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ORIGINAL RESEARCH

ASSOCIATION OF FETAL HEART RATE PATTERNS IN THE SECOND STAGE OF LABOUR WITH NEONATAL OUTCOME: A PROSPECTIVE OBSERVATIONAL STUDY AT A RURAL TERTIARY CARE TEACHING HOSPITAL

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ABSTRACT

Background: Fetal heart rate (FHR) monitoring during the second stage of labour is a central component of intrapartum surveillance, permitting early recognition of evolving fetal hypoxia and timely obstetric intervention. Abnormal FHR patterns have been associated with adverse neonatal outcomes including low Apgar scores, birth asphyxia and admission to the neonatal intensive care unit (NICU).

Objective: To evaluate the association between fetal heart rate patterns during the second stage of labour and neonatal outcomes at a rural tertiary care teaching hospital.

Methods: This prospective observational study was conducted in the Department of Obstetrics and Gynaecology over an 18-month period. Two hundred women with term singleton cephalic pregnancies entering the second stage of labour were enrolled consecutively. Continuous cardiotocography was interpreted according to the FIGO 2021 intrapartum classification as normal, suspicious or pathological. Maternal characteristics, intrapartum events, mode of delivery and neonatal outcomes were recorded, with neonatal assessment performed by a paediatrician blinded to the cardiotocographic findings. Categorical associations were tested by the chi-square or Fisher's exact test and continuous variables by Student's t-test or the Mann–Whitney U test, with $p < 0.05$ considered significant.

Results: Fetal heart rate patterns were normal in 128 women (64.0%), suspicious in 44 (22.0%) and pathological in 28 (14.0%). Variable decelerations were the commonest abnormality (13.0%), followed by late decelerations (9.0%) and reduced baseline variability (5.5%). Emergency caesarean section was performed in 57.1% of women with pathological tracings compared with 9.4% of those with normal tracings ($\chi^2 = 32.84$, $p < 0.001$). Neonates delivered after pathological tracings had significantly higher rates of Apgar < 7 at one minute (53.6% vs 6.3%), neonatal resuscitation (57.1% vs 7.0%) and NICU admission (50.0% vs 4.7%) (all $p < 0.001$). Late decelerations carried the highest crude odds of adverse neonatal outcome (OR 8.9), followed by prolonged decelerations (7.4) and reduced variability (6.8). Overall, 170 neonates (85.0%) were healthy at birth; birth asphyxia occurred in 25 (12.5%), hypoxic-ischaemic encephalopathy in 2 (1.0%) and early neonatal death in 3 (1.5%).

Conclusion: Pathological fetal heart rate patterns during the second stage of labour were strongly associated with operative delivery and adverse neonatal outcome, with late decelerations and reduced baseline variability the most informative individual abnormalities. Continuous electronic fetal monitoring with systematic interpretation and prompt intervention supports early recognition of fetal compromise. These associations are unadjusted and should be interpreted as hypothesis-generating pending multivariable analysis.

Keywords: Fetal heart rate; Cardiotocography; Second stage of labour; Neonatal outcome; Apgar score; Neonatal Intensive care Fetal distress; Intrapartum monitoring.

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INTRODUCTION

Labour is a dynamic physiological process during which continuous assessment of fetal well-being is essential if a favourable neonatal outcome is to be secured. The second stage is of particular concern: frequent uterine contractions, maternal expulsive effort and transient reduction in uteroplacental perfusion combine to reduce fetal oxygen reserve at precisely the point at which demand is greatest. Early recognition of fetal compromise during this interval permits timely obstetric intervention and can substantially reduce perinatal morbidity and mortality. Intrapartum fetal heart rate (FHR) monitoring has accordingly become an indispensable element of contemporary obstetric practice [1,2].

Cardiotocography (CTG) remains the most widely used method of electronic fetal monitoring in labour. By recording the fetal heart rate and uterine activity simultaneously, it yields information on baseline rate, baseline variability, accelerations and decelerations, allowing the clinician to distinguish a reassuring fetal state from evolving hypoxia and acidaemia. The International Federation of Gynecology and Obstetrics (FIGO), the American College of Obstetricians and Gynecologists (ACOG) and the World Health Organization each recommend standardised interpretation of these patterns in order to improve diagnostic consistency and optimise neonatal outcome [3–5].

Although FHR abnormalities are encountered frequently in labour, their predictive value for adverse neonatal outcome remains contested. Recurrent late decelerations, prolonged decelerations, fetal bradycardia, reduced baseline variability and the sinusoidal pattern are regarded as pathological findings that may signal hypoxia requiring immediate action. Variable decelerations and transient tachycardia, by contrast, occur commonly in uncomplicated labour and must be interpreted within the whole clinical context. Accurate interpretation is therefore required in both directions to avoid delayed intervention on the one hand and unnecessary operative delivery on the other [6–8].

Prolongation of the second stage has itself been associated with fetal acidaemia, meconium aspiration, neonatal encephalopathy, low Apgar scores and NICU admission, and a recent systematic review and meta-analysis has quantified the relationship between second-stage and active pushing duration and adverse maternal and neonatal outcome [9]. Continuous surveillance across this interval facilitates early recognition of compromise and allows timely operative vaginal delivery or emergency caesarean section where indicated.

Advances in electronic fetal monitoring have refined understanding of the relationship between CTG abnormality and neonatal outcome. Contemporary work has shown that specific intrapartum patterns are independently associated with cord acidaemia and neonatal compromise, that structured management algorithms improve the timeliness of intervention, and that fetal cardiac functional indices in early labour predict adverse intrapartum outcome [10–12]. Nevertheless, the modest positive predictive value of an abnormal trace continues to contribute to operative intervention in fetuses who prove not to be compromised, which underlines the need to interpret cardiotocography alongside the whole clinical picture [13].

The burden of intrapartum fetal distress remains substantial in low- and middle-income settings, and particularly in rural districts where delays in recognition, referral and intervention contribute materially to adverse perinatal outcome. The institution in which this study was conducted is a tertiary care teaching hospital serving a large rural obstetric population, conducting approximately 6,000 to 7,000 deliveries annually, in which labour is managed using the WHO Labour Care Guide [14]. Continuous evaluation of fetal heart rate patterns is routine, yet local data relating these patterns to neonatal outcome are limited.

The present study was therefore undertaken to evaluate the association between fetal heart rate patterns during the second stage of labour and neonatal outcome, and to determine which individual abnormalities are most closely related to Apgar score, neonatal resuscitation, NICU admission and birth asphyxia in this population [15].

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MATERIALS AND METHODS

Study design and setting

This prospective observational analytical study was conducted in the Department of Obstetrics and Gynaecology of a tertiary care rural teaching hospital with comprehensive maternal and neonatal services, including continuous electronic fetal monitoring, emergency obstetric care, a neonatal intensive care unit and facilities for operative vaginal and caesarean delivery. The study ran for 18 months, from November 2022 to May 2024.

Participants and sample size

Two hundred eligible women entering the second stage of labour were enrolled by consecutive sampling. The sample size was calculated from the expected prevalence of abnormal fetal heart rate patterns in labour, at 95% confidence, 80% power and a 5% level of significance.

Inclusion criteria were singleton pregnancy; gestational age ≥ 37 completed weeks; cephalic presentation; entry into the second stage of labour; a live fetus at the onset of labour; and written informed consent.

Exclusion criteria were multiple pregnancy; preterm labour below 37 weeks; breech or other malpresentation; known major fetal congenital anomaly; intrauterine fetal demise; elective caesarean section before labour; and incomplete clinical records.

Clinical assessment and fetal monitoring

Maternal age, parity, booking status, body mass index, gestational age, educational and socioeconomic status, previous obstetric history and associated medical disorders were recorded on a predesigned proforma. Labour was managed according to standard institutional protocols using the WHO Labour Care Guide.

Continuous cardiotocography was performed throughout the second stage where indicated, with intermittent auscultation used in low-risk women in accordance with institutional policy. Tracings were interpreted independently by trained obstetricians using the FIGO 2021 intrapartum classification and categorised as normal, suspicious or pathological. Baseline rate, baseline variability, accelerations, and early, variable, late and prolonged decelerations were each documented, together with the sinusoidal pattern where present, indication for operative intervention, presence of meconium-stained liquor, and maternal and intrapartum complications were also recorded.

Neonatal outcome assessment

Immediately after delivery the neonate was assessed by a paediatrician blinded to the intrapartum cardiotocographic findings. Recorded variables were birth weight, sex, Apgar score at one and five minutes, need for resuscitation, NICU admission and duration of stay, respiratory distress, birth asphyxia, neonatal seizures, hypoxic-ischaemic encephalopathy (HIE) and early neonatal death within seven days.

The primary outcome was the association between fetal heart rate pattern in the second stage and neonatal outcome. Secondary outcomes were the association between abnormal patterns and operative delivery, the incidence of meconium-stained liquor, the requirement for neonatal resuscitation, NICU admission, Apgar scores and early neonatal complications.

Statistical analysis

Data were entered in Microsoft Excel and analysed using IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA). Continuous variables are expressed as mean ± standard deviation and categorical variables as frequency and percentage. Groups were compared using Student’s t-test for normally distributed continuous variables, the Mann–Whitney U test where distribution was non-normal, and the chi-square or Fisher’s exact test for categorical variables; one-way analysis of variance was used for comparison across the three fetal heart rate categories. A two-sided $p < 0.05$ was considered statistically significant. Odds ratios presented in this report are unadjusted.

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Ethical considerations

The protocol was approved by the Institutional Ethics Committee before commencement, and written informed consent was obtained from every participant. Confidentiality was maintained throughout, and the study conformed to the ethical principles of the Declaration of Helsinki (2013 revision). [Author action: approval number and date to be inserted.]

RESULTS

Two hundred women with term singleton cephalic pregnancies entering the second stage of labour were studied. Ninety-eight (49.0%) were aged 20 to 25 years, 118 (59.0%) were primigravid and 164 (82.0%) were booked; mean gestational age was 38.8 ± 1.2 weeks. The cohort therefore comprised predominantly low-risk term pregnancies suitable for evaluation of intrapartum fetal heart rate patterns (Table 1).

Fetal heart rate patterns were normal in 128 women (64.0%), suspicious in 44 (22.0%) and pathological in 28 (14.0%), so that abnormal tracings accounted for just over a third of the cohort (Table 2). Among individual abnormalities, variable decelerations were commonest (26 women, 13.0%), followed by late decelerations (18, 9.0%), reduced baseline variability (11, 5.5%), baseline tachycardia (9, 4.5%), prolonged decelerations (7, 3.5%), baseline bradycardia (6, 3.0%) and a sinusoidal pattern in one woman (0.5%). Deceleration patterns were thus the commonest indicators of intrapartum compromise (Table 3).

Mode of delivery differed markedly across the three categories ($\chi^2 = 32.84$, $p < 0.001$). Normal vaginal delivery was achieved in 106 of 128 women with normal tracings (82.8%) but in only 5 of 28 with pathological tracings (17.9%), whereas emergency caesarean section was performed in 12 of 128 (9.4%) and 16 of 28 (57.1%) respectively. Instrumental delivery was also more frequent as the tracing deteriorated (Table 4, Figure 1).

Neonatal outcomes deteriorated in parallel with the cardiotocographic category (Table 5, Figure 2). An Apgar score below 7 at one minute occurred in 8 of 128 neonates in the normal group (6.3%), 11 of 44 in the suspicious group (25.0%) and 15 of 28 in the pathological group (53.6%); the corresponding figures at five minutes were 1.6%, 11.4% and 32.1%. Neonatal resuscitation was required in 7.0%, 27.3% and 57.1% respectively, and NICU admission in 4.7%, 22.7% and 50.0%. Meconium aspiration followed the same gradient. All comparisons were statistically significant.

Percentages are within each fetal heart rate category. NICU, neonatal intensive care unit.

When individual abnormalities were examined, late decelerations carried the highest crude odds of adverse neonatal outcome (OR 8.9), with an Apgar below 7 in 78% and NICU admission in 67% of affected neonates. Prolonged decelerations (OR 7.4) and reduced baseline variability (OR 6.8) followed, whereas variable decelerations — although the commonest abnormality — carried substantially lower odds (OR 3.6), and baseline tachycardia the lowest (OR 2.9). Late decelerations and reduced variability were thus the most informative individual predictors of fetal compromise (Table 6, Figure 3).

Overall, 170 neonates (85.0%) were healthy at birth. Mild birth asphyxia occurred in 14 (7.0%), moderate asphyxia in 8 (4.0%) and severe asphyxia in 3 (1.5%); hypoxic-ischaemic encephalopathy developed in 2 (1.0%) and early neonatal death occurred in 3 (1.5%). Adverse outcomes were concentrated among pregnancies with pathological tracings (Table 7).

Placed alongside contemporary literature, the present findings show the same direction and broad magnitude of association between pathological cardiotocography and neonatal compromise (Table 8).

Table 1. Demographic characteristics of the study population (n = 200)

Variable	Frequency (n)	Percentage (%)
Age <20 years	24	12.0
Age 20–25 years	98	49.0
Age 26–30 years	56	28.0
Age >30 years	22	11.0

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Variable	Frequency (n)	Percentage (%)
Primigravida	118	59.0
Multigravida	82	41.0
Booked	164	82.0
Unbooked	36	18.0
Mean gestational age	38.8 ± 1.2 weeks	—

Table 2. Distribution of fetal heart rate patterns in the second stage of labour

FHR pattern (FIGO 2021)	Number (n)	Percentage (%)
Normal	128	64.0
Suspicious	44	22.0
Pathological	28	14.0
Total	200	100.0

Table 3. Types of abnormal fetal heart rate pattern

Abnormal pattern	Number (n)	Percentage of cohort (%)
Baseline tachycardia	9	4.5
Baseline bradycardia	6	3.0
Reduced baseline variability	11	5.5
Variable decelerations	26	13.0
Late decelerations	18	9.0
Prolonged decelerations	7	3.5
Sinusoidal pattern	1	0.5

Percentages are of the whole cohort (n = 200). The individual abnormalities total 78 among 72 women with suspicious or pathological tracings because more than one abnormality was present in some tracings; categories are therefore not mutually exclusive.

Table 4. Mode of delivery according to fetal heart rate pattern

Mode of delivery	Normal (n = 128)	Suspicious (n = 44)	Pathological (n = 28)	Total
Normal vaginal delivery	106	22	5	133
Instrumental delivery	10	12	7	29
Emergency caesarean section	12	10	16	38
Total	128	44	28	200

$\chi^2 = 32.84$, $p < 0.001$.

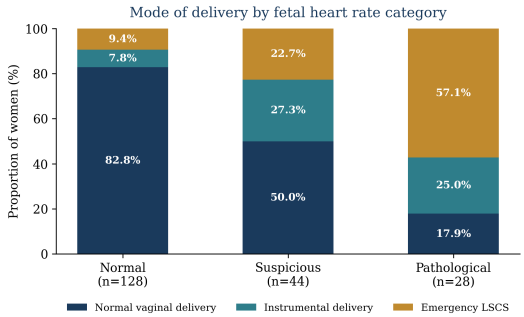

Figure 1. *Mode of delivery by fetal heart rate category, showing the progressive rise in operative intervention as the tracing deteriorates.*

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Table 5. Neonatal outcome according to fetal heart rate pattern

Outcome	Normal (n = 128)	Suspicious (n = 44)	Pathological (n = 28)	p value
Apgar < 7 at 1 minute	8 (6.3%)	11 (25.0%)	15 (53.6%)	<0.001
Apgar < 7 at 5 minutes	2 (1.6%)	5 (11.4%)	9 (32.1%)	<0.001
Meconium aspiration	2 (1.6%)	4 (9.1%)	7 (25.0%)	0.002
Neonatal resuscitation	9 (7.0%)	12 (27.3%)	16 (57.1%)	<0.001
NICU admission	6 (4.7%)	10 (22.7%)	14 (50.0%)	<0.001

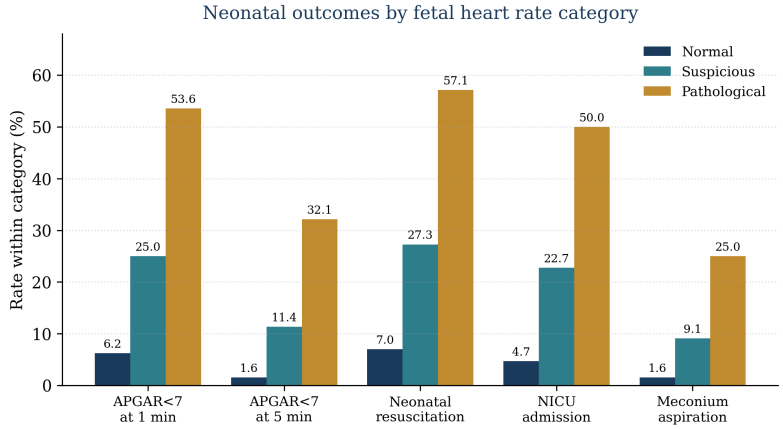

Figure 2. *Neonatal outcome rates by fetal heart rate category.*

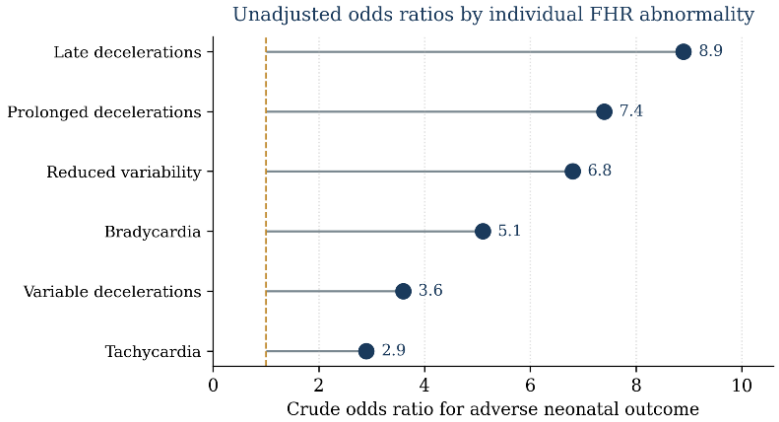

Figure 3. *Unadjusted odds ratios for adverse neonatal outcome by individual fetal heart rate abnormality (dashed line, OR = 1).*

Table 6. Association of individual fetal heart rate abnormalities with neonatal outcome

FHR abnormality	n	Apgar < 7 (%)	NICU admission (%)	Crude odds ratio
Baseline bradycardia	6	67	50	5.1
Baseline tachycardia	9	44	33	2.9
Reduced baseline variability	11	73	55	6.8
Variable decelerations	26	46	39	3.6
Late decelerations	18	78	67	8.9
Prolonged decelerations	7	71	57	7.4
Sinusoidal pattern	01	0	0	0.1

Table 7. Overall neonatal outcome (n = 200)

Outcome	Number (n)	Percentage (%)
Healthy neonate	170	85.0

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Outcome	Number (n)	Percentage (%)
Mild birth asphyxia	14	7.0
Moderate birth asphyxia	8	4.0
Severe birth asphyxia	3	1.5
Hypoxic-ischaemic encephalopathy	2	1.0
Early neonatal death (≤ 7 days)	3	1.5

Table 8. Comparison with contemporary studies and guidelines

Source	Year	Population	Pattern emphasised	Principal outcome	Relation to present study
Tarvonen et al. [7]	2021	Cohort study	Zigzag pattern	Early sign of fetal hypoxia	Consistent: abnormal variability preceded compromise
Ghi et al. [8]	2021	Retrospective cohort	Baseline 150–160 bpm at ≥40 weeks	Higher incidence of labour complications	Consistent: baseline abnormality relates to outcome
Tarvonen et al. [10]	2024	7,932 deliveries	Abnormal intrapartum CTG	Cord acidaemia; improved outcome with dual registration	Similar association between abnormal CTG and compromise
Cheung et al. [11]	2024	Multicentre	Pathological CTG	Timely intervention; NICU admission	Comparable increase in operative delivery
Dall'Asta et al. [12]	2025	Prospective observational	Fetal cardiac function in early labour	Adverse intrapartum and neonatal outcome	Comparable predictive relationship
Aboukhater et al. [9]	2025	Systematic review	Prolonged second stage / pushing	Maternal and neonatal morbidity	Supports emphasis on the second stage
ACOG [4]	2025	Practice guideline	Category III tracing	Expeditious delivery indicated	Comparable rise in emergency caesarean section
FIGO [3]	2021	Consensus guideline	Late decelerations	Fetal hypoxia	Findings consistent with recommendations
Present study	2026	200 women	Late decelerations; reduced variability	Low Apgar, NICU admission, operative delivery	—

DISCUSSION

In this cohort of 200 women monitored through the second stage of labour, pathological fetal heart rate patterns were observed in 14.0%, suspicious patterns in 22.0% and normal patterns in 64.0%. The central finding is a consistent, graded relationship between the cardiotocographic category and both operative intervention and neonatal outcome: as the tracing deteriorated, the likelihood of caesarean section, low Apgar score, resuscitation and NICU admission each rose substantially.

Emergency caesarean section was performed in 57.1% of women with pathological tracings compared with 9.4% of those with normal tracings. This reflects the intended clinical response to evidence of fetal compromise in the second stage, and accords with multicentre work showing that standardised management algorithms for abnormal fetal heart rate patterns increase the timeliness of intervention [11]. Chandraharan and Arulkumaran have similarly argued that prompt recognition of a pathological trace, followed by decisive action, is fundamental to the prevention of intrapartum hypoxic brain injury [6].

Variable decelerations were the commonest abnormality at 13.0%, followed by late decelerations at 9.0% and reduced baseline variability at 5.5%. Frequency and prognostic weight, however, diverged sharply: variable decelerations carried a crude odds ratio of only 3.6, whereas late decelerations carried 8.9 and reduced variability 6.8. This dissociation is clinically important, since the commonest abnormality was among the least predictive. It is consistent with the observation of Tarvonen and colleagues that abnormal variability, including the zigzag pattern, appears as an early marker of hypoxia

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before significant acidaemia develops [7], and with evidence that baseline abnormalities at or beyond 40 weeks are associated with an increased incidence of labour complications [8].

Neonatal outcomes followed the same gradient. NICU admission occurred in 50.0% of neonates delivered after a pathological trace compared with 4.7% after a normal trace, and an Apgar below 7 at one minute in 53.6% versus 6.3%. Comparable predictive relationships have been reported by Dall'Asta and colleagues, who found that intrapartum fetal cardiac functional abnormalities predicted adverse neonatal outcome including intensive care admission and acidaemia [12], and by Tarvonen and colleagues in a large cohort in which abnormal intrapartum cardiotocography was associated with cord acidaemia and neonatal compromise [10].

The prominence of late decelerations as the strongest individual predictor aligns with guideline classification. The ACOG clinical practice guideline places recurrent late decelerations with absent variability within Category III, requiring immediate evaluation and expeditious delivery because of the associated risk of hypoxia and metabolic acidaemia [4], and FIGO recommends corrective measures or operative delivery when a pathological pattern persists [3]. That an unselected rural cohort reproduces this hierarchy supports the external validity of the classification in settings distant from the centres in which it was derived.

The overall neonatal outcome was favourable, with 85.0% of neonates healthy at birth. Nonetheless, birth asphyxia of some degree occurred in 12.5%, hypoxic-ischaemic encephalopathy in 1.0% and early neonatal death in 1.5%. These figures are consistent with evidence that prolongation of the second stage, particularly of active pushing, is associated with increased neonatal morbidity [9], and with recommendations that adherence to evidence-based protocols for the management of intrapartum fetal heart rate abnormalities reduces neonatal acidaemia and intensive care admission [13]. The WHO Labour Care Guide, used in this institution, is designed precisely to structure such surveillance and prompt timely action [14].

Two cautions should temper interpretation. First, cardiotocography has limited positive predictive value: a substantial proportion of abnormal traces occur in fetuses who are not hypoxic, and the resulting operative intervention carries its own morbidity. Adjunctive techniques have been investigated to improve specificity, though the evidence for fetal pulse oximetry in particular has not supported routine adoption [15]. Second, the associations reported here are unadjusted, and confounding by gestational age, parity, second-stage duration, meconium-stained liquor and mode of delivery cannot be excluded [1,2].

CONCLUSION

Pathological fetal heart rate patterns during the second stage of labour were strongly associated with operative delivery and with adverse neonatal outcome, including low Apgar scores, the need for resuscitation and NICU admission. Late decelerations and reduced baseline variability were the most informative individual abnormalities, notably more predictive than the more frequently encountered variable decelerations. Continuous electronic fetal monitoring, interpreted systematically against a current standardised classification and acted upon promptly, supports early recognition of fetal compromise in rural tertiary care practice. Because the associations reported here are unadjusted, they should be regarded as hypothesis-generating; multivariable analysis incorporating umbilical cord acid–base data would allow the independent contribution of individual fetal heart rate abnormalities to be established.

Ethical Approval

Approved by the Institutional Ethics Committee prior to commencement.

Source of Funding

None.

Strengths and limitations

New paragraph...

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Conflicts of Interest

The authors declare no conflict of interest.

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