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Original Research Article

Monitoring Intrapartum Fetal Distress by Cardiotocography & Observe its Relation with Umbilical Cord Blood Sampling & Perinatal Outcome

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Abstract

Background: Cardiotocography (CTG) being a simple noninvasive tool has been used more frequently in recent decades to detect fetal distress & to reduce neonatal mortality &morbidity related to fetal hypoxia. On the other hand, umbilical cord blood gas can be used to detect fetal acidaemia due to fetal distress more accurately. This study aimed to correlate fetal monitoring findings by intrapartum CTG with umbilical cord blood pH & lactate level &test the ability of CTG to predict fetal distress & neonatal outcome. ***Materials and Methods:*** This prospective cross-sectional observational study was conducted in the Department of Obstetrics and Gynecology of Chittagong Medical College Hospital, Chattogram, Bangladesh for one year from July 2020 to June 2021. It included 80 term singleton pregnancies in active labour. Intrapartum CTG was taken and classified into normal, suspicious and pathological according to FIGO guidelines of CTG monitoring 2015. Mode of delivery, liquor colour, Apgar scores at 1 and 5 minutes, and admission to the neonatal intensive care unit (NICU), adverse neonatal outcomes were observed. Immediately after delivery of the baby 10 cm of the umbilical cord was clamped doubly and 2-3 ml of umbilical cord arterial blood was taken immediately in a pre-heparinized syringe and sent to a laboratory for assessment of pH and lactate to detect fetal acidosis. Antenatal CTG was correlated to neonatal outcomes and cord blood acidosis by statistical analysis. ***Results:*** In this study, 40.0% of the women had normal CTG, 38.8% had suspicious CTG, and 21.2% had pathological CTG. There was a significant worsening of neonatal outcomes across these three groups concerning depressed (<7) Apgar scores at 1 minute (40.6%, 80.6%, and 100%; P<0.001), depressed Apgar scores at 5 minutes (3.1%, 22.6%, and 47.1%; P<0.001), and admission to the NICU (9.4%, 38.6%, and 70.7%; P<0.001). When CTG was pathological or suspicious CTG delivery by LSCS was 5.33 times higher (RR: 5.33; 95% CI: 2.09 -13.63) compared to subjects with normal CTG. There was also a progressive worsening of cord blood pH (7.25±0.05, 7.20±0.06, and 7.13±0.09; P<0.001) and a progressive increase in lactate (3.66±1.01 mmol/l, 4.79±1.61 mmol/l, and 6.63±2.18 mmol/l; P<0.001). ***Conclusions*:** It should be concluded that pathological CTG which correlates intrapartum fetal hypoxia with cord blood acidaemia and adverse neonatal outcomes. As cardiotocography is a simple, cost-effective noninvasive tool it can be used to detect fetal distress in labour. Continues CTG monitoring can be offered or recommended in every labour room setting to detect fetal distress & early intervention to prevent neonatal morbidity & mortality.

Keywords: Intrapartum Fetal Distress**,** Cardiotocography, Umbilical Cord & Perinatal.

INTRODUCTION

Fetal distress has been described as "a condition in which fetal physiology is so altered to make death or permanent injury a probability within a relatively short period and usually considered to denote disruption of normal fetal oxygenation, ranging from mild hypoxia to profound fetal asphyxia" [1]. The oxygen supply to the fetus is interrupted with every uterine contraction during labour. A healthy fetus has in build mechanisms to tide over these short periods of

hypoxia without any consequences. However, a fetus with borderline reserves due to chronic uteroplacental insufficiency may decompensate and show overt asphyxia during labour [2, 3]. Despite the advances in fetal monitoring during labour, one of the most critical causes of neonatal death and neurologic injuries remains intrapartum asphyxia [4]. During labour and birth, intrapartum asphyxia leads to hypoxia and fetal acidosis. Thus, a reliable method for detecting acidosis can be a helpful tool for predicting adverse neonatal outcomes due to intrapartum asphyxia [5]. It was found that cord blood pH is the most sensitive parameter for the diagnosis of fetal asphyxia and should be performed in all high-risk births, as this may help provide appropriate care to the newborn at birth and prevent and decrease neonatal morbidity and mortality [6]. The umbilical artery pH is a predictor of adverse neonatal outcomes, and the Blood Gas Analysis (BGA) of cord blood is a helpful tool for screening newborns at risk. Universal umbilical cord BGA should be considered for all deliveries because it is an accurate screening test for neonatal hypoxia [7]. Intrapartum fetal monitoring is another way to address severe perinatal hypoxia related to perinatal death or permanent neurological damage. Currently, the two most widely accepted techniques of fetal monitoring are 'intermittent auscultation (IA) of fetal heart rate (FHR)' and 'cardiotocography' (CTG) [8]. Intrapartum continuous fetal monitoring is mandatory in any labour considered as high risk. Continuous electrical fetal monitoring (EFM) by CTG is the most common obstetrics procedure in the United States, and 75% of women in Canada have continuous EFM while most of these women (70–80%) are at low risk [9, 10]. CTG involves continuous recording of FHR as well as uterine contractions. The 'cardiac' part of the CTG, the FHR, is recorded using a transducer placed on the maternal abdomen (external monitoring) or an electrode placed on the fetal scalp (internal monitoring). The external transducer is an ultrasound device that uses the Doppler principle. It is printed on paper in a similar way to an electrocardiography (ECG). There is a second transducer, the 'toco' component, which is also placed on the maternal abdomen below the uterine fundus, and it records the contractions [11]. According to National Institute for Health and Care Excellence (NICE), guideline 2017, CTG tracings were interpreted as normal, suspicious (suspicious), and pathological. According to NICHD 2008 Classification, intrapartum CTG tracing is classified into Normal (category I trace), Indeterminate (category II trace), and Abnormal (category III trace) [12, 13]. Changes observed on the CTG trace may reflect a fetal response to the ongoing hypoxic or mechanical stresses during labour, such as compression of the umbilical cord or reducing the placental blood flow. If appropriately interpreted, the CTG trace will provide information regarding the nature of the ongoing hypoxic and mechanical stress and fetal compensatory mechanisms [11]. The rates of cesarean section (CS) and instrumental deliveries have been continuously increasing over the last 40 years. An important driver of this rising rate of operative deliveries is the use of CTG in labour [14]. CTG has a high false-positive rate and has high intra-observer variability [11]. On the other hand, controversy regarding the routine practice of CTG is ongoing. A recent Cochrane review reported that CTG during labour is associated with reduced rates of neonatal seizures, but no apparent differences in cerebral palsy, infant mortality, or other standard neonatal well-being measures. However, continuous CTG was associated with increased CS and instrumental vaginal births [15]. In addition, recent studies are inconsistent regarding the correlation between CTG and cord BGA. Some studies reported the low predictive value of CTG tracings in the diagnosis of neonatal acidaemia and prediction of poor neonatal outcomes, while others reported a highly significant correlation between CTG and umbilical cord blood pH is being acidic [16-22]. Intrauterine hypoxia can lead to 20-40% of the stillbirths, preventable by intrapartum fetal monitoring [13]. In Bangladesh, the vast majority of labour (low and high risk) is monitored by intermittent auscultation of fetal heart rate. Intrapartum fetal monitoring by CTG has been introduced in Chittagong Medical College Hospital (CMCH) for a couple of years. The purpose of CTG monitoring is to determine fetal bradycardia and other fetal heart rate abnormalities during labour to minimize fetal death and adverse neonatal consequences of fetal hypoxia so that early intervention can be carried out. To date, CTG is not a regular monitoring tool due to a lack of agreement on nomenclature and definitions for interpretation of FHR and partly due to inter-observer and intraobserver bias. The bias can be solved through regular audits of CTG tracings against fetal conditions at birth. In this regard, fetal umbilical cord acid-base status has been used as a Gold standard tool for audit [23]. Currently, there are very few studies done in Bangladesh, especially in CMCH, to determine the predictive value of CTG diagnosis of fetal distress by following up on the newborn for acidaemia and or poor neonatal outcome. In this regard, it was rational to do this study to correlate intrapartum CTG findings with umbilical cord blood pH at birth and perinatal outcome at the study site. The study results would help us evaluate the success of CTG as FHR monitoring practices in predicting fetal acidosis during labour and the poor perinatal and neonatal outcome. So this noninvasive CTG can be introduced as a regular intrapartum monitoring tool in the labour ward to reduce inter-observer bias which is common in the case of IA by stethoscope. This study will grow attitudes toward using CTG tracing along with umbilical cord blood sampling to observe and evaluate adverse neonatal consequences of fetal hypoxia and acidosis. Moreover, the study results would help us to evaluate the success of CTG as an FHR monitoring tool and predicting fetal acidosis in labour and justify the indication of emergency cesarean section for fetal distress. This study was designed to correlate intrapartum fetal

distress with the help of CTG with umbilical cord blood sampling by measuring cord blood pH and lactate level and its perinatal outcome.

METHODOLOGY & MATERIALS

This perspective cross-sectional observational study was conducted in the Department of Obstetrics and Gynecology of Chittagong Medical College Hospital, Chattogram, Bangladesh for one year from July 2020 to June 2021. It included 80-term singleton pregnancies in active labour. Intrapartum CTG was taken and classified into normal, suspicious, and pathological according to FIGO guidelines of CTG monitoring 2015. Mode of delivery, liquor colour, Apgar scores at 1 and 5 minutes, and admission to the neonatal intensive care unit (NICU), adverse neonatal outcomes were observed. Immediately after delivery of the baby 10 cm of the umbilical cord was clamped doubly and 2-3 ml of umbilical cord arterial blood was taken immediately in a pre-heparinized syringe and sent to a laboratory for assessment of pH and lactate to detect fetal acidosis. Antenatal CTG was correlated to neonatal outcomes and cord blood acidosis by statistical analysis.

RESULTS

More than half (52.5%) of the participants were in the 20-29 years age group, followed by 42.5% (42/80) in the below 20 years age group, and only 5.0% (4/80) in the 30-39 years age group. This table shows that. Thirty-four (42.5%) women were nulliparous, and more than half (57.5%) of the participants were at term pregnancy. There were 6 women (7.5%) with mild oligohydramnios, 14 (17.5%) with meconium-stained liquor, 11 (13.8%) women with less fetal movement, and 12 (15.0%) were with post-term pregnancy. After summarizing different CTG parameters, it was found that 38.8% (31/80) of subjects had suspicious CTG, and 21.2% (17/80) had pathological CTG findings. The remaining 40.0% (32/80) had Normal CTG. The CTG categories of the participants are depicted in Figure 1. This figure reveals that, out of 80 women, 53.8% were delivered by normal virginal delivery, and 43.7% were delivered by cesarean section. Only 2 (2.5%) of the women were delivered by forceps delivery figure-2. This table states that the birth weight range was <2.5 kg in only 3 (3.8%) of cases, and 29 (36.3%) of patients had a weight >3.0 kg. 68.8% and 20.0% had Apgar scores <7 at 1 minute and 5 minutes, respectively Table 3. This table states that Bag-mask ventilation was administered in 17.5% of newborns and 33.8% required admission to the neonatal care unit. Five (6.3%) developed hypoxic Ischemic encephalopathy and 6 (7.5%) neonatal deaths. The amniotic fluid's thin and thick meconium staining was noted in 37.5% and 18.8% of births Table 3. This table states that the majority of the neonates with normal acid-base status had normal CTG tracing in contrast to the neonates with cord blood acidaemia, where the majority of the CTG tracing was either suspicious (48.0%) or pathological (44.0%) (Table XIV). A significant association was found between the type of CTG and umbilical cord artery blood pH (p=0.005) Table 4. Table 5 states that, the proportion of Apgar scores <7 at 1 minute was highest in the pathological CTG group (100%), moderate in the suspicious group (80.0%), and lowest in the normal group (40.6%; P < .001 for trend). The Apgar scores at 5 minutes followed the same pattern (47.1%, 22.6%, and 3.1%, respectively; P < .001 for trend). Table X shows that adverse neonatal outcomes were more observed in participants with intrapartum abnormal CTG tracing type. However, among different outcomes, birth asphyxia, neonatal sepsis, and MAS observed a significantly higher proportion with abnormal CTG. Figure 3 shows that cord blood lactate level had a significant positive correlation with CTG tracing (Spearman rho value of 0.590; p<0.001) indicated with changing from CTG type normal to suspicious and pathological cord blood acidemia (increasing lactate level) increased.

Table-1: Demographic Characteristics of the Participants (N=80)

Characteristics	Frequency	Percentage
Age group		
<20 years	34	42.5
20-29 years	42	52.5
30-39 years	4	5
Parity		
0	34	42.5
1	42	52.5
2-4	4	5
Gravida		
Primi	30	37.5
Multi	47	58.8
	3	3.8
Gestational age		
37-40 weeks	46	57.5
40-42 weeks	34	42.5
Gestational risk factors		

Miloligohydramniosos	6	7.5
Meconium stained liquor	14	17.5
Less fetal movement	11	13.8
Postdated pregnancy	12	15
No risk factors	37	46.3

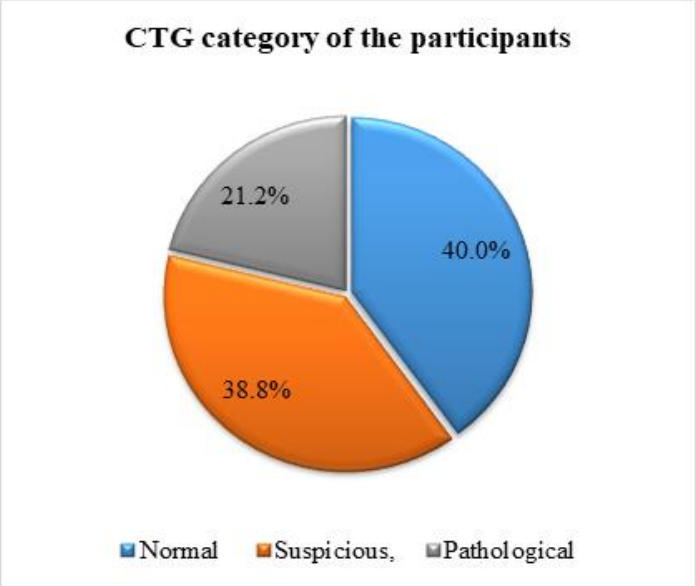

Figure-1: Overall CTG interpretation of the participants

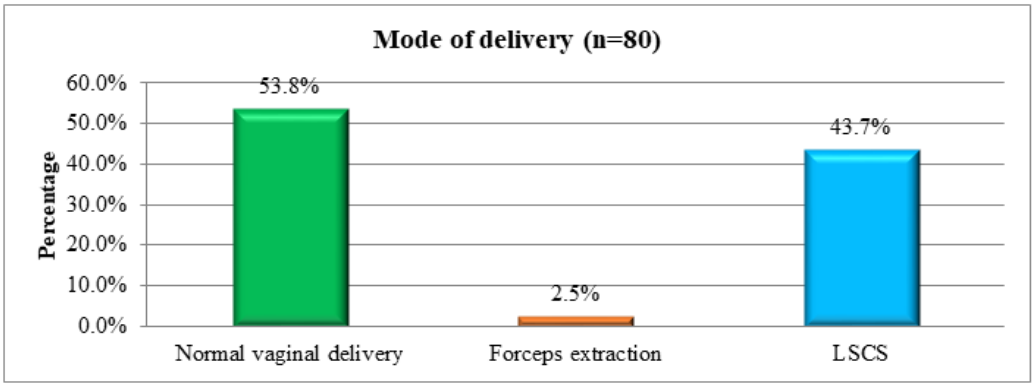

Figure-2: Mode of delivery of the participants

Table-2: Neonatal outcome

Variables	Frequency	Percentage
Liquor colour		
Clear	35	43.8
Thin meconium	30	37.5
Thick meconium	15	18.8
Sex		
Male	37	46.3
Female	43	53.8
Birth weight		
<2.5 kg	3	3.8
2.5-3.0 kg	48	60
>3.0 kg	29	36.3
APGAR <7 at 1 min	55	68.8
APGAR <7 at 5 min	16	20

Table-3: Neonatal outcome

Variables	Frequency	Percentage
Resuscitation		
Not needed	63	78.8
Bag-mask ventilation	14	17.5
PPV	3	3.8
Need NICU admission	27	33.8
Neonatal seizure	10	12.5
Birth asphyxia	31	38.8
Neonatal sepsis	9	11.3
Meconium aspiration syndrome	15	18.8
Hypoxic Ischemic encephalopathy	5	6.3
Neonatal death	6	7.5

Table-4: Association of overall CTG interpretation with cord blood acid-base status

CTG tracing	Cord blood acid-base status		P-value
	Normal (n=55)	Acidaemia (n=25)	
Normal	30 (54.5)	2 (8.0)	0.005*
suspicious	19 (34.5)	12 (48.0)	
Pathological	6 (10.9)	11 (44.0)	

Table-5: Association between overall CTG interpretation and APGAR scores

CTG	APGAR score at 1 min		APGAR score at 5 min	
	<7	≥7	<7	≥7
Normal (n=32)	13 (40.6)	19 (59.4)	1 (3.1)	31 (96.9)
Suspicious (n=31)	25 (80.6)	6 (19.4)	7 (22.6)	24 (77.4)
Pathological (n=17)	17 (100.0)	0 (0)	8 (47.1)	9 (52.9)
P value	0.001		0.001	

Table-6: Association between CTG type and adverse neonatal outcomes

Neonatal outcome	CTG tracing		P-value*
	Normal (n=32)	Abnormal (n=48)	
Neonatal seizure	2 (6.3)	8 (16.7)	0.301
Birth asphyxia	2 (6.5)	29 (60.4)	<0.001
Neonatal death	0(0)	6(12.5%)	0.076
Neonatal sepsis	0 (0)	9 (18.8)	0.01
MAS	2 (6.3)	13 (27.1)	0.021
HIE	0 (0)	5 (10.4)	0.08

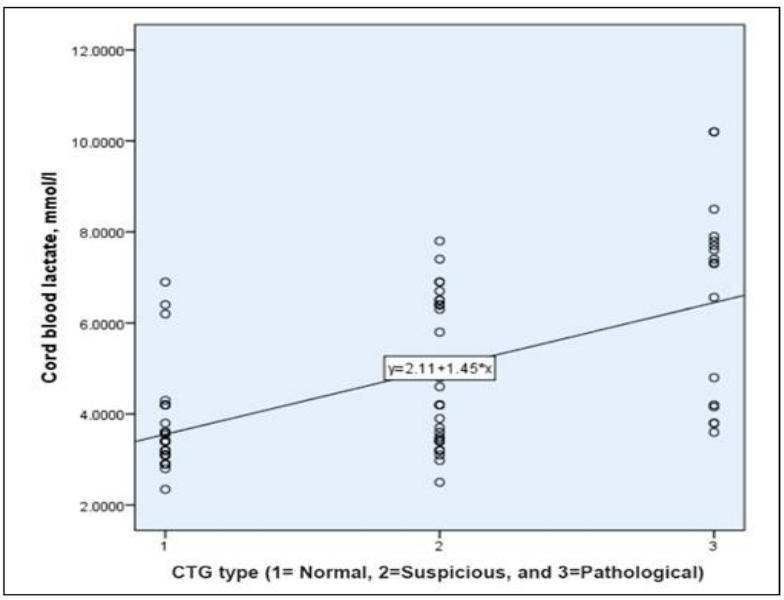

Figure-3: Correlation between CTG type and cord blood lactate level

DISCUSSION

CTG is one of the simple noninvasive fetal monitoring tools in pregnancy and during childbirth. In the majority of the hospitals in developed countries, it is the most commonly used tool for fetal surveillance [15]. The reason to carry out this study was to analyze the relation of CTG findings with cord blood pH and lactate level and perinatal outcome. For these purposes, 80 women in active labour were selected from the Department of Gynecology and Obstetrics of CMCH. All the participants were subjected to CTG during labour and their perinatal outcomes were recorded. The study demonstrated a significant relationship between abnormal (suspicious and pathological) CTG tracings and poor perinatal outcomes and between abnormal CTG tracing and cord blood acidosis. In this study, the majority of the study subjects belong to the age group 20-29 years, followed by 42.5% of study subjects between 18 -20 years and 5% were between 30 -39 years of age. This study population can be compared to Neerja S *et al*., 2020 majority of mothers were 25-30 years [24]. The relationship between maternal age and CTG type is not statistically significant. In this study, the majority of study subjects were multigravida 58.8% and belong 37.5% belongs to primigravida which is comparable to the study by Neerja S *et al*., 2020; parity was not statistically significant in our study [24]. Regarding risk factors, this study only included mild oligohydramnios; meconium-stained liquor, less fetal movements and postdated pregnancy but high-risk pregnancies like anaemia, GDM, PROM, Chorioamnionitis, prolonged labour, severe oligohydramnios, cord prolapse, abruption placentae were posted term pregnancy was excluded from this study subjects which was similar to the study done by Sonal B & Namita *et al*., 2020 [25]. It was found in our study that the participants without any risk factors are more likely to have normal and CTG, more than half of the participants having fewer fetal movements had pathological CTG. According to FIGO guidelines, CTG traces were divided into Normal (reassuring), Suspicious (non-reassuring), and Pathological (abnormal) in the present study, and it was found that 40% of the traces belonged to a normal pattern, 38.8% belonged to suspicious, and 21.2% were abnormal. In another study, 50.2% of the subjects had normal CTG tracing, 36.5% had suspicious CTG tracing and 13.3% had abnormal intrapartum CTG tracing which was similar to the present study [20]. According to CTG findings, 49.0% of cases were reassuring and 51.0% were non-reassuring in the study of Salma *et al*., (2018) previously conducted in Bangladesh [26]. These differences can be explained by the fact that the study by Salma *et al*., (2018) had included cases with less fetal movement only [26]. In the present study, patients with fewer fetal movements were 11 (13.8%). In the current study, the majority of the women having normal CTG traces (75%) had clear liquor, on the contrary, 51.6% and 16.1% of the suspicious group had thin and thick meconium-stained liquor 47% of the pathological CTG group had thick meconium stained liquor. Kumar *et al*., 2016 found that thick meconium in amniotic fluid was associated with poor neonatal outcomes and acidosis [27]. This was supported by another study by Tayade *et al*., 2012 which concluded that the moderate and thick meconium group had a significantly greater risk of a low Apgar score, poor neonatal outcome & NICU admission [28]. Another study by Neerja S *et al*., 2020 observed that as the CTG became abnormal the proportion of mothers having thick meconium increased [24]. The present study revealed a significant association between CTG tracing type and mode of delivery. Out of 32 study subjects with normal CTG tracing, most had a normal vaginal delivery (87.5%). Cesarean delivery rates were 12.5% and 54.8% in the normal and suspicious CTG groups respectively, but 82.4% in the pathological CTG group. All these data indicated that subjects with pathological CTG had a 7.06 times higher chance of delivering by LSCS than subjects with normal CTG. Subjects with pathological or suspicious CTG had a 5.33 times higher chance of delivering by LSCS than subjects with normal CTG. Similarly, Neeraja *et al*., (2020) also found a significant relation between CTG and mode of delivery [19]. Out of 50 study subjects with normal vaginal delivery, all 50 had the normal type of CTG in their study. Out of 43 mothers delivered by lower segment CS delivery, no one was found to have a normal type of CTG, 25 were found to have the suspicious type of CTG, and 18 were found to have an abnormal type of CTG. Thus, if the CTG is normal, it results in normal delivery [24]. For decades, Low Apgar scores have been used as a surrogate measure for birth asphyxia and subsequent adverse neurodevelopmental outcomes. The present study demonstrated comparatively good neonatal outcomes in the normal CTG group with only a 3.1% Apgar score being <7 in 5 minutes. None of the neonates developed hypoxic encephalopathy; the NICU admission rate was very low. In contrast, the neonatal outcomes in the group with pathological CTG traces were comparatively poor; with 100% of Apgar scoring less than 7 in 1 minute and 46.1% of Apgar scoring more than 7 in 5 minutes, the majority (70.5%) need NICU admission in this group. Among them 5 developed HIE, these findings are similar to a study conducted by Salma *et al*., 2018 where abnormal CTG findings showed a significant relationship with a low Apgar score, birth asphyxia and admission to NICU. Similarly, Neerja S *et al*., 2020 found NICU admission rates and birth asphyxia rates proportionally increased as the type of CTG changed from normal to pathological [26, 24]. In contrast to the present study's findings, Ashley failed to detect a good correlation between CTG findings and neonatal outcomes in 2018. In her research, there was a poor correlation between CTGs and neonatal outcomes. Nelson *et al*., (2016) reported a 98% false-positive rate of CTGs [14]. The main reason for the introduction of continuous CTG monitoring in clinical practice was a belief that it would reduce devastating neonatal outcomes like neonatal

death and neonatal hypoxic brain injury – in otherwise healthy babies [29]. In the present study, out of 80 deliveries, 5 neonates developed HIE. CTG tracing was found pathological in all 5 of them, there were 6 neonatal deaths in NICU one due to neonatal sepsis and the other 5 due to severe birth asphyxia and complications of HIE. Another commonly observed abnormality was birth asphyxia, meconium aspiration syndrome, and neonatal seizure among NICU admitted babies. These different adverse neonatal outcomes were observed in babies having pathological CTG group. Similarly, a study conducted by Syed w, Liaqat N *et al*., 2020 also observed adverse neonatal outcomes and increased NICU admission rates among neonates having abnormal intrapartum CTG traces [30]. Umbilical cord blood gas analysis represents one of the most objective ways to evaluate the newborn metabolic status and rule out perinatal asphyxia [23]. In this study, we mainly focused on cord blood pH and lactate level. In this study, 11.3% of study subjects had cord blood pH less than 7.1 and 20 % had cord blood pH between <7.2-7.1 but 68.8% had cord blood pH ≥ 7.2. In this study, 64.7% of the pathological CTG had acidosis and 38.7% of cases with suspicious CTG had acidosis. Only 6.3% of the subjects with normal CTG had acidosis. These data meant a significant association between CTG tracing type and cord blood pH. Also, there was an increased risk of having abnormal cord blood pH with an abnormal CTG. These values are comparable with the study by Ray (2017), where 52.5% of the cases with abnormal CTG had acidosis and 22.7% of cases with suspicious CTG had acidosis and only 7.3% of the subjects with normal CTG had acidosis [31]. Similarly, Aboulghar *et al*., (2013) reported that 50% of pathological CTG had acidosis, and 19.2% of patients with suspicious CTG had acidosis [32]. They also found that pathological (rather than suspicious) CTG significantly increased abnormal cord blood pH risk. The present study's findings were also comparable to Kaban et al. (2012), who studied 101 term pregnant women admitted for delivery [33]. In their study, 85 neonates had normal cord arterial pH, and 13 had fetal acidosis as diagnosed by cord arterial pH values <7.2. Of the 13 neonates with acidosis, 5 had non-reactive CTG tracings intrapartum. All 85 neonates without acidosis had reactive CTG tracings. The mean value of cord artery blood pH recorded in the normal CTG group in the current study (7.25±0.05) was close to others reported 7.28 ± 0.06 [34]. The cord blood lactate level in the normal CTG group (3.66±1.01) of the present study was close to the findings of Gjerris *et al*., (2008), who reported a mean of 4.63 ± 2.33, but much lower than Hamed *et al*., (2012), who reported a mean of 1.86 ± 0.99. A different methodology through measuring lactate in whole blood could be an explanation. The result of the present study confirmed that increased umbilical cord blood lactate was an accurate predictor of neonatal morbidity due to intrapartum asphyxia, as evident by the low Apgar score at 5 minutes and the requirement of NICU admission. By comparing the ROC curves areas, both lactate and pH were similar in predicting poor neonatal outcomes. In addition, although there are numerous proposals for cut-off values of pH and lactate to be used for confirming intrapartum asphyxia and predicting a poor outcome (Patil *et al*., 2018; Neacsu *et al*., 2021), the greatest sensitivity and specificity were achieved in the current study by using a cut-off value of 7.19 for pH, and 4.7 mmol/l for lactate for prediction of 5-minutes APGAR score <7 [23]. In the present study, sensitivity and specificity of cord blood lactate were almost similar to cord arterial pH in predicting adverse neonatal outcomes like low Apgar score and NICU admission. A similar observation was reported by Patil *et al*., (2018). But, Neacsu *et al*., (2021) said that lactate was superior to pH in predicting adverse neonatal outcomes [23]. Through the ROC curves, the values of cord lactate and pH that correspond to the highest sensitivity and specificity for detecting Apgar score <7 at minutes and NICU admission were determined in the present study. The study revealed a cut-off value of 6.35 mmol/L of cord blood lactate with sensitivity and specificity of 68.8% and 81.2% to predict a low Apgar score <7 after 5 min. Hamed *et al*., (2012) reported a cut-off value of 4.8 mmol/L of cord blood lactate with sensitivity and specificity of 68 and 89% to predict a low Apgar score <7 after 5 min [34]. In the present study, we tried to measure the correlation between CTG traces and cord blood pH and lactate level, a moderate negative correlation was observed between CTG and cord blood pH. Likewise, a moderate positive correlation was found between CTG these patients' babies were admitted to NICU, thus depicting a positive correlation between fetal acidosis and subsequent need for NICU admission [21]. Deshpande *et al*., (2019) also observed a significant correlation between CTG and cord lactate levels [35]. The study of Hamed *et al*., (2012) showed that umbilical cord blood lactate and pH had an inverse correlation with the 1- and 5-min Apgar scores in all CTG groups which were not statistically significant. [34] An abnormal CTG had a sensitivity of 84.6% and a specificity of 83.3% in detecting acidosis, which meant that while an abnormal CTG tracing could detect 84.6% of subjects with acidosis, it had a good ability to identify those who did not have acidosis because of its high specificity. It was also found that an abnormal CTG had a positive predictive value of 64.7% and an NPV of 93.8%, which meant that in the absence of an abnormal CTG, the chance of having acidosis was very little. The overall diagnostic accuracy of an abnormal CTG in diagnosing fetal acidosis was 83.7%. This was comparable to Ray and his colleague's (2017) study, where the sensitivity, specificity, PPV, NPV, and overall accuracy were 47.5%, 92.72%, 63.33%, 86.96%, and 83.25% respectively [31]. A suspicious CTG had a sensitivity of 85.7%, specificity of 61.2%, PPV of 38.7%, NPV of 93.8%, and overall diagnostic accuracy of 66.7%. Its high sensitivity indicated that suspicious CTG could detect 85.7% of subjects who had acidosis. However, its low specificity did not have

a good ability to identify those with acidosis. In contrast, Ray and his colleague (2017) reported a comparatively lower sensitivity (22.73%) and higher specificity (92.72%) of suspicious CTG in detecting fetal acidosis. However, when pathological and suspicious CTGs were considered together for acidosis diagnosis, it had a higher sensitivity of 92.0% and NPV (93.8%), but specificity and PPV were low, 54.6%, and 47.9%, respectively. It meant that in the absence of a pathological or a suspicious CTG, there was significantly less chance of having a fetus with acidosis. When pathological and suspicious CTG were taken together to diagnose acidosis, Ray and her colleague (2017) found a higher sensitivity of 80% in detecting acidosis [31]. The specificity of both abnormal and suspicious CTG in detecting acidosis was 56.91%. The PPV NPV of this combined group was 29.33% and 92.72%, respectively. Moreover, the NPV of both pathological CTG and combined pathological and suspicious CTG groups was good, 87.5%. This meant that CTG had a confident safety profile to avoid missing the diagnosis in patients at risk and a relevant cost/benefit profile to avoid unnecessary LSCS of patients who would not benefit from such surgical intervention. The CTG is an easy, painless, and cost-effective test for evaluating fetal well-being. This study did not attempt to demonstrate an ability to decrease CS rates, nor does it try to link fetal monitoring by CTG with long-term neurologic function and cerebral palsy. It did attempt to show that EFM by CTG tracing could discriminate during labour healthy fetuses who have a high likelihood of a normal early outcome. This CTG classification system for EFM accurately predicts normal outcomes of healthy fetuses. It was also highly predictive of fetal distress resulting in umbilical cord acidemia and adverse neonatal sequelae. In conclusion, CTG can be used as an accurate predictor of neonatal morbidity caused by intrapartum hypoxia.

Limitations of the study

The sample size was small due to resource constraints during the period of the global corona pandemic. Samples were collected from a single public tertiary hospital so the results cannot be generalized. The study included only term neonates; thus, the results may not be valid for preterm births. The only short-term outcome was taken into consideration but babies with severe birth asphyxia could not be followed for assessment of neurodevelopmental delay cerebral palsy and other consequences due to the short period of the study period.

CONCLUSION AND RECOMMENDATIONS

The purpose of this study was to test the ability of CTG tracings to predict early fetal hypoxia & neonatal morbidity as well as assess the correlation between CTG tracings and cord blood acidosis. In conclusion, CTG being a simple noninvasive tool was found to be a good predictor of a healthy fetus in normal pregnancies between 37-42 weeks of gestation, and the probability of an adverse neonatal outcome was associated with pathological CTG tracings. Finally, it should be concluded that continuous CTG monitoring should be offered and recommended in labour room settings to predict neonatal mortality and morbidity. CTG as a noninvasive procedure can be used as an accurate predictor of intrauterine fetal hypoxia and may act as a tool for timely intervention & reduce neonatal morbidity. More extensive studies are needed to assess the predictive ability of CTG and cord blood acid-base status for better assessment of neonatal outcomes. CTG should be introduced for regular fetal monitoring in all setups of this country for better diagnosis of fetal distress during labour and better perinatal outcome.

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REFERENCES

1. Parer, J. T., & Livingston, E. G. (1990). What is fetal distress?. *American journal of obstetrics and gynecology*, *162*(6), 1421-1427.
2. Srinivas, S. K., Sammel, M. D., Stamilio, D. M., Clothier, B., Jeffcoat, M. K., Parry, S., ... & Metlay, J. (2009). Periodontal disease and adverse pregnancy outcomes: is there an association?. *American journal of obstetrics and gynecology*, *200*(5), 497-e1.
3. Yeh, Y. H., Hsieh, Y. L., Lee, Y. T., & Hu, C. C. (2012). Protective effects of Geloina eros extract against carbon tetrachloride-induced hepatotoxicity in rats. *Food Research International*, *48*(2), 551-558.
4. Ahearne, C. E., Boylan, G. B., & Murray, D. M. (2016). Short and long term prognosis in perinatal asphyxia: An update. *World journal of clinical pediatrics*, *5*(1), 67.
5. Omo-Aghoja, L. (2014). Maternal and fetal Acid-base chemistry: a major determinant of perinatal outcome. *Annals of medical and health sciences research*, *4*(1), 8-17.
6. Kumar, S., Stecher, G., Li, M., Knyaz, C., & Tamura, K. (2018). MEGA X: molecular evolutionary genetics analysis across computing platforms. *Molecular biology and evolution*, *35*(6), 1547.
7. Silva, J. D., Barletta, M., Lima, A. R., & Ferreira, G. V. (2018). Use of resources and microplastic contamination throughout the life cycle of grunts (Haemulidae) in a tropical estuary. *Environmental Pollution*, *242*, 1010-1021.
8. Sholapurkar, R. B., & Mahajan, Y. S. (2015). Review of wind energy development and policy in India. *Energy Technology & Policy*, *2*(1), 122-132.
9. Chen, Y., Fay, S., & Wang, Q. (2011). The role of marketing in social media: How online consumer

reviews evolve. *Journal of interactive marketing*, *25*(2), 85-94.
10. Davies, P. G., Spencer, S. J., Quinn, D. M., & Gerhardstein, R. (2002). Consuming images: How television commercials that elicit stereotype threat can restrain women academically and professionally. *Personality and social psychology bulletin*, *28*(12), 1615-1628.
11. Pinas, A., & Chandraharan, E. (2016). Continuous cardiotocography during labour: Analysis, classification and management. *Best practice & research Clinical obstetrics & gynaecology*, *30*, 33-47.
12. Ellington, D. R., & Richter, H. E. (2013). Indications, contraindications, and complications of mesh in surgical treatment of pelvic organ prolapse. *Clinical obstetrics and gynecology*, *56*(2), 276.
13. Srinivas, S. K., Sammel, M. D., Stamilio, D. M., Clothier, B., Jeffcoat, M. K., Parry, S., ... & Metlay, J. (2009). Periodontal disease and adverse pregnancy outcomes: is there an association?. *American journal of obstetrics and gynecology*, *200*(5), 497-e1.
14. Young, C. S., Hicks, M. R., Ermolova, N. V., Nakano, H., Jan, M., Younesi, S., ... & Pyle, A. D. (2016). A single CRISPR-Cas9 deletion strategy that targets the majority of DMD patients restores dystrophin function in hiPSC-derived muscle cells. *Cell stem cell*, *18*(4), 533-540.
15. Shakur, H., Roberts, I., Fawole, B., Chaudhri, R., El-Sheikh, M., Akintan, A., ... & Loto, O. (2017). Effect of early tranexamic acid administration on mortality, hysterectomy, and other morbidities in women with post-partum haemorrhage (WOMAN): an international, randomised, double-blind, placebo-controlled trial. *The Lancet*, *389*(10084), 2105-2116.
16. Johnson, K. W., Torres Soto, J., Glicksberg, B. S., Shameer, K., Miotto, R., Ali, M., ... & Dudley, J. T. (2018). Artificial intelligence in cardiology. *Journal of the American College of Cardiology*, *71*(23), 2668-2679.
17. Yusuf, S., Joseph, P., Rangarajan, S., Islam, S., Mente, A., Hystad, P., ... & Dagenais, G. (2020). Modifiable risk factors, cardiovascular disease, and mortality in 155 722 individuals from 21 high-income, middle-income, and low-income countries (PURE): a prospective cohort study. *The Lancet*, *395*(10226), 795-808.
18. Kumar, S., Stecher, G., Li, M., Knyaz, C., & Tamura, K. (2018). MEGA X: molecular evolutionary genetics analysis across computing platforms. *Molecular biology and evolution*, *35*(6), 1547.
19. Prasad, S., Holla, V. V., Neeraja, K., Surisetti, B. K., Kamble, N., Yadav, R., & Pal, P. K. (2020). Parkinson's disease and COVID-19: perceptions and implications in patients and caregivers. *Movement Disorders*.
20. Scholz, P., Bogdanov, S., Hessels, J. W. T., Lynch, R. S., Spitler, L. G., Bassa, C. G., ... & Wharton, R. S. (2017). Simultaneous X-ray, gamma-ray, and radio observations of the repeating fast radio burst FRB 121102. *The Astrophysical Journal*, *846*(1), 80.
21. Ly, T. K., Ho, T. D., Behra, P., & Nhu-Trang, T. T. (2020). Determination of 400 pesticide residues in green tea leaves by UPLC-MS/MS and GC-MS/MS combined with QuEChERS extraction and mixed-mode SPE clean-up method. *Food chemistry*, *326*, 126928.
22. Tepper, S., Ashina, M., Reuter, U., Brandes, J. L., Doležil, D., Silberstein, S., ... & Lenz, R. (2017). Safety and efficacy of erenumab for preventive treatment of chronic migraine: a randomised, double-blind, placebo-controlled phase 2 trial. *The Lancet Neurology*, *16*(6), 425-434.
23. Lassau, N., Ammari, S., Chouzenoux, E., Gortais, H., Herent, P., Devilder, M., ... & Blum, M. G. (2021). Integrating deep learning CT-scan model, biological and clinical variables to predict severity of COVID-19 patients. *Nature communications*, *12*(1), 1-11.
24. Neerja, S. O. O. D. Online teaching-learning during covid-19: Experience of nursing programmes of ignou. *Online Teaching-Learning During Covid-19: Experience Of Nursing Programmes of Ignou Dr. Neerja SOOD, School of Health Sciences, IGNOU, Maidan Garhi, New Delhi–110068*…… *3-13*, 3.
25. Singh, N. A. (2020). Sentiment analysis on motor vehicles amendment act, 2019 an initiative by the government of India to follow traffic rule. In 2020 International Conference on Computer Communication and Informatics (ICCCI), (pp. 1-5). IEEE.
26. Bhangu, A., Ademuyiwa, A. O., Aguilera, M. L., Alexander, P., Al-Saqqa, S. W., Borda-Luque, G., ... & Iftekhar, F. (2018). Surgical site infection after gastrointestinal surgery in high-income, middle-income, and low-income countries: a prospective, international, multicentre cohort study. *The Lancet Infectious Diseases*, *18*(5), 516-525.
27. Kumar, S., Stecher, G., Li, M., Knyaz, C., & Tamura, K. (2018). MEGA X: molecular evolutionary genetics analysis across computing platforms. *Molecular biology and evolution*, *35*(6), 1547.
28. Chaurasia, O. P., Ballabh, B., Tayade, A., Kumar, R., Kumar, G. P., & Singh, S. B. (2012). Podophyllum L.: An endergered and anticancerous medicinal plant–An overview.
29. Shakur, H., Roberts, I., Fawole, B., Chaudhri, R., El-Sheikh, M., Akintan, A., ... & Loto, O. (2017). Effect of early tranexamic acid administration on mortality, hysterectomy, and other morbidities in women with post-partum haemorrhage (WOMAN):

an international, randomised, double-blind, placebo-controlled trial. *The Lancet*, *389*(10084), 2105-2116.

30. Syed, W., Liaqat, N., Naseeb, G., & Khattak, S. M. (2022). Relationship of placental edge thickness and cervical length to gestational age at delivery in patients with placenta previa. *Pakistan Journal of Medical Sciences*, *38*(5).
31. Saran, R., Robinson, B., Abbott, K. C., Agodoa, L. Y., Albertus, P., Ayanian, J., ... & Shahinian, V. (2017). US renal data system 2016 annual data report: epidemiology of kidney disease in the United States. *American journal of kidney diseases*, *69*(3), A7-A8.
32. Aboulghar, M., & Islam, Y. (2013). Twin and preterm labor: prediction and treatment. *Current Obstetrics and Gynecology Reports*, *2*(4), 232-239.
33. Lee, J. S., FitzGibbon, E. J., Chen, Y. R., Kim, H. J., Lustig, L. R., Akintoye, S. O., ... & Kaban, L. B. (2012, June). Clinical guidelines for the management of craniofacial fibrous dysplasia. In *Orphanet journal of rare diseases* (Vol. 7, No. 1, pp. 1-19). BioMed Central.
34. Alves, D., Arkani-Hamed, N., Arora, S., Bai, Y., Baumgart, M., Berger, J., ... & LHC New Physics Working Group. (2012). Simplified models for LHC new physics searches. *Journal of Physics G: Nuclear and Particle Physics*, *39*(10), 105005.
35. Dwyer-Lindgren, L., Cork, M. A., Sligar, A., Steuben, K. M., Wilson, K. F., Provost, N. R., ... & Hay, S. I. (2019). Mapping HIV prevalence in sub-Saharan Africa between 2000 and 2017. *Nature*, *570*(7760), 189-193.