



ASSOCIATION OF CARDIOTOCOGRAPIC DIAGNOSIS OF INTRAPARTUM FOETAL DISTRESS AND IMMEDIATE UMBILICAL ARTERY CORD BLOOD PH

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ABSTRACT

Background: Intrapartum fetal distress remains a significant contributor to perinatal morbidity and mortality, necessitating timely and accurate diagnosis. Cardiotocography (CTG) is widely used for continuous fetal monitoring; however, its predictive accuracy for fetal acidemia is limited by high false-positive rates. Umbilical artery cord blood pH serves as an objective biochemical marker for assessing fetal hypoxia and metabolic status at birth. The present study aimed to evaluate the association between cardiotocographic diagnosis of intrapartum fetal distress and immediate umbilical artery cord blood pH.

Methods: A hospital-based, prospective, observational study was conducted in the Department of Obstetrics and Gynaecology over a period of 18 months. A total of 88 antenatal women with gestational age >37 weeks in labor with singleton cephalic pregnancy and non-reassuring CTG were included. Continuous CTG monitoring was performed using a BPL Diva machine and interpreted according to NICE guidelines. Following delivery, umbilical arterial cord blood samples were collected and analyzed for pH using a blood gas analyzer. Neonatal outcomes including APGAR scores, need for resuscitation, NICU admission, and complications were recorded. Statistical analysis was done using SPSS with chi-square and t-test, considering $p < 0.05$ as significant.

Results: The mean maternal age was 25.04 ± 3.80 years, with majority in 21–25 years age group (56.82%). Cord blood acidosis was observed in 11 cases (12.5%). Significant associations were found between cord blood acidosis and gestational age ($p = 0.001$), induced labour ($p = 0.001$), meconium-stained liquor ($p = 0.001$), and mode of delivery, with LSCS being higher in acidosis cases (81.8%, $p = 0.001$). No significant association was found with maternal age, religion, socio-economic status, gravidity, fetal movement, or Bishop score. Neonates with acidosis had significantly lower APGAR scores at 1 minute (5.18 vs 6.44) and 5 minutes (6.36 vs 8.40) ($p < 0.001$). All acidosis cases required resuscitation and NICU admission, and 100% had birth asphyxia, showing strong association with adverse neonatal outcomes.

Conclusion: Early identification of high-risk intrapartum factors and timely obstetric intervention can reduce perinatal morbidity. Integration of CTG findings with objective biochemical assessment is essential for improving clinical decision-making and neonatal prognosis.

KEYWORDS: Cardiotocography, Fetal Distress, Umbilical Cord Blood pH, Acidosis, APGAR Score.

Introduction

Fetal well-being during labour represents a critical concern in obstetric practice as timely recognition and management of fetal compromise can significantly impact both immediate and long-term neonatal outcomes. Intrapartum fetal assessment has evolved from intermittent auscultation to continuous monitoring techniques[1]. Intrapartum fetal distress, characterized by inadequate fetal oxygenation during labor, remains one of the most common indications for emergency obstetric interventions. It is associated with serious complications including hypoxic-ischemic encephalopathy, neurological impairment, multiorgan dysfunction, and perinatal mortality[2,3].

Cardiotocography has emerged as the primary modality for continuous intrapartum fetal surveillance in contemporary obstetric practice, offering real-time recordings of fetal heart rate and maternal uterine contractions[3,4]. Electronic fetal monitoring through cardiotocography was introduced into clinical practice with aiming of detecting intrapartum fetal hypoxia early to enable timely and appropriate clinical action to prevent adverse perinatal outcomes[5]. Standard classification systems, such as those proposed by the International Federation of Gynecology and Obstetrics, provide guidelines for categorizing cardiotocography traces and determining appropriate management strategies based on the identified pattern[6,7].

Despite its widespread use in labour wards worldwide, cardiotocography interpretation remains inherently subjective, with inter-observer agreement as low as 29%. The high false-positive rate associated with cardiotocography has been a persistent challenge in obstetric practice, with rates approaching 60% or higher in certain populations, often leading to increased rates of operative deliveries including instrumental births and cesarean sections performed for suspected fetal distress that may not represent true fetal compromise[8]. Given the limitations of cardiotocography in accurately predicting fetal acidemia and the need for more objective markers of intrapartum asphyxia, umbilical cord blood gas analysis has gained increasing importance in obstetric practice[6,9].

The measurement of umbilical artery blood pH immediately following delivery provides a direct and objective assessment of the newborn's metabolic status and serves as the definitive indicator of fetal oxygenation during labor. Unlike cardiotocography, which provides indirect information about fetal well-being through heart rate patterns, umbilical cord blood gas analysis offers direct biochemical evidence of the acid-base status of the neonate at the time of birth. It provides

valuable objective data for quality assurance programs, medicolegal documentation in cases of adverse outcomes and retrospective evaluation of intrapartum management decisions, allowing for continuous improvement in obstetric care practices[1,10]. Therefore, the study aimed to identify the association between cardiotocographic diagnosis of intrapartum fetal distress and immediate umbilical artery cord blood pH.

Materials and Methods

Study Design and Setting

A prospective observational study was carried out in the Department of Obstetrics and Gynaecology at the tertiary care hospital, Jaipur, Rajasthan, India over a period of 18 months. The study was performed in accordance with the principles of Declaration of Helsinki and the Institutional Ethics Committee approval was obtained (Ref. No.: NIMSUR/IEC/2024/1020, dated 11/05/2024).

Study Population

Antenatal women with a gestational age of >37 weeks in labour with singleton pregnancy with cephalic presentation with non-reassuring CTG and participated willingly were included in the study. Multifetal gestation, gestational age < 37 weeks, patients underwent LSCS for indication other than fetal distress, high-risk pregnancies due to anemia, hypertension, thyroid disorders, diabetes, epilepsy, asthma, intrauterine growth retardation, oligohydramnios, preterm deliveries, and maternal infections were excluded from the study. Written informed consent was obtained from all the participants before enrolment.

Sample Size Calculation

The sample size was calculated using the standard formula for prevalence studies:

$$n = \frac{Z_{1-\alpha/2}^2 \times p \times (1 - p)}{d^2}$$

Where Z = 1.96 (at 95% confidence level), p = estimated prevalence ~18.7%, (derived from previous studies), and d = absolute allowable error of 8%.

$$\text{Therefore, } n = \frac{1.96^2 \times 0.187 \times (1 - 0.187)}{0.08^2} = 88.6 \approx 88$$

A total of 88 eligible women were enrolled in the study.

Study Endpoint

The primary endpoint was to determine the incidence of acidemia in cord blood pH among those neonates delivered

in view of non-reassuring Cardiotocography and the secondary endpoint was to establish the rate of caesarean section in cases of diagnosed intrapartum fetal distress.

Methodology

All the selected antenatal women in active labour were admitted and underwent continuous cardiotocography (CTG) monitoring using the BPL Diva CTG machine (paper speed of 1 cm per minute) to assess fetal well-being during labor. The CTG traces obtained were interpreted by the attending obstetrician. An external transducer was used for recording fetal heart rate patterns and uterine contractions. The findings were categorized as reassuring or non-reassuring based on the NICE Guideline CG190 criteria[11]. Any abnormal or non-reassuring CTG patterns were promptly reviewed and the delivery plan was adjusted to ensure optimal maternal and fetal outcomes.

Following delivery, arterial cord blood samples were collected from the umbilical cord of each newborn. The sampling was performed immediately after birth using a pre-heparinized 2cc syringe under strict aseptic precautions to prevent contamination and clot formation. The collected cord blood represented the fetal arterial circulation, providing valuable biochemical information regarding fetal oxygenation and acid-base status at the time of birth.

The arterial cord blood samples were analyzed using the Radiometer ABL 800 Basic blood gas analyzer (average turnaround time of 15 minutes). Parameters such as pH, partial pressures of oxygen (pO_2) and carbon dioxide (pCO_2) and base excess were measured. According to the institutional protocol, a pH value of less than 7.2 was considered indicative of fetal acidosis or acidemia suggesting intrauterine hypoxia or distress. In addition, the Apgar score for each newborn was assessed five minutes after birth based on five standard criteria: heart rate, respiratory effort, muscle tone, reflex irritability and color. These parameters in combination with the CTG findings and arterial blood gas analysis, offered a comprehensive assessment of fetal well-being and the effectiveness of intrapartum monitoring.

Statistical Analysis

All the necessary data were collected, entered into Microsoft Excel and analyzed using IBM SPSS version 24.0. Statistical analysis was performed using IBM SPSS

version 24. Descriptive data was summarized by mean $\pm$ SD for continuous data and proportions for categorical data. The independent samples t-test was used to compare continuous variables (birth weight, APGAR scores) between acidosis and non-acidosis groups. The Pearson chi-square test was employed for categorical variables (gender, gestational age, onset of labour, type of liquor, mode of delivery, etc.) to assess associations with cord blood acidosis. A p-value <0.05 was considered as statistically significant.

Results

Among 88 participants, majority [50 (56.82%)] aged 21-25 years, followed by [28 (31.82%)] belonged to 26-30 years age group. The mean age of the participants was 25.045 ± 3.808 years. Figure 1 illustrates age distribution of the participants.

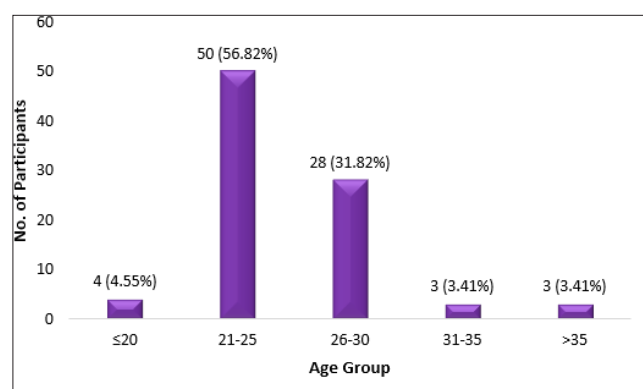


Figure 1. Maternal Age Distribution

Cord blood acidosis was observed in 11 cases (12.5%). Significant associations were found between cord blood acidosis and gestational age ($p=0.001$), induced labour ($p=0.001$), meconium-stained liquor ($p=0.001$), and mode of delivery ($p=0.001$). The majority of acidosis cases (63.6%) were in the 40-40+6 weeks gestational age group. Induced labour was associated with acidosis in 45.5% of cases compared to only 3.9% in the non-acidosis group. Meconium-stained liquor was present in 54.5% of acidosis cases versus 7.8% in non-acidosis cases. LSCS was performed in 81.8% of acidosis cases compared to 22.1% in non-acidosis cases. No significant association was found with gender of the fetus, mothers' socio-economic status, gravidity, fetal movement, or Bishop's score (Table 1).

Table 1: Association of Cord Blood Acidosis with Various Parameters

Parameter	Category	Acidosis (n=11)	No Acidosis (n=77)	Total	χ^2	p-value
Gender of the Fetus	Male	5 (45.5%)	40 (51.9%)	45	0.162	0.687
	Female	6 (54.5%)	37 (48.1%)	43		
Socio-economic Status	Class I	1 (9.1%)	2 (2.6%)	3	1.398	0.497
	Class II	6 (54.5%)	50 (64.9%)	56		
	Class III	4 (36.4%)	25 (32.5%)	29		
Gravidity	Primigravida	3 (27.3%)	13 (16.9%)	16	3.700	0.448
	G2	2 (18.2%)	29 (37.7%)	31		
	G3	3 (27.3%)	26 (33.8%)	29		
	G4	2 (18.2%)	7 (9.1%)	9		
	G5	1 (9.1%)	2 (2.6%)	3		
Gestational Age	37-37+6	2 (18.2%)	31 (40.3%)	33	24.468	0.001*
	38-38+6	1 (9.1%)	20 (26.0%)	21		
	39-39+6	0 (0%)	16 (20.8%)	16		
	40-40+6	7 (63.6%)	10 (13.0%)	17		
	42	1 (9.1%)	0 (0%)	1		
Onset of Labour	Induced	5 (45.5%)	3 (3.9%)	8	20.114	0.001*
	Spontaneous	6 (54.5%)	74 (96.1%)	80		
Fetal Movement	Decreased	1 (9.1%)	3 (3.9%)	4	0.599	0.439
	Present	10 (90.9%)	74 (96.1%)	84		
Bishop's Score	Favourable	7 (63.6%)	65 (84.4%)	72	2.794	0.095
	Unfavourable	4 (36.4%)	12 (15.6%)	16		
Type of Liquor	Clear	5 (45.5%)	71 (92.2%)	76	17.865	0.001*
	MSL	6 (54.5%)	6 (7.8%)	12		
Mode of Delivery	LSCS	9 (81.8%)	17 (22.1%)	26	16.502	0.001*
	NVD	2 (18.2%)	60 (77.9%)	62		

*Statistically significant (p<0.05)

The mean birth weight in the acidosis group was 2.757 ± 0.312 kg compared to 2.709 ± 0.228 kg in the non-acidosis group. This difference was not statistically significant ($p=0.539$). Neonates with acidosis had significantly lower APGAR scores at both 1 minute (5.18 vs 6.44) and 5 minutes (6.36 vs 8.40) compared to those without acidosis ($p<0.001$ for both), shown in Table 2.

Table 2: Comparison of Mean Birth Weight and APGAR Score with Core Blood Acidosis

Parameter	Group	N	Mean (kg)	Std. Deviation	t-value	p-value
Birth Weight	Acidosis	11	2.757	0.312	0.617	0.539
	No Acidosis	77	2.709	0.228		
APGAR at 1 min	Acidosis	11	5.182	0.751	5.551	<0.001*
	No Acidosis	77	6.442	0.698		
APGAR at 5 min	Acidosis	11	6.364	1.027	8.209	<0.001*
	No Acidosis	77	8.403	0.730		

*Statistically significant (p<0.05)

All neonates with acidosis (100%) required initial resuscitation and NICU admission, compared to only 7.8% and 6.5%, respectively in the non-acidosis group. No birth asphyxia found in the non-acidosis group. These associations were highly significant (p<0.001). No early neonatal deaths were reported in either group (Table 3).

Table 3: Association of Fetal Outcomes with Core Blood Acidosis

Fetal Outcome	Acidosis (n=11)	No Acidosis (n=77)	p-value
Initial Resuscitation Required	11 (100%)	6 (7.8%)	<0.001*
NICU Admission	11 (100%)	5 (6.5%)	<0.001*
Birth Asphyxia	11 (100%)	0 (0%)	<0.001*
Respiratory Distress Syndrome	0 (0%)	3 (3.9%)	0.741
Seizure Disorder	0 (0%)	1 (1.3%)	0.704
Jaundice	0 (0%)	1 (1.3%)	0.704
Early Neonatal Death	0 (0%)	0 (0%)	-

*Statistically significant (p<0.05)

Discussion

The present study was conducted to evaluate the association between various maternal, intrapartum, and neonatal factors with cord blood acidosis and its impact on neonatal outcomes.

The majority of women in the present study belonged to the 21–25 years age group (56.82%), followed by 26–30 years (31.82%), with a mean age of 25.04 ± 3.80 years. These findings were closely comparable with Sethia et al. (2022), who reported that most participants were also in the 21–25 years age group (47.8%) with a mean age of 24.21 ± 3.43 years[12]. Similarly, Neeraja et al. (2020) found that the majority of mothers belonged to the 20–25 years age group (53%), followed by 26–30 years (35%)[13]. Sharma et al. (2022) also reported that most enrolled cases were from the 21–30 years age group (82.80%), supporting the present study findings[14].

Fetal gender distribution in the present study was almost

equal (male 51.1%, female 48.9%), with no significant association with cord blood acidosis (p=0.687). Sharmin et al. (2022) reported comparable gender distribution with 46.3% males and 53.8% females[10].

A significant association was found between advancing gestational age and cord blood acidosis (p=0.001). The majority of acidosis cases (63.6%) occurred in the 40–40+6 weeks group, while earlier gestational age groups had comparatively fewer cases. This finding is clinically significant as post-term pregnancies are known to be at increased risk of uteroplacental insufficiency that can lead to fetal hypoxia and acidosis. Sharma et al. (2022) reported that 79.2% of cases were between 37–40 weeks gestation[14]. Sharmin et al. (2022) also reported progressive worsening of fetal condition with CTG severity, with mean cord blood pH decreasing from 7.25 ± 0.05 (normal CTG) to 7.20 ± 0.06 (suspicious) and 7.13 ± 0.09 (pathological), indicating that fetal hypoxia and acidosis are more closely related to intrapartum compromises[10].

In this study, among the acidosis group, 45.5% had induced labour compared to only 3.9% in the non-acidosis group. This finding is concerning as induction of labour may expose the fetus to uterine hyperstimulation, cord compression, and subsequent hypoxia, particularly when the cervix is unfavorable. Neeraja et al. (2020) observed that 43% of cases required LSCS, most of which were associated with abnormal CTG patterns[13]. Kanagal et al. (2022) reported that babies born with pathological CTG had significantly higher rates of acidosis (62.6%) and were more likely to undergo operative interventions[15]. Sharmin et al. (2022) demonstrated that the LSCS rate increased 5.33 times in abnormal CTG cases, along with worsening neonatal outcomes and declining cord blood pH (7.25 to 7.13)[10].

Meconium-stained liquor showed a strong association with cord blood acidosis ($p=0.001$), being present in 54.5% of acidosis cases compared to only 7.8% in non-acidosis cases. This finding is supported by Neeraja et al. (2020), who reported that as CTG became abnormal, the proportion of thick meconium increased significantly, correlating with fetal distress and adverse neonatal outcomes[13]. Mukhopadhyay et al. (2024) highlighted that meconium staining, when associated with fetal acidemia, represents an obstetrical hazard, indicating underlying hypoxia and metabolic compromise[16]. However, Kumar et al. (2016) reported that although 16.67% cases had meconium-stained liquor, not all were associated with acidosis, suggesting that MSL alone is not always predictive but becomes significant when associated with fetal distress[17].

In the present study, LSCS was significantly associated with cord blood acidosis ($p=0.001$), with 81.8% of acidosis cases delivered by LSCS compared to 22.1% in non-acidosis cases. This finding reflects the clinical decision-making process where operative delivery is performed in response to suspected fetal distress. Kanagal et al. (2022) also observed that babies with pathological CTG had significantly higher rates of acidosis (62.6%) and NICU admission (55%), and these cases were more likely to undergo operative delivery[15]. Ghafoor et al. (2023) reported that pathological CTG cases had significantly higher NICU admission (77.1%) and adverse outcomes, with a strong association with low cord blood pH[18].

In our study, neonates with cord blood acidosis had significantly lower APGAR scores at both 1 minute (5.18 vs 6.44) and 5 minutes (6.36 vs 8.40) ($p<0.001$). Mukhopadhyay et al. (2024) also observed that 14.3% of neonates in the abnormal CTG group had APGAR <7 , with significantly lower pH values (7.03 vs 7.17, $p<0.001$)[16].

In the present study, all neonates with acidosis (100%) required resuscitation, NICU admission, and had birth asphyxia, compared to only 7.8%, 6.5%, and 0% respectively in the non-acidosis group, and these differences were statistically highly significant ($p<0.001$). Kumar et al. (2016) reported that among neonates with acidosis (33.34%

cases), 70% required NICU admission, with some requiring ventilation[17]. Ghafoor et al. (2023) reported 77.1% NICU admission in pathological CTG cases, which were also associated with low cord blood pH[18].

However, the study has some limitations. The single-centre study with small sample size limits the generalizability and causal inference. Selection bias, inter-observer variability in CTG interpretation may have influenced the study findings. Moreover, long-term neonatal outcomes were not evaluated in this study.

Conclusion

This study demonstrates that intrapartum fetal distress on CTG is significantly associated with cord blood acidosis and adverse neonatal outcomes. While maternal demographic factors lacked predictive value, higher gestational age (≥ 40 weeks), induced labour, meconium-stained liquor, and operative delivery were significantly associated with acidosis. Neonates with acidosis had markedly lower APGAR scores and universally required resuscitation and NICU admission. CTG remains a valuable screening tool for fetal distress; however, its diagnostic accuracy improves significantly when correlated with umbilical cord blood pH. Early recognition of high-risk intrapartum factors combined with objective biochemical assessment enables timely intervention, reduces perinatal morbidity, and improves neonatal outcomes.

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Conflict of Interest

The authors do not have any conflicts of interest.

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