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ABNORMAL CARDIOTOCOGRAPHY FINDINGS AND ITS ASSOCIATION WITH ADVERSE FETAL OUTCOMES

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ABSTRACT

Prediction of the perinatal outcomes is important for high-risk pregnant patients presenting with different medical and obstetrical complications by Cardiotocography (CTG). **Objectives:** The study was carried out to evaluate whether abnormal cardiotocography can reflect fetal hypoxia and predict fetal outcomes and to what extent one can rely on CTG record. **Material & Method:** Prospective observational study was done on 101 high risk pregnant patients presented in Department of Obstetrics and Gynae, Dhaka Medical College Hospital, meeting the inclusion criteria were subjected to perform CTG testing. The CTG tracing was categorized according to the National Institute for Health and Care Excellence (NICE) guideline into normal, suspicious and pathological CTG tracing groups. Both suspicious and pathological CTG were considered here as abnormal CTG tracing group. Specific fetal outcome measures were observed and correlated with CTG tracing. **Result:** Fetal distress developed during delivery in 3.39% of patients with a normal CTG tracing whereas 54.76% patients with an abnormal CTG tracing. The admission test had sensitivity 92%, specificity 75%, positive predictive value 54.8% and negative predictive value 96.6% for predicting Apgar score <7 in one minute. Admission in neonatal intensive care unit was required in 1.69% of patients with normal CTG trace and 35.7% patients with abnormal CTG trace. **Conclusion:** Significant relationship with high sensitivity and high negative predictive value was found between CTG tracing and fetal outcomes.

KEYWORDS: Cardiotocography, CTG tracing, Abnormal Fetal Outcomes, Apgar Score.

1. INTRODUCTION

Early diagnosis of fetal distress during labour is one of the challenges for obstetrician to avoid an adverse outcome. Fetal heart rate monitoring is an essential component of antepartum and intrapartum fetal surveillance. Fetal heart sounds were first described by the French physician Marsac almost 350 years ago, but it needed another 150 years for obstetric auscultation using mechanical stethoscope.[1] Intermittent auscultation of fetal heart sounds by Pinard stethoscope and character of amniotic fluid were previously used to monitor the fetus during labour.

Most recently, fetal heart rate (FHR) and uterine contractions (UC) have been recoded using electronic methods. In the 1950s and early 1960s, Edward Hon[2] and Caldeyro-Barcia[3] initially detailed reliable techniques for obtaining fetal heart rate (FHR) and uterine contraction (UC) data. This eventually resulted in the introduction of the first commercial fetal monitor in 1968. Fetal heart rate and uterine contraction signals are continuously monitored by a new technology called electronic fetal monitoring (EFM).

In the most parts in the world the technology became known as cardiotocography (CTG), the Greek words "kardia" means heart and "tokos" means labor and childbirth.[4] Now-a-days cardiotocography record is used to monitor the fetal heart rate and uterine contraction and temporal relationship of fetal heart rate to uterine contractions.[5] Fetal distress can be detected early by cardiotocography with more reliability.[6] It is reassuring for both the mother and health care provider that the fetus is in good health when cardiotocography trace is reactive.[7] In the recent years, several electronic technologies e.g. ultrasound, handheld Doppler, fetal electrocardiography and fetal pulse oximetry etc for fetal surveillance were developed.[4]

As a screening test for fetal surveillance antepartum cardiotocography has achieved general acceptance throughout world.[8,9] Continuous cardiotocography during labor is linked to decreased newborn seizures, but

there are no appreciable changes in baby mortality, cerebral palsy, or other common indicators of neonatal health. Additionally, an increase in assisted vaginal deliveries and cesarean sections is linked to continuous cardiotocography.[5]

CTG tracing is classified based on the analysis fetal heart rate (FHR) pattern. The characteristics of FHR pattern can be reassuring, non-reassuring or abnormal. There are several guidelines (FIGO, NICE, ACOG) available for CTG classification. According to NICE guidelines the CTG pattern is categorized into normal, suspicious and pathological. When all FHR features are reassuring, CTG tracing is normal. If one of the three features is non-reassuring, the tracing is suspicious. When one feature abnormal or two features non-reassuring, the tracing is pathological.[10] Suspicious and pathological CTG tracing are considered as abnormal.

Research had been carried out in many countries to find out the relationship of CTG pattern with fetal and neonatal outcomes. The association between abnormal CTG pattern and adverse fetal and neonatal outcomes with sensitivity between 75.7 - 81.25% and specificity between 77.2 - 82.2% was reported in literatures.[11,12] However, Bhartia et al, found insignificant association between CTG pattern and fetal outcomes with low sensitivity and low positive predictive value.[13]

Though CTG is used worldwide to determine fetal well-being to detect intrapartum hypoxia, it has low specificity and low positive predictive value and has also a high intra and inter-observer variation.[14] To overcome these problem different adjunctive technologies are used though they are not available in our country. Fetal scalp blood sampling for pH and lactate increases the predictability of fetal hypoxia when it is used along with CTG.[15] Analysis of ST segment of fetal electrocardiograph (STAN) is one of the new modalities used with CTG that can detect metabolic acidosis more accurately.[16] Computer assisted interpretation of CTG is also being used to improve inter-observer variation.[17,18]

Cardiotocography is a non-invasive method of fetal monitoring which is simple, cost-effective and available in many centers of our country. However, study on relationship between abnormal CTG tracing and fetal outcomes is limited. The research question address in this work was to find the plausible association between abnormal cardiotocography and adverse fetal outcomes. Accurate detection of fetal distress is very important because sometimes an obstetrician has to take a quick decision for intervention for better fetal outcome. Sometimes delay in intervention may cause great damage even fetal and neonatal loss. Cardiotocography is a useful screening tool for detection of antepartum and intrapartum fetal distress. Many studies have been done worldwide to see the accuracy of CTG tracing for prediction of fetal hypoxia. But previous studies have reported controversy regarding the ability of the test to detect fetal hypoxia. In our country cardiotocography is available in many government and private facilities. Therefore, it is quite important to find accuracy and correlation of abnormal CTG tracing with adverse fetal outcomes. Moreover, with prediction of early fetal hypoxia accurately using CTG tracing results, we can take some immediate measures to avoid an adverse fetal outcome.

Study related to cardiotocography is limited in our country. The research aims to evaluate the association between abnormal cardiotocography (CTG) and adverse fetal outcomes, especially the predictability fetal outcomes in regard to CTG tracing in the form of Apgar score, admission in the neonatal care unit and fetal and neonatal mortality. In this study, Dhaka medical college hospital was selected for data collection as it is a tertiary care hospital and referral center. More complicated obstetric patients are referred from peripheral hospitals. Therefore, it is an ideal place for a researcher to work with the high-risk obstetric patients.

2. MATERIALS AND METHODS

Patients having high risk pregnancy admitted in Dhaka Medical College Hospital, Dhaka during the study period (from Feb 2021- Feb 2022) fulfilling the inclusion and exclusion criteria were assigned for the study. Purposive sampling technique was followed, and the sampling size was calculated as 42 using the following formula with 95% confidence level.

$$n = \frac{P_1(100-P_1)+P_2(100-P_2)}{(P_1-P_2)^2}\left(z_\alpha + z_\beta\right)^2$$

Where, P_1 =72 is the proportion of fetal distress in normal CTG group and P_2 =30 is the proportion of fetal distress in abnormal CTG group that has been obtained from previous study. The Z score value of z_α = 1.96 and z_β = 2.33 are for 5% and 95% level of significance respectively.

The sample inclusion criterion was a pregnancy between 34-42 weeks of gestation with the presence of any indication for FHR tracing present. Patients with multiple pregnancy, inability to obtain a satisfactory FHR tracing, Fetal congenital anomaly and Intra uterine fetal death had been excluded from the study samples. A structured data collection form was developed containing all the variables of interest. The variables of interest were considered as a) the socio demographic variable (age), b) Obstetrics variables (Parity, Gestational age and Liquor color), c) Independent variables (Normal CTG tracing and Abnormal CTG tracing), d) Dependent variables (Apgar score: in 1 min and 5 min, NICU admission, Stillbirth or early neonatal death). The Data was collected by interview, observation, and clinical examination. Fig. 1 illustrates the study workflow of this research.

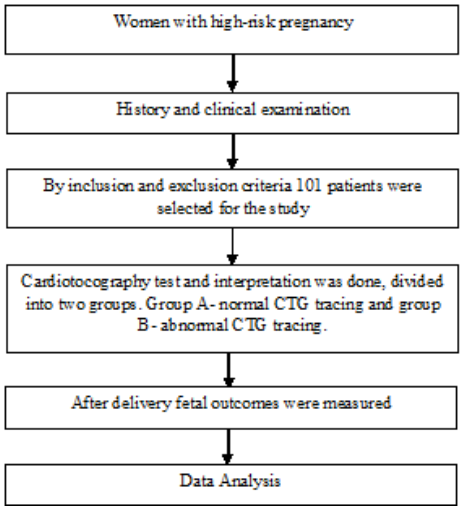

Fig. 1: Study work-flow chart of the research.

3. RESULTS AND DISCUSSIONS

In this study, total 101 high risk patients were included who fulfilled the inclusion criteria as mentioned in previous chapters. Cardiotocography was performed and depending upon CTG findings two groups of patients were made. Group A includes 59 patients with normal CTG, whereas Group B includes 42 patients having abnormal CTG including both suspicious and pathological traces. In the Group B, among 42 patients having abnormal CTG, 26 patients had suspicious CTG, and 16 patients had pathological CTG. These patients were admitted Dhaka Medical College Hospital in last two years. Results observed are analyzed and described in the subsequent section.

Table 1: CTG tracing of study patients based on their age group. [N=101]

N=101		Frequency	CTG Type				P-Value
			Group A Normal (59)		Group B Abnormal (42)		
			N	%	N	%	
Age	< 20	11	6	10.2	5	11.9	0.598
	20-24	24	16	27.1	8	19.0	
	25-29	37	22	37.3	15	35.7	
	30-34	22	10	16.9	12	28.6	
	≥ 35	7	5	8.5	2	4.8	

The demographic characteristics have been shown in table 1 which gives the proportion of study patients in different age group. Highest number of patients falls into the age group 25-29 and only 7 patients age were ≥ 35 years. Among normal CTG tracing group 37.3 % patients were in the age group 25 -29 and in abnormal CTG tracing group 35.7 % patients were in the age group 25-29. The mean age group of the women found in our study was 26.2 ± 5.0 years. Correlation between CTG tracing and age group was found statistically not significant.

Table 2: CTG tracing of study patients based on their GA and Parity [N = 101].

N=101		Frequency	CTG Type				P-Value
			Group A Normal (59)		Group B Abnormal (42)		
			N	%	N	%	
Gestational Age	Pre-Term	39	15	25.5	24	57.1	0.005
	Term	46	33	55.9	13	31.0	
	Post dated	16	11	18.6	5	11.9	
Parity	Primigravida	38	21	35.6	17	40.5	0.618
	Multigravida	63	38	64.4	25	59.5	

The CTG of the study patients were analyzed according to their gestational age and parity as given in Table 2. Among 101 patients, 39 patients were pre-term, 46 patients were term and 16 patients were postdated. In normal CTG tracing group 55.9 % patients were term pregnancy and in abnormal CTG tracing group 57.1 % patients were pre-term. Correlation of gestational age and CTG tracing was found statistically significant. Among 101 patients, 63 patients were multigravida and 38 patients were primigravida. In normal CTG tracing group 64.4 % patients were multigravida and 35.6 % patients were primigravida and in abnormal CTG tracing group 59.5 % patients were multigravida and 40.4 % patients were primigravida. Correlation between parity and CTG tracing was found statistically not significant.

Table 3: Correlation between liquor color and CTG tracing [N = 101].

(N=101)		Total Count		CTG Tracing				P-Value
				Group A Normal (59)		Group B Abnormal (42)		
		N	%	N	%	N	%	
Liquor Color	Clear	88	87.1	56	94.92	32	76.20	0.006
	Meconium	13	12.9	3	5.08	10	23.80	

Correlation between liquor color and CTG tracing was given in table 3. Clear liquor was found in 87.1 % cases and meconium-stained liquor was for 12.9 % among the total study patients. Meconium-stained liquor was found in 23.8 % of patients in abnormal CTG tracing group and only 5.08 % in normal tracing group. Correlation of CTG tracing and liquor color was found as statistically significant, p=0.006).

Correlation between CTG tracing and Apgar score was given in Table 4. In normal CTG tracing there was no cases of Apgar score in 1 min below 4, only 2 (3.3 %) cases Apgar score in 1 min between 4 to 6. In abnormal CTG tracing group 45.2 % babies belonged to normal Apgar score in 1 min, only 2.4 % babies were severely distressed, and 52.4 % babies were moderately distressed. Correlation between CTG tracing and Apgar score in 1 min was found statistically significant ($p < 0.001$).

Table 4: Correlation between APGAR score and CTG tracing [N = 101].

Perinatal Outcomes		CTG Type				P-Value
		Group A Normal (59)		Group B Abnormal (42)		
		N	%	N	%	
APGAR Score 1min	Normal (7-10)	57	96.61	19	45.2	< 0.001
	Moderately distressed (4-6)	2	3.39	22	52.4	
	Severely distressed (below 4)	0	0.00	1	2.4	
APGAR Score 5min	Normal (7-10)	59	100.00	34	80.9	< 0.001
	Moderately distressed (4-6)	0	0.00	7	16.7	
	Severely distressed (below 4)	0	0.00	1	2.4	

All the babies with normal Apgar score in 5 min were found in normal CTG tracing group. Whereas 80.9 % babies with normal Apgar score in 5 min were found in abnormal CTG tracing group and 16.7 % babies were found in moderately distresses and only 2.4 % babies were severely distressed in this group. Correlation between CTG tracing and Apgar score in 5 min was found statistically significant ($p < 0.001$).

Table 5: Correlation between fetal outcomes and CTG tracing [N =101].

Fetal Outcomes		CTG Type				P-Value
		Group A Normal (59)		Group B Abnormal (42)		
		N	%	N	%	
NICU admission	No (85)	58	98.31	27	64.3	< 0.001
	Yes (16)	1	1.69	15	35.7	
Neonatal Death	No (99)	59	100.00	40	95.2	0.09
	Yes (2)	0	0.00	2	4.8	

Out of 101 neonates, 16 had NICU admission. In normal CTG tracing group only 1 baby had NICU admission. In abnormal tracing group 15 (35.7 %) neonates were needed NICU admission. Correlation between CTG tracing and NICU admission was found statistically significant ($p < 0.001$) (Table. 5). There were only two neonatal deaths in abnormal CTG tracing group. Correlation between CTG type and neonatal death was statistically insignificant (P= 0.206) (Table.5).

Table 6: Performance of CTG for diagnosis of fetal distress [N = 101].

Sensitivity	Specificity	Positive Predictive Value (PPV)	Negative Predictive Value (NPV)
92.0%	75.0%	54.8%	96.6%

The sensitivity of CTG for fetal hypoxia in 1 min was 92 %, specificity 75 % with high negative predictive value 96.6 %. (Table 6).

Admission CTG is the best screening test for identifying patients who are more likely to experience intrapartum fetal hypoxia since it is non-invasive and effective.[19-21] However, in normal and low-risk women, admission CTG is not useful as a screening test to detect intrapartum fetal distress because it may discover almost twice as many fetuses with an abnormal pattern that increase the need for caesarean delivery.[13] It is the most used tool for fetal surveillance in developed and developing countries.[20] This is the reason to carry out this study to analyze the relationship between abnormal cardiotocography of high-risk patients and fetal outcomes.

In the present prospective study, the various type of fetal heart rate pattern was found in high-risk antenatal women. Chi-square test of significance was performed. According to NICE guidelines 2014, CTG traces were categorized into normal, suspicious and pathological and in this study suspicious and pathological CTG counted as abnormal CTG.

The mean age group of the women found in our study was 26.2 ± 5.0 years. More than 60% of the study women fall into the age group 20-29. This is comparable to the study conducted by Salahuddin et al where the mean age of the patients was 29.4 ± 4.27 years.[22] Another study conducted in BSMMU also had patients with mean age 26.7±4.9 years.[23] In the present study 45.5 % patients were found in term pregnancy but the percentage of preterm delivery was quite high 38.6%. Only 37.6 % female were primigravida while 62.3 % female were multigravida.

Normal CTG pattern was observed in 58.4 % while suspicious and pathological pattern was observed in 25.7 % and 15.8 % in high-risk pregnancies respectively in our study, so the abnormal CTG tracing was 41.6 %. In the study by Bhartiya et al, 60 % of the traces belonged to non-reassuring pattern, 37 % belonged to reassuring and 3% were abnormal, categorized according to NICE guideline 2001.[13] In the Dhakare et al. study, a normal CTG pattern was found in 62.9% of high-risk pregnancies, whereas suspicious and abnormal patterns were seen in 13.3% and 23.8% of pregnancies, respectively.[12] Compared to a different study[24] conducted by Rahman et al., among 160 high-risk pregnancy cases, 77% of women had "reactive" admission CTGs, 14.4% had "equivocal" CTGs, and 8.7% had "ominous" CTGs. According to Sandhu et al.'s study, 67% of high-risk pregnancies had normal CTG results, 23% had equivocal results, and 10% had abnormal CTG patterns.[25]

In this investigation, meconium-stained liquid was detected in 12.9% of patients and 23.8% patients of the abnormal tracing group. Gupta et al found in a similar investigation, in non-reactive cases 66.2 % had meconium-stained liquor.[11]

In the current study 25 (24.7%) of the cases had an Apgar score of less than 7 at 1 minute after birth; several of these patients improved at 5 minutes following rapid resuscitation. At 5 min the resulting Apgar score <7 was found only in 8 (7.9 %) cases. Babies born to patients with a normal CTG pattern had better Apgar scores at one minute; 96.61% of them had scores more than seven, while only 3.39% had scores below seven. Nonetheless, 45.2% of the abnormal CTG group had an Apgar score greater than 7, while 54.8% had less than 7. All the babies had normal Apgar score >7 in 5 min with normal CTG group and 80.9 % had normal Apgar score in 5 min in abnormal CTG group, 16.7 % babies were moderately distressed Apgar score 4-6 in 5 min, 2.4 % babies were severely distressed Apgar score below 4 in 5 min. The correlation between CTG types and Apgar score was statistically significant.

This result was comparable to those of Salahuddin et al[22] where in reassuring CTG pattern Apgar score in one min, 62.1% babies had >7 and 37.9% had Apgar score <7. Patients with non-reactive CTG had 65.6% had score <7, out of them 18.9% had score of less than 5. Low Apgar score at 5 min persisted in 28.2% of neonates in reassuring CTG group and 46.7% of neonates in non-reactive CTG group. This result was statistically significant.

In the study conducted by Rahman et al[24], 6.5% babies with reactive CTG, 26.1% babies with equivocal CTG and 64.3% with ominous CTG group were found Apgar score <7 at 5 min. This result was statistically significant also.

Bhatiya et al[13] reported no significant association between pathological CTG and Apgar score. Their observation in low-risk group are as follows; Apgar score less than 4 was found in 1% in non-reassuring cases, 4-6 Apgar score was found in 2% and Apgar score >7 was found 20% in reassuring cases, 14% in non-reassuring cases and 2% in abnormal cases. In high-risk cases, Apgar score <4 was found in 6%, Apgar score 4-6 was found in 12% and Apgar score >7 was found in 46%. This result was statistically insignificant.

NICU admission was needed in 1.69% and 35.7 % cases in normal and abnormal CTG group respectively, which was statistically significant. Neonatal death found in this study was low. There were two neonatal death was found in abnormal CTG group, one stillborn in suspicious CTG group and one early neonatal death in pathological CTG group. Correlation between CTG type and neonatal mortality was not statistically significant as because low mortality rate. However, this was not comparable with the reports published by Salahuddin et al[22] as they found 7.2% babies needed resuscitation in reactive CTG

group whereas 15.5% babies required resuscitation in non-reactive CTG group. In normal CTG group, 8.3% needed admission in NICU, whereas 18.6% of neonates with abnormal CTG were admitted and treated in NICU. There was significant correlation between stillbirths and early neonatal deaths. Stillbirths were 2.4%and 4.4% in reactive and non-reactive CTG group respectively whereas early neonatal death was 4.1% and 13.9% in reactive and non-reactive CTG group respectively.

Study conducted by Gupta et al had shown that 75.7% babies with non-reactive CTG and 22.8% of reactive babies were admitted in nursery.[11] There was no perinatal mortality in reactive CTG group and 12.2% in non-reactive group. These results were statistically significant.

Another study conducted by Bhartiya et al[13], among 128 high-risk cases, 31 neonates were admitted in NICU and 7 neonates died. Death rate in high-risk cases was found to be 5%. In non-reassuring group 25 neonates were admitted in NICU and 5 neonates died. Thus, mortality rate was 2.5%. In abnormal cases, 2 neonates were admitted in NICU and one died. Correlation of admission CTG with NICU admission and mortality was found statistically insignificant.

The sensitivity of CTG to detect intrapartum fetal hypoxia in one minute was 92.0%, specificity was 75.0%, positive predictive value 54.8% and negative predictive value 96.6%. According to Dhakare et al [12], the sensitivity and specificity of CTG for predicting abnormal outcome (NICU admission) was 81.25% and 82.2%, while it's PPV and NPV was 66.6% and 90.9% respectively. Gupta et al[11] found in their study that the sensitivity of CTG for NICU admission 75.7%, specificity 77.2% with PPV 65.9% and a high NPV 84.5%. According to Bhartiya et al [13], the sensitivity of admission CTG to detect intrapartum fetal distress is 25%, specificity 75.38% and positive predictive value 39.68%. The findings discussed in this section in regard to the relationship between CTG tracing and perinatal outcomes have shown a good agreement with results published in several literatures.[11-13,19,22-25]

4. CONCLUSION

CTG is widely used as a screening tool to detect fetal hypoxia in many countries. It is simple, non-invasive, easily available and cost effective and can be used in heavy workload hospital with limited resources. High false positive rate was observed in this study which increases the chance of operative interventions. Despite of its high false positive rate, CTG has several advantages like early detection of intrapartum hypoxia and prevention of unnecessary delay in intervention which reduces fetal mortality and morbidity. Study had found significant relationship between CTG tracing and fetal outcomes especially for Apgar score and NICU admission with high sensitivity and negative predictive value.

Many adjunctive technologies are also used in many countries to reduce its false-positive rate and to enhance positive predictive value. However, these technologies are not available in our country. Different adjunctive methods are fetal ECG, fetal scalp blood sampling for pH or lactate estimation. Fetal scalp blood sampling is sensitive test for identification of fetal acidemia but as it is an invasive procedure and has to be repeated during labor and it requires special set-up, it is not widely available.

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