

Original Research Article

STUDY OF CARDIOTOCOGRAPH IN ANTENATAL WOMEN IN FIRST STAGE OF LABOUR

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ABSTRACT

Background: Intrapartum fetal surveillance is essential for early identification of fetal compromise during labour. Cardiotocography (CTG) is a widely used non-invasive method for assessing fetal wellbeing, although its relationship with fetal and neonatal outcomes remains variable. **Objectives:** To evaluate the association between CTG patterns in the first stage of labour and fetal distress, mode of delivery and neonatal outcomes.

Materials and Methods: This study included 300 term antenatal women in the first stage of labour admitted to the Department of Obstetrics and Gynaecology. All women underwent CTG recording and the tracings were classified as normal, suspicious or pathological. Maternal and intrapartum outcomes, including meconium-stained liquor, fetal distress and mode of delivery, were recorded. Neonatal outcomes were assessed using Apgar scores, neonatal complications and NICU-related outcomes. The diagnostic performance of CTG was assessed using sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV).

Results: Of the 300 women, 228 (76.0%) had normal CTG, 38 (12.67%) had suspicious CTG and 34 (11.33%) had pathological CTG. Fetal distress occurred in 17.10% of the normal group, 34.21% of the suspicious group and 73.53% of the pathological group ($p < 0.0001$). Meconium-stained liquor was observed in 9.21%, 31.58% and 47.06% of the respective groups. LSCS was performed in 10.09% of women with normal CTG, 84.21% with suspicious CTG and 91.18% with pathological CTG. Among neonates in the pathological CTG group, 55.89% had Apgar <7 at 1 minute and 20.59% had Apgar <7 at 5 minutes. Meconium aspiration syndrome, neonatal seizures and hypoxic-ischaemic encephalopathy occurred in 14.70%, 17.65% and 8.82%, respectively. CTG demonstrated a sensitivity of 49.35%, specificity of 84.75%, PPV of 52.78% and NPV of 82.89%.

Conclusion: CTG is a useful, simple and non-invasive method of intrapartum fetal surveillance and is significantly associated with fetal distress, operative delivery and adverse neonatal outcomes. Its relatively high specificity and negative predictive value support its usefulness in identifying fetuses unlikely to have significant compromise. However, its lower sensitivity and positive predictive value indicate that CTG findings should be interpreted in conjunction with maternal risk factors, labour progress and other clinical findings rather than being used as an isolated diagnostic test for fetal hypoxia.

Keywords: Cardiotocography; fetal distress; intrapartum fetal monitoring; labour; Apgar score; neonatal outcome; caesarean section.

INTRODUCTION

Labour is a period of considerable physiological stress for the fetus, particularly because uterine contractions impose repeated transient reductions in uteroplacental perfusion. The ability of the fetus to tolerate this stress is an important determinant of intrapartum wellbeing. Consequently, assessment of fetal condition during labour remains a fundamental component of obstetric care, with the fetus requiring surveillance for evidence of evolving hypoxia and compromise.^[1]

Intrapartum fetal hypoxia, when unrecognized or inadequately managed, may be associated with adverse neonatal outcomes. Therefore, timely identification of fetuses at risk and appropriate obstetric intervention are essential to minimize fetal morbidity and mortality. An ideal method of fetal surveillance should be non-invasive, reliable, readily available, reproducible and sufficiently easy to interpret to facilitate timely clinical decision-making. Fetal heart rate monitoring during labour can be performed by intermittent auscultation or electronic fetal monitoring. Although intermittent auscultation remains an established method of fetal assessment, its intermittent and subjective nature may limit continuous assessment, documentation and verification, particularly in busy labour wards with limited personnel. Electronic fetal monitoring provides a continuous, non-invasive and recordable assessment of fetal heart rate and uterine activity, potentially allowing earlier recognition of fetal compromise and facilitating timely intervention.^[2,3] Cardiotocography (CTG), which simultaneously assesses fetal heart rate patterns and uterine activity, is therefore widely used for antenatal and intrapartum fetal surveillance. Changes in baseline heart rate, variability, accelerations and decelerations provide information regarding the fetal response to the physiological stress of labour. However, CTG abnormalities do not invariably indicate fetal hypoxia, and interpretation must be considered in the context of the overall clinical picture. The clinical impact of CTG on neonatal outcomes has also remained an area of ongoing debate.

The clinical relevance of CTG abnormalities can be assessed by examining their relationship with immediate maternal and neonatal outcomes. In the study material, pathological CTG patterns were associated with a substantially higher incidence of fetal distress, with fetal distress occurring in 73.53% of the pathological group compared with 34.21% of the suspicious group and 17.1% of the normal group. Similarly, abnormal CTG patterns were associated with increased operative delivery; 91.18% of women with pathological CTG tracings underwent lower-segment caesarean section compared with 10.09% of those with normal tracings.^[4,5]

Neonatal outcomes also demonstrated an association with CTG classification. Babies born following pathological CTG patterns had higher frequencies of

low Apgar scores and neonatal complications, including meconium aspiration syndrome, neonatal seizures and hypoxic-ischaemic encephalopathy. In the study population, 55.89% of neonates in the pathological CTG group had an Apgar score below 7 at one minute, while meconium aspiration syndrome, neonatal seizures and hypoxic-ischaemic encephalopathy were more frequently observed in the pathological group.

These findings emphasize the potential value of CTG as an intrapartum surveillance tool, particularly for identifying fetuses who may require closer monitoring or timely delivery. At the same time, the reported diagnostic performance in the study showed relatively high specificity and negative predictive value, but lower sensitivity and positive predictive value, highlighting that CTG findings should not be interpreted in isolation.^[6]

Therefore, evaluation of CTG patterns in relation to fetal distress, mode of delivery and short-term neonatal outcomes is clinically relevant. The present study was undertaken to assess the association between cardiotocographic patterns during the first stage of labour and maternal and neonatal outcomes, with particular emphasis on fetal distress, mode of delivery, Apgar scores and neonatal complications.

MATERIALS AND METHODS

Study Design and Setting

This cross-sectional study was conducted in the Department of Obstetrics and Gynaecology, Government General Hospital, Nalgonda, over a period of two years from October 2023 to September 2025. The study included antenatal women at term gestation who were admitted to the labour ward in the first stage of labour with a cephalic presentation.

Study Participants

A total of 300 antenatal women in the first stage of labour were included in the study. A detailed history was obtained regarding the last menstrual period, parity, previous obstetric history, antenatal care, medical history, immunization and dietary status. Each participant underwent a general, physical and systemic examination. Obstetric assessment included abdominal and per-vaginal examination, assessment of gestational age, liquor, cervical dilatation and effacement, membrane status, station of the presenting part and pelvic assessment.

Inclusion Criteria

Women fulfilling the following criteria were included:

- Term antenatal women in the first stage of labour.
- Women with cephalic presentation.
- Women with relevant maternal or obstetric risk factors, including hypertensive disorders of pregnancy, diabetes mellitus, antepartum haemorrhage, intrauterine growth restriction, oligohydramnios, polyhydramnios, maternal pyrexia and heart disease.

Exclusion Criteria

The study excluded:

- Preterm and post-term pregnancies in labour.
- Multiple gestations in labour.

Clinical and Laboratory Assessment

Routine investigations, including haemogram, blood grouping and Rh typing, blood glucose screening and complete urine examination, were performed. Additional investigations were undertaken when clinically indicated. Ultrasonography findings were also recorded.

Cardiotocography

Admission cardiotocography was performed for all participants. Before CTG recording, information regarding recent food intake, medications and time of the day was documented because these factors could influence fetal activity. The procedure was explained to each woman, and cooperation was obtained before recording. The woman was positioned in the left lateral position. The fetal heart was localized and an ultrasound transducer was placed over the maternal abdomen using coupling gel and secured with an adjustable elastic strap. Uterine activity was simultaneously assessed using an external pressure-sensitive tocodynamometer positioned over the uterine fundus and secured with a belt. CTG was recorded for 20 minutes. The tracing was assessed for baseline fetal heart rate, baseline variability, accelerations and decelerations. Based on the CTG findings, tracings were classified as **normal, suspicious or pathological**. Women with reactive/normal tracings were subsequently monitored intermittently by auscultation. Those with persistently suspicious tracings were placed on continuous CTG monitoring. In women with pathological tracings, particularly those demonstrating late, significant variable or prolonged decelerations, delivery was expedited as clinically indicated.

Intrapartum and Maternal Outcomes

Progress of labour was monitored using a partogram. The colour of the liquor was recorded, particularly noting the presence or absence of meconium staining. The mode of delivery was documented and categorized as vaginal, instrumental or lower-segment caesarean section (LSCS). Where LSCS was performed, the indication for operative delivery was recorded.

Neonatal Outcomes

Neonatal outcome was assessed using Apgar scores at 1 and 5 minutes after birth. Admission to the neonatal intensive care unit (NICU) and neonatal complications were also recorded. The neonatal complications assessed included meconium aspiration syndrome, neonatal seizures and hypoxic-ischaemic encephalopathy. Mothers and neonates were followed until discharge. The study material demonstrated increasing neonatal morbidity across the normal, suspicious and pathological CTG groups.

Statistical Analysis

Data collected during the study were analyzed using the chi-square test for categorical variables. A *p* value of <0.05 was considered statistically significant. The diagnostic performance of CTG was assessed using sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV). In the study, sensitivity was 49.35%, specificity was 84.75%, PPV was 52.78% and NPV was 82.89%. The association between CTG classification and fetal distress, liquor colour, mode of delivery, Apgar scores and neonatal complications was assessed statistically.

RESULTS

A total of 300 antenatal women in the first stage of labour at term gestation were included in the study. The demographic characteristics, CTG patterns, maternal risk factors, intrapartum findings, mode of delivery and neonatal outcomes were evaluated.

Table 1: Distribution of study participants according to maternal details (N = 300)

Maternal age (years)	n	%
16–20	93	31.00
21–25	163	54.33
26–30	39	13.00
31–35	5	1.67
Total	300	100.00
Gravidity		
Primigravida	175	58.34
Gravida 2	91	30.34
Gravida 3	28	9.33
Gravida 4	5	1.66
Gravida 5	1	0.33
Gestational age (weeks)		
37	81	27.00
38	86	28.67
39	83	27.67
40	50	16.66
CTG pattern		
Normal	228	76.00
Suspicious	38	12.67
Pathological	34	11.33

The majority of women (54.33%) were aged 21–25 years, followed by those aged 16–20 years (31.0%). Primigravidas constituted the largest group (58.34%), followed by women who were gravida 2 (30.34%). The largest proportion of women were at 38 weeks of gestation (28.67%), followed by 39

weeks (27.67%), 37 weeks (27.0%) and 40 weeks (16.66%).

Normal CTG tracings were observed in 228 (76.0%) women, while 38 (12.67%) had suspicious and 34 (11.33%) had pathological tracings.

Table 2: Distribution of maternal risk factors according to CTG pattern (N = 80)

Maternal risk factor	Normal, n (%)	Suspicious, n (%)	Pathological, n (%)
Abruptio placenta (n=2)	0	1 (4.17)	1 (7.69)
Oligohydramnios (n=13)	5 (11.63)	6 (25.00)	2 (15.38)
Pregnancy-induced hypertension (n=31)	15 (34.90)	10 (41.67)	6 (46.17)
Gestational diabetes mellitus (n=4)	2 (4.64)	2 (8.33)	0
PROM (n=11)	8 (18.60)	2 (8.33)	1 (7.69)
Anaemia (n=18)	13 (30.23)	3 (12.50)	2 (15.38)
Cord prolapse (n=1)	0	0	1 (7.69)
Total	43	24	13
Colour of liquor			
Clear	207 (90.79)	26 (68.42)	18 (52.94)
Meconium stained	21 (9.21)	12 (31.58)	16 (47.06)
Mode of delivery			
Vaginal delivery	184 (80.70)	2 (5.26)	2 (5.88)
Instrumental delivery	21 (9.21)	4 (10.53)	1 (2.94)
LSCS	23 (10.09)	32 (84.21)	31 (91.18)
Indication for LSCS			
Fetal distress	11 (47.83)	9 (28.13)	21 (67.74)
Non-progression of labour	6 (26.09)	14 (43.75)	5 (16.12)
Previous LSCS	4 (17.39)	3 (9.38)	2 (6.45)
Cephalopelvic disproportion	2 (8.69)	5 (15.62)	1 (3.23)
Abruptio placenta	0	1 (3.12)	0
Abruptio placenta with fetal distress	0	0	1 (3.23)
Cord prolapse with fetal distress	0	0	1 (3.23)

Pregnancy-induced hypertension was the most frequent risk factor across the CTG groups and accounted for 46.17% of women with pathological CTG patterns. Other reported risk factors included anaemia, oligohydramnios, PROM, gestational diabetes mellitus, abruptio placenta and cord prolapse.

Meconium-stained liquor was more frequent with increasing CTG abnormality, occurring in 9.21% of women with normal CTG, 31.58% with suspicious CTG and 47.06% with pathological CTG. This association was statistically significant ($p < 0.0001$).

LSCS was performed in 91.18% of women with pathological CTG and 84.21% of women with suspicious CTG, compared with 10.09% in the normal CTG group. The association between CTG pattern and mode of delivery was statistically significant ($p < 0.0001$). Fetal distress was the commonest indication for LSCS in the pathological CTG group (67.74%) and normal CTG group (47.83%). In the suspicious CTG group, non-progression of labour was the commonest indication (43.75%).

Table 3: Association between fetal distress and CTG pattern (N = 300)

Fetal distress	Normal, n (%)	Suspicious, n (%)	Pathological, n (%)
Present	39 (17.10)	13 (34.21)	25 (73.53)
Absent	189 (82.90)	25 (65.79)	9 (26.47)
Total	228 (100)	38 (100)	34 (100)
Apgar score at 1 minute			
<7	68 (29.83)	10 (26.32)	19 (55.89)
≥7	160 (70.17)	28 (73.68)	15 (44.11)
Apgar score at 5 minutes			
<7	19 (8.33)	5 (13.16)	7 (20.59)
≥7	209 (91.67)	33 (86.84)	27 (79.41)

The proportion of fetal distress increased progressively from the normal to pathological CTG groups, from 17.10% to 73.53%. The association between pathological CTG and fetal distress was statistically significant ($p < 0.0001$). An Apgar score <7 at 1 minute was observed in 55.89% of neonates

in the pathological CTG group compared with 29.83% in the normal group and 26.32% in the suspicious group. At 5 minutes, the proportion of neonates with Apgar score <7 was highest in the pathological CTG group (20.59%), while 79.41% of neonates in this group had an Apgar score ≥7.

Table 4: Neonatal complications according to CTG pattern (N = 300)

Neonatal outcome	Normal, n (%)	Suspicious, n (%)	Pathological, n (%)	p value
Meconium aspiration syndrome	8 (3.51)	4 (10.53)	5 (14.70)	0.01
Neonatal seizures	5 (2.19)	2 (5.26)	6 (17.65)	<0.01
Hypoxic-ischaemic encephalopathy	2 (0.88)	1 (2.63)	3 (8.82)	<0.01
No complications	213 (93.42)	31 (81.58)	20 (58.83)	—
Total	228 (100)	38 (100)	34 (100)	

Neonatal complications were more frequent among neonates associated with pathological CTG patterns. Meconium aspiration syndrome, neonatal seizures and hypoxic-ischaemic encephalopathy were reported in 14.70%, 17.65% and 8.82%, respectively, of neonates in the pathological group.

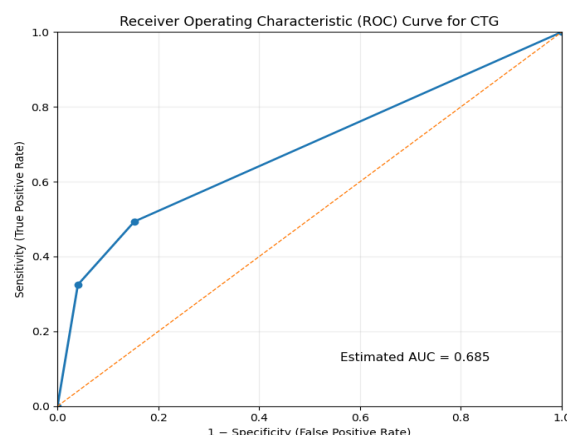


Figure 1: Receiver operating characteristic (ROC) curve demonstrating the diagnostic performance of cardiotocography for prediction of fetal distress

The ROC curve constructed from these aggregated thresholds gives an estimated AUC of 0.685.

Diagnostic parameter	Value (%)
Sensitivity	49.35
Specificity	84.75
Positive predictive value	52.78
Negative predictive value	82.89

CTG demonstrated relatively high specificity and negative predictive value, whereas sensitivity and positive predictive value were comparatively lower.

DISCUSSION

The present study evaluated the association between intrapartum cardiotocography (CTG) patterns and maternal, intrapartum and neonatal outcomes among 300 women in the first stage of labour. A normal CTG pattern was observed in 228 (76.0%) women, while 38 (12.67%) had suspicious CTG and 34 (11.33%) had pathological CTG. The proportion of pathological traces in the present study was somewhat higher than that reported in some previous studies. This difference may be related to variation in study populations, referral patterns, inclusion criteria and the proportion of high-risk pregnancies managed at the study centre. Similar variation in the distribution of CTG categories has been reported in recent Indian studies, reflecting differences in obstetric risk profile and CTG classification systems. For example, Ranjana et al,^[7] reported reactive, suspicious and pathological CTG patterns in 67%, 22% and 11% of women, respectively, in a prospective study of 300 term pregnancies.

CTG pattern and fetal distress

A statistically significant association was observed between CTG pattern and fetal distress in the present study. Fetal distress occurred in 17.1% of women

with normal CTG, 34.21% of those with suspicious CTG and 73.53% of those with pathological CTG ($p < 0.0001$). Thus, the frequency of fetal distress increased progressively with worsening CTG abnormality. This finding is consistent with the observations of Vijay Nikita et al,^[8] who reported fetal distress in 5.2% of women with reactive CTG, 40% with equivocal CTG and 66.7% with ominous CTG. Hafizur Rahman et al,^[6] reported corresponding rates of 11%, 39% and 86%, while Vidya Gaikwad et al,^[9] reported rates of 8.4%, 48% and 75%, respectively. The pathological-group rate of 73.53% in the present study was therefore particularly comparable with the 75% reported by Vidya Gaikwad et al.^[9]

Recent evidence also supports the relationship between increasingly abnormal fetal heart-rate patterns and adverse intrapartum outcomes. A 2023 systematic review and meta-analysis of the three-tier fetal heart-rate classification system demonstrated that adverse neonatal indicators, including low Apgar score and severe neonatal acidemia, increased with worsening fetal heart-rate category, although the authors emphasized that CTG categories provide an approximate rather than definitive prediction of neonatal outcome. Similarly, Ranjana et al,^[7] found a

significant association between CTG abnormality and caesarean delivery and reported more favourable neonatal outcomes among women with reactive CTG compared with pathological CTG. The progressive increase in fetal distress observed in the present study therefore supports the role of CTG as an intrapartum surveillance tool for identifying fetuses at increased risk of compromise. However, an abnormal CTG should be interpreted in conjunction with the clinical circumstances, labour progress, maternal condition and other fetal assessments rather than being regarded as synonymous with fetal hypoxia.

CTG pattern and meconium-stained liquor

The present study demonstrated a statistically significant association between CTG abnormality and meconium-stained liquor. Meconium staining was present in 9.21% of women with normal CTG, 31.58% with suspicious CTG and 47.06% with pathological CTG ($p < 0.0001$). The increasing frequency of meconium-stained liquor across the CTG categories suggests that abnormal intrapartum fetal heart-rate patterns may coexist with clinical features of fetal compromise. These findings are comparable with those of Vijay Nikita et al,^[8] who reported meconium-stained liquor in 3.9%, 25% and 33.3% of women with reactive, equivocal and ominous CTG, respectively. Hafizur Rahman et al,^[6] reported rates of 8.9%, 39.1% and 71.14%, respectively, while Richa U. Lohana et al,^[3] observed meconium staining in 8.24% of the reactive group compared with 33.33% of the non-reactive group. Vidya Gaikwad et al,^[8] similarly demonstrated an increasing frequency of meconium-stained liquor with worsening CTG pattern. The present findings should nevertheless be interpreted cautiously because meconium-stained liquor is not specific for fetal hypoxia. Meconium passage may occur in the absence of significant hypoxic injury, particularly at term and post-term gestations. Consequently, the presence of meconium should be interpreted together with the CTG pattern and the overall clinical condition rather than being used in isolation as an indication of fetal compromise.

CTG pattern and mode of delivery

A strong and statistically significant association was observed between CTG abnormality and mode of delivery. LSCS was performed in only 10.09% of women with normal CTG, compared with 84.21% of women with suspicious CTG and 91.18% of those with pathological CTG ($p < 0.0001$). Thus, operative delivery increased markedly as the CTG pattern became more abnormal. The findings are consistent with Vidya Gaikwad et al,^[9] who reported LSCS rates of 24.3%, 55.55% and 75% in reactive, suspicious and pathological groups, respectively. Lila Vyas et al,^[10] reported LSCS in 6.67% of women with reactive CTG compared with 88% of those with non-reactive CTG. More recent evidence provides similar observations. Singh et al,^[11] in a 500-woman observational study from North India, reported that LSCS was significantly more frequent among women with non-reassuring and abnormal CTG patterns. The

authors also reported that abnormal CTG had high specificity and negative predictive value but relatively low sensitivity and positive predictive value for birth asphyxia and NICU admission. Similarly, Ranjana et al,^[7] reported significantly higher caesarean delivery rates among women with abnormal CTG compared with those with reactive CTG.

The high LSCS rate observed in the suspicious and pathological groups in the present study may therefore reflect the clinical response to perceived fetal compromise. However, the association between abnormal CTG and caesarean delivery should not necessarily be interpreted as evidence that every abnormal trace represents established fetal hypoxia. A systematic review and network meta-analysis involving 33 trials and 118,863 women found that intrapartum surveillance strategies differed in their effects on emergency caesarean delivery, while none demonstrated a clear reduction in neonatal acidemia, NICU admission, Apgar score or perinatal death. This highlights the importance of appropriate CTG interpretation and correlation with the clinical context to minimize unnecessary operative intervention.

Indications for LSCS

In the present study, fetal distress was the most common indication for LSCS in the pathological CTG group, accounting for 21 (67.74%) cases. In the suspicious CTG group, non-progression of labour was the commonest indication, accounting for 43.75%, while fetal distress accounted for 28.13%.

The predominance of fetal distress as an indication for caesarean delivery among women with pathological CTG is consistent with the expected clinical response to a persistently abnormal fetal heart-rate pattern. Ram Bharat Meena et al,^[12] similarly reported fetal compromise-related indications among women with non-reactive CTG. Recent studies have also demonstrated a close relationship between abnormal CTG and operative delivery. Singh et al,^[11] found significantly increased LSCS rates among women with non-reassuring and abnormal CTG patterns. However, contemporary evidence emphasizes that suspicious or intermediate CTG patterns require ongoing assessment rather than automatic immediate delivery. A 2023 systematic review of CTG interpretation guidelines found considerable variation among clinical practice guidelines, emphasizing the importance of standardized interpretation and management. Thus, the decision for operative delivery should incorporate the persistence and severity of the CTG abnormality, stage of labour, response to intrauterine resuscitative measures and feasibility of vaginal delivery.

CTG pattern and Apgar score

The present study demonstrated poorer immediate neonatal condition among neonates associated with pathological CTG. At 1 minute, Apgar score <7 was observed in 29.83% of neonates in the normal CTG group, 26.32% in the suspicious group and 55.89% in the pathological group. At 5 minutes, the

corresponding proportions were 8.33%, 13.16% and 20.59%, respectively. These findings are broadly comparable with previous studies. Vijay Nikita et al,^[8] reported Apgar <7 at 1 minute in 1.3%, 15% and 66.67% of neonates in reactive, equivocal and ominous groups, respectively. Richa U. Lohana et al,^[3] reported Apgar <7 at 1 minute in 5.88% of neonates in the reactive group compared with 53.33% in the non-reactive group, while Vidya Gaikwad et al,^[9] reported low Apgar scores in 12.6%, 55.55% and 75% of the reactive, suspicious and pathological groups, respectively.

Recent evidence further supports the association between abnormal CTG and low Apgar scores. A 2023 meta-analysis found that the proportion of neonates with Apgar score <7 increased with worsening fetal heart-rate category. Singh et al,^[11] in an Indian observational study, likewise found an association between non-reassuring/abnormal CTG and adverse neonatal outcomes, including neonatal seizures. Nevertheless, Apgar score is a measure of the newborn's clinical condition after birth and is not a specific diagnostic marker of intrapartum hypoxia. Therefore, the association between abnormal CTG and low Apgar scores should be interpreted as an association with poorer immediate neonatal condition rather than definitive evidence that CTG alone accurately diagnoses fetal hypoxia.

Neonatal complications

The present study demonstrated an increasing frequency of neonatal complications with worsening CTG abnormality. Meconium aspiration syndrome occurred in 3.51% of neonates in the normal CTG group, 10.52% in the suspicious group and 14.70% in the pathological group. Neonatal seizures occurred in 2.19%, 5.26% and 17.65%, respectively, while hypoxic-ischaemic encephalopathy occurred in 0.88%, 2.63% and 8.82%, respectively. The progressive increase in neonatal seizures and hypoxic-ischaemic encephalopathy across CTG categories suggests that pathological intrapartum fetal heart-rate patterns identify a population at increased risk of short-term neonatal morbidity. Richa U. Lohana et al,^[3] similarly observed a greater proportion of meconium aspiration among neonates born following non-reactive CTG, while Ram Bharat Meena et al,^[12] reported neonatal seizures in association with non-reactive CTG.

These findings are also supported by more recent evidence. Singh et al,^[11] reported significantly higher neonatal seizure rates among neonates associated with non-reassuring and abnormal CTG patterns. However, systematic reviews indicate that the relationship between CTG-based surveillance and major neonatal outcomes is complex. Continuous CTG has been associated with reduced neonatal seizures in randomized evidence, but this benefit has not consistently translated into reductions in other important outcomes such as cerebral palsy or perinatal mortality, while operative delivery may increase. Therefore, the findings of the present study support the use of CTG as a component of

intrapartum fetal surveillance but also reinforce that CTG abnormalities should prompt timely clinical assessment and appropriate intervention rather than being interpreted as an isolated predictor of neurological injury.

Diagnostic performance of CTG

The diagnostic performance of CTG in the present study showed a sensitivity of 49.35%, specificity of 84.75%, positive predictive value of 52.78% and negative predictive value of 82.89%. Thus, CTG demonstrated relatively higher specificity and negative predictive value than sensitivity and positive predictive value. These findings indicate that a normal CTG was more useful for identifying women unlikely to have the adverse outcome being assessed, whereas an abnormal CTG was less specific for confirming the presence of actual fetal hypoxia. This distinction is clinically important because CTG abnormalities can occur in the absence of significant metabolic acidosis or neurological injury. The present findings can be compared with those of Kumar N et al,^[1] who reported sensitivity, specificity, positive predictive value and negative predictive value of 57.89%, 93.82%, 68.75% and 90.47%, respectively. Although the diagnostic values in the present study were somewhat lower, the overall pattern of relatively good specificity and negative predictive value with lower sensitivity and PPV was similar. Recent Indian evidence provides further support for this interpretation. Singh et al,^[11] reported that abnormal CTG had high specificity and negative predictive value but comparatively low sensitivity and positive predictive value for detection of birth asphyxia and NICU admission. Similarly, Nagpal et al,^[13] in a study of 200 high-risk and low-risk women, reported that the absence of a category III tracing was particularly useful for reassuring fetal well-being.

The diagnostic limitations of CTG have also been highlighted in recent systematic reviews. A 2023 systematic review of CTG interpretation guidelines demonstrated variability between guidelines in classification and management recommendations. Furthermore, a 2023 meta-analysis of three-tier fetal heart-rate interpretation concluded that although adverse neonatal outcomes increased with worsening CTG category, CTG classification remained an imprecise predictor of individual neonatal prognosis. Thus, the relatively high specificity and negative predictive value observed in the present study suggest that a reassuring CTG can provide useful evidence of a lower immediate risk of adverse fetal status. Conversely, the relatively modest sensitivity and PPV indicate that an abnormal CTG should not be regarded as definitive evidence of fetal hypoxia. CTG findings should be integrated with maternal condition, labour progress, fetal movement, liquor characteristics and, where clinically indicated, additional fetal assessment.

Overall, the present study demonstrates a clear gradient between CTG abnormality and adverse maternal and neonatal outcomes. As the CTG pattern progressed from normal to suspicious and

pathological, there was a corresponding increase in fetal distress, meconium-stained liquor, caesarean delivery, low Apgar scores, neonatal seizures, meconium aspiration syndrome and hypoxic-ischaemic encephalopathy.

The findings are consistent with recent observational evidence from India. Ranjana et al,^[7] studying 300 term pregnancies, reported that reactive CTG was associated with more favourable neonatal outcomes, while pathological CTG was associated with increased operative intervention. Singh et al,^[11] in a larger Indian cohort of 500 women, similarly found increased operative intervention and neonatal seizures among women with abnormal CTG. These observations are further supported by contemporary systematic reviews showing that abnormal fetal heart-rate patterns are associated with adverse neonatal indicators, although CTG alone has limited ability to distinguish true fetal hypoxia from non-hypoxic causes of an abnormal tracing.

The high rate of operative delivery associated with suspicious and pathological CTG in the present study should therefore be interpreted in the context of the tertiary-care setting and the possibility of clinician response to perceived fetal compromise. Contemporary evidence indicates that CTG can facilitate identification of fetuses requiring intervention, but its use may also increase operative delivery without consistently demonstrating improvement in all major neonatal outcomes.

Accordingly, the findings of the present study support CTG as an important component of intrapartum fetal surveillance, particularly for identifying pregnancies requiring closer observation or timely intervention. At the same time, the moderate sensitivity and PPV observed in this study emphasize that CTG should not be used as a stand-alone diagnostic test for fetal hypoxia. Appropriate classification, continuous reassessment and correlation with the clinical circumstances remain essential for optimizing maternal and neonatal outcomes.^[14]

The present study demonstrated the same overall pattern reported in previous studies, namely an increase in fetal distress with increasing CTG abnormality. The fetal distress rate in the pathological group (73.53%) was particularly similar to that reported by Vidya Gaikwad et al,^[9] (75%). The lower rate in the suspicious group compared with some earlier studies may reflect differences in study population, CTG classification, clinical management and referral characteristics.

CONCLUSION

In conclusion, cardiotocography (CTG) is a simple, non-invasive and useful method of intrapartum fetal surveillance, with pathological CTG patterns showing a significant association with fetal distress, meconium-stained liquor, caesarean delivery, low

Apgar scores and adverse neonatal outcomes. In the present study, CTG demonstrated good specificity (84.75%) and negative predictive value (82.89%), although its sensitivity (49.35%) and positive predictive value (52.78%) were relatively lower. These findings indicate that CTG is valuable for identifying fetuses at increased risk of compromise and guiding timely obstetric intervention; however, abnormal CTG findings should be interpreted in conjunction with maternal risk factors, progress of labour and other clinical findings rather than being considered a definitive diagnosis of fetal hypoxia.

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