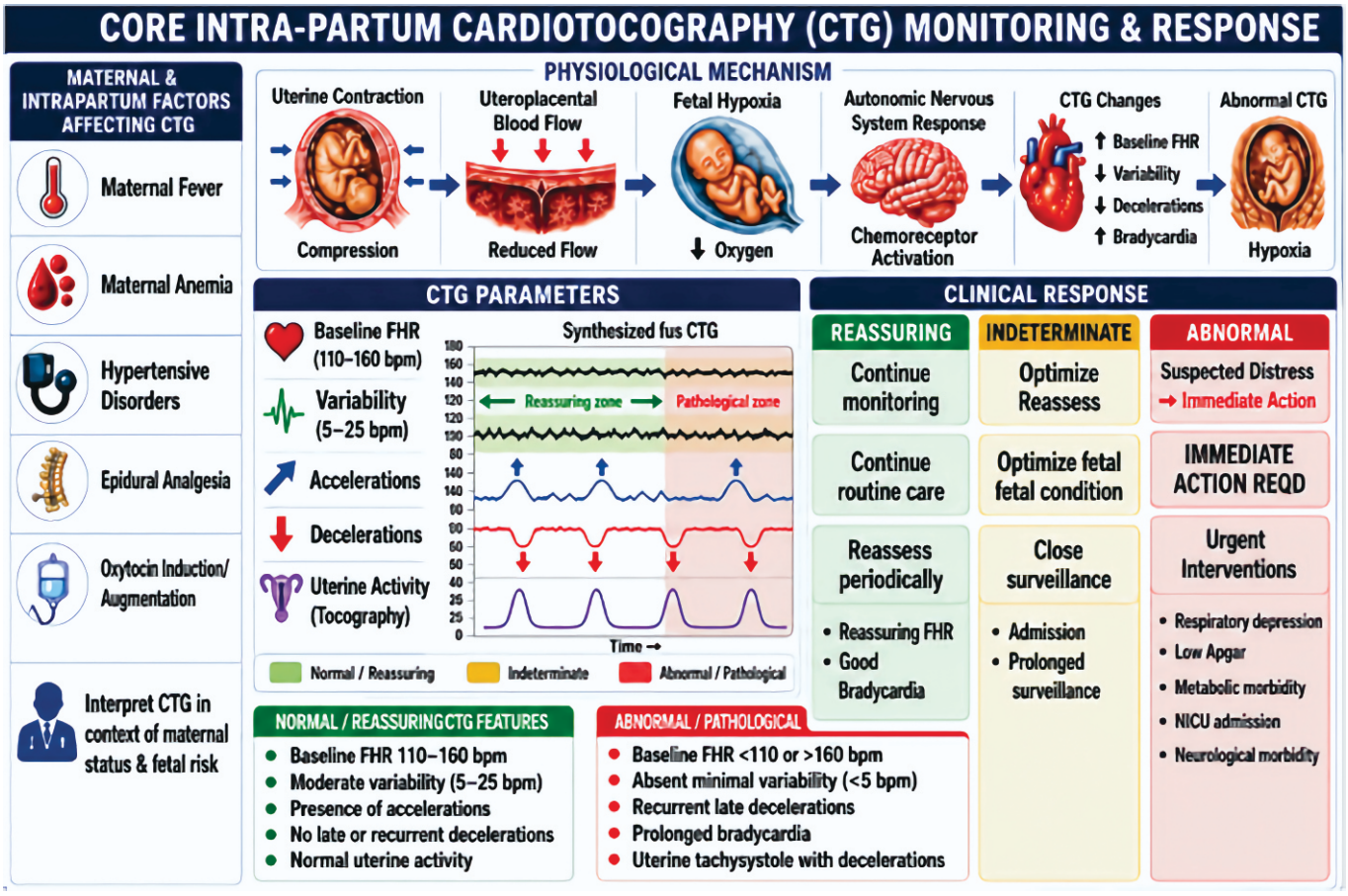


**Figure 1: Intrapartum cardiotocography (CTG) monitoring and its correlation with fetomaternal outcomes.**

Many fetuses with non-reassuring CTG patterns are subsequently born without evidence of hypoxia or metabolic acidosis. Therefore, CTG findings should always be interpreted alongside the overall clinical picture, including labour progress, maternal condition, fetal risk factors, and, where available, adjunctive investigations such as fetal scalp blood sampling or lactate estimation. This comprehensive approach minimizes unnecessary interventions while ensuring timely management of genuine fetal compromise [7,8].

Several maternal and intrapartum factors may alter CTG interpretation and should always be considered during clinical assessment. Maternal fever commonly produces fetal tachycardia, while maternal anemia and hypertensive disorders may impair placental perfusion, increasing fetal susceptibility to hypoxic changes. Epidural analgesia can cause maternal hypotension and secondary alterations in fetal heart rate patterns. Likewise, labour induction or augmentation with oxytocin may result in uterine tachysystole, reducing fetal oxygenation and producing transient CTG abnormalities without true fetal compromise. Recognition of these influencing factors is essential to avoid both underdiagnosis of fetal distress and unnecessary operative intervention. Accordingly, current international guidelines recommend that CTG interpretation should always be integrated with maternal clinical status, labour characteristics, and fetal risk assessment to ensure accurate diagnosis and optimal perinatal outcomes [9-11]. **Figure 1.** The figure illustrates the relationship between maternal and intrapartum factors, CTG patterns, fetal hypoxia, clinical interventions, delivery decisions, and their impact on feto-maternal outcomes. Early identification of abnormal CTG patterns facilitates timely management and improves perinatal outcomes.

The study aims to evaluate how intrapartum CTG changes correlate with subsequent clinical management decisions and perinatal outcomes. The objectives are to determine which CTG patterns are associated with an increased risk of neonatal respiratory depression and to assess the mode of delivery among women who exhibit abnormal CTG findings, thereby identifying patterns that may necessitate operative or cesarean intervention.

## MATERIAL & METHODS

This prospective observational study was conducted at the Department of Obstetrics and Gynecology, KD Medical College and Hospital, Mathura from 2023 to 2026. Ethical approval has been obtained from the Ethical Approval Committee of KD Medical College and Hospital, Mathura.

### *Study Population*

The study population comprised pregnant women admitted to the labor room of K. D. Medical College Hospital and Research Centre, Mathura, during the study period. Participants were enrolled consecutively after providing informed consent until the required sample size was achieved. Eligible women included those in labor with a gestational age of more than 34 weeks and less than 42 weeks, excluding multiple pregnancies, non-viable fetuses, congenital anomalies, intrauterine fetal demise, and those refusing continuous CTG monitoring.

### *Data Analysis*

Data were entered into SPSS version 26 and Microsoft Excel for statistical analysis and report generation. Descriptive statistics, including frequencies, proportions, rates, ratios, means, and standard deviations, were used to summarize the data. Categorical variables were analyzed using the chi-square test, with a p-value of less than 0.05 considered statistically significant. Baseline comparability was assessed for age, BMI, parity, and obstetric history, with stratified analysis performed where appropriate.

## RESULTS

Among the 100 study participants, the majority were aged 27–31 years (29%), followed by 36–40 years (23%), while 13% belonged to the 22–27 years age group. Gravidity was almost equally distributed between second and third gravida (28% each), followed by fourth gravida (24%) and primigravida (20%). Most women were para 1 (39%), and 53% were categorized as low-risk pregnancies. Reassuring CTG patterns were observed in 60% of women, while 23% had suspicious and 17% had pathological tracings. Normal baseline variability was present in 52%, whereas 48% demonstrated reduced variability. Two or more accelerations were recorded in 60% of cases, while 60% had no decelerations, 95% had no early decelerations, and 65% had no late decelerations. Resuscitative measures were required in 37% of women, with maternal repositioning (16%) and intravenous fluids with oxygen (13%) being the most common interventions. Hyperstimulation occurred in 45% of cases, and oxytocin was administered in 51%. CTG abnormalities were most frequently detected during the latent phase of labor (45%), followed by the second stage (31%) and active phase (24%). Clear amniotic fluid was observed in 75% of deliveries, while meconium-stained liquor was present in 25%. Normal vaginal delivery was the predominant mode of birth (60%), whereas 28% underwent cesarean section and 12% required instrumental delivery. Most neonates achieved favorable Apgar scores, with 51% scoring 8–9 at one minute and 66% scoring 9–10 at five minutes. Birth asphyxia occurred in 31% of neonates, while 37% required NICU admission, indicating that although the majority experienced favorable maternal and neonatal outcomes, abnormal CTG findings were associated with increased neonatal morbidity and obstetric intervention.

NICU admission was significantly associated with CTG pattern ($\chi^2$=58.66, p<0.001), with most neonates having reassuring CTG not requiring NICU admission (54%), whereas suspicious CTG was strongly associated with NICU admission (23%), indicating a significant relationship between abnormal CTG findings and adverse neonatal outcomes **(Table 1)**. Birth asphyxia showed a highly significant association with CTG pattern ($\chi^2$=80.20, p<0.001), with all reassuring CTG cases free of birth asphyxia (60%), while suspicious (23%) and pathological (8%) CTG

patterns were strongly associated with birth asphyxia, indicating that abnormal CTG findings predict adverse neonatal outcomes **(Table 2)**. The 1-minute APGAR score was significantly associated with CTG pattern ($\chi^2$=69.69, p<0.001), with reassuring CTG predominantly associated with higher APGAR scores (7–9), while suspicious and pathological CTG patterns were linked to lower APGAR scores (3–6), indicating poorer immediate neonatal condition **(Table 3)**. The 5-minute APGAR score showed a highly significant association with CTG pattern ($\chi^2$=65.02, p<0.001), with reassuring CTG predominantly associated with higher APGAR scores (8–10), whereas suspicious and pathological CTG patterns were linked to lower APGAR scores (4–7), indicating poorer neonatal recovery following delivery **(Figure 2)**. The color of liquor was significantly associated with CTG pattern ($\chi^2$=21.49, p<0.001), with reassuring CTG predominantly observed in cases with clear liquor (53%), while suspicious and pathological CTG patterns were more frequent in meconium-stained liquor, indicating an increased risk of fetal compromise **(Table 4)**. Mode of delivery was significantly associated with CTG pattern ($\chi^2$=101.47, p<0.001), with all women having reassuring CTG undergoing normal vaginal delivery (60%), whereas pathological and suspicious CTG patterns were strongly associated with cesarean (28%) and instrumental deliveries (12%), reflecting increased obstetric intervention in the presence of abnormal CTG findings **(Figure 3)**. Descriptive analysis showed no significant differences in age, gestational age, baseline fetal heart rate, time to abnormal CTG detection, or birth weight across CTG patterns (p>0.05). However, cord blood pH differed significantly (Kruskal–Wallis=32.93, p<0.001), with pathological and suspicious CTG patterns demonstrating lower mean cord pH than reassuring CTG, indicating a strong association between abnormal CTG findings and fetal acidosis **(Table 5)**.

**Table 1: Distribution of CTG_Pattern by NICU_Admission**

| | CTG_Pattern | | | |
|---|---|---|---|---|
| **NICU_Admission** | **Pathological** | **Reassuring** | **Suspicious** | **Total** |
| No | 9 (9.0%) | 54 (54.0%) | 0 (0.0%) | 63 (63.0%) |
| Yes | 8 (8.0%) | 6 (6.0%) | 23 (23.0%) | 37 (37.0%) |
| Total | 17 (17.0%) | 60 (60.0%) | 23 (23.0%) | 100 (100.0%) |

**Table 2: Distribution of CTG_Pattern by Birth_Asphyxia**

| | CTG_Pattern | | | |
|---|---|---|---|---|
| **Birth_Asphyxia** | **Pathological** | **Reassuring** | **Suspicious** | **Total** |
| No | 9 (9.0%) | 60 (60.0%) | 0 (0.0%) | 69 (69.0%) |
| Yes | 8 (8.0%) | 0 (0.0%) | 23 (23.0%) | 31 (31.0%) |
| Total | 17 (17.0%) | 60 (60.0%) | 23 (23.0%) | 100 (100.0%) |

**Table 3: Distribution of CTG_Pattern by APGAR_1min**

| | **CTG_Pattern** | | | |
|---|---|---|---|---|
| **APGAR_1min** | **Pathological** | **Reassuring** | **Suspicious** | **Total** |
| 3 | 0 (0.0%) | 0 (0.0%) | 8 (8.0%) | 8 (8.0%) |
| 4 | 3 (3.0%) | 3 (3.0%) | 6 (6.0%) | 12 (12.0%) |
| 5 | 3 (3.0%) | 3 (3.0%) | 6 (6.0%) | 12 (12.0%) |
| 6 | 2 (2.0%) | 0 (0.0%) | 3 (3.0%) | 5 (5.0%) |
| 7 | 4 (4.0%) | 21 (21.0%) | 0 (0.0%) | 25 (25.0%) |
| 8 | 2 (2.0%) | 10 (10.0%) | 0 (0.0%) | 12 (12.0%) |
| 9 | 3 (3.0%) | 23 (23.0%) | 0 (0.0%) | 26 (26.0%) |
| **Total** | **17 (17.0%)** | **60 (60.0%)** | **23 (23.0%)** | **100 (100.0%)** |

**Table 4: Distribution of CTG_Pattern by Color_of_Liquor**

| | **CTG_Pattern** | | | |
|---|---|---|---|---|
| **Color_of_Liquor** | **Pathological** | **Reassuring** | **Suspicious** | **Total** |
| Clear | 13 (13.0%) | 53 (53.0%) | 9 (9.0%) | 75 (75.0%) |
| Meconium stained | 4 (4.0%) | 7 (7.0%) | 14 (14.0%) | 25 (25.0%) |
| Total | 17 (17.0%) | 60 (60.0%) | 23 (23.0%) | 100 (100.0%) |

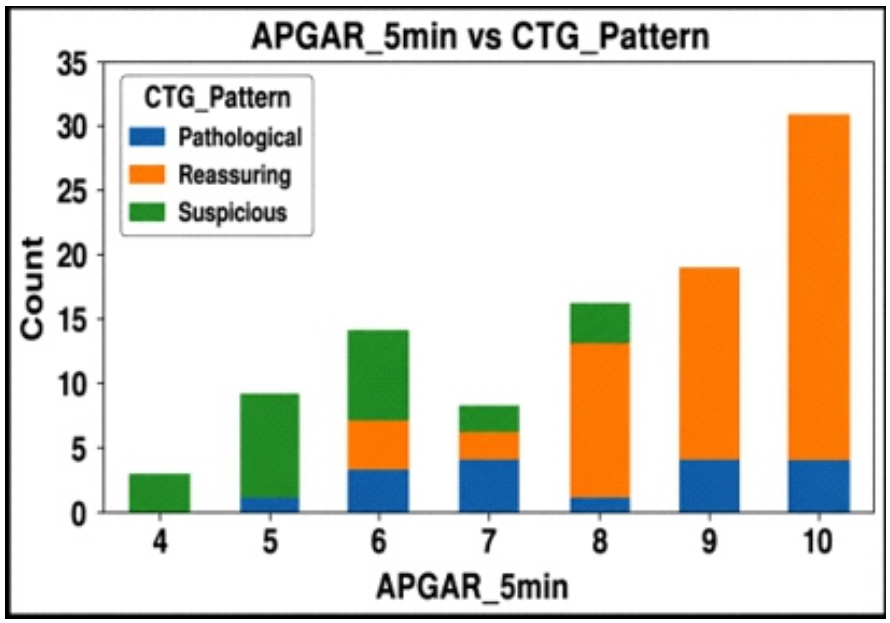


**Figure 2: Distribution of APGAR_5min vs CTG_Pattern**

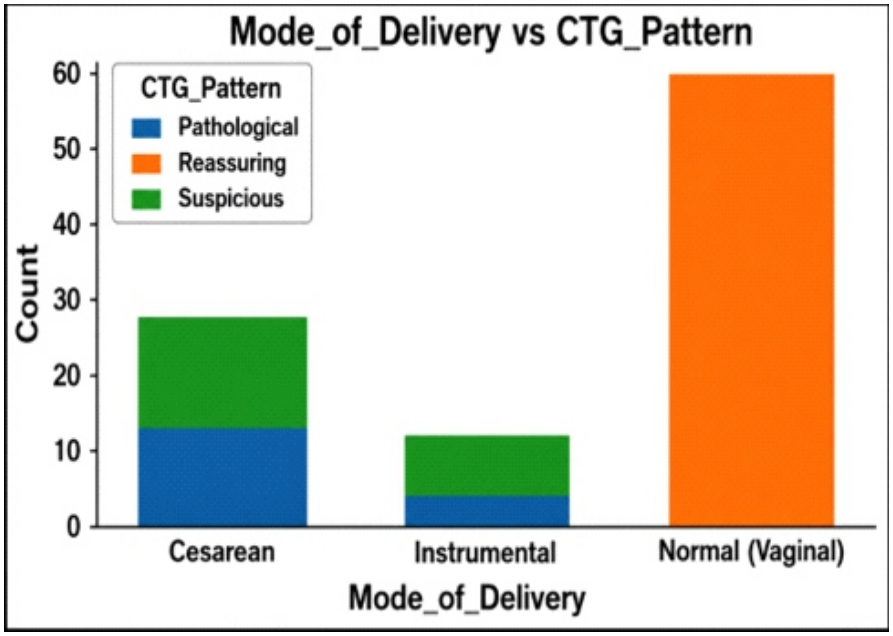


**Figure 3: Distribution of Mode_of_Delivery vs CTG_Pattern**

**Table 5: Descriptive Statistics by CTG_Pattern**

| Variable | CTG_Pattern | | | | |
|---|---|---|---|---|---|
| | Pathological | Reassuring | Suspicious | Kruskal-Wallis Statistic | p-value |
| | Mean ± SD | Mean ± SD | Mean ± SD | | |
| Age | 28.35 ± 5.29 | 30.22 ± 6.77 | 30.57 ± 6.01 | 2.0782 | 0.3538 |
| Gestational_Age_weeks | 36.71 ± 1.53 | 37.92 ± 2.07 | 37.55 ± 1.63 | 5.714 | 0.0574 |
| Baseline_FHR | 135.18 ± 13.31 | 133.15 ± 15.45 | 137.74 ± 13.12 | 1.5487 | 0.461 |
| Time_Abnormal_CTG_Detection_hr | 5.29 ± 1.75 | 5.15 ± 1.8 | 4.77 ± 1.64 | 0.9667 | 0.6167 |
| Birth_Weight_kg | 2.85 ± 0.42 | 2.91 ± 0.44 | 2.89 ± 0.44 | 0.2435 | 0.8854 |
| Cord_pH | 7.04 ± 0.11 | 7.17 ± 0.1 | 7.01 ± 0.1 | 32.9342 | 0.0 |

## DISCUSSION

Intrapartum cardiotocography (CTG) remains one of the most widely accepted methods for continuous fetal surveillance during labor because of its ability to identify early signs of fetal hypoxia and facilitate timely obstetric intervention. In the present study, CTG findings demonstrated a significant association with both maternal and neonatal outcomes, supporting its clinical value in intrapartum management. The demographic profile of the study population revealed that most women belonged to the 27–31-year age group, with a predominance of multigravida and para 1 women. **Singh SK, et. al; 2022,** included a relatively older maternal population and a higher proportion of multiparous women, factors that may influence labor progression, CTG interpretation, and delivery outcomes. Similar observations regarding the influence of maternal age, gravidity, and parity on intrapartum outcomes have been reported by earlier investigators [12,13].

Nearly half of the participants were categorized as high-risk pregnancies, a distribution comparable to other prospective studies evaluating intrapartum CTG. Previous literature consistently demonstrates that high-risk pregnancies exhibit a greater incidence of non-reassuring CTG patterns, increased operative deliveries, lower Apgar scores, and higher NICU admissions than low-risk pregnancies. Correspondingly, our study observed a relatively higher proportion of suspicious and pathological CTG tracings than many published reports, suggesting that the greater representation of high-risk pregnancies may have contributed to the increased prevalence of abnormal fetal heart rate patterns [12,14,15].

Assessment of CTG characteristics showed that reduced baseline variability, absence of accelerations, and the presence of decelerations, particularly late decelerations, were frequently associated with adverse neonatal outcomes. Nearly half of the study population demonstrated reduced variability, a proportion exceeding that reported in several previous studies. Reduced variability is widely recognized as an indicator of impaired fetal oxygenation and has been significantly associated with fetal acidemia, low Apgar scores, and increased perinatal morbidity. Conversely, the presence of multiple accelerations generally reflected reassuring fetal status and favorable neonatal outcomes, while persistent decelerations, especially late decelerations, indicated fetal compromise and an increased likelihood of operative intervention [16,17]. Maternal resuscitative measures, including maternal repositioning, oxygen administration, intravenous fluid infusion, and discontinuation of oxytocin, were implemented in selected patients with abnormal CTG patterns. Although the frequency of these interventions was lower than that reported in large multicenter studies, their use reflects current recommendations aimed at improving uteroplacental perfusion before considering operative delivery. Uterine hyperstimulation and oxytocin augmentation were observed in a considerable proportion of patients and may have contributed to the occurrence of non-reassuring CTG patterns [12,18].

Most women had clear amniotic fluid, while one-quarter presented with meconium-stained liquor. Meconium staining demonstrated a strong association with suspicious and pathological CTG patterns, consistent with previous evidence indicating increased fetal distress, operative delivery, and adverse neonatal outcomes in such pregnancies. Normal vaginal delivery remained the predominant mode of delivery in the present study; however, pathological and suspicious CTG patterns were strongly associated with increased cesarean section and instrumental deliveries, corroborating findings from several observational studies that identified abnormal CTG as an important determinant of operative intervention [12,19,20].

Neonatal outcomes further emphasized the predictive value of CTG monitoring. Lower Apgar scores, birth asphyxia, and NICU admissions were significantly more common among neonates with pathological or suspicious CTG tracings, whereas reassuring CTG patterns were consistently associated with favorable neonatal adaptation. Although our study reported higher rates of birth asphyxia and NICU admission than several published cohorts, these differences may reflect the greater proportion of high-risk pregnancies and abnormal CTG findings in the study population. Furthermore, umbilical cord pH was significantly lower among pathological and suspicious CTG groups, confirming the established relationship between abnormal fetal heart rate patterns, fetal acidemia, and neonatal compromise [12,21,22].

Overall, the present findings reinforced that intrapartum CTG is an effective screening tool for identifying fetuses at risk of hypoxia and adverse perinatal outcomes. Although its high sensitivity may contribute to increased operative delivery rates because of limited specificity, CTG remains invaluable when interpreted alongside clinical findings and obstetric risk factors. Appropriate interpretation of CTG patterns, combined with timely obstetric intervention, can improve fetomaternal outcomes while minimizing unnecessary operative procedures, thereby supporting its continued role as an essential component of modern intrapartum fetal surveillance [21,22].

## CONCLUSION

This study of 100 laboring women concludes that intrapartum cardiotocography (CTG) is an effective tool for assessing fetal well-being and predicting fetomaternal outcomes. Reassuring CTG patterns were strongly associated with normal vaginal delivery, favorable APGAR scores, normal cord blood pH, and absence of birth asphyxia. In contrast, suspicious and pathological CTG patterns were significantly linked to fetal acidosis, low APGAR scores, birth asphyxia, NICU admission, and operative delivery for fetal distress. CTG monitoring proved valuable in guiding timely clinical interventions and improving perinatal outcomes in labor management.

## LIMITATIONS & FUTURE PERSPECTIVES

The study's limitations include a single-centre setting, a relatively small sample size, and a short study duration, which may limit the

broader applicability of the results. Future studies should incorporate multicentre designs with larger populations to enhance validity, assess long-term outcomes, and investigate advanced diagnostic & management approaches. Such efforts will improve overall patient care & help minimize complications.

## CLINICAL SIGNIFICANCE

The clinical significance of this study lies in its potential to bridge the gap between research findings and practical health-.care, diagnosis, and treatment outcomes. By highlighting real-care applications. It emphasizes the importance of translating scientific observations into meaningful improvements in patient world relevance, the study contributes to evidence based medical practice and supports informed clinical decision making. Ultimately, the findings aim to enhance patient quality of life, optimize therapeutic strategies, and promote better disease management in clinical settings.

## ABBREVIATIONS

**CTG:** Cardiotocography
**NICU:** Neonatal Intensive Care Unit
**APGAR:** Appearance, Pulse, Grimace, Activity, Respiration
**FHR:** Fetal Heart Rate
**IV:** Intravenous

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## AUTHOR CONTRIBUTIONS

All authors significantly contributed to the study conception and design, data acquisition, or data analysis and interpretation. They participated in drafting the manuscript or critically revising it for important intellectual content, consented to its submission to the current journal, provided final approval for the version to be published, and accepted responsibility for all aspects of the work. Additionally, all authors meet the authorship criteria outlined by the International Committee of Medical Journal Editors (ICMJE) guidelines.

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## CONFLICT OF INTEREST

Authors declared that there is no conflict of interest.

## FUNDING

None

## ETHICAL APPROVAL & CONSENT TO PARTICIPATE

All necessary consent & approval was obtained by authors.

## CONSENT FOR PUBLICATION

All necessary consent for publication was obtained by authors.

## DATA AVAILABILITY

All data generated and analyzed are included within this research article. The datasets utilized and/or analyzed in this study can be obtained from the corresponding author upon a re-asonable request.

## USE OF ARTIFICIAL INTELLIGENCE (AI) & LARGE LANGUAGE MODEL (LLM)

The authors confirm that no AI & LLM tools were used in the writing or editing of the manuscript, and no images were altered or manipulated using AI & LLM.

## AUTHOR'S NOTE

This article serves as an important educational tool for the scientific community, offering insights that may inspire future research diretions. However, they should not be relied upon independently when making treatment decisions or developing public health policies.

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