Scientific Research Publishing

Open Journal of Obstetrics and Gynecology, 2023, 13, 528-549
https://www.scirp.org/journal/ojog
ISSN Online: 2160-8806
ISSN Print: 2160-8792

Admission Cardiotocography: Its Role in Predicting Perinatal Outcome in Term, Uncomplicated (Low Risk) Pregnant Women in Spontaneous Labour

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How to cite this paper: Tharindu, E.A.D. (2023) Admission Cardiotocography: Its Role in Predicting Perinatal Outcome in Term, Uncomplicated (Low Risk) Pregnant Women in Spontaneous Labour *Open Journal of Obstetrics and Gynecology*, **13**, 528-549.
https://doi.org/10.4236/ojog.2023.133048

Received: February 2, 2023
Accepted: March 21, 2023
Published: March 24, 2023

Abstract

Introduction: Labour admission cardiotocography (CTG) is commonly used non-invasive method of fetal monitoring in Sri Lanka. It may have a potentialto predict perinatal outcome in low-risk term pregnancies. **Objectives:** Objectives of the study were to determine the perinatal outcomes of normal, suspicious and pathological admission CTGs and role of labour admission cardiotocography as a predictive test for perinatal outcome in low-risk term pregnancies in spontaneous labour. **Methods:** This study was a prospective observational study done involving 445 low risk, term pregnancies in spontaneous labour. Labour admission CTG was performed in each pregnancy and categorized into normal, suspicious and pathological CTG according to criteria depicted by National Institute of Clinical Excellence (NICE) guideline 2007. Apgar score less than 7 at five minutes, resuscitation at birth, admission to neonatal intensive care unit (NICU), seizure within first 24 hours of birth and meconium-stained amniotic fluid were the primary outcome measures to assess fetal asphyxia. Mode of delivery in each category, nuchal cord at birth were also assessed. **Results:** Majority of participants were in 25-to-29-year age group and were nulliparous. Frequencies of normal, suspicious and pathological CTG were 74.8%, 18% and 7.2% respectively. Pathological CTG was significantly associated with low Apgar score compared to non-pathological CTG group ($p < 0.005$) while other outcome measures were not significant. Rate of operative delivery was 68% in pathological group and 20.8% in non-pathological CTG group. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of labour admission CTG to detect fetal asphyxia were 51.85%, 95.69%, 43.75% and 96.85% respectively. **Conclusions:** Incidence of pathological labour admission CTG was 7.2%. Apgar

score less than 7 at five minutes of birth was significantly associated with pathological CTG group compared to non-pathological CTG ($p < 0.05$). Worsening of CTG from normal to pathological showed increasing rate of operative delivery. Even though sensitivity and positive predictive values of labour admission CTG were low, specificity and negative predictive values were high for detecting low Apgar score. Therefore, labour admission CTG has a value in excluding adverse perinatal outcomes in low-risk term pregnancies in spontaneous labour.

Keywords

Admission Cardiotocography, Apgar Score, NICU, Meconium

1. Introduction

1.1. Background

Surveillance of fetal wellbeing at labour is important to ensure delivery of a healthy baby. Fetal heartbeat is a useful indicator of fetal wellbeing. Therefore, monitoring fetal heartbeat by the means of fetal stethoscope (Pinard) and Electronic fetal monitoring (EFM) provides vital information regarding fetal wellbeing and fetal distress. Cardiotocography (CTG) is a form of electronic fetal monitoring which gives a record of fetal heart activity and maternal uterine contractions. It utilizes Doppler ultrasound transducer to detect changes in fetal heart rate pressure transducer to detect uterine contractions. Alteration in fetal heart rate commonly denotes shortage of oxygen to fetus (fetal hypoxia). Advantages of CTG are that it gives a written record of fetal heart activity in relation to uterine contractions and also it can be used continuously unlike Pinard or handheld Doppler device. Thus, it is useful in labor where uterine contractions can affect placental circulation to limit blood supply to the fetus. Therefore, fetuses that may be compromised or potentially compromised, by shortage of oxygen can be detected prior to the delivery by use of cardiotocography hence clinicians can implement necessary interventions at an early stage of labour.

Routine electronic fetal heart rate monitoring has become an established obstetric practice in many parts of the world including Sri Lanka. Economic constraints, poor resources availability has limited routine and continuous use of cardiotocography in some parts of developing world.

Admission test is a method, which was first described few decades ago in order to detect fetuses at risk by performing CTG in early labour. One role of admission CTG is to screen for compromised fetus at the beginning of labour and another role is to select women in need of continuous CTG monitoring.

1.2. Justification

In many maternity wards in Sri Lanka, electronic fetal monitoring by cardiotocography and fetal heartbeat auscultation by Pinard stethoscope are the two

main methods used to monitor fetal wellbeing in labour. More sophisticated method such as fetal blood sampling for pH is more definitive in assessing fetal hypoxia. Though it is commonly used in developed countries, Sri Lankan maternity units do not have the necessary facilities to perform fetal blood sampling to detect fetal acidosis. Therefore, clinicians in Sri Lanka often have to take decisions regarding management of delivery based on cardiotocography.

Cardiotocograph has become an essential element in decision-making regarding management of labour in maternity units in Sri Lankan. Labour admission cardiotocography is widely practiced in Sri Lankan labour suits despite evidence against it. Author has witnessed practice of intrapartum cardiotocography in many labour suits in tertiary care maternity units as a reassurance of good fetal wellbeing. Although many research has been done globally on the topic of intrapartum cardiotocography and association of pathological cardiotocography to perinatal outcome, in Sri Lankan context, number of studies done on the same issue found to be scanty. Therefore, studies done to evaluate prevalence of reactive, suspicious and pathological admission cardiotocography and prevalence of perinatal outcome by means of low Apgar, admission to neonatal intensive care facility and resuscitation at birth in each type would be of value in benchmarking research on topic of intrapartum fetal monitoring and perinatal outcome in Sri Lanka. It is unarguable that maternity units in Sri Lanka need newer technologies of monitoring fetal wellbeing such as computerized CTG, fetal blood sampling and fetal ST segment analysis (STAN). Inference of this study may help to provide information to change intrapartum practices for the betterment of the patients and use of resources in maternity care units in Sri Lanka.

2. Literature Review

Electronic fetal monitoring was introduced approximately thirty years back as an alternative to fetal heart auscultation. Thereafter of electronic fetal monitoring by means of cardiotocography had become widely used throughout the world. It is now an accepted method of assessing fetal wellbeing in the women with pregnancies at risk of fetal hypoxia. Admission test (cardiotocography) had come to the picture in mid-eighties, and it was described as an alternative method of monitoring fetal heart rate during labour to pick the women at risk whose fetus were compromised on admission or were likely to become compromised in labour [1].

Many research had been done all over the world to assess the role of intrapartum cardiotocography up to date. Randomized controlled studies, observational studies and systemic reviews done on this topic provide evidence for and against role of admission cardiotocography and its use in low-risk pregnancies. One such observational study stated that abnormal admission test carries high incidence of admission to special care baby unit ($p < 0.05$) and meconium-stained amniotic fluid ($p < 0.01$) when interpreted by expert clinicians [2]. Same study denoted that admission test in lower-risk deliveries may be of value if inter-

preted by expert clinician and therefore can help in identifying women and babies at risk of adverse outcome.

In addition, there are many observational studies published praising admission cardiotocography and its value. Another study suggested that fetal admission test is useful in predicting the absence of intra-partum fetal distress irrespective of the criterion used for evaluation. Redefined reactivity appears to be most predictive of intrapartum fetal distress. Therefore, the negative predictive value of admission test for intrapartum fetal distress was the greatest benefit of admission cardiotocography according to the investigators of that study. In simple terms, group with nonreactive cardiotocograph was six times more likely to have fetal distress compared with reactive group. However, the criteria used to define reactivity of CTG and fetal distress in this study was different to currently accepted method [3].

Another cross-sectional study concluded that the admission CTG has high specificity, it has role in obstetric wards of developing countries with a heavy workload and limited resources to help in 'triaging' fetuses [4]. There was significant increase in incidence of fetal distress with the worsening of cardiotocography from reactive to ominous trace ($p < 0.001$).

Several randomized controlled studies have also been done on this subject to compare admission test with alternative methods such as fetal heart auscultation. Also, there are studies done to compare intermittent with continuous cardiotocography in labour as well. Out of such reviews, Cochrane review stated that continuous cardiotocography during labour is associated with reduction in neonatal seizures, but no reduction in cerebral palsy, infant mortality or other measures of neonatal wellbeing. However, it is associated with increased rates of caesarian section and operative vaginal delivery [5].

Randomized controlled study to compare admission test and intermittent auscultation of fetal heart rate stated that the rates of caesarean-section delivery, instrumental delivery, and episiotomy did not differ between groups, although all interventions were slightly more frequent in the admission cardiotocography group than in the usual care group [6]. Study denoted that majority of perinatal deaths cannot be prevented by improved fetal monitoring at labour.

Another systematic review declared that there is no evidence supporting the labour admission test in low-risk women [7]. In addition, admission test can lead to more obstetric intervention without improving neonatal outcome according to that particular study. Therefore, most of the randomized controlled studies did not emphasize the benefit of admission test by and largely.

A case control study showed that specific abnormal findings on electronic monitoring of the fetal heart rate were associated with an increased risk of cerebral palsy. However, the false positive rate was extremely high. Since cesarean section is often performed when such abnormalities are noted and are associated with risk to the mother, their findings arouse concern that, if these indications were widely used, many cesarean sections would be performed without benefit and with the potential for harm [8].

Though many maternal units perform cardiotocography at onset of labour the National institute of clinical excellence (NICE) guidelines does not routinely recommend admission CTG for low-risk pregnant women [9]. But in high-risk pregnant mothers and low-risk mothers who show abnormal CTG changes they recommend monitoring by continuous cardiotocography. Nevertheless, there is evidence both for and against admission cardiotocography in literature survey.

Published research done on the topic of "Admission cardiotocography" test in Sri Lanka is littlein number. However, Goonewardene *et al.* did research on Fetal acoustic stimulation test (FAST) for early intrapartum fetal monitoring stated that combination of Non stress test (NST) with FAST is a good method of screen for hypoxia in early intrapartum period. Furthermore, it demonstrated that compared to oxytocin challenge test (OCT), FAST has similar predictive value of hypoxia. Outcome measure for hypoxia was taken as Apgar score less than seven at five minutes of birth in that study [10].

Several other studies were designed to find predictive ability of intrapartum pathological cardiotocography in detecting adverse fetal/neonatal outcome. A case control study done by Bogdanovic *et al.* denoted that pathological cardiotocography record with high probability indicated possibility of existence of perinatal asphyxia. However, cardiotocography has a large number of false positive findings. This study reported 66.17% of group with hypoxic-ischaemic encephalopathy babies had pathological CTG in their intrapartum period in comparison to 27.50% in control group. This study also showed sensitivity of 66% and specificity of 27% for pathological CTG [11].

Several studies showed correlation between pathological cardiotocography and low Apgar score and neonatal encephalopathy/hypoxic ischaemic encephalopathy. Spencer and associates in their case-control study demonstrated that pathological cardiotocography is statistically more frequent at neonatal encephalopathy [12].

Some authors also investigated correlation between characteristic features of tracing in pathological cardiotocography to the adverse fetal outcome. Petrivic *et al.* came up with the results that late decelerations and loss of variability were highly predictive patterns of cardiotocography record for fetal distress and to lesser extent variable decelerations. Reduced variability with late decelerations or prolong decelerations carry 80% association with fetal asphyxia [13].

In additional several observational studies were also done to determine the frequency of pathological cardiotocography and frequencies of low Apgar scores in low-risk population. Lubna *et al.* done an observational study in low-risk women showed frequency of 6.35% of pathological cardiotocography in labour [14]. Khursheed *et al.* reported prevalence to be 11% [15] and in contrast Breuker and associate reported prevalence of pathological CTG in low-risk pregnancies as 3.1% only [16]. Out of pathological CTGs, only 18.18% of newborns had Apgar score below seven at five minutes. Sheik *et al.* also demonstrated that babies born to mothers with pathological CTG had an Apgar score of seven or less in 18.86% of cases [17]. Therefore, literature shows so much disparity in inci-

dence of pathological CTG in low risk women.

In 1952, Dr. Virginia Apgar devised scoring system that assessed clinical status of the neonate at one minute and need for prompt intervention to establish breathing. Since then, it had modified to form currently using system. Apgar scoring system provided standardized assessment for newborns after birth [18]. Scoring system composed of five components, color, heart rate, reflexes muscle tone and respiration. Each component is given score of 0, 1 or 2 individually and total is taken for the first minute, fifth minute and tenth minute after birth respectively. As American academy of pediatrics noted five-minute Apgar score less than seven clearly confers an increased relative risk of cerebral palsy, reported to be as high as 20-fold to 100-fold over that of infants with a 5-minute Apgar score of 7 - 10 [19].

Presence of meconium-stained liquor is widely accepted as serious sign of fetal compromise and contributes to increase perinatal morbidity [20] [21]. Aspiration of meconium-stained liquor in intrauterine period may result in Meconium aspiration syndrome, which is a leading cause of neonatal death [22]. There are several known factors associated with meconium-stained amniotic fluid such as post-term pregnancy, pre-eclampsia, maternal hypertension, placental insufficiency, oligohydramnios and maternal tobacco and cocaine consumption. Also, meconium may be aspirated during the labour and cause Neonatal respiratory distress syndrome [23]. A prospective cross sectional analytical study on neonatal outcome in meconium-stained amniotic fluid showed meconium stained amniotic fluid is associated with increased neonatal morbidity and mortality. And also caesarian section was performed twice as common in women presenting with meconium stained amniotic fluid [24]. According to these evidence, it was apparent that Apgar score, neonatal encephalopathy, neonatal intensive care unit admissions and meconium stained liquor are suitable measures to detect fetal hypoxia at birth.

Burglund *et al.* published a case-control study in British Journal of Obstetricians and Gynecologists stated that there is some form of substandard care during labour was present in two-thirds of deliveries of infants with a low Apgar score at 5 minutes, and in one-third of the controls. The main reasons for substandard care were related to the misinterpretation of CTGs, not acting in a timely fashion on abnormal CTGs, and the incautious use of oxytocin. Assuming that substandard care is a risk factor for a low Apgar score, they estimated that the number of infants with an Apgar score of <7 at five minutes could be substantially reduced by preventing substandard care [25].

Even though previous studies do not support routine use of labour admission test for low-risk pregnancies, majority of well-conducted studies have used Caesarian section for fetal distress as end point for their analysis. But Apgar score, resuscitation at birth, admission to NICU and cord blood pH value would reflect fetal hypoxia at birth accurately than that. Therefore, consideration should be given to more objective outcome measures for fetal hypoxia.

Also studies in literature have used many criteria for interpretation of cardi-

otocography. That might cause imbalance in comparing different studies in literature. Currently accepted framework for interpretation of CTG may be useful in that context.

Literature shows that careful monitoring of fetuses by cardiotocography in intrapartum period and proper interpretation of cardiotocographs can improve standard care in labour. Therefore, the purpose of this study would be to determine whether the admission CTG in uncomplicated pregnancies predict perinatal outcome in terms of Apgar less than seven at five minutes, admission to NICU, need for resuscitation and secondary outcomes such as meconium stained amniotic fluid, cord round neck and mode of delivery. The findings of this study would benefit in triaging uncomplicated pregnancies at term in labour to different care pathways in practice.

3. Objectives

3.1. General Objective

- To determine perinatal outcomes in newborns of term, low risk pregnant mothers with normal, suspicious and pathological types in admission cardiotocography born by spontaneous onset of labour.

3.2. Specific Objectives

- To determine the frequency of normal, suspicious and pathological cardiotocography in low-risk term pregnancies with spontaneous labour.
- To determine the frequency of neonates with Apgar score below seven at five minutes in normal, suspicious and pathological types of admission cardiotocography.
- To determine the frequency of newborns admitted to neonatal intensive care unit for the management of birth asphyxia of mothers with normal, suspicious and pathological types of admission cardiotocography.
- To determine the frequency of newborn who had Neonatal seizures in first 24 hours in the absence of other known causes of mothers with normal, suspicious and pathological types of admission cardiotocography.
- To evaluate frequency of meconium-stained liquor, cord round neck at delivery with normal, suspicious and pathological types of admission cardiotocography.
- To evaluate the frequency of normal vaginal delivery and operative delivery with normal, suspicious and pathological types of admission cardiotocography.
- To determine sensitivity, specificity, positive predictive value and negative predictive value of Admission cardiotocography in detecting fetal Apgar score less than 7 at five minutes of birth.

4. Materials & Methods

a) Study design

Prospective observational study.

b) Study setting

Study was conducted at antenatal unit (Ward 19), Labour ward and Special care baby unit/NICU at Teaching hospital Peradeniya during the period from 01st of September 2014 to 01st of March 2015.

c) Inclusion criteria

Study included all uncomplicated singleton pregnancies at period of gestation of 37 to 41 with fetus in cephalic presentation. All pregnancies had spontaneous onset of labour.

d) Exclusion criteria

Pregnant women who had medical complications were excluded from the study. Medical complications included Diabetes, hypertensive disorders, thyroid disorders and haematological diseases etc. Also pregnancies with Preterm pre-labour rupture of membranes (PPROM), intrauterine growth restriction, detected congenital anomalous fetus, multiple pregnancies, cord prolapse, placental abruption, abnormal lie and non cephalic presentation was excluded from the study. Fetuses who were already suffering from fetal growth restriction we redetected by trans-abdominal ultrasonography performed prior to delivery at term.

e) Method

The participants were chosen out of pregnant women who admitted to the antenatal unit ward nineteen, Teaching hospital Peradeniya. Detailed antenatal history was reviewed from each participant by medical officers using hand-held antenatal record and hospital admission records. Antenatal clinic notes were also reviewed thoroughly to detect any existing risk in pregnancy. The medical officer performed proper examination including major organ system examination of all participants. Routine ultrasound scan abdomen was performed in all the women admitted at term to the ward to measure fetal growth parameters, amniotic fluid index and Doppler studies. Risk in the pregnancy was assessed and pregnant women who were eligible for the study were chosen according to inclusion and exclusion criteria. Informed written consent was obtained from the eligible pregnant mothers.

Recruited pregnant women were enrolled to study when they felt labour pain spontaneously. Spontaneous labour pain was defined as onset of regular painful uterine contractions, which gradually increase in severity and frequency. Onset of labour pain was confirmed clinically by obstetric ward medical officer or ward midwife. Pregnant women were transferred to the labour room when they were in established labour. Established labour denotes painful regular uterine contraction and progressive cervical changes. Minimal cervical dilatation for transfer to the labour ward was taken as four centimeters. Cardiotocograph was taken in the left semi-lateral position on labour bed for at least twenty minutes. All cardiotocographs were taken from TOITU model MT-516 class I BF 26 cardiotocography machine made by Toitu Co. Ltd. Japan. Paper speed was set at standard 1 cm per minute. Intrapartum cardiotocograph were categorized to

three main groups reactive, suspicious and pathological according to criteria depicted by National Institute of Clinical Excellence guidelines on fetal surveillance September 2007 [9]. Categorization was based on the pattern of CTG recording as shown below (Table 1). Baseline heart rate, variability, accelerations and decelerations of each cardiotocograph may determine the type of category (Table 2). Interpretation of CTG was done by obstetric postgraduate trainee (Registrar) or trained medical officer.

Normal baseline heart rate was considered as fetal heart rate from 110 to 160 beats per minute. Normal baseline variability was within 5 to 25 beats per minute. Acceleration was defined as increase in fetal heart rate more than 15 beats per minute for 15 seconds or more. Deceleration was reduction of fetal heart rate more than 15 beats per minute for 15 seconds or more.

Cardiotocography was considered reassuring when the baseline heart rate was between 110 to 160 beats per minute, variability more than 5 beats, accelerations present with absence of decelerations. Abnormal features of cardiotocography were baseline heart rate less than 100 beats per minute, more than 180 beats per minute, sinusoidal pattern for more than 10 minutes duration, variability less than 5 beats, absence of accelerations and presence of late decelerations, atypical decelerations, prolong deceleration for more than 3 minutes. Non reassuring cardiotocographs were ones with baseline heart rate between 100 - 109 beats per minute, 161 - 180 beats per minute, variability <5 or >40 beats for <90 minutes, early deceleration, variable deceleration or prolong deceleration less than 3-minute duration.

Cardiotocography was considered normal when baseline heart rate, variability, acceleration and deceleration features were in reassuring category. It was considered suspicious when at least one feature was in non-reassuring category and remaining was in reassuring category. Pathological cardiotocography was defined when two or more of above-mentioned features were in non-reassuring category or at least one feature was in abnormal category (Table 2).

Following admission cardiotocography, those with normal CTG tracing were subjected to routine quarter hourly fetal heart sound auscultation and routine management of normal labour. Those with suspicious CTG were managed by continuous CTG monitoring. Those with pathological CTG had undergoneurgent delivery by operative delivery. Apgar score was estimated at one, five and ten minutes respectively after delivery, in all neonates as a routine in the hospital using standard Apgar scoring system.

Apgar score was based on the colour, muscle tone, respiratory effort, heart rate and response to stimuli. It was assessed by examination of the newborn at specific time limits after birth. Each component will be given a score after the examination of the newborn. Total of scores will be given out of 10 at 1 minute, 5 minute and 10 minute after birth (Table 3).

Medical officer at labour ward or the paediatric medical officer assessed Apgar score at the delivery. Paediatric medical officer decided to resuscitate the newborns and to admit to neonatal intensive care unit (NICU) depending on the

Table 1. Categorizing the individual features of the cardiotocography.

Feature	Baseline (bpm)	Variability (bpm)	Decelerations	Accelerations
Reassuring	110 - 160	>5	None	Present
Non-reassuring	100 - 109 161- 180	<5 for 40 - 90 Minutes	Typical variable decelerations with over 50% of contractions, occurring for over 90 minutes Single prolonged deceleration for up to 3 minutes	Absence of acceleration if otherwise normal trace is of uncertain significance
Abnormal	<100 >180 Sinusoidal pattern > 10 minutes	<5 for 90 Minutes	Either atypical variable decelerations with over 50% of contractions or late decelerations, both for over 30 minutes Single prolonged deceleration for more than 3 minutes	Absent

bpm: Beats per minute.

Table 2. Cardiotocography classification.

Category	Definition
Normal	A CTG where all four features fall into the reassuring category.
Suspicious	A CTG whose features fall into one of the non-reassuring categories and the remainder of the features are reassuring.
Pathological	A CTG whose features fall into two or more non-reassuring categories or one or more abnormal categories.

CTG: Cardiotocography.

Table 3. Apgar score.

Sign	0	1	2
Heart rate	Absent	Below 100 per minute	Over 100 per minute
Respiratory effort	Absent	Slow, irregular	Good, crying
Muscle tone	Limp	Some flexion of extremities	Active motion
Response to catheter in nostril	No response	Grimace	Cough or sneeze
Color	Blue, pale	Body colourpink, extremities blue	Completely pink

state of the neonate after discussion with the paediatrician. All neonates were closely monitored for seizure activity during first 24 hours of birth as all delivered women were kept in the ward for minimum of 24 hours duration. Possible other causes for the seizure activity were investigated and excluded and ultrasonography of neonatal brain was performed in an event of seizure in every neonate. Apgar score less than 7 at five minutes considered as a low Apgar as it was associated with increased risk of neurological disability.

Color of amniotic fluid at the time of delivery was noted by midwife or medical officer. Moderate to thick meconium-stained liquor was defined as either dark green or thick tenacious or any meconium stained fluid containing lumps

of meconium [9]. In addition, presence of cord around the neck of delivering fetus at the time of the delivery was also noted.

Above-mentioned outcome measures were entered on a preformed data entry sheet. Percentages calculated for each type of admission cardiotocography. Outcome measures calculated as percentages in each group of admission cardiotocography respectively. Those data along with demographic data were depicted in tables and graphs in the results section of final manuscript.

f) Sample size calculation

Sample size was calculated according to statistical formula for comparison of proportions of two sample groups as shown below. Confidence level is set at 95% and power is set at 80%. P_1 was the assumed proportion of low Apgar score in Pathological CTG group while P_2 was the assumed proportion of Low Apgar score in non-pathological CTG group. Frequency of pathological cardiotocography was mentioned as approximately 8 percent in the literature. Also frequency of low Apgar in pathological cardiotocography group was 18% [14].

$$n = \frac{P_1(1-P_1)+P_2(1-P_2)}{(P_1-P_2)^2} \times f_{\alpha\beta}$$

n = sample size of first group, $f_{\alpha\beta}$ = constant.

Total sample size was approximately four hundred and fifty pregnant women. Therefore four hundred and fifty women who fulfill inclusion criteria will be recruited for the study.

g) Outcome measures

Primary outcome measures were:

- Apgar score of less than seven at five minutes
- Admission to neonatal intensive care unit or special care baby unit for birth asphyxia
- Neonatal seizure within first 24 hours of birth in the absence of other known causes
- Neonatal death within first 24 hours of birth due to asphyxia
- Secondary outcome measures were
- Moderate to thick meconium-stained liquor
- Cord round the neck of the newborn at the time of delivery.

h) Statistical analysis

Proportion of neonates who had low Apgar score (<7 at 5 minutes), admitted to NICU, seizure activity due to asphyxia and neonatal death within 24 hours due to asphyxia were calculated in each category of cardiotocography. Demographic data of sample were also presented. Statistical significance was calculated between groups with normal CTG and pathological CTG groups. The P value of 0.005 was considered to indicate statistical significance. Sensitivity, Specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated for labour admission CTG for detection of fetal distress (Apgar score < 7 at 5 minutes). Those data were presented on Data will be analyzed using computer based SPSS version 20 software.

i) Ethical considerations

Informed written consent was taken from the participants of the study. Information sheets were given in all three languages (Sinhala, Tamil and English) with the comprehensive details of the study in simple language. Subjects were allowed to leave the study at any moment. Study would not interfere with the labour management policy or neonatal management in the unit. Identity of the participants and their offspring were not disclosed at any point of time in the study. Data were entered on a data entry sheet, which was anonymous and entered by the medical officers looking after the patient at ward. No person was allowed to access data entry sheet except principal investigator who analyzed data. Ethical approval was taken from the Ethical review committee of Postgraduate institute of medicine, University of Colombo, Sri Lanka. (Approval number ERC/PGIM/2016/010).

5. Results

Total number of women who were eligible according to inclusion criteria was four hundred and forty five (n = 445). Calculation of demographic characteristics showed majority of participants, that is 286 (63.3%) belonged to Sinhalese ethnicity. Tamil and Muslim ethnicities were 85 (19.1%) and 74 (16.6%) respectively. Ages of the study population spanned from sixteen years to forty-three years. Highest proportion (38.4%) of participating women was in 25 - 29 year category. Teenage pregnancies were shown to be 18 (4%) while 66 women (14.8%) were above 35 years of age. Two hundred and twenty nine (51.5%) women who participated in this study were in their first pregnancy. Remaining participants were multiparous women of which nine were grand multipara. Above mentioned data are depicted below (Table 4).

Recruited women (445) were subjected to cardiotocography in labour, 333 (74.8%) pregnant women were categorized as having normal pattern of cardiotocography. Pathological group consist of 32 (7.2%) pregnant women while 80 (18%) had suspicious cardiotocography (Table 5).

The percentage of neonates who had Apgar less than seven at five minutes was 27 (6.1%). Among the group that had normal pattern intrapartum CTG, 10 (3%) neonates had Apgar score below seven at five minutes of birth while 3 (3%) in suspicious and 14 (45%) in pathological group had Apgar less than seven at five minutes. There was a significant difference ($p < 0.005$) between Pathological group and normal/suspicious group with regards to the Apgar score less than seven at five minutes of birth (Table 6).

Vast majority of newborns (404) did not need resuscitation at birth while 41 neonates received resuscitation due to birth asphyxia. Four (12.5%) of them belonged to pathological cardiotocography group while 20 (6%) neonates were in normal CTG group (Table 4). No statistical significance was noted between normal and pathological CTG groups with regards to resuscitation at birth (p = 0.16 (Table 7).

Table 4. Demographic data of the study population (n = 445).

	Frequency	Percentage (%)
Ethnicity		
Sinhalese	286	64.3
Tamil	85	19.1
Muslim	74	16.6
Age group		
≤19	18	4.0
20 - 24	66	14.8
25 - 29	171	38.4
30 - 34	124	27.9
35 - 39	54	12.1
≥40	12	2.7
Gravid		
1	229	51.5
2	122	27.4
3	63	14.2
4	22	4.9
≥5	9	2.0

Table 5. Frequency of normal, suspicious and pathological cardiotocography (n = 445).

	Frequency	Percentage (%)
Normal	333	74.8
Suspicious	80	18.0
Pathological	32	7.2
Total	445	

Table 6. Association of Apgar score at five minutes with cardiotocography (n = 445).

	Apgar score at five minutes	
	Apgar score ≥ 7	Apgar score < 7
Normal	323	10
Suspicious	77	3
Pathological	18	14
Total	418	27

Table 7. Association of resuscitation at birth with cardiotocography (n = 445).

	Resuscitation at birth	
	Resuscitation not needed	Resuscitation needed
Normal	313	20
Suspicious	63	17
Pathological	28	4
Total	404	41

Only 6.2% of neonates had to admit to neonatal intensive care unit (NICU) for the further management. Four neonates out of 32 of pathological group (12.5%) needed NICU care while 22 out of 392 non-pathological CTG groups (5.6%) had to get admit to NICU for birth asphyxia. However there was no significant difference between two groups ($p = 0.096$) (Table 8).

Twelve neonates in this study population were detected having seizure activity due to birth asphyxia during first day of life. However seven (2.1%) of neonates were belonged to normal pattern admission CTG, while three (3.9%) in suspicious group and two (6.6%) were in pathological category. There was no significant difference between pathological group and non-pathological group (Table 9).

Meconium-stained liquor was noted in 56 out of 445 of study population. Thirty-nine (11.7%) of them belonged to normal admission CTG group while suspicious and pathological groups had 11 (13.7%) and 6 (18.7%) respectively. But there was no significant difference in the incidence of meconium stained amniotic fluid in pathological CTG group compared to incidence in the normal CTG group. There were no fetal or neonatal death occurred during course of the study. Sixty-six of total number of deliveries showed nuchal cord (cord around the neck) at the time of delivery. Forty-five (13.5%) out of 333 normal cardiotocography had nuchal cord while in pathological group, it was seven (21.8%) neonates out of 32.

Final mode of delivery was also calculated in each category. Out of 333 normal CTG, 67 (20.1%) of mothers undergone operative delivery while 22 (68%) of 32 pathological CTG group needed operative delivery. In the suspicious category operative delivery was 23.75 percent (Table 10). There was apparent trend of increasing rate of operative delivery when labour admission CTG worsens from normal to pathological. In addition, pathological CTG group had significantly high rate of operative delivery compared to non-pathological group ($p < 0.05$).

In evaluating predictive ability of the labour admission CTG, investigator found out that pathological type intrapartum admission CTG has a sensitivity of 51.85% in detecting neonates with Apgar score less than seven at five minutes of birth in the study population. Specificity of pathological cardiotocography is 95.69% according to study population while positive predictive value and negative predictive value calculated to be 43.75% and 96.85% respectively.

Table 8. Association of admissions to NICU with cardiotocography ($n = 445$).

	NICU admission	
	Not needed	Needed
Normal	322	11
Suspicious	69	11
Pathological	28	4
Total	419	26

NICU: Neonatal intensive care unit.

Table 9. Association of Seizure due to asphyxia with cardiotocography (n = 445).

	Seizures due to asphyxia	
	Seizures not present	Seizures present
Normal	326	7
Suspicious	77	3
Pathological	30	2
Total	433	12

Table 10. Association of meconium-stained amniotic fluid, nuchal cord and mode of delivery with cardiotocography (n = 445).

	Type of cardiotocography		
	Normal	Suspicious	Pathological
Color of amniotic fluid			
Clear	294	69	26
Meconium	39	11	6
Nuchal cord			
Absent	288	66	25
Present	45	14	7
Mode of delivery			
NVD	266	61	10
Vacuum	2	3	12
Forceps	10	2	0
CS	55	14	10

NVD*:* Normal vaginal delivery; CS: Caesarean section.

6. Discussion

Study was done at Teaching hospital Peradeniya, which is a tertiary care hospital, situated in Central province of Sri Lanka. Many pregnant women attend directly or referred to antenatal clinics in the hospital, which held on almost every weekday. Majority of women were Sinhalese in ethnicity while Tamil and Muslim ethnicities contributed to remaining part. In analyzing demographic data, proportions of ethnicities, which included in the study, are in comparable with population in Central Province. Among pregnant women in study population, highest proportion of women was between 25 years to 29 years of age. Majority of women who participated in the study were in their first pregnancy. Frequency of women decreased with the increase in parity.

This study involved low risk pregnancies at term that had spontaneous labour. Therefore, vast majority of women had normal pattern cardiotocography in labour while 7.2% had pathological pattern cardiotocography. Similar study done by Lubna *et al.* on 173 low risk term pregnancies with admission cardiotocogra-

phy stated to have 6.35% of pathological cardiotocography while rest had normal findings. Rahman *et al.* performed study to evaluate predictive ability of admission CTG in high-risk pregnancies showed incidence of pathological CTG to be 8.75%. Pathological CTG warrants urgent delivery. Therefore, having 7.2% of pathological incidence in low risk pregnancies is an important issue as routine admission labour CTG is not recommended in clinical literature. Since unavailability of secondary test for fetal wellbeing such as fetal blood sampling in our set up also has to take into consideration.

Fetuses suffering from growth restriction, congenital abnormalities and maternal medical comorbidities would be confounding factors in assessment of intrapartum fetal distress. Due to that reason investigator included only low risk pregnancies as participant to control confounders. Some of the earlier studies have involved high-risk pregnancies to assess predictability of labour admission CTG. However, placental pathology as well as fetal physiology in labour changes depending on maternal/fetal comorbidities.

Methods of induction of labour is well known to be associated with fetal distress therefore needs robust fetal monitoring. Due to the same reason investigator had included pregnancies with spontaneous onset of labour. Thereby it eliminates another confounding factor.

When analyzing data there was a significant difference between pathological cardiotocography group and non-pathological group with regards to the Apgar less than seven at five minutes of birth ($p < 0.005$). However, other outcome measures such as resuscitation at birth, admission to NICU, seizure activity and meconium stained amniotic fluid at birth did not have significant difference between pathological and non-pathological groups. Number of other studies also showed similar findings to index study. Das *et al.* observed that there was a marked difference in the number of neonates with Apgar score < 7 at 5 minutes in abnormal admission test group [26]. Earlier studies stated that pathological labour admission CTG had significant association with Apgar score, meconium in amniotic fluid, NICU admissions and resuscitation at birth. But most of those studies are done on high-risk pregnancies as opposed to low risk pregnancies. In contrast, research done by Ducey *et al.* on 405 women in latent phase of labour could not find significant difference with Apgar score at five minutes and meconium stained liquor [27].

According to results the number of operative deliveries were increased with worsening of cardiotocography from normal to pathological. This in comparison with previous studies as in Elimian *et al.* have done research on 426 women who went into spontaneous labour at term to evaluate the role of fetal admission test. It found out that nonreactive fetal admission test was more likely to be delivered by Caesarean section, to have fetal distress and longer hospital stay [3].

Sensitivity, specificity, positive predictive value and likelihood ratio of pathological admission cardiotocography in detecting fetal distress is quite comparable with studies in literature (**Table 8**). Study done by Ducey *et al.* for determining value of fetal heart rate tracing in the latent phase of labour on 405 women

showed screening fetal heart rate tracing had sensitivity of 57% and specificity of 98% and positive predictive value of 75% respectively [27]. However primary endpoint was taken as emergency caesarian section due to fetal distress in contrast to Apgar score, meconium, resuscitation, NICU admission and seizures.

Index study also showed a trend of increasing rates of operative delivery towards worsening of labour admission CTG from normal to pathological. Hegde *et al.* in their study done on 200 low risk pregnancies also observed similar results [28]. Pathological CTG warrants operative delivery unless pregnancy is at second stage of labour and about to deliver. And also, suspicious CTG leads to continuous cardiotocography monitoring in labour. In the absence of secondary confirmatory test to ascertain fetal compromise in Sri Lanka setting, operative delivery rate might increase from admission cardiotocography.

Retrospective study done by Ellen Blix on 932 women in first stage of labour showed fetal distress in 5.8% and 5.3 % had operative delivery because of fetal distress. Also, sensitivity was 15%, positive predictive value was 16%, specificity of 95% and negative predictive value of 97% respectively. In conclusion they mentioned labour admission test as a screening tool for fetal distress in labour in low-risk women has low sensitivity and many false positive tests [29]. Investigators in previous studies had taken end point of study as caesarian section for fetal distress to calculate predictive ability as screening test. However caesarean section for fetal distress necessarily would not reflect true hypoxia in fetus. Nevertheless, according to our data, it can be concluded that fetal admission test is useful in predicting the absence of intrapartum fetal distress as it has high specificity and negative predictive value (**Table 11**).

7. Limitations

Risk assessment of the study participants were made at the admission to the antenatal unit based on information given by the patient and the antenatal records. There was a possibility of antenatal compromise of the fetus due to placental insufficiency not being detected at the antenatal period. Even though symphysio-fundal height (SFH) measurements during antenatal period and ultrasound scan (without Doppler) after admission to the antenatal unit was performed, still there can be fetal growth restriction in the fetus as clinical examination and ultrasonography have low sensitivity for the detection of late fetal growth restriction in low risk pregnancies. Such growth-restricted fetus might show features of fetal distress at delivery.

Cardiotocography interpretation has proven to have high inter-observer and intra-observer error in literature. Studies done by Blix *et al.* compared assessment of 845 labour admission tests between obstetricians and midwives, found out that inter-observer agreement on labour admission test can be variable in different setting [30]. Even though postgraduate trainee interpreted cardiotocographs and categorized them on this study, there is still a possibility that error might occur due to misinterpretation. Interpretation of error can be mitigated by use of computerized cardiotocography thereby improves sensitivity and specificity.

Table 11. Comparison of sensitivity, specificity, PPV and NPV of admission cardiotocography with previous studies.

Study	Sensitivity	Specificity	PPV	NPV
Present study	**51.85%**	**95.69%**	**43.75%**	**96.85%**
Ducey *et al.*	57%	98%	75%	-
Blix *et al.*	15%	95%	16%	97%
Ingemarsson	23.5%	99.4%	40%	98.7%
Rahman *et al.*	60%	94.8%	56.8%	88.6%

PPV: Positive predictive value, NPV: Negative predictive value.

Another objective of this study was to determine the predictive ability of intrapartum cardiotocography for adverse perinatal outcomes. Focused perinatal outcome measures were Apgar score less than seven at 5 minutes, resuscitation needed at birth, NICU admissions, seizure events within first 24 hours and meconium-stained liquor. Apgar score has presumably been objective method of assessing depressed neonate at birth. However, Apgar score at 5minutes has little predictive ability for long-term complications unless it is moderately (<7) or very low (<4). In addition, moderately or very low Apgar score persisting beyond 10 minutes has increased association with poor neonatal outcome. Therefore, measuring persistence of low Apgar score beyond or up to 10 minutes might reflect adverse perinatal outcome more meaning fully. Other outcome measures such as resuscitation at birth, admissions to neonatal intensive care unit and seizure activity within first 24 hours were subjective and might differ between institutions and observers. None of the above outcome measures were gold standard in detecting fetal hypoxia in labour. In that context fetal blood sampling, neonatal or cord blood pH would have been more objective measurement of fetal acidosis in labour. Nevertheless, unavailability of resources did not permit usage of pH monitoring of all participating women.

8. Conclusions & Recommendations

Labour admission CTG is routinely practiced in many maternity units in Sri Lanka though evidence is against it. Study was designed and implemented to know how the incidences of different types of admission cardiotocography in spontaneous labour in low-risk pregnancy and its ability to foresee possible fetal hypoxia. Categorization of CTGs was done using criteria depicted by National Institute of Clinical Excellence guidelines on fetal surveillance 2007. Incidence of pathological CTG in low-risk term pregnancies in spontaneous labour was 7.2%.

Study also showed Apgar score less than 7 at 5 minutes of birth is significantly associated with pathological admission cardiotocography than normal or suspicious admission cardiotocography. But other outcome measures such as resuscitation at birth, seizure activity, NICU admissions and meconium-stained amniotic fluids did not show significant association with type of labour admission CTG. Therefore, labour admission cardiotocography may be a good test to ex-

clude fetal hypoxia in low risk, term singleton pregnancies.

The incidence of operative delivery was increasing gradually with worsening of labour admission cardiotocography from normal to pathological. Therefore, routine labour admission cardiotocography might increase emergency caesarean section rates and operative vaginal deliveries for fetal distress and operative vaginal deliveries in low-risk pregnancies in labour.

Study concluded that labour admission cardiotocography has low sensitivity in low-risk term pregnant women in spontaneous labour. However, it has a high specificity and high negative predictive value to exclude low Apgar score at five minutes. Labour admission cardiotocography in term low risk women had sensitivity of 51.85%, specificity of 95.69% and positive predictive value of 43.75%.

Useful early predictive test to detect fetuses who will be compromised in labour is important. Newer advancements such as computer analysis of CTG may mitigateerrors of CTG like inter-observer and intra-observer variation in interpretation. Understanding pattern recognition of CTG according to fetal physiology and newer CTG categorization may revolutionize intrapartum monitoring in future. Fetal scalp sampling to detect acidosis in fetus will also be useful component to have in labour care to solve ambiguities.

To ensure optimal fetal surveillance and to reduce emergency caesarean sections for assumed fetal distress Sri Lanka might need secondary fetal wellbeing testing such as fetal blood sampling for pH or computerized CTG analysis. Training and teaching of caregivers in assessing and interpretation of cardiotocography might also enhance quality obstetric care.

Funding

Any institution or authority had not funded this study.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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List of Abbreviations

bpm:	Beats Per Minute
CTG:	Cardiotocography
EFM:	Electronic Fetal Monitoring
FAST:	Fetal Acoustic Stimulation Test
NICE:	National Institute of Clinical Excellence
NICU:	Neonatal Intensive Care Unit
NPV:	Negative Predictive Value
NST:	Non Stress Test
OCT:	Oxytocin Challenge Test
pH:	potential of Hydrogen
PPROM:	Preterm Pre-Labour Rupture of Membranes
PPV:	Positive Predictive value
SFH:	Symphysio Fundal Height
SPSS:	Statistical Package for the Social Sciences
STAN:	ST Segment Analysis