# ADMISSION CARDIOTOCOGRAPHY AS A PREDICTOR OF PERINATAL OUTCOME AND ASSOCIATED FACTORS AMONG LABORING MOTHERS, AT A TEACHING HOSPITAL, NORTH WEST ETHIOPIA

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## ABSTRACT

**BACKGROUND:** Worldwide, more than 2.6 million stillbirths occur annually, with birth asphyxia being one of the causes. Among the proposed methods to reduce birth asphyxia is the use of admission cardiotocography. However, literature demonstrating its effectiveness in predicting perinatal outcomes is scarce. Hence, this study aims to evaluate its effectiveness in predicting perinatal outcomes and associated factors.

**OBJECTIVE:** To assess the perinatal outcome of laboring mothers with admission cardiotocography, its predictive power for perinatal outcomes, and associated factors.

**METHODS:** A prospective single-center observational study was conducted among 385 laboring mothers with admission cardiotocography admitted to the University of Gondar Hospital labor ward. The data were coded and entered using EpiData version 4.6. Data analysis was done using STATA version 14. Descriptive and bivariate statistical analyses were conducted using the chi$^2$ test. Variables with a p-value < 0.2 were subjected to multivariate analysis to identify independent factors associated with outcome variables. A p-value < 0.05 was considered statistically significant.

**RESULTS:** Among the 385 laboring mothers with admission cardiotocography, 82% had normal results, 14% had suspicious cardiotocography, and the remaining 4% had pathological admission cardiotocography. Mothers with abnormal admission cardiotocography had higher rates of low Apgar scores. Similarly, NICU admissions, development of ominous or non-reassuring fetal heart rate patterns, and meconium-stained liquor were more common in the abnormal cardiotocography group. The sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of admission cardiotocography for ominous or non-reassuring fetal heart rate patterns in labor were 42.9%, 86%, 34.2%, 89.8%, and 79.7%, respectively. For low Apgar scores, these values were 75%, 82.4%, 4.3%, 99.6%, and 82.3%. For NICU admission, the corresponding values were 23%, 82.3%, 15.7%, 88.3%, and 75%. Maternal risk was the only significant factor associated with NICU admission. Decision-to-delivery interval and admission cardiotocography patterns were independent factors associated with ominous or non-reassuring fetal heart rate patterns in labor.

**CONCLUSION:** Admission cardiotocography is a specific screening test with good negative predictive value for detecting ominous or non-reassuring fetal heart rate patterns, development of meconium-stained liquor, predicting NICU admission, and low Apgar scores, but it has poor sensitivity and fair diagnostic accuracy. Clinical vigilance regarding the pattern of admission cardiotocography at the time of labor ward admission is warranted.

**KEYWORDS:** labor admission test, stillbirth, cardiotocography, birth asphyxia, perinatal outcome

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## INTRODUCTION

In an attempt to describe fetal heart rate sounds, Anton Friedrich Hohlt designed a fetal stethoscope in 1834, which was further modified by DePaul in 1847. Later, in 1876, Pinard's stethoscope, which is still used today, was introduced[1,2]. Following that, in 1968, cardiotocography (CTG), a new technology that uses electronic methods to acquire fetal heart rate and uterine contraction signals, was introduced[2].

Admission cardiotocography, or labor admission test (LAT), is a 20-minute CTG performed when a woman is admitted to the labor ward. An observational study by Ingmerson et al. served as the first scientific evidence for its introduction. It has two potential roles: to serve as an early screening test to detect compromised fetuses and to help select women who need continuous electronic fetal monitoring during labor[3,4].

Currently, more than 2.6 million stillbirths occur annually, with an estimated stillbirth rate of 18.4 per 1,000 live births. Middle- and low-income countries are responsible for 98% of stillbirths, with more than three-quarters occurring in two regions: South Asia and Sub-Saharan Africa[5,6]. Stillbirths can be antepartum or intrapartum, with intrapartum deaths accounting for nearly half of the cases, especially in developing countries where over one million fetuses die annually. In response, the World Health Organization (WHO) released the Every Newborn Action Plan (ENAP) in 2014, targeting a national stillbirth rate of 12 or fewer per 1,000 births in every country by 2030[7–9].

LAT, or admission cardiotocography, is one of the fetal monitoring tools used to reduce intrapartum deaths associated with asphyxia (10). Despite being a relatively inexpensive test, it is not widely practiced in developing countries. Additionally, literature on the efficacy of admission cardiotocography in predicting perinatal outcomes and associated factors is scarce[1,11,12].

## Methods and Materials

## Methods and Materials

### Study Design

Prospective single-center observational study.

### Study Setting

The study was conducted in one of the tertiary hospitals in Ethiopia, located in Gondar town in the northwest part of the country, 727 km from Addis Ababa. The Department of Obstetrics and Gynecology at the University of Gondar Hospital provides specialty and subspecialty services to over 7 million people and manages more than 10,000 annual deliveries. The labor ward has 9 beds and a separate labor OPD for triage, where admission CTGs are performed.

### Study Period

The study was conducted from June 1 to August 1, 2022, at the University of Gondar Hospital.

**Inclusion Criteria:** All laboring mothers with spontaneous onset of labor, cephalic presentation, term pregnancies, and admission CTG.

**Exclusion Criteria:** Mothers with congenital fetal anomalies, malpresentations, preterm pregnancies, prior sedative use (diazepam or narcotics), multiple gestations, intrauterine fetal death, cord prolapse, or false labor.

### Study Population

All laboring mothers admitted to the University of Gondar Hospital labor ward with admission CTG during the study period who met the inclusion criteria.

### Sample Size and Sampling Technique

To determine the maximum sample size, a single population proportion formula was used with the following assumptions: 95% confidence interval, 5% margin of error, and 50% estimated proportion due to lack of comparable studies. This yielded a sample size of 385.

**Sampling Technique and Procedures**

Participants were selected using systematic random sampling. At the labor ward, 10–15 laboring mothers with admission CTG are admitted daily. From the delivery registration book, chart numbers of mothers meeting the inclusion criteria were selected beginning with the first case each day and including odd-numbered cases (7–8 cases per day) until the sample size was met.

**Tool/Method and Data Collection**

Upon arrival at the labor OPD, a detailed obstetric history and general physical and pelvic examinations were conducted to determine the stage of labor. Using a Philips Goldway CTG monitor at a paper speed of 1 cm/min, admission CTGs were performed to record fetal heart rate and uterine contractions. The 2017 National Institute for Health and Care Excellence (NICE) guideline was used to categorize admission CTGs as follows:

**Table 1: Description and category of CTG traces for intrapartum care (NICE guideline 2017) (13, 14, 15).**

| Description | Baseline (Beats/min) | Base line variability ( beats/min) | Feature Decelerations |
|---|---|---|---|
| Reassuring | 110 to 160 | 5 to 25 | None or early variable with no concerning characteristics for < 90 min |
| Non-reassuring | 100 to109 or 161 to 180 | <5 for 30 to 50 min or >25 for 15 to 25 min | Variable with no concerning characteristics for > 90 min or Variable with any concerning characteristics in up to 50% of contractions for > 30 min or variable with any concerning characteristics in > 50%of contractions for < 30 min or late deceleration in over 50% of contractions for < 30 min or with maternal or fetal risk factor. |
| Abnormal | Below 100 or above 180 | <5 for> 50 minor>25 for >25min or sinusoidal. | Variable with any concerning characteristics in > 50% of contractions for > 30 minor late deceleration for over 30 min or acute bradycardia or single prolonged deceleration for > 3 min |

**Reactive/Normal:** All features are normal.

**Equivocal/Suspicious:** One non-reassuring feature and two reassuring features.

**Ominous/Pathologic:** One abnormal feature and two non-reassuring features.

After this, mothers were admitted to the labor ward for follow-up. Those with normal admission CTG were monitored via intermittent auscultation or CTG, depending on their risk, while those having suspicious CTG were initially resuscitated to correct for possible underlying causes by intranasal oxygen supplementation, IV fluid administration, and changing position, and the CTG was repeated at the labor ward. For those who had pathologic CTG, they were evaluated immediately to exclude acute events like cord prolapse, abruption, or uterine rupture. Then, in the absence of these acute events, resuscitation was started to correct underlying causes, and if it was still pathologic despite these efforts, delivery of the baby was made by cesarean

section or instrumental delivery, depending on the stage of labor.

Data was collected from patients' charts by three midwives after necessary training was given, using a structured English version questionnaire, which was adapted from similar studies. Validity of the questionnaire was established by conducting a pretest on 5% of the sample and through discussions with experts (specialists, subspecialists, and public health experts). The laboring mothers were admitted to the labor ward and followed until delivery based on existing protocol. The neonatal outcomes immediately after delivery and during the first seven days were accessed from maternal charts or clinical records of neonates admitted to the NICU. When appropriate, phone numbers from patients' charts were used to extract necessary information after explaining the research and obtaining their consent.

**Data Quality Assurance**

The study protocol was approved by the ethical review board of the University of Gondar. Groups of experts were involved to validate the questionnaire. In addition, training was given to data collectors, and the collected data were checked daily for consistency and completeness by supervisors.

**Data Analysis**

The data collected were coded and entered into EpiData version 4.6 and then exported to STATA version 14 for analysis. The data were analyzed using descriptive statistics such as frequency, percentages, sensitivity, specificity, NPV, PPV, and diagnostic accuracy. Cross-tabulation was conducted to check the relationship between dependent and independent variables. After checking validity, a chi-square test and bivariate analysis were conducted to identify explanatory variables for multivariate regression with a p-value of < 0.2.

Biologically plausible explanatory variables were entered into multivariate logistic regression to identify independent factors associated with the outcome variable, and those variables with a p-value of < 0.2 were subjected to multivariate analysis to identify independent factors associated with outcome variables. The findings were presented in p-values and confidence intervals. A p-value of < 0.05 was set for statistical significance.

**Ethical Consideration**

Ethical clearance was obtained from the Ethical Review Committee of the University of Gondar under IRB number SOM/1467/2022 of UOG COM. A letter of permission and a support letter were obtained from the UOG administrative unit to commence the study at the labor ward.

When needed, patients were communicated with by phone on a voluntary basis, respecting their right not to give information. They were also assured that all data collected from them would be used for research purposes only. Confidentiality was maintained by omitting the names of respondents.

**Results**

Socio-demographic characteristics of laboring mothers with admission CTG

Among 385 laboring mothers having admission CTG majority 90% were in the age group 19-34. About 88.83 % were urban dwellers. Regarding educational status 33.77% were educated up to secondary school, 26.75 % up to primary level, 22.60% up to bachelor's degree & 10.90% couldn't read & write. Majority of the participants were housewives representing 76.88% followed by civil servants accounting for 15.06 %. Also, most of the laboring mothers 98.96% were married. (table2)

**Table 2: The socio demographic characteristics of laboring mothers with admission CTG admitted to UOG hospital L/W, North West Ethiopia from June 1 to August 1, 2022 G.C.**

| Socio demographic characteristics. | Frequency. | Percentage (%) | Cumulative. |
|---|---|---|---|
| **Age of laboring mothers.** | | | |
| ≤ 18 | 1 | 0.40 | 0.26 |
| 19 – 34 | 347 | 90.00 | 90.4 |
| ≥ 35 | 37 | 9.60 | 100 |
| Total | 385 | 100 | |
| **Occupation of laboring mothers.** | | | |
| Housewife | 296 | 76.88 | 76.88 |
| Civil servant | 58 | 15.06 | 91.95 |
| Merchant | 21 | 5.45 | 97.40 |
| Student | 4 | 1.04 | 98.44 |
| Daily laborer | 3 | 0.78 | 100 |
| Total | 385 | 100 | |
| **Marital status of laboring mothers.** | | | |
| Married | 381 | 98.96 | 98.96 |
| Single | 2 | 0.52 | 99.48 |
| Divorced | 1 | 0.26 | 99.47 |
| Widowed | 1 | 0.26 | 100 |
| Total | 385 | 100 | |
| **Educational status of laboring mothers.** | | | |
| Can't read & write | 42 | 10.91 | 10.91 |
| Read & write only | 22 | 5.71 | 16.62 |
| Primary education | 103 | 26.75 | 33.37 |
| Secondary education | 130 | 33.77 | 77.14 |
| Bachelor's degree | 87 | 22.60 | 99.74 |
| Others | 1 | 0.26 | 100 |
| Tota | 385 | 1001 | |
| **Place of residence of laboring mothers** | | | |
| Urban | 342 | 88.83 | 88.83 |
| Rural | 43 | 11.17 | 100 |
| Total | 385 | 100 | |

**Pattern of admission CTG of laboring mothers admitted to GUH L/W, North West Ethiopia, from June 1 to August 1, 2022 G.C.**

As shown in figure 1below most of the laboring mothers 82% were having normal admission CTG, 14 % were having Suspicious CTG & 4% were noted to have pathologic admission CTG.

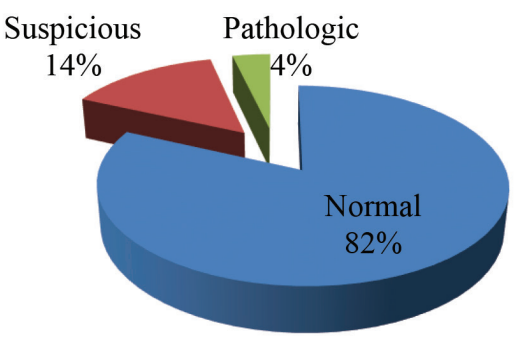


**Figure 1: Pattern of admission CTG of laboring mothers admitted to UOG hospital L/W, North West Ethiopia, from June 1to august 1 2022.**

**Pattern of admission CTG & risk of laboring mothers admitted to UOG hospital**

Among 246 high risk laboring mothers 205(83%) & among 139 low risk mothers110 (79 %) had normal admission CTG .It means 17% of high risk & 21 % low risk laboring mothers had abnormal admission CTG. Showing almost comparable result between low and high risk mothers.

**Pattern of admission CTG and perinatal out come with 1st min Apgar score**

Among 315 laboring mothers with normal admission CTG 1(0.3%), among 56 laboring mothers with suspicious admission CTG 1(2%) and from14 laboring mothers with pathologic admission CTG 2(14%) developed low Apgar score, clearly showing increased risk of low Apgar score with the degree of **abnormal admission CTG.**

**Pattern of admission CTG & perinatal outcome with meconium -stained liquor**

Of 315 laboring mothers with normal admission CTG 29(9%), of 56 laboring mothers with suspicious admission CTG12(14%) and from 14 laboring mothers with pathologic admission CTG 4(21%) developed meconium - stained liquor in labor, showing increased risk of developing meconium-stained liquor with the degree of abnormal admission CTG.

**Pattern of admission CTG and perinatal out come with NICU admission**

Similarly, among 315 laboring mothers with normal admission CTG 37(12%),among 56 laboring mothers with suspicious admission CTG 8(14%) and among 14 laboring mothers with pathologic admission CTG 3(21%) were admitted to NICU, implying the risk of NICU admission increases with the degree of abnormality of admission CTG.

**Pattern of admission CTG and perinatal out come with ominous/Non-reassuring fetal heart rate pattern in labor.**

Finally the data also shows that, among 315 laboring mothers with normal admission CTG 32(10%), from 56 laboring mothers with suspicious admission CTG 14(25%) and among 14 laboring mothers with pathologic admission CTG 10 (71%) developed ominous/NRFHRP in labor, indicating again the risk of developing ominous/NRFHRP in labor increases with the degree of abnormality in pattern of admission CTG.

**Relationship between admission CTG and mode of delivery**

We can also see from figure 2 below percentage of operative delivery increased with increase in degree of abnormality of admission CTG, while that of vaginal delivery showed a decreasing pattern with increase in the abnormality of admission CTG.

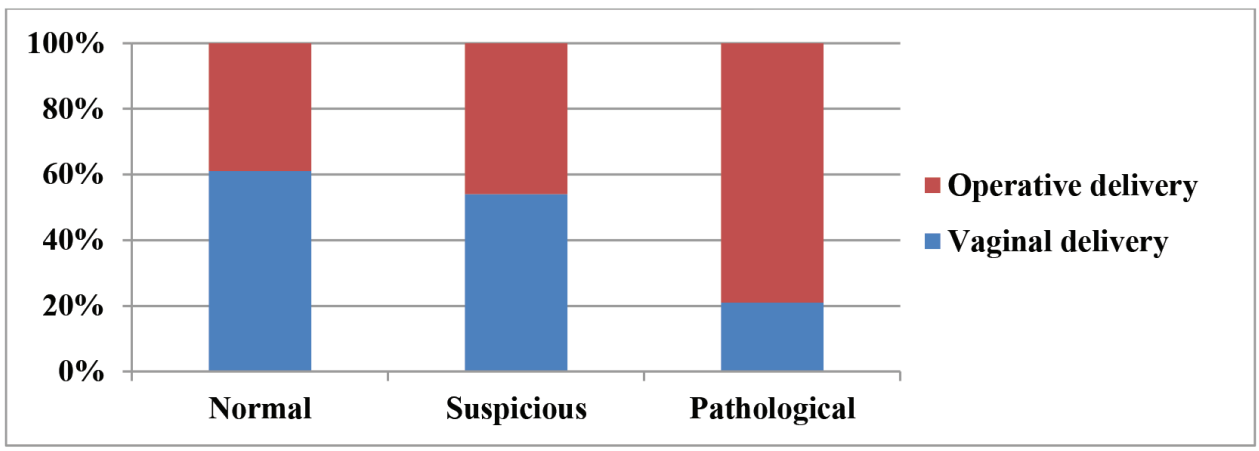


**Figure 2: Graph showing the relationship between admission CTG and mode of delivery of laboring mothers admitted to UOG hospital L/W, North West Ethiopia, from June 1to august 1 2022.**

**Neonatal outcome of laboring mothers with admission CTG admitted to UOG hospital L/W**

As depicted in table 2 below all of the laboring mothers admitted to labor ward & included in the study delivered live neonates. About 48 (12.47%) of neonates were transferred to NICU for evaluation & treatment. Most of these neonates stayed for less than a day. Among 18 neonates who stayed in NICU more than a day and only two neonates died.

**Table 2: The socio demographic characteristics of laboring mothers with admission CTG admitted to UOG hospital L/W, North West Ethiopia from June 1 to August 1, 2022 G.C.**

| | Frequency. | Percentage (%) | Cumulative. |
|---|---|---|---|
| **Neonatal outcome** | | | |
| Alive | 385 | 100 | 100 |
| Still birth | 0 | | 100 |
| Total | 385 | 100 | |
| **Apgar score at 1st min** | | | |
| <7 | 4 | 1.04 | 1.04 |
| ≥7 | 381 | 98.96 | 100 |
| Tota | 385 | 1001 | |
| **Neonates transferred to NICU** | | | |
| Yes | 48 | 12.47 | 12.47 |
| No | 337 | 87.53 | 100 |
| Total | 385 | 100 | |
| **Days spent at NICU** | | | |
| < a day | 30 | 62.50 | 62.50 |
| 1-4 days | 18 | 37.50 | 100 |
| Total | 48 | 100 | |
| **Neonatal condition at discharge** | | | |
| Improved | 45 | 93.75 | 93.75 |
| Deteriorated/crossed | 1 | 2.10 | 95.85 |
| Died | 2 | 4.20 | 100 |
| Total | 48 | 100 | |

**The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of admission CTG**

As shown in table 3 below, admission CTG has Sensitivity (Sn) of 42.90%, Specificity (Sp) of 86%, Positive predictive value (PPV) of 34.30%, Negative predictive value (NPV) of 89.80% and diagnostic accuracy of 79.70% for detecting fetal distress in labor. Similarly, admission CTG has Sn of 75%, Sp of 82.40%, PPV of 4.30%, NPV of 99.65 and diagnostic accuracy of 82.3% for detecting low 1st minute Apgar score. Also it has Sn of 23%, Sp of 82.30%, PPV of 15.70%, NPV of 88.30% and diagnostic accuracy of 75% for predicting NICU admission.

**Table 3: The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of admission CTG for fetal distress in labor, NICU admission & low 1st min Apgar score of mothers with admission CTG admitted to UOG hospital L/W North West Ethiopia, from June 1 to August 1 2022G.C.**

| | Sensitivity | Specificity | PPV | NPV | Diagnostic accuracy |
|---|---|---|---|---|---|
| Fetal distress | 42.90% | 86% | 34.30% | 89.80% | 79.70% |
| Apgar score | 75% | 82.40% | 4.30% | 99.60% | 82.30% |
| NICU admission | 23% | 82.30% | 15.7% | 88.30% | 75% |

Bivariate analysis using Pearson's chi$^2$ test was done to see the relationship between independent variables and outcome of interest.

Pearson's chi$^2$ test was done to see the relationship between independent variables & the development of meconium stained liquor in labor. It showed significant association for the following six variables Marital status chi$^2$ (3) = 7.9598, Pr=0.047,Parity chi $^2$(2) = 19.7348, Pr=0.000,Quality of care chi $^2$(1)=8.8538,Pr=0.000,decision to delivery interval chi $^2$(2) =32.1237,Pr=0.000,insicion to delivery interval chi $^2$(1)=37.2572, Pr=0.000 and finally the pattern of admission CTG chi$^2$(2)=10.893,Pr=0.04. And of these six variables, only two variables showed significant association during multivariate analysis. These includes decision to delivery interval P > [t] 0.011., 95 CI [-0.0481,-0.00612], incision to delivery interval P> [t] 0.000., 95 CI [0.0263, 0.0729].

Similarly bivariate analysis using Pearson's chi $^2$ was done to see variables independently associated with the NICU admission (table 4). The analysis revealed only four variables were associated with NICU admission .These includes gestational age of laboring mothers chi $^2$(2) =10.4709, Pr=0.033, the risk of the patient chi $^2$(1) =7.1588, Pr=0.007, the decision to delivery interval chi $^2$(3) =8.1670, Pr=0.043, the incision to delivery interval chi $^2$(2) =7.4389, Pr =0.024.Among these four variables on multivariate analysis only the risk of the patient showed significant association. That is P> [t] 0.02., 95 CI [0.0134, 0.1533].

**Table 4: Summary of factors affecting NICU admission among the laboring mothers with admission CTG admitted to UOG hospital L/W, North West Ethiopia, from June 1 to August 1 2022 G.C.**

| Variables | NICU admission of the neonates | | | Pearson's chi ² test | Probability |
|---|---|---|---|---|---|
| | Yes | No | Total | | |
| **Age of laboring mothers** | | | | | |
| ≤ 18 | 0 | 1 | 1 | $X^2(2) = 0.375$. | 0.033 |
| 19 – 34 | 43 | 304 | 347 | | |
| ≥ 35 | 5 | 32 | 37 | | |
| Total | 48 | 337 | 385 | | |
| **Marital status** | | | | | |
| Married | 48 | 333 | 381 | | |
| Single | 0 | 2 | 2 | | |
| Divorced | 0 | 1 | 1 | $X^2(3) = 0.5757$ | 0.902 |
| Widowed | 0 | 1 | 1 | | |
| Total | 48 | 337 | 385 | | |
| **Educational status** | | | | | |
| Can't read & write | 5 | 37 | 42 | | |
| Read & write | 1 | 21 | 22 | | |
| Primary education | 17 | 89 | 103 | | |
| Secondary education | 16 | 114 | 130 | $X^2(5) = 8.4231$ | 0.134 |
| Bachelor's | 11 | 76 | 87 | | |
| Others | 1 | 0 | 1 | | |
| Total | 48 | 337 | 385 | | |
| **Place of residence** | | | | | |
| Urban | 41 | 301 | 385 | | |
| Rural | 7 | 36 | 43 | $X^2(1) = 0.644$. | 0.422 |
| Total | 48 | 337 | 385 | | |
| **ANC booking** | | | | | |
| Yes | 46 | 332 | 378 | | |
| No | 2 | 5 | 7 | $X^2(1) = 1.6943$. | 0.193 |
| Total | 48 | 337 | 385 | | |
| **Parity** | | | | | |
| Primiparous | 22 | 154 | 176 | | |
| Multiparous | 20 | 167 | 187 | $X^2(2) = 4.9572$. | 0.084 |
| Grand multiparous | 6 | 16 | 22 | | |
| Total | 48 | 337 | 385 | | |
| **Gestational age** | | | | | |
| Early term | 1 | 39 | 52 | | |
| Full term | 15 | 127 | 142 | | |
| Late term | 4 | 35 | 39 | $X^2(4) = 10.4709$. | 0.033 ** |
| Post term | 0 | 16 | 16 | | |
| 9 months of amenorrhea | 16 | 120 | 136 | | |
| Total | 48 | 337 | 385 | | |
| **Iron supplementation** | | | | | |
| Yes | 46 | 2 | 48 | | |
| No | 318 | 19 | 337 | $X^2(1) = 0.1764$. | 0.675 |
| Total | 364 | 21 | 385 | | |
| **Deceased fetal movement** | | | | | |
| Yes | 2 | 4 | 6 | | |
| No | 46 | 333 | 379 | $X^2(1) = 2.4316$. | 0.119 |
| Total | 48 | 337 | 385 | | |
| **Risk of the patient** | | | | | |
| High | 39 | 207 | 246 | $X^2(1) = 7.1588$. | 0.007 ** |
| Low | 9 | 130 | 139 | | |
| Total | 48 | 337 | 385 | | |
| **Oxytocin use** | | | | | |
| Yes | 8 | 35 | 43 | $X^2(1) = 1.6706$ | 0.196 |
| No | 40 | 302 | 342 | | |
| Total | 48 | 342 | 385 | | |
| **Decision to delivery interval** | | | | | |
| 10 – 20 min | 1 | 12 | 13 | $X^2(2) = 8.167$. | 0.043 ** |
| 21 – 50 min | 25 | 116 | 141 | | |
| 51 – 90 min | 1 | 1 | 2 | | |
| Total | 27 | 129 | 156 | | |
| **Incision to delivery interval** | | | | | |
| < 10 min | 23 | 98 | 121 | $X^2(2) = 7.4389$. | 0.024 ** |
| 10 – 30 min | 2 | 33 | 35 | | |
| Total | 25 | 131 | 156 | | |
| **New onset of complication** | | | | | |
| APH | 3 | 5 | 8 | | |
| Shoulder dystocia | 0 | 1 | 1 | $X^2(2) = 4.8219$. | 0.09 |
| None | 45 | 331 | 376 | | |
| Total | 48 | 376 | 385 | | |
| **Pattern of admission CTG** | | | | | |
| Normal | 37 | 278 | 315 | | |
| Suspicious | 8 | 48 | 56 | $X^2(2) = 1.35$. | 0.509 |
| Pathologic | 3 | 11 | 14 | | |
| Total | 48 | 337 | 335 | | |

** Variables which showed significant association.

Finally bivariate analysis using Pearson's chi$^2$ test was done to see the association between the independent variables and the development of fetal distress in labor, the result showed that eight variables were associated with the development of fetal distress in labor. These were educational status chi$^2$(5) =9.2428, Pr=0.1, parity chi$^2$(2) =5.9823., Pr=0.05, inter delivery interval chi $^2$(1) =13.384., Pr=0.02, marital status chi $^2$(3) =8.113, Pr=0.04., risk of the patient chi$^2$(1) = 6.1179, Pr=0.013. , decision to delivery interval chi $^2$(2) =111.55, Pr=0.000., incision to delivery interval chi $^2$(1) =103.0764, Pr=0.000. And pattern of admission CTG chi $^2$(2) =46.2455 Pr=0.000. (Table 5)Among these five variables, on multivariate analysis, only two variables were significantly associated with the development of fetal distress in labor these are, decision to delivery interval P > [t] 0.001., 95 CI [0.0392, 0.1507], and the pattern of admission CTG P > [t] 0.000., 95 CI [-0.2426,-0.1196].

**Table 5: Summary of factors affecting the development of fetal distress in labor among the laboring mothers with admission CTG admitted to GUH L/W, North West Ethiopia, from June 1to August 1 2022 G.C.**

| Variables | Development of fetal distress in labor | | | Pearson's chi ² test | Probability |
|---|---|---|---|---|---|
| | Yes | No | Total | | |
| **Age of laboring mothers** | | | | | |
| ≤18 | 1 | 1 | 1 | | |
| 19 – 34 | 49 | 298 | 347 | $X^2(2) = 1.4175.$ | 0.701 |
| ≥ 35 | 7 | 30 | 37 | | |
| Total | 56 | 329 | 385 | | |
| **Marital status** | | | | | |
| Married | 54 | 327 | 381 | | |
| Single | 1 | 1 | 2 | $X^2(3) = 8.113.$ | 0.044 ** |
| Divorced | 0 | 1 | 1 | | |
| Widowed | 1 | 0 | 1 | | |
| Total | 56 | 329 | 385 | | |
| **Educational status** | | | | | |
| Can't read & write | 5 | 37 | 42 | | |
| Read & write | 6 | 16 | 22 | | |
| Primary education | 15 | 88 | 103 | $X^2(5) = 9.2428.$ | 0.1** |
| Secondary education | 17 | 113 | 130 | | |
| Bachelor's | 12 | 75 | 87 | | |
| Others | 1 | 0 | 1 | | |
| Total | 56 | 329 | 385 | | |
| **Place of residence** | | | | | |
| Urban | 51 | 291 | 342 | $X^2(1) = 0.3315.$ | 0.565 |
| Rural | 5 | 38 | 43 | | |
| Total | 56 | 329 | 385 | | |
| **ANC booking** | | | | | |
| Yes | 55 | 323 | 378 | $X^2(1) = 0.0004.$ | 0.984 |
| No | 1 | 6 | 7 | | |
| Total | 56 | 329 | 385 | | |
| **Inter delivery interval** | | | | | |
| ≤ 33 months | 14 | 221 | 235 | | |
| >33 | 8 | 68 | 76 | $X^2(1) = 13.384.$ | 0.02 ** |
| Total | 22 | 189 | 211 | | |
| **Parity** | | | | | |
| Primiparous | 34 | 142 | 176 | $X^2(2) = 5.9823.$ | 0.05** |
| Multiparous | 20 | 167 | 187 | | |
| Grand multiparous | 2 | 20 | 22 | | |
| Total | 56 | 329 | 385 | | |
| **Gestational age** | | | | | |
| Early term | 7 | 45 | 52 | | |
| Full term | 17 | 125 | 142 | | |
| Late term | 9 | 30 | 39 | $X^2(4) = 3.2312.$ | 0.52 |
| Post term | 2 | 14 | 16 | | |
| 9 months of amenorrhea | 21 | 115 | 136 | | |
| Total | 56 | 329 | 385 | | |
| **Iron supplementation** | | | | | |
| Yes | 53 | 311 | 364 | | |
| No | 3 | 18 | 21 | $X^2(1) = 0.0012.$ | 0.972 |
| Total | 56 | 329 | 385 | | |
| **Deceased fetal movement** | | | | | |
| Yes | 2 | 4 | 6 | | |
| No | 54 | 325 | 379 | $X^2(1) = 1.7309.$ | 0.188** |
| Total | 56 | 329 | 385 | | |
| **Risk of the patient** | | | | | |
| High | 44 | 202 | 246 | $X^2(1) = 6.1179.$ | 0.013 ** |
| Low | 12 | 127 | 139 | | |
| Total | 56 | 329 | 385 | | |
| **Oxytocin use** | | | | | |
| Yes | 6 | 37 | 43 | $X^2(1) = 0.0136.$ | 0.907 |
| No | 50 | 229 | 342 | | |
| Total | 56 | 342 | 385 | | |
| **Decision to delivery interval** | | | | | |
| 10 – 20 min | 10 | 4 | 14 | $X^2(2) = 111.552.$ | 0.000 ** |
| 21 – 50 min | 43 | 97 | 140 | | |
| 51 – 90 min | 1 | 1 | 2 | | |
| Total | 54 | 102 | 156 | | |
| **Incision to delivery interval** | | | | | |
| < 10 min | 50 | 71 | 121 | $X^2(1) = 103.076.$ | 0.000 ** |
| 10 – 20 min | 3 | 32 | 35 | | |
| Total | 53 | 103 | 156 | | |
| **New onset of complication** | | | | | |
| APH | 1 | 7 | 8 | | |
| Shoulder dystocia | 0 | 1 | 1 | $X^2(2) = 0.1992.$ | 0.905 |
| None | 55 | 321 | 376 | | |
| Total | 56 | 329 | 385 | | |
| **Pattern of admission CTG** | | | | | |
| Normal | 32 | 283 | 315 | $X^2(2) = 46.2455.$ | 0.000 ** |
| Suspicious | 14 | 42 | 56 | | |
| Pathologic | 10 | 4 | 14 | | |
| Total | 56 | 329 | 385 | | |

** Variables which showed significant association.

## Discussion

This study shows that about 82% of laboring mothers had normal admission CTG, 14% had suspicious, and the remaining 4% had pathologic admission CTG. A somewhat comparable finding was reported in a study done in the Department of Obstetrics & Gynecology in India, where a 20-minute admission CTG done on 500 laboring mothers showed a normal admission CTG in 80.20%, suspicious in 12.40%, and pathologic in 7.40%[3]. Similarly, a study done in Pakistan in 2006 on 100 high- and low-risk laboring mothers revealed normal admission CTG in 75%, suspicious in 22%, and pathologic in 3% of laboring mothers[16]. However, somewhat different results were noted in another study done in the Department of Obstetrics & Gynecology in India, where 67% of laboring mothers had normal admission CTG, 21% had suspicious, and 12% had pathologic tracing[15]. Also, a prospective study done in India in 2020 showed that about 68% of laboring mothers had normal admission CTG, 21% suspicious, and 11% pathologic admission CTG[17]. Therefore, in the last two studies, we see that the proportion of abnormal admission CTG—which includes suspicious and pathologic—accounts for 33% and 32%, respectively, somewhat higher than the value observed in our study. This difference could be attributed to variations in interpretation of CTG among health professionals. It could also be due to the small number of laboring mothers included in the studies or the sampling methods they used.

The collected data also tend to show that laboring mothers with abnormal admission CTG have a higher rate of operative delivery. For example, about 79% of mothers with pathologic admission CTG, 46% of those with suspicious CTG, and 39% of those with normal CTG ended up in operative delivery. One study conducted in 2019 in Karachi, Pakistan, also showed comparable results: operative delivery was 41% among mothers with normal admission CTG, 57% among those with suspicious CTG, and 92% among those with pathologic CTG. The incidence of vaginal delivery appeared to be higher in the normal group compared to the abnormal group[18].

Regarding the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of admission CTG for ominous or NRFHRP in labor: sensitivity was 42.90%, specificity 86%, PPV 34.30%, NPV 89.80%, and diagnostic accuracy 79.70%. For prediction of low Apgar score, admission CTG had a sensitivity of 75%, specificity of 82.40%, PPV of 4.30%, NPV of 99.60%, and diagnostic accuracy of 82.30%. For NICU admission, CTG had a sensitivity of 23%, specificity of 82.30%, PPV of 15.70%, NPV of 88.30%, and diagnostic accuracy of 75%. Somewhat comparable findings were reported in a study conducted in one of the medical colleges in India, which showed a sensitivity of 53.9%, specificity of 93.35%, PPV of 75.76%, and NPV of 84.04%. This shows that admission CTG can be used with good reliability to detect fetuses who are hypoxic and need continuous monitoring and immediate intervention[6]. Supporting this, a study done in Andhra Pradesh, India, showed the sensitivity, specificity, PPV, NPV, and diagnostic accuracy of admission CTG in detecting fetal distress in labor were 37.20%, 91.62%, 51.60%, 85.60%, and 81.08%, respectively. This shows that CTG has high specificity in predicting fetal distress and good NPV to enable clinicians to accurately exclude fetal distress in an individual patient[17].

The results of this study also appear to show that among patients with normal admission CTG, 0.32% developed low Apgar score, 9.20% developed MSL in labor, 11.70% were admitted to NICU, and 10.20% developed ominous or NRFHRP in labor. Among the 56 patients with suspicious admission CTG, 1.8% developed low Apgar score, 21.4% developed MSL in labor, 14.30% were admitted to NICU, and 25% developed ominous/NRFHRP in labor. Among the pathologic group, 14.30% developed low Apgar score at the first minute, 28.60% developed MSL in labor, 21.45% were admitted to NICU, and 71.40% developed ominous/NRFHRP in labor. The observed findings also show statistically significant associations: development of low Apgar

score with $\chi^2(2) = 25.7923$, $p = 0.000$; development of ominous or NRFHRP in labor with $\chi^2(14) = 41.43$, $p = 0.000$; development of MSL in labor with $\chi^2(2) = 10.89$, $p = 0.04$. However, the findings for NICU admission were not statistically significant: $\chi^2(2) = 1.35$, $p = 0.509$. These findings are comparable to other studies done in India, which showed that fetal distress was common among the pathologic group, accounting for 51.60%, followed by 40% in the suspicious group and 14% in the reactive or normal group. Moderate to thick meconium was seen in 48.38% of the pathologic admission CTG group compared to 33.30% in the suspicious and 10.47% in the normal group, with the association being statistically significant. NICU admission was also higher in the pathologic group (25.80%), followed by 18.33% in the suspicious and 8.90% in the normal group. Similarly, the first-minute Apgar score was <7 in 22.60% of the pathologic group, 15% of the suspicious group, and 6.80% of the normal group (18). Supporting this, another study showed that among patients in the normal admission CTG group, 10.40% developed MSL in labor, 7.4% developed low Apgar score at the fifth minute, and were admitted to NICU. In the suspicious group, 33.30% developed MSL in labor, 28.60% developed low Apgar score, and were admitted to NICU. The pathologic group developed MSL in 75% of cases, and 66.70% developed low Apgar score and NICU admission (19). Hence, similar to these studies, the findings of our study show that occurrence of MSL in labor, development of low Apgar score, and NICU admission appear to be more common in the suspicious and pathologic groups compared to the normal (reactive) group.

Findings of this study show that risk of the patient is associated with NICU admission. This finding is supported by a study done in India in 2021, which showed that high-risk pregnancies are associated with high rates of low Apgar scores and neonatal deaths in the NICU. Similarly, a study done in the Department of Obstetrics & Gynecology in India in 2024 showed that NICU admissions were more frequent in high-risk pregnancies, reaching up to 60%. Another study done in Bengaluru, Karnataka, revealed that the rate of early neonatal death in NICU and long hospital stays were high in high-risk pregnancies [20,21,22]. These findings together support that the risk of the patient at the time of admission is strongly associated with NICU admissions.

Results of this study also found that the pattern of admission CTG is associated with NRFHRP in labor requiring intervention. A study conducted in Nigeria similarly found that CTG abnormalities in labor were more common among mothers with non-reactive admission CTG. Another study done in Sri Lanka stated that mothers with non-reactive admission tests were more likely to develop fetal distress. Supporting this, a study done in India reported that the incidence of fetal distress worsens with abnormal admission tests (23, 24, 25). Therefore, these findings suggest that admission CTGs at the time of admission to the labor ward require due emphasis.

In addition, results of this study suggest that inter-delivery interval is associated with the development of NRFHRP requiring intervention in labor. This finding might be explained by the fact that mothers with short inter-delivery intervals are at risk of developing many adverse pregnancy outcomes such as low birth weight, intrauterine growth restriction, pregnancy-induced hypertension, gestational diabetes, obstetric cholestasis, and scar dehiscence, as evidenced by a study done in New Delhi in 2023[26].

The study also indicated that the decision-to-delivery interval was associated with the development of meconium-stained liquor. In line with this finding, a study done in the northwest part of Ethiopia showed that among the different factors associated with the development of meconium-stained amniotic fluid, one was prolonged labor. A prolonged stressful environment for the fetus might result in increased peristalsis of the fetal gastrointestinal tract and relaxation of the anal sphincter, leading to the passage of meconium[27]. Therefore, this finding might suggest that delay in delivery of the fetus after the decision to deliver

might worsen the fetal condition, as evidenced by the presence of meconium-stained liquor at the time of delivery.

**Conclusion and Recommendation**

Suspicious and pathologic admission CTG groups had higher rates of meconium-stained liquor, abnormal fetal heart rate patterns, lower Apgar scores, and NICU admissions compared to normal CTG groups. Admission CTG is a useful screening test with good ability to rule out problems but limited sensitivity. It is recommended to do admission CTG for all laboring mothers to identify those needing closer monitoring. Additional tests like fetal scalp pH can help improve detection and reduce unnecessary surgeries. In developing countries like ours, where the issue of availing continuous electronic fetal monitoring for all laboring mothers is difficult, doing admission CTG for all laboring mothers helps in identifying mothers who really need close monitoring in labor.

**Abbreviations**

CTG – cardiotocography
ENAP – Every Newborn Action Plan
EFM – Electronic Fetal Monitor
FHR – fetal heart rate
IV – intravenous
LAT – labor admission test
L/W – labor ward
NICE – National Institute for Health and Care Excellence
NICU – neonatal intensive care unit
NRFHRP – non-reassuring fetal heart rate pattern
SB – stillbirth
SBR – stillbirth rate
Sn – sensitivity
Sp – specificity
PPV – positive predictive value
NPV – negative predictive value
WHO – World Health Organization
UOG – University of Gondar

Declarations

Data availability

Data sets used or analyzed during this study are available from the corresponding author upon reasonable request.

**Competing interest**

Authors have no conflict of interest to declare in this study.

**Author's contribution**

All authors (TG, AE, SB, ZM & TH) participated in the conception, formal analysis, interpretation, supervision, writing of the original draft, and approval of the final manuscript.

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