

Association between CTG Parameters One Hour before Delivery and Neonatal Asphyxia

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How to cite this article: Sarah Muhammed Yaseen, Suha Abdul Jaleel Wadi. Association between CTG Parameters One Hour before Delivery and Neonatal Asphyxia. Indian Journal of Public Health Research and Development / Vol. 17 No. 2, April-June 2026.

Abstract

Background: Cardiotocography (CTG) is a vital tool in obstetric practice for real-time fetal monitoring. However, its predictive value in identifying neonatal asphyxia remains underexplored, particularly in the critical hour before delivery.

Aim of the Study: This study investigates the association between CTG monitoring in the last hour before delivery and neonatal asphyxia, aiming to evaluate its predictive value.

Patients and Methods: This study is a descriptive retrospective cohort study conducted at Al-Elwiya Maternity Teaching Hospital between January 2024 and January 2025. The study included 250 pregnant women presented with labour condition to the mentioned hospital, CTG monitoring was applied continuously. After delivery (whether by vaginal delivery or caesarean section) CTG of last hour before delivery was compared for the neonates who had asphyxia and those without asphyxia. Inclusion criteria were: Term months, no history of taking drug, before delivery that affects the heart rate of the fetus (as magnesium sulphate, narcotics and pain killers), no history of fever, no history of drugs, addition, not smoker, not alcoholic, babies without congenital anomalies. Exclusion criteria: Preterms, mothers with medical disease like diabetes mellitus and hypertension, addiction to smoking and alcohol, mothers taking drugs that affect the heart rate of the fetus like (magnesium sulphate, narcotics and pain killers, maternal fever, neonates with congenital anomaly, extremes of reproductive age group and extremes of BMI (<18.5 or ≥ 25 kg/m²).

Results: Pathological CTG patterns were observed in 70% of the asphyxia group, compared to 1.6% in the non-asphyxia group. Late decelerations, absent variability, and accelerations were significantly associated with asphyxia. Caesarean delivery was more common in the asphyxia group. The need of NICU admissions further emphasized the poor neonatal outcomes.

Conclusion: CTG monitoring in the last hour before delivery shows significant predictive potential for neonatal asphyxia. Specific CTG patterns can guide timely obstetric interventions, which can lead to improve neonatal outcomes.

Keywords: Cardiotocography, Neonatal asphyxia, Fetal monitoring, CTG patterns, Obstetric outcomes.

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Submission date: May 8, 2025

Revision date: Sept 18, 2025

Published date: April 14, 2026

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Introduction

Cardiotocography (CTG) is a technique used to monitor the fetal heartbeat and uterine contractions during pregnancy and labor. The machine used to perform the monitoring is called a cardiotocograph. It aids early fetal distress detection^(1, 2). Recent studies suggest that specific CTG pattern, like recurrent late deceleration and reduced variability, may indicate fetal distress, potentially leading to neonatal asphyxia if not addressed promptly⁽³⁾.

The physiology of fetal heart rate (FHR) is a complex process governed by the autonomic and somatic components of the central nervous system, essential for maintaining fetal well-being during gestation and particularly through the stress of labor. The autonomic nervous system, comprised of the sympathetic and parasympathetic systems, plays a pivotal role in modulating the FHR. The sympathetic system is responsible for increasing heart rate, preparing the body for 'fight or flight' responses, while the parasympathetic system, through mechanisms such as the action of baroreceptors and chemoreceptors, seeks to decrease the heart rate, promoting rest and digest activities. This dynamic balance between the two systems establishes the baseline FHR and its variability, observed in clinical settings as fluctuations on the cardiotocography⁽⁴⁾. A normal CTG trace is pivotal in assessing fetal well-being, providing insights into the fetal heart rate and its regulation by the autonomic and somatic nervous systems during pregnancy and labor⁽⁵⁾. Neonatal asphyxia is the medical condition resulting from deprivation of oxygen to a newborn infant during the birth process leading to physical harm to the brain, causing immediate neurological deficits and long term (for living babies). It is a major cause of neonatal morbidity and mortality worldwide, emphasizing the need for effective preventive strategies⁽⁶⁾. The incidence of perinatal asphyxia is 2-10 per 1000 births in developed countries, but the rate rises up to (10) times higher in developing countries where there may be limited access to maternal and neonatal care. Of these affected infants, 15-20% die in the neonatal period, and up to 25% of survivors are left with permanent neurological deficits⁽⁷⁾. Perinatal asphyxia can occur due to maternal events (hemorrhage, amniotic fluid embolism, hemodynamic collapse),

placental events (acute abruption), uterine events (rupture), cord events (tight nuchal cord, cord prolapse/avulsion) and intrapartum infection (maternal fever in labor)⁽⁸⁾. The asphyxia can occur prior to the birth (50% prepartum, during birth 40%, and immediately postpartum 10%)⁽⁹⁾. Categorization of CTG according to NICE guideline including the 4 features of the CTG (contractions, baseline FHR, variability, decelerations) as white, amber and red (red indicates increasing levels of concern). Alongside consideration of the presence of accelerations to classify the overall CTG trace⁽¹⁰⁾. FIGO classification of categorize CTG pattern into: normal, suspicious and pathological also using the 4 feature of CTG (contractions, baseline FHR, variability, decelerations)⁽¹¹⁾.

Health care professional should consider the entire clinical picture, including maternal observations, contraction frequency, and labor progression together with fetal heart assessment using CTG categorizations mentioned above to make informed care decisions and ensure timely interventions according to the results⁽¹¹⁾.

The aim of this study was to predict the association between abnormal CTG patterns one hour before delivery and the occurrence neonatal asphyxia outcomes. The predictive value of pre-delivery CTG monitoring for neonatal asphyxia has been a subject of extensive research and clinical debate. CTG monitoring is a standard practice in obstetrics, aiming to identify fetuses at risk of asphyxia by assessing the FHR patterns and uterine contractions and providing invaluable insights into fetal wellbeing during labor. The primary goal is to predict asphyxia and intervene before it causes irreversible harm⁽¹²⁾.

There is a gap in understanding the correlation between CTG patterns observed an hour before delivery and neonatal asphyxia outcomes, with some researchers advocating for continuous monitoring⁽¹³⁾.

Patients and Methods

Study Design

This was a descriptive retrospective cohort study, carried out in the Department of Obstetrics and Gynecology, Department of Neonatal Intensive Care Unit at Al-Elwiya Teaching Hospital, Baghdad, Iraq during a period of one year from 15th of January

2024, till 15th of January 2025. The study protocol was approved by Scientific Counseling of Obstetrics and Gynecology. All patients informed about the nature of study and verbal consent was taken from them.

Sample size and date collection

250, term, pregnant women were included in the study. They were presented with labour condition in the labour room of the mentioned hospital above. Questionnaire was arranged for each patient including: age, parity, gravidity, LMP, time of quickening, pregnancy test if available or early ultrasound and calculation of the gestational age was done accordingly. Height and weight was measured followed by calculation of BMI (weight in kilograms divided by the height in squared meters). Previous medical, drug, social and obstetrical history was taken. All should have anomaly scan done during their antenatal period.

Inclusion criteria

Term, no history of taking drugs that affect the fetal heart like magnesium sulphate, narcotics, and pain killers before delivery. No history of fever, no history of drug addiction, smoking or alcohol consumption. Neonates without congenital anomalies.

Exclusion criteria

Preterms, Medical diseases like diabetes mellitus and hypertension. Addiction to drugs, alcohol and smoker. Mothers taking drugs that affect the heart rate of the fetus like magnesium sulphate, narcotics,

pain killers, and maternal fever. Congenital anomalies of the baby. Extremes of reproductive age groups. Extremes of BMI (<18.5 or ≥25 kg/m²).

CTG data and labour details

All patients included in the study were monitored continuously by CTG which was performed by obstetricians or other healthcare professionals. Labour details, type of delivery (vaginal or cesarean section) were recorded in the patient form.

Diagnosis of neonatal asphyxia

Usually done by senior pediatrician in the neonatal resuscitation room in the labour or theater or NCU. Asphyxia was diagnosed based on a combination of clinical and biochemical criteria. Clinically, neonates with an Apgar score of less than 7 at 5 minutes were considered. Biochemical criteria included arterial blood gas pH less than 7.1 or base deficit greater than 12 mmol/L. Information on any neurological sequelae was also included to assess the long-term impact of asphyxia.

CTG assessment

Expert obstetricians interpret each CTG trace for each patient retrospectively after delivery. The CTG parameter included in the study were those in the last hour baby delivery for both asphyxia and no-asphyxia neonates. CTG parameters as defined by FIGO classification was evaluated for each CTG trace and then blinded to the neonatal outcome, to compare CTG parameters between asphyxia and no-asphyxia neonates (blinded CTG).

Table (1): FIGO classification of CTG ⁽¹⁾.

Category	Criteria	Interpretation
Normal	- Baseline FHR: 110-160 bpm - Variability: 5-25 bpm - No repetitive decelerations	- No hypoxia or acidosis - No intervention required
Suspicious	- Missing one or more features of normal but without pathological features	- Low probability of hypoxia or acidosis - Requires action to correct reversible causes or close monitoring
Pathological	- Baseline FHR: <100 bpm - Reduced, increased variability, or sinusoidal pattern - Repetitive late/prolonged decelerations (>30 min or >20 min if reduced variability) - Deceleration lasting >5 min	- High probability of hypoxia or acidosis - Immediate action needed, including possible expedited delivery

Statistical analysis

The data analyzed using Statistical Package for Social Sciences (SPSS) version 26. The data presented as mean, standard deviation and ranges. Categorical data presented by frequencies and percentages. Independent t-test (two tailed) was used to compare the continuous variables accordingly. A level of p-value less than 0.05 was considered significant

Results

During study period 6892 women were delivered,

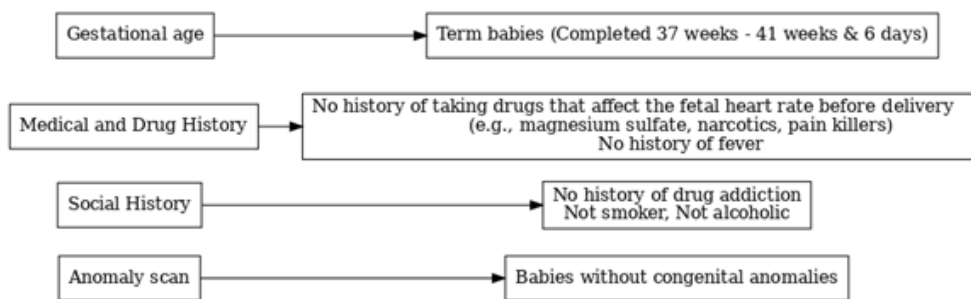


Figure (1): Flowchart of the study inclusions

- Maternal age was similar between the asphyxia group (28.26±6.17 years) and the no-asphyxia group (28.99±5.79 years), with no significant difference (P = 0.425). Gravidity and parity also showed no statistically significant differences between the two groups, with mean values of 5.23±2.22 and 3.28 ± 1.54 in the asphyxia group compared to 5.67 ± 2.37 and 3.67 ± 1.81 in the no-asphyxia group (P = 0.237 and P = 0.204, respectively).

the neonatal department reported 29 cases of term neonatal asphyxia of different causes, the incidence of asphyxia was 4.49 per 1000 term newborns. According to the flowchart of the study inclusion cited below, 250 cases of delivered women will be included in the study and were divided into two groups: 10 cases of mothers delivered babies with asphyxia (asphyxia group) and 240 women delivered babies without asphyxia (no-asphyxia group). All 250 patients who were chosen should have CTG records in the last hour before delivery.

Similarly, the number of previous miscarriages was comparable, with mean values of 0.96 ± 0.91 in the asphyxia group and 1 ± 0.84 in the no-asphyxia group (P = 0.755). Maternal BMI did not differ significantly between the two groups, with values of 27.07 ± 2.35 in the asphyxia group and 27.24 ± 2.44 in the no-asphyxia group (P = 0.641) (Table 2).

Table (2): Distribution of patients' demographics according to the groups.

Variables	Asphyxia	No-asphyxia	P value
	Mean ±SD	Mean ±SD	
Age	28.26 ±6.17	28.99 ±5.79	0.425
Gravidity	5.23 ±2.22	5.67 ±2.37	0.237
Parity	3.28 ±1.54	3.67 ±1.81	0.204
Miscarriage	0.96 ±0.91	1 ±0.84	0.755
BMI	27.07 ±2.35	27.24 ±2.44	0.641

- Induction of labor was not significantly associated with neonatal asphyxia, occurring in 60% of the asphyxia group and 61.7% of the no-asphyxia group (P=0.556).

Mode of delivery showed a significant association with neonatal asphyxia

(P < 0.001). Caesarean section (C/S) was more common in neonates with asphyxia (90%) compared to those without asphyxia (47.9%). Conversely, vaginal delivery was significantly less frequent in the asphyxia group (10%) compared to the no-asphyxia group (52.1%) (Table 3).

Table (3): Induction of labor and mode of delivery according to study groups.

Variables		Asphyxia	No-asphyxia	P value
		No. (%)	No. (%)	
Induction of Labor	Yes	6 (60)	148 (61.7)	0.556
	No	4 (40)	92 (38.3)	
Mode of delivery	Vaginal	1 (10)	125 (52.1)	<0.001
	C/S	9 (90)	115 (47.9)	
Causes of C/S	Fetal distress	7 (77.8)	36 (31.3)	<0.001
	Failure to progress	2 (22.2)	68.7	

- **CTG Variables:** CTG parameters demonstrated significant differences between the asphyxia and no-asphyxia groups:

Variability: Absence of variability was observed in 70% of the asphyxia group, compared to none in the no-asphyxia group ($P < 0.001$). Variability was present in all neonates without asphyxia (100%) but only in 30% of those with asphyxia.

Accelerations: Absence of accelerations was significantly more common in the asphyxia group (80%) compared to the no-asphyxia group (11.3%) ($P < 0.001$).

Decelerations: Decelerations were observed

in 40% of the asphyxia group and 91.1% of the no-asphyxia group ($P < 0.001$).

Type of Deceleration: Late decelerations were exclusive to the asphyxia group (75%), while early decelerations were observed only in the no-asphyxia group (74.9%) ($P < 0.001$). Variable decelerations were similar in frequency in both groups (25% vs. 25.1%).

Baseline Fetal Heart Rate (FHR): The mean baseline FHR was significantly lower in the asphyxia group (98.11 ± 4.34 bpm) compared to the no-asphyxia group (134.13 ± 13.33 bpm) ($P < 0.001$) (Table 4).

Table (4): CTG Variables according to study groups.

Variables		Asphyxia	No-asphyxia	P value
		No. (%)	No. (%)	
Variability	Absent	7 (70)	0 (0)	<0.001
	Present	3 (30)	240 (100)	
Acceleration	Absent	8 (80)	27 (11.3)	<0.001
	Present	2 (20)	213 (88.7)	
Deceleration	Absent	6 (60)	21 (8.9)	<0.001
	Present	4 (40)	219 (91.1)	
Type of deceleration	Early	0 (0)	164 (74.9)	<0.001
	Variable	1 (25)	55 (25.1)	
	Late	3 (75)	0 (0)	
Baseline FHR	Mean \pm SD	98.11 \pm 4.34	134.13 \pm 13.33	<0.001

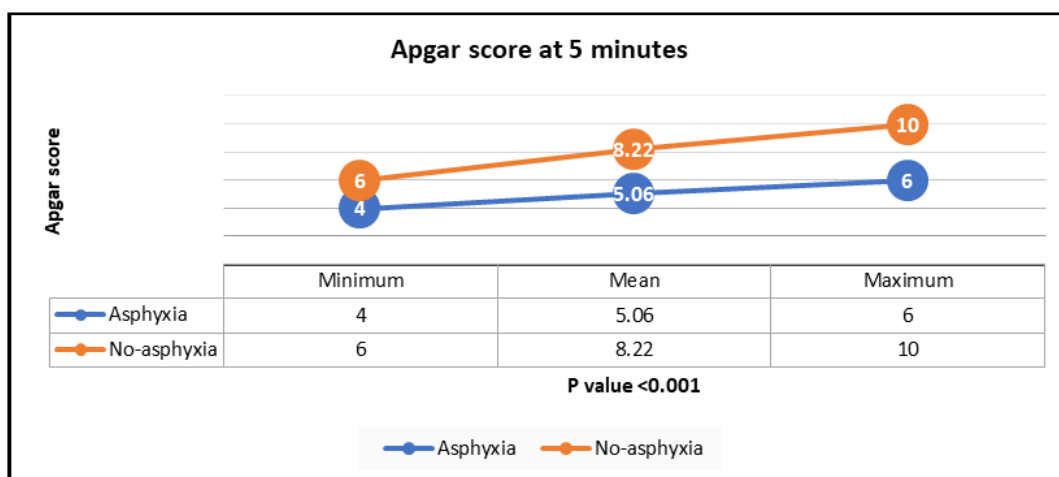
- CTG categorization showed a strong association with neonatal asphyxia ($P < 0.001$). In the asphyxia group, 80% of cases were classified as pathological,

compared to only 1.6% in the no-asphyxia group. Normal CTG patterns were observed in 10% of the asphyxia group and 81.3% of the no-asphyxia group (Table 5).

Table (5): CTG categorization according to study groups.

Category	Asphyxia	No- asphyxia	P value
	No. (%)	No. (%)	
Normal	1 (10)	195 (81.3)	<0.001
Suspicious	1 (10)	41 (17.1)	
Pathological	8 (80)	4 (1.6)	

- The Apgar scores at 5 minutes were significantly lower in the asphyxia group compared to the no-asphyxia group ($P < 0.001$). The minimum, mean, and maximum Apgar scores in the asphyxia group were 4, 5.06, and 6, respectively, while in the no-asphyxia group, they were 6, 8.22, and 10. These findings highlight the reduced neonatal condition in cases of asphyxia (Figure 2).

**Figure (2): Apgar score according to study group.**

- NICU admission was required for all neonates in the asphyxia group (100%), while only 12.1% of neonates in the no-asphyxia group required NICU admission. None of the neonates in the asphyxia group avoided NICU care, whereas 87.9% of neonates in the no-asphyxia group did not require NICU admission. This stark difference highlights the strong association between neonatal asphyxia and the need for NICU admission (Table 6).

Table (6): NICU admission rate.

NICU	Asphyxia	No-asphyxia	P value
	No. (%)	No. (%)	
Yes	10 (100)	29 (12.1)	N/A
No	0 (0)	211 (87.9)	

N/A: not applicable.

Discussion

The current study, there was a significant association between pathological CTG (absence of fetal heart accelerations, reduced variability, late decelerations and bradycardia seen in the last hour

before delivery and neonatal asphyxia ($p < 0.001$). In addition this study showed that suspicious CTG patterns were observed more often in the no-asphyxia group (17.2%) than in the asphyxia group (10%). Normal CTG patterns were more frequent in the no-asphyxia group (81.3%) than in asphyxia group (10%).

As compared to other studies, they found that pathological CTG patterns, are indicative of potential fetal hypoxia and associated with adverse neonatal outcomes⁽¹⁴⁾.

In the current study, the absence of FHR accelerations was significantly more common in the asphyxia group (80%) compared to no-asphyxia group (11.3%) and ($p < 0.001$). This finding underscores the importance of FHR accelerations as indicators of fetal well-being.

FHR accelerations are typically associated with fetal movements and reflect an intact central nervous system and adequate oxygenation, they are indicator of fetal well-being, as compared with other studies, they found that their absence during labor was associated with an increased risk of fetal hypoxia, neonatal acidemia and adverse outcomes⁽¹⁵⁾.

The current study showed that all neonates without asphyxia exhibited variability and there is significant association between absence of variability and neonatal asphyxia ($p < 0.001$).

FHR variability, is the fluctuation in the time intervals between adjacent heartbeats, it indicates healthy neurocardiac function and is generated by heart- brain interactions and dynamic non-linear autonomic nervous system processes⁽¹⁶⁾.

As compared with the studies, they found that reduced or absent FH variability was a strong indicator of fetal hypoxia, potential asphyxia and newborn acidemia⁽¹⁷⁾.

Decelerations in FHR are common during labour. The pattern of deceleration is more indicative of development of fetal hypoxia and later on neonatal asphyxia. Early decelerations are caused by the compression of the baby's head during uterine contractions. The compression causes vagal stimulation which slows the fetal heart rate. Late decelerations are caused by decreased blood flow to the placenta and can signify an impending fetal acidemia, the usual cause of this type is uteroplacental insufficiency. Variable decelerations are caused by direct umbilical cord compression, which lead to decelerations in the FHR. FHR accelerations or increase in heart rate is a sign that the baby is doing well. Early decelerations happen during contractions

and are also considered normal. However late decelerations may indicate that there is a decrease in blood flow from the placenta. A variable deceleration can happen when the umbilical cord is temporarily compressed and can be a sign that the baby isn't getting enough oxygen⁽¹⁸⁾.

In the current study, early decelerations were observed only in the no-asphyxia group ($p < 0.001$). Late decelerations were exclusive to the asphyxia group. Variable decelerations were similar in frequency in both groups (about 25%).

As compared with other studies, they found that certain patterns of decelerations, such as recurrent late decelerations with minimal or absent variability, are more concerning for fetal acidemia and hypoxia⁽¹⁹⁾.

In the current study, neonates in the asphyxia group had significantly lower 5 minute Apgar scores compared to those in the no-asphyxia group ($p < 0.001$) and all neonates in the asphyxia group required NICU admission, whereas only 12% of those in the no asphyxia group did.

As compared with other studies in their systematic review and meta-analysis, they found that cases of neonatal asphyxia were associated with poor neonatal outcomes, low Apgar score, and higher NICU admission rates⁽²⁰⁾.

Neonatal asphyxia, characterised by impaired gas exchange leading to hypoxemia and hypercapnia, often necessitates advanced supportive measures available in NICUs to manage potential complications such as respiratory distress, metabolic acidosis and organ dysfunction.

In the current study showed that maternal age, gravidity, parity, BMI, labor induction for any cause showed no significant association with neonatal asphyxia.

In comparison with other studies, they found that age less than 20 years had increase in the risk of birth asphyxia. This difference because current study patients were matched regarding their age to eliminate the demographic bias⁽²¹⁾.

Regarding gravidity some studies showed the same as current study⁽²²⁾ while other studies showed that primigravida is a significant risk factor for the

development of birth asphyxia^(23, 24). Regarding BMI, current study showed no significant association between BMI and birth asphyxia.

In comparison with other studies, they showed that obesity was associated with higher rate of birth asphyxia compared to normal weight mothers^(25, 26). This difference between studies because the current study selected cases with matched BMI (avoidance of extremes of weight).

In the current study showed no significant association with the labor induction.

In comparison with other studies, they found the same non significance between induction of labor and birth asphyxia. This other study stated that although induction of labor is associated with uterine contractions and possibility of changes in fetal heart rate but the rate of neonatal asphyxia is not elevated providing the proper management of labor and judicious use of uteritonic agent⁽²⁷⁾.

In current study, mode of delivery was significantly associated with neonatal asphyxia ($p < 0.001$). Caesarean section was more prevalent among neonates with asphyxia compared to those without. Vaginal delivery was less frequent in the asphyxia group. The high rate of CIS in the asphyxia group could be a consequence of underlying perinatal complications necessitating surgical intervention.

In comparison with their studies, they found that the mode of delivery per se was not associated with the presence of neonatal asphyxia⁽²⁸⁾.

The differences between studies reported above related to different sample size and different study design.

Conclusions

CTG monitoring in the last hour before delivery shows significant value in prediction of neonatal asphyxia. Pathological CTG patterns can guide timely obstetric interventions, which can lead in improvement of neonatal outcomes and decreases the incidence of neonatal asphyxia.

Ethical clearance: Verbal permission was obtained from each patient prior to collecting data, and information were anonymous. Names were

removed and replaced by identification codes. All informations were kept confidential in a password secured laptop and data were used exclusively for the research purposes.

Ethical approval was taken from ministry of health reference no 427 and dated 23/1/2024 committed in Iraq.

Conflict of Interest: The author declares that she has no conflict of interest.

Funding: Self-funding.

References

1. Ayres-de-Campos D, Spong CY, Chandrachan E. FIGO consensus guidelines on intrapartum fetal monitoring: Cardiotocography. *International Journal of Gynecology & Obstetrics*. 2015;131(1):13-24.
2. Kamala BA, Kidanto HL, Wangwe PJ, Dalen I, Mduma ER, Perlman JM, et al. Intrapartum fetal heart rate monitoring using a handheld Doppler versus Pinard stethoscope: a randomized controlled study in Dar es Salaam. *Int J Womens Health*. 2018;10:341-8.
3. Clark SL, Nageotte MP, Garite TJ, Freeman RK, Miller DA, Simpson KR, et al. Intrapartum management of category II fetal heart rate tracings: towards standardization of care. *American journal of obstetrics and gynecology*. 2013;209(2):89-97.
4. Kasahara Y, Yoshida C, Saito M, Kimura Y. Assessments of heart rate and sympathetic and parasympathetic nervous activities of normal mouse fetuses at different stages of fetal development using fetal electrocardiography. *Frontiers in Physiology*. 2021;12:652828.
5. Jongen G. Simulation of the cardiotocogram during labor: towards model-based understanding of fetal physiology. 2016.
6. Ndjapa-Ndamkou C, Govender L, Bhoora S, Chauke L. The role of the placenta in perinatal asphyxia, neonatal encephalopathy, and neurodevelopmental outcome: A review. *African Journal of Reproductive Health*. 2023;27(1):107-18.
7. Odd D, Heep A, Luyt K, Draycott T. Hypoxic-ischemic brain injury: Planned delivery before intrapartum events. *J Neonatal Perinatal Med*. 2017;10(4):347-53.
8. Kapaya H, Williams R, Elton G, Anumba D. Can Obstetric Risk Factors Predict Fetal Acidemia at Birth? A Retrospective Case-Control Study. *J Pregnancy*. 2018;2018:2195965.

9. Viaroli F, Cheung PY, O'Reilly M, Polglase GR, Pichler G, Schmölder GM. Reducing Brain Injury of Preterm Infants in the Delivery Room. *Front Pediatr*. 2018;6:290.
10. Pereira S, Chandrahara E. Recognition of chronic hypoxia and pre-existing foetal injury on the cardiotocograph (CTG): Urgent need to think beyond the guidelines. *Porto biomedical journal*. 2017;2(4):124-9.
11. Chandrahara E. Updated NICE Cardiotocograph (CTG) guideline: Is it suspicious or pathological. *J Clin Med Surgery*. 2023;3(2):1129.
12. Alfirevic Z, Devane D, Gyte GM, Cuthbert A. Continuous cardiotocography (CTG) as a form of electronic fetal monitoring (EFM) for fetal assessment during labour. *Cochrane Database Syst Rev*. 2017;2(2):Cd006066.
13. Hamilton E, Warrick P, O'Keeffe D. Variable decelerations: do size and shape matter? *The Journal of Maternal-Fetal & Neonatal Medicine*. 2012;25(6):648-53.
14. Farquhar CM, Armstrong S, Masson V, Thompson JMD, Sadler L. Clinician Identification of Birth Asphyxia Using Intrapartum Cardiotocography Among Neonates With and Without Encephalopathy in New Zealand. *JAMA Network Open*. 2020;3(2):e1921363-e.
15. Cahill AG, Tuuli MG, Stout MJ, López JD, GA. M. A prospective cohort study of fetal heart rate monitoring: deceleration area is predictive of fetal acidemia. *American journal of obstetrics and gynecology*. 2018;218(5):523.
16. Shaffer F, Ginsberg J. An overview of heart rate variability metrics and norms. *Front Public Health*. 2017; 5: 258.
17. Ukoha EP, Wen T, Reddy UM. Induction of labor vs expectant management among low-risk patients with 1 prior cesarean delivery. *American Journal of Obstetrics & Gynecology*.
18. Christiansen S, Nwankwo C. Fetal heart accelerations and decelerations. *Very Well Health*, 2024.
19. Abbasalizadeh F, Abbasalizadeh S, Pouraliakbar S, Bastani P. Correlation between nonreassuring patterns in fetal cardiotocography and birth asphyxia. 2015.
20. Getaneh FB, Sebsbie G, Adimasu M, Misganaw NM, Jember DA, Mihretie DB, et al. Survival and predictors of asphyxia among neonates admitted in neonatal intensive care units of public hospitals of Addis Ababa, Ethiopia, 2021: a retrospective follow-up study. *BMC pediatrics*. 2022;22(1):262.
21. Aslam HM, Saleem S, Afzal R, Iqbal U, Saleem SM, Shaikh MWA, et al. Risk factors of birth asphyxia. *Italian Journal of Pediatrics*. 2014;40(1):94.
22. Nauman Kiyani A, Khushdil A, Ehsan A. Perinatal Factors Leading to Birth Asphyxia among Term Newborns in a Tertiary Care Hospital. *Iran J Pediatr*. 2014;24(5):637-42.
23. Gizachew S, Wogie G, Getnet M, Lonsako AA. Magnitude of neonatal asphyxia and its predictors among newborns at public hospitals of Wolaita Zone in Southern Ethiopia, 2023. *BMC Pediatrics*. 2024;24(1):142.
24. Techane MA, Alemu TG, Wubneh CA, Belay GM, Tamir TT, Muhye AB, et al. The effect of gestational age, low birth weight and parity on birth asphyxia among neonates in sub-Saharan Africa: systematic review and meta-analysis: 2021. *Italian Journal of Pediatrics*. 2022;48(1):114.
25. Mitha A, Chen R, Johansson S, Razaz N, Cnattingius S. Maternal body mass index in early pregnancy and severe asphyxia-related complications in preterm infants. *International Journal of Epidemiology*. 2020;49(5):1647-60.
26. Ahmed R, Mosa H, Sultan M, Helill SE, Assefa B, Abdu M, et al. Prevalence and risk factors associated with birth asphyxia among neonates delivered in Ethiopia: A systematic review and meta-analysis. *PloS one*. 2021;16(8):e0255488.
27. Tegegnetwork SS, Gebre YT, Ahmed SM, Tewachew AS. Determinants of birth asphyxia among newborns in Debre Berhan referral hospital, Debre Berhan, Ethiopia: a case-control study. *BMC Pediatrics*. 2022;22(1):165.
28. Sawangkum PS, Salemi JL, Tanner JPP, Kaimal AJ. 586 Association of Mode of Delivery for Periviable Birth with Neonatal Outcomes. *American Journal of Obstetrics & Gynecology*. 2024;230(1):S317.