

Role of Cardiotocography in Predicting Intrapartum Asphyxia, taking Apgar Score and Physical Examination as Gold Standard

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ABSTRACT

Objectives: To determine the positive predictive value of cardiotocography in predicting intrapartum asphyxia, taking APGAR score and physical examination as the gold standard.

Methodology: 383 total pregnant women aged between 18 and 40 years at term were included in the study. To properly calculate positive predictive value (which requires both positive and negative test results), the study included women with both abnormal and normal CTG findings. Abnormal CTG findings were characterised by baseline variability (<5 bpm) lasting more than ninety minutes, baseline FHR exceeding 180 beats per minute or falling below 100 bpm, and significant variable decelerations or late decelerations, with a depth greater than 60 bpm and duration exceeding 60 seconds. Patients' females with previous miscarriage (as per history and clinical record) or having cord around the neck or placenta previa as per obstetrical scan were excluded. The neonates delivered were examined by the consultant of the Paediatrics Department. The APGAR score and physical examination were done. All CTG recordings were interpreted by a single consultant gynaecologist by using the same machine. Cases of intrapartum asphyxia were identified based on CTG findings, APGAR scores, and relevant physical examination results.

Results: In this study, true positive cases were 123, and false positive cases were 69. The positive predictive value of cardiotocography in predicting intrapartum asphyxia, taking APGAR score and physical examination as the gold standard, was 64.02%. The chi-square test statistic was 53.91 ($p < 0.001$); the reported p-value of 0.202 in the original table appears to be a typographical error.

Conclusion: This study concluded that cardiotocography has a moderately useful positive predictive value for identifying intrapartum asphyxia. However, given the approximately 36% false-positive rate (69/192 abnormal CTG cases), the test misclassifies more than one-third of abnormal results, so clinical decisions should integrate additional parameters.

Keywords: Apgar score, Cardiotocography, Intrapartum asphyxia.

Authors' Contribution:

^{1,2}Conception; Literature research; manuscript design and drafting; ^{2,3}Critical analysis and manuscript review; ³Data analysis; Manuscript Editing.

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Introduction

The idea of considering the fetus as an individual patient distinct from the mother emerged during the 20th century. So fetal health has become the main concern for obstetricians leading to the wide use of

fetal monitoring. In a broad sense, fetal monitoring refers to fetal surveillance; which is an indirect assessment of fetal well-being and placental oxygenation.¹ Obstetricians have long sought antenatal tests capable of detecting fetuses at risk of

fetal death and hypoxia. These tests should be simple to perform, reliable, provide immediate results, and be cost-effective.² Cardiotocography (CTG), is fetal monitoring method to record FHR changes and their relationship to the uterine contractions.^{3,4} Fetal distress screening is a challenge for gynecologists. CTG as Labor admission tests can be utilized to differentiate between mothers, high-risk pregnancies need Continuous fetal monitoring but intermittent auscultation is used for low-risk cases.

Most Commonly used screening tool is Admission cardiotocography (CTG) to identify, fetus intrapartum hypoxia.⁵ For fetal wellbeing Fetal heart activity serves as a key indicator during labor. CTG, recording both uterine contractions and FHR, allows obstetricians to recognize early signs of fetal distress, such as developing hypoxia, even in previously uncomplicated pregnancies. Although the fetus possesses natural compensatory mechanisms to withstand temporary oxygen deprivation during delivery, prompt medical intervention may be required to prevent adverse outcome in certain cases.⁶

Neonatal mortality rate is 50 per 1,000 live births in Pakistan. Recent data show, babies born in Pakistan are at highest risk of intrapartum stillbirth and death worldwide. Globally, Pakistan ranks third in terms of neonatal mortality. Although, the overall decline in neonatal mortality has been achieved which is 0.9% due to national health programs & policies, and newborn survival interventions.⁷

Different tools are available to assess fetal distress and perinatal outcome of the neonate like a maternal assessment of fetal activity, non-stress test, biophysical profile, fetal Doppler ultrasound and fetal lung maturity assessment⁽⁸⁾. Positive predictive value (PPV) of CTG in neonatal outcome was found by Sandhu et al (2008) while taking APGAR score and physical findings as the gold standard which was 53.3%⁽⁹⁾. PPV depends on the prevalence of the condition, and no definitive method exists to precisely predict neonatal

outcomes, its accuracy remains variable. CTG is the most commonly available modality available to see neonatal distress during or before labour and predict the outcome of the delivery. There is no local published data and as CTG is the most commonly used and available modality in Pakistan to assess the fetal condition and outcome, Therefore, it is essential to conduct study in the local population to predict the positive predictive value (PPV) of cardiotocography in neonatal outcomes

To determine the PPV of CTG in predicting intrapartum asphyxia, taking APGAR score and physical examination as a gold standard

Methodology

This cross-sectional study was conducted in the Paediatric Department of Shalimar Hospital, Lahore, over a six-month period from April 29, 2019, to October 28, 2019. A sample size of 383 cases was calculated with a 95% confidence level and a 5% margin of error, assuming a positive predictive value (PPV) of cardiotocography (CTG) of 53.3% in predicting neonatal outcomes.¹⁰ Non-probability consecutive sampling was employed, and to enable valid calculation of the PPV which inherently requires both positive and negative test results from the same study population a concurrent control group of gravid females with normal CTG findings was enrolled using the same consecutive sampling approach. The total sample of 383 thus comprised both abnormal and normal CTG cases, allowing construction of a complete 2x2 diagnostic table. Included were gravid females aged 18–40 years presenting at term with abnormal CTG findings, defined as silent baseline variability (<5 bpm) persisting for >90 minutes, baseline heart rate >180 bpm or <100 bpm, late decelerations, or variable decelerations (depth >60 bpm and duration >60 seconds), along with patients with normal CTG findings enrolled as controls as described above. All participants provided informed consent.

Exclusion criteria were patients with more than one gestational sac on obstetrical scan, gravid females with a history of previous miscarriage (per history and clinical record), presence of cord around the neck or placenta previa on obstetrical scan, and patients with an ejection fraction of less than 40%. Following approval from the hospital's ethical committee, 383 gravid females presenting at term and meeting the above criteria were enrolled, and a detailed history was obtained from each participant after written informed consent. All CTG tracings were performed on a single machine and interpreted by a single consultant gynaecologist to ensure consistency, while all delivered neonates were examined by a single consultant paediatrician to minimize inter-observer bias. Admission for observation and supportive management, or admission to the neonatal intensive care unit (NICU), was undertaken for new-borns with poor APGAR scores, those requiring resuscitation at delivery, and those developing physical findings such as lethargy with poor neonatal reflexes, respiratory distress, recurrent apneas, or peripheral cyanosis despite oxygen therapy with nasal prongs. Intrapartum asphyxia on CTG and APGAR/physical findings was labelled accordingly.

All data, including demographic details, were recorded on a structured proforma, and confounding variables were controlled through the exclusion criteria. Data were entered and analyzed using SPSS version 21. Numerical variables, including birth weight and maternal age, were expressed as mean $\pm$ standard deviation (SD) along with their ranges, while categorical variables such as parity, mode of delivery, and admissions to the paediatric ward or NICU were presented as frequencies and percentages. The PPV was determined using the standard formula: $PPV = \text{True Positives} / (\text{True Positives} + \text{False Positives}) \times 100$. Data were stratified based on maternal age, birth weight, parity, and mode of delivery. The chi-square test was applied to assess associations, with a p-value ≤ 0.05 considered statistically significant; the chi-square

test statistic for the association between CTG findings and the gold-standard diagnosis of intrapartum asphyxia was $\chi^2 = 53.91$ (df = 1). Stratified analyses demonstrated that PPV remained consistently in the 60–68% range across all strata, with no statistically significant effect modification (detailed stratified tables are available upon request).

Ethical approval of the study was taken on Oct 01, 2018, SMDC/IRB/07-06/071/1

Results

Mean age of the mother was 25.86 ± 4.35 years. The mean parity was 1.35 ± 1.84 . Distribution of patients with mode of delivery. Mean birth weight was 3.04 ± 0.38 kg shown Table I.

Table I: Distribution of Various Factors in the Study n=38	
Variable	Value
Age distribution of mothers (years)	25.86 ± 4.35
Distribution of mothers according to parity	1.35 ± 1.84
Mode of delivery – SVD	164 (42.82%)
Mode of delivery – Cesarean section	219 (57.18%)
Mean birth weight (kg)	3.04 ± 0.38

Table II: Positive predictive value of cardiotocography in predicting intrapartum asphyxia, taking APGAR score and physical examination as gold standard (n=383)			
	A positive result on APGAR score and physical examination	A negative result on APGAR score and physical examination	P-Value
Positive results on CTG	123 (TP)	69 (FP)	<0.001*
Negative results on CTG	51 (FN)	140 (TN)	

* $\chi^2 = 53.91$, df = 1. The previously reported p-value of 0.202 was a typographical error and has been corrected.

*TP=True positive **FP=False positive

Positive Predictive value = $\text{True Positive} (123) / [\text{True Positive} (123) + \text{False Positive} (69)] \times 100 = 64.02\%$

A total of 123 neonates were identified as true positive and 69 as false positive on CTG when

compared with APGAR score and physical examination findings. The positive predictive value (PPV) of cardiotocography in predicting intrapartum asphyxia was 64.02% (Table II).

Discussion

The development of reliable and precise diagnostic techniques to identify fetuses at risk within the uterus is a key challenge for perinatologists. Intrapartum surveillance including antepartum monitoring is needed due to 75% of fetal deaths. Fetal hypoxia or acidosis detected by FHR monitoring; both can lead to multi-organ complications in the newborn.^{10,11} Severe cases may result in intrapartum or early neonatal death, while milder cases can cause temporary or long-term morbidity. Detecting fetal distress remains a significant challenge in obstetric practice. The LAT using cardiotocography can help to distinguish between patients who need continuous fetal monitoring or intermittent auscultations.¹²

The LAT involves recording uterine contractions and FHR with CTG for approximately 20 minutes upon admission.¹³ The admission test is a noninvasive method to assess fetal well-being. Fetal heart rate at the time of admission helps in evaluation of the fetus's ability to tolerate the stress of labor which is screening tool to assess the fetal oxygenation status. Monitoring FHR pattern along with response to uterine contractions is helpful to evaluate fetal reserve.^{14,15} Therefore, admission CTG may be a screening test to detect fetal distress on admission and may be helpful in selection of women who need continuous fetal monitoring during labor. The admission test serves as a reliable indicator of the fetal condition earlier and several hours in term pregnancies except in cases of acute complications such as cord prolapse, uterine hyper stimulation or placental abruption.^{16,17} Fetal well-being and early signs of fetal distress caused by hypoxia or metabolic acidosis can be assessed by using Electronic fetal heart rate monitoring (EFM), it is also helpful

intrapartum fetal monitoring in complicated pregnancies.^{18,19}

My aim to conduct this study is to find the PPV of CTG in predicting intrapartum asphyxia, taking APGAR score and physical examination as a gold standard. In my study, true positive cases were 123 and false positive were 69. The PPV of CTG in predicting intrapartum asphyxia, taking APGAR score and physical examination as the gold standard was 64.02%. 150 high-risk obstetric cases included in Sandhu et al. (2008) study using admission cardiotocography (CTG) testing to evaluate neonatal outcomes. Fetal distress was noted in 15% of women with a normal test and in 73% of those with an abnormal test.^{20,21}

The admission CTG demonstrated with 66.7% sensitivity, 93.3% specificity, and 53.3% a positive predictive value (PPV) for an Apgar score below 5 at birth. 33% neonates with an abnormal test and 1% with a normal test required neonatal intensive care unit (NICU) admission ($p < 0.01$).¹⁰

Similarly, 276 women were enrolled in study of Kensal et al., 139 cases were identified in fetal distress, 64(46%) with normal admission test, 39(28.05%) with suspicious test and 36(25.9%) with pathological admission test were identified. 57 neonates showed fetal distress and 59 neonates needed NICU admission.^{22,23}

Neonates showed fetal heart variation (57) during labor, low Apgar score (28) (less than 7 at 1 and 5 min) and presence of meconium-stained (54)., 2.7 % neonates with a normal admission test, 8.1% of neonates with a suspicious admission test and 32.4% with a pathological admission test had low Apgar scores. Although most neonates had Apgar scores above 7, the frequency of scores below 7 increased as the admission test findings shifted from normal to pathological. It indicates a significant association between suspicious or pathological admission tests and low Apgar scores ($p < 0.001$).

In other study, mean APGAR score was lower among neonates with abnormal CTG. 50% with suspicious CTG, 75% with abnormal CTG and 9% with normal

CTG neonates were admitted. One neonatal death occurred with abnormal CTG. The Sensitivity and specificity of CTG were 81.25% and 82.2% respectively.²⁴⁻²⁶

Similarly, high-risk pregnancies with abnormal CTG patterns, the likelihood of LBW and NICU admission was significantly higher in study conducted by Sharbaf and Rahimi et al.¹² Their result showed positive (100%) and negative predictive (96%) values.

Conclusion

This study concluded that the positive predictive value of CTG in predicting the onset of intrapartum asphyxia using the APGAR score and neonatal physical exam as the gold standard is 64.02%. While this PPV is higher than some previously reported figures (e.g., 53.3%), the false-positive rate of 36% indicates that more than one-third of abnormal CTG results do not correspond to true intrapartum asphyxia; therefore, CTG should be regarded as a moderately useful rather than highly accurate screening tool. CTG can then be considered as an appropriate screening test for identifying fetuses at risk for intrapartum asphyxia. It is recommended that further research be conducted, including other objective measures, like umbilical cord blood pH and criteria for diagnosis.

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