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ORIGINAL ARTICLE

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Role of the cerebroplacental ratio and non-stress test in predicting adverse perinatal outcomes in high-risk pregnancies

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ABSTRACT

Objective: High-risk pregnancies are associated with increased risk of fetal and maternal morbidity and mortality. The non-stress test (NST) is the standard method for antenatal fetal monitoring, while the cerebroplacental ratio (CPR) has emerged as a noninvasive tool for predicting adverse perinatal outcomes. We aimed to evaluate the role of the CPR and NST in predicting adverse perinatal outcomes in high-risk pregnancies.

Methods: A prospective study was conducted with 672 high-risk pregnant women at Haiphong Hospital of Obstetrics and Gynecology in Vietnam from February 2024 to February 2025. All participants had a gestational age of 32 weeks or more. The CPR and an NST were performed on each woman. They were monitored until delivery to identify adverse perinatal outcomes, including cesarean section due to fetal distress, a 5-minute Apgar score below 7, admission to the neonatal intensive care unit, and perinatal death.

Results: There was a significant difference between CPR and NST between groups with adverse and normal perinatal outcomes ($p < 0.05$). After adjusting for confounding factors, significant associations were found between CPR and adverse perinatal outcomes in women with hypertensive disorders of pregnancy, fetal growth restriction, and hyperglycemia in pregnancy, with OR (95% CI) of 5.92 (1.38–25.45), 11.11 (1.61–76.76), and 6.66 (1.53–28.99), respectively. Similarly, NST results showed significant associations, with ORs (95% CI) of 13.56 (2.59–71.05), 15.44 (2.46–96.98), and 15.35 (3.01–78.33), respectively. While the sensitivity of CPR and NST in high-risk cases is low, their specificity exceeds 90%, and their overall accuracy exceeds 80%. The positive likelihood ratio (LR+) of the NST exceeds that of the CPR in predicting adverse perinatal outcomes across different high-risk groups. Notably, the LR+ for the combined CPR and NST in women with high-risk pregnancies, hypertensive disorders of pregnancy, fetal growth restriction, and hyperglycemia in pregnancy was 5.14, 16.2, 32.14, and 42.4, respectively.

Conclusion: In addition to NST, CPR is a valuable predictor of adverse perinatal outcomes in high-risk pregnancies. The NST shows greater predictive accuracy than the CPR when forecasting adverse perinatal outcomes across different high-risk groups. Combining these two indices provides a stronger prediction for adverse perinatal outcomes.

SYNOPSIS:

The cerebroplacental ratio, along with the non-stress test, provides two noninvasive methods that may help improve the prediction of adverse perinatal outcomes in high-risk pregnancies

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Cerebroplacental ratio; non-stress test; high-risk pregnancies; adverse perinatal outcomes; fetal Doppler

Introduction

Fetal hypoxia during the perinatal period is a leading cause of morbidity and mortality, potentially resulting in long-term issues like developmental delays and cerebral palsy. Identifying high-risk pregnancies is crucial for timely interventions. The non-stress test (NST) is commonly used to assess

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fetal well-being; a non-reactive NST may indicate poor outcomes, while a reactive test usually suggests a healthy fetus [1]. However, relying on fetal heart rate as a screening tool can be time-consuming, difficult to interpret, and may have low sensitivity with high false-positive rates. Additionally, fetal heart rate changes might only reflect the current condition of the fetoplacental unit rather than long-term placental health.

Doppler ultrasonography is essential in obstetrics for monitoring high-risk pregnancies. It provides a noninvasive evaluation of fetal hemodynamics and the fetomaternal circulation, enabling earlier detection of fetal compromise than non-stress testing. This helps in managing labor stress and may reduce the need for cesarean sections [2]. The cerebroplacental ratio (CPR) has recently gained significant attention as a key predictor of perinatal outcomes [3]. A decreased CPR indicates increased placental resistance relative to fetal cerebral blood flow, which may suggest compromised placental function and potential growth issues. CPR is calculated as the ratio of the middle cerebral artery (MCA) pulsatility index to the umbilical artery (UA) pulsatility index and indicates hypoxemia through reduced MCA resistance and/or increased UA resistance. Some studies suggest that CPR is a more effective predictor of perinatal outcomes than MCA or UA Doppler measurements alone, and that it shows a strong association with intrauterine hypoxia. Although fetal Doppler assessment is undeniable in cases of fetal growth restriction, the role of CPR in high-risk pregnancies remains inconsistent and needs further validation. Additionally, there is limited research comparing both NST and CPR for predicting adverse perinatal outcomes across the entire spectrum of high-risk pregnancies. Therefore, this study aimed to determine the role of CPR and NST in predicting adverse perinatal outcomes in high-risk pregnancies.

Materials and methods

Study design and participants

A prospective study was conducted among pregnant women aged 18 to 40 years who were hospitalized at Hai Phong Obstetrics and Gynecology Hospital from February 2024 to February 2025. Upon discharge, pregnant women were examined and managed throughout their pregnancies until delivery. Inclusion criteria included pregnant women with singleton live fetuses beyond 32 weeks of gestation and high-risk pregnancies. Participants who provided written informed consent were included in the study. Gestational age was determined based on either the first day of the last menstrual period or the expected date of delivery as calculated by ultrasound in the first trimester.

The exclusion criteria included: (1) significant structural fetal anomalies or chromosomal disorders; and (2) loss to follow-up.

Obstetric management followed standard hospital protocols. Doppler velocimetry and NST were performed weekly or twice weekly, depending on the severity of each high-risk pregnancy. If the NST and CPR were both normal, surveillance tests were repeated according to the above protocols unless the maternal condition required delivery; the final assessment of parameters before pregnancy termination was used for analysis.

A total of 792 high-risk pregnant women participated in the study, in accordance with the recruitment guidelines. Data were collected during the first visit through interviews, using self-designed records to assess maternal and fetal characteristics, as well as CPR ratio and NST results at recruitment and during hospitalization. After excluding 120 participants due to severe fetal anomalies or loss to follow-up, the final analysis included 672 women (Figure 1).

Assessment of cerebroplacental ratio and non-stress test

During recruitment, participants underwent a baseline ultrasound and Doppler color flow study using Volusion Expert 22 machines (GE HealthCare Austria). A 3.5 MHz curvilinear probe was used transabdominally to obtain Doppler flow velocity waveforms from the UA and MCA per ISUOG guidelines [4]. In a semi-recumbent position on the left lateral side, UA velocity waveform measurements were taken using pulsed wave Doppler, ensuring the angle of insonation aligned with the UA. At least

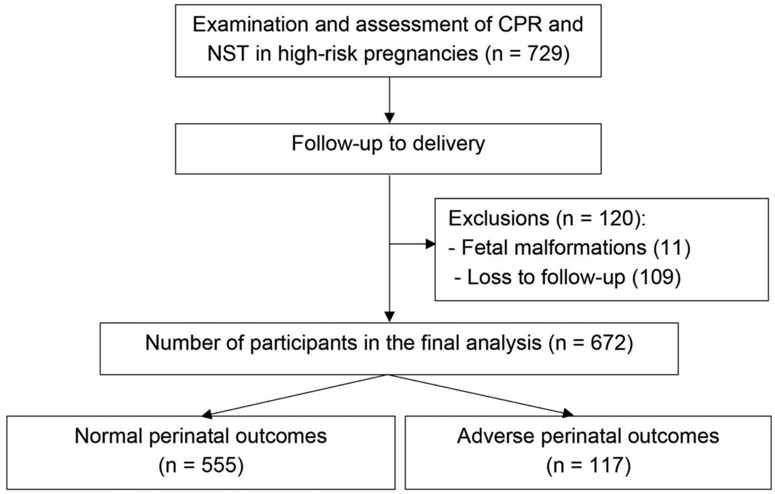

Figure 1. Flow chart showing the participants' recruitment for the study.

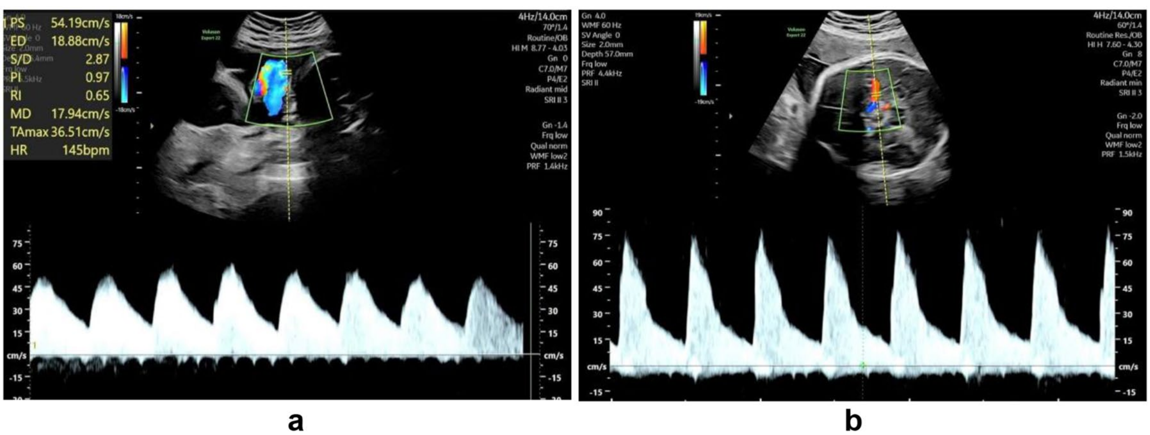

Figure 2. Fetal Doppler ultrasonography measurements: (a) MCA velocity waveform measurement; (b) UA velocity waveform measurement.

four consecutive waveforms of similar height were frozen to estimate the UA pulsatility index (UA-PI) without fetal movement (Figure 2a). The MCA was assessed using the biparietal diameter standard plane, and color Doppler imaging visualized the pulsating MCA for its pulsatility index. Keep the ultrasound beam angle close to 0°. Set the velocity scale to 4–6 kHz and the vessel wall filter to ≤50–60 Hz to reduce noise. A sweep speed of 75–100 cm/s is recommended for clear visualization of the peak systolic envelope and accurate measurement of peak systolic velocity (Figure 2b). Care was taken to reduce transducer pressure on the maternal abdomen to avoid affecting fetal intracranial pressure. The CPR was calculated as the ratio of MCA-PI to UA-PI; values below the 5th percentile were considered abnormal for gestational age [5]. Figure 2 illustrates representative middle cerebral artery (MCA) velocity waveform (a) and umbilical artery (UA) velocity waveform (b) obtained from a patient at 32 weeks of gestation with fetal growth restriction, demonstrating the Doppler velocimetry used to calculate the cerebroplacental ratio (CPR).

Additionally, an NST was performed using the MT-610 (ToiTu, Japan). The fetal heart rate probe is positioned on the mother's abdomen at the fetal heart, while the toco probe is placed at the uterine fundus, with the woman lying on her back, tilted 15 degrees to the left. The NST is classified as normal, suspicious, or pathological per guidelines [6,7]. For this study, a pathological NST was considered abnormal. For analysis, we combined cases with normal and suspicious NST results to create the 'normal group' and compared it with the 'abnormal group'.

Outcomes definitions

The primary outcome of this study was adverse perinatal outcomes, which were defined as one or more of the following criteria: cesarean section due to fetal distress, a 5-min Apgar score below 7, admission to the neonatal intensive care unit, and perinatal death.

High-risk pregnancies were defined by the presence of any of the following conditions: hypertensive disorders of pregnancy, fetal growth restriction, hyperglycemia in pregnancy, maternal anemia, post-dated pregnancies, or oligohydramnios.

Hypertensive disorders of pregnancy (HDP) are defined by blood pressure of ≥140/90 mmHg on two separate occasions and are classified by the International Society for the Study of Hypertension in Pregnancy [8].

Fetal growth restriction (FGR) is defined as an estimated fetal weight (EFW) or abdominal circumference (AC) below the 10th percentile, with a CPR below the 5th percentile or UA-PI above the 95th percentile. It can also be identified if EFW or AC is below the 3rd percentile, regardless of Doppler status [9].

A postdate pregnancy was defined as gestational age beyond 40 weeks from the first day of the last menstrual period [10].

Hyperglycemia in pregnancy encompasses all levels of hyperglycemia severity, divided into "Diabetes in pregnancy", which is diagnosed before or during pregnancy, and "Gestational diabetes" (GDM), diagnosed for the first time during pregnancy [11].

Oligohydramnios is diagnosed when the amniotic fluid index (AFI) is under 5 cm or the single deepest pocket is less than 2 cm, falling below the 2.5th percentile in the second and third trimesters [12].

Maternal anemia is defined as having a hemoglobin level below 11 g/dL during the first and third trimesters, and below 10.5 g/dL during the second trimester [13].

Statistical analysis

SPSS version 26.0 was used for the statistical analysis (SPSS, Armonk, NY, USA). Categorical variables are presented as frequencies (n) and percentages (%), while continuous variables are expressed as means and standard deviations. Odds ratios (OR) with 95% confidence intervals (CI) were calculated to determine the association between outcomes and independent variables. A multivariate binary regression model was employed to assess the relationship between CPR, NST, and adverse perinatal outcomes, with p-values <0.05 considered statistically significant. The sensitivity, specificity, likelihood ratio, positive and negative predictive values, and accuracy of the CPR and NST for predicting adverse perinatal outcomes were determined.

Ethical approval and consent to participate

The research was approved by the Ethical Council in Biomedical Research at Haiphong University of Medicine and Pharmacy, Vietnam (Ethics Committee ID number 314/QD-YDHP), and the Scientific Council of Haiphong Hospital of Obstetrics and Gynecology, Vietnam (IEC, 1189/QD-BVPSHP). Participants received detailed study information, and confidentiality was maintained; all signed written informed consent before participating.

Results

Among the 672 participants with high-risk pregnancies in our study, 264 women experienced two or more complications simultaneously. 7.1% of women had an abnormal CRP, and 7.9% had an abnormal NST. One hundred seventeen experienced adverse perinatal outcomes (17.4%). The most common adverse outcomes included cesarean delivery due to fetal distress ($n = 70$), neonates admitted to the NICU ($n = 27$), an Apgar score below seven at 5 min ($n = 18$), and perinatal death ($n = 02$).

There was a significant difference between the CPR and NST results in the adverse and normal perinatal outcomes group ($p < 0.001$) (Table 1).

There were significant associations between CRP, NST, and adverse perinatal outcomes in women with high-risk pregnancies, with OR (95% CI) of 3.17 (1.53–6.56) and 3.09 (1.55–6.14), respectively (Table 2).

After adjusting for confounding factors, significant associations were found between CRP and adverse perinatal outcomes in women with hypertensive disorders of pregnancy, fetal growth restriction, and hyperglycemia in pregnancy, with OR (95% CI) of 5.92 (1.38–25.45), 11.11 (1.61–76.76), and 6.66 (1.53–28.99), respectively.

Besides that, significant associations were found between NST and adverse perinatal outcomes in these women, with OR (95% CI) of 13.56 (2.59–71.05), 15.44 (2.46–96.98), and 15.35 (3.01–78.33), respectively.

In contrast, no significant associations were found between CPR, NST, and adverse perinatal outcomes in women with postdate pregnancies, oligohydramnios, and maternal anemia ($p > 0.05$) (Table 3).

In various high-risk maternal conditions, the sensitivity of using CPR and NST to predict adverse perinatal outcomes is low; however, their specificity exceeds 90%. The accuracy of these parameters for prognosis is over 80%. The LR+ of NST is higher than that of CPR in predicting adverse perinatal outcomes across different high-risk groups. Notably, the LR+ of the combined CPR and NST in women with high-risk pregnancies, hypertensive disorders of pregnancy, fetal growth restriction, and

Table 1. The difference in participants according to the adverse neonatal outcomes ($n = 672$).

Variables		Adverse neonatal outcomes		p-value
		No ($n = 555$)	Yes ($n = 117$)	
Maternal age (years; mean ± SD)		30.9 ± 5.9	29.6 ± 5.6	0.033[a]
Obstetric history (n,%)	Nulipare	225 (81.5)	58 (18.5)	0.475[b]
	Multipare	300 (83.6)	59 (16.4)	
Gestational age (weeks; mean ± SD)		38.5 ± 1.4	37.7 ± 3.2	0.005[a]
BMI (kg/ m^2; mean ± SD)		21.4 ± 3.1	21.5 ± 3.0	0.916[a]
Mother with chronic illness	No	494 (82.3)	106 (17.7)	0.613[b]
	Yes	61 (84.7)	11 (15.3)	
Type of high-risk pregnancies	Hypertensive disorders of pregnancy	93 (80.2)	23 (19.8)	0.450[a]
	Fetal growth restriction	75 (78.1)	21 (21.9)	0.213[a]
	Postdate pregnancies	179 (77.8)	51 (22.2)	0.019[a]
	Hyperglycemia in pregnancy	212 (87.6)	30 (12.4)	0.010[a]
	Oligohydramnios	81 (79.4)	21 (20.6)	0.358[a]
	Maternal anemia	152 (83.1)	31 (16.9)	0.844[a]
Number of high-risk pregnancies	1	346 (84.8)	62 (15.2)	0.121[b]
	2	182 (78.4)	50 (21.6)	
	≥ 3	27 (84.4)	5 (15.6)	
Type of delivery	Vaginal delivery	83 (88.3)	11 (11.7)	0.001[c]
	Induction of labor	66 (95.7)	3 (4.3)	
	C-section	406 (79.8)	103 (20.2)	
Birth weight (gram)		3063.7 ± 498.6	2763.2 ± 739.4	<0.001[b]
Apgar at the 1st minute	≥7	554 (84.8)	99 (15.2)	<0.001[c]
	<7	1 (5.3)	18 (94.7)	
Apgar at the 5th minute	≥7	555 (84.3)	103 (15.7)	<0.001[c]
	<7	0	14 (100)	
CRP (n,%)	Normal	530 (85.1)	93 (14.9)	<0.001[b]
	Abnormal	25 (52.1)	23 (47.9)	
NST (n,%)	Normal	527 (85.1)	92 (14.9)	<0.001[b]
	Anormal	28 (52.8)	25 (47.2)	

[a]Student's t-test, [b]chi-square test, [c]Fisher's exact test SD: standard deviation; BMI: Body mass index; CPR: cerebroplacental ratio; NST: non-stress test.

Table 2. Models of the relationship between cerebroplacental ratio, non-stress test, and adverse perinatal outcomes ($n = 672$).

Variables	Crude OR (95% CI)	p	aOR (95% CI)[d]	p
CPR	5.24 (2.86–9.63)	< 0.001	3.17 (1.53–6.56)	0.002
NST	5.12 (2.86–9.16)	< 0.001	3.09 (1.55–6.14)	0.001

[d]Variables in the model: maternal age, obstetric history, mother with chronic illness, gestational age, BMI, NST, and CPR.

Table 3. The association between cerebroplacental ratio, non-stress test, and adverse perinatal outcomes in different maternal conditions.

Variables		Crude OR (95%CI)	p	aOR (95% CI)[e]	p
Hypertensive disorders of pregnancy (n = 116)	CPR	9.39 (2.71–32.58)	< 0.001	5.92 (1.38–25.45)	0.017
	NST	16.00 (3.81–67.20)	< 0.001	13.56 (2.59–71.05)	0.002
Fetal growth restriction (n = 96)	CPR	23.67 (6.28–89.23)	< 0.001	15.44 (2.46–96.98)	0.004
	NST	24.40 (6.27–111.18)	< 0.001	11.11 (1.61–76.76)	0.015
Postdate pregnancies (n = 230)	CPR	1.28 (0.44–3.74)	0.651	1.36 (0.41–4.53)	0.618
	NST	1.00 (0.38–2.64)	0.995	0.90 (0.31–2.62)	0.839
Hyperglycemia in pregnancy (n = 242)	CPR	13.08 (4.14–41.30)	< 0.001	6.66 (1.53–28.99)	0.012
	NST	18.91 (5.27–67.88)	< 0.001	15.35 (3.01–78.33)	0.001
Oligohydramnios (n = 102)	CPR	2.03 (0.35–11.90)	0.434	2.14 (0.27–16.78)	0.469
	NST	0.96 (0.10–9.09)	0.973	1.03 (0.09–11.51)	0.980
Maternal anemia (n = 183)	CPR	5.17 (0.70–38.22)	0.107	6.31 (0.74–53.45)	0.091
	NST	2.55 (0.45–14.59)	0.292	2.77 (0.44–17.39)	0.277

[e]Adjusting for maternal age, BMI, obstetric history, amniotic fluid, and placental maturity.

Table 4. Diagnostic performance of cerebroplacental ratio and non-stress test in predicting adverse perinatal outcomes in different maternal conditions.

Parameters		Se	Sp	NPV	PPV	LR^+	LR^-	ACC
High-risk pregnancies (*n* = 672)	CPR	0.20	0.96	0.85	0.48	1.41	0.84	0.82
	NST	0.21	0.95	0.85	0.47	4.23	0.83	0.82
	CPR*NST	0.44	0.98	0.84	0.52	5.14	0.91	0.83
Hypertensive disorders of pregnancy (*n* = 116)	CPR	0.35	0.95	0.85	0.62	0.47	0.69	0.83
	NST	0.17	0.92	0.86	0.27	2.04	0.91	0.80
	CPR*NST	0.17	0.99	0.83	0.80	16.2	0.84	0.83
Fetal growth restriction (*n* = 96)	CPR	0.60	0.95	0.90	0.75	11.3	0.42	0.87
	NST	0.52	0.96	0.88	0.79	13.10	0.50	0.86
	CPR*NST	0.43	0.99	0.86	0.90	32.14	0.58	0.86
Hyperglycemia in pregnancy (*n* = 242)	CPR	0.28	0.97	0.91	0.57	9.75	0.75	0.89
	NST	0.27	0.98	0.90	0.67	14.13	0.75	0.89
	CPR*NST	0.20	0.99	0.90	0.86	42.4	0.80	0.90

hyperglycemia in pregnancy was 5.14, 16.2, 32.14, and 42.4, respectively, indicating a strong combined ability of these two indices to predict adverse perinatal outcomes in high-risk pregnancies (Table 4).

Discussion

This study on 672 women with high-risk pregnancies revealed a significant and independent association between the CPR and NST with adverse perinatal outcomes, especially in cases of HDP, FGR, and hyperglycemia in pregnancy. Furthermore, the predictive value for adverse perinatal outcomes improves when these two parameters are combined, compared to using each one separately.

Our findings were consistent with a previous study of 200 high-risk pregnancies, indicating that normal Doppler and NST results predict successful term pregnancies. Conversely, the incidence of cesarean section due to fetal distress, low Apgar scores, NICU admissions, and the need for ventilation was higher in cases where both tests were abnormal [14]. CTG signals are crucial for detecting systemic hypoxia and acidemia, impacting fetal cardiovascular health. They help assess risks of adverse outcomes and fetal stress. However, human analysis of FHR traces is often unreliable, with experts missing 35–92% of patterns and having low interobserver agreement (29%) [15]. False-positive rates for identifying at-risk fetuses can reach 60%, leading to unnecessary interventions. Computerized CTG, particularly the Dawes–Redman system, enhances antepartum CTG analysis, providing consistent assessments, outperforming humans in identifying normal tracings, and reducing recording time. It highlights patterns such as accelerations and decelerations, but does not always indicate actual abnormality. Advances in machine learning show promise, but computerized CTG cannot yet predict pregnancy outcomes or specific diseases. A study by GD Jones (2025) finds that while the Dawes–Redman algorithm effectively identifies healthy pregnancies, its low sensitivity limits its capability to detect at-risk fetuses, suggesting a need for optimization in high-risk cases. Effective labor management involves identifying patients at risk for intrapartum hypoxia, but complications often develop in low-risk pregnancies, suggesting current methods may lack accuracy [16]. Recent studies have examined using CPR and uterine artery Doppler in normally sized fetuses late in pregnancy to detect subclinical placental insufficiency, although their predictive value remains limited. A study by A. Dall'Asta et al. (2024) found that combining antenatal and intrapartum characteristics with CPR and uterine artery Doppler data effectively identifies cases requiring intervention due to fetal compromise in low-risk term pregnancies, indicating it could help screen for reduced placental reserve [17]. In appropriate for gestational age fetuses near term, Buca D et al. (2020) showed that CPR and maternal Doppler are not associated with or predictive of adverse pregnancy outcomes [18].

Hypertensive disorders of pregnancy are the most common high-risk conditions, increasing the risk of adverse outcomes for mothers and neonates. Even before symptoms, preeclamptic pregnancies can show structural and circulatory placental abnormalities. Doppler ultrasound evaluates abnormal fetal hemodynamics by assessing changes in placental resistance, helping identify fetuses with increased placental resistance and decreased cerebral resistance [19]. Our results showed that, although the sensitivity is low (20%), CPR is highly predictive of adverse perinatal outcomes in women with HDP, with a high specificity of 96% and an accuracy of 90.9%, consistent with previous studies [20].

Fetal growth restriction remains a significant challenge in obstetrics due to its association with adverse perinatal outcomes and long-term health risks for newborns. The clinical importance of CPR assessments is especially evident in cases of late-onset FGR [21]. The CPR assesses blood flow abnormalities in the maternal-fetal-placental unit, revealing early fetal responses to chronic hypoxia and identifying complications. Doppler ultrasound parameters change earlier in FGR fetuses than traditional monitoring methods, making them more diagnostic of FGR. In early pregnancy, MCA blood flow resistance changes are minimal, with significant decreases only in late pregnancy, even with a normal NST. Overall, Doppler ultrasound, especially the CPR, is crucial for assessing suspected FGR to improve outcomes. Abnormal CPR is the second-earliest indicator after MCA Doppler changes, providing a valuable opportunity to enhance fetal health [22].

Table 4 shows that the LR+ of NST is higher than that of CPR for predicting adverse perinatal outcomes across various high-risk groups, suggesting a stronger predictive value. This contrasts with Nayak et al. (2022), who found that CPR had higher sensitivity (84.6% vs. 61.5%) and specificity (91.3% vs. 69.4%) than NST in a study of 65 women with HDP [23]. The findings may differ due to the smaller sample size in their study. Our results indicate that combining CPR with NST enhances the predictive value of adverse perinatal outcomes compared to each test alone, yielding combined LR+ values of 5.1, 16.2, 32.1, and 42.4 across high-risk pregnancies, women with HDP, FGR, and hyperglycemia. These results are consistent with previous studies [23–25]. Yelikar et al. (2013) found that fetal compromise is more severe when both abnormal Doppler and NST are present, with significant issues arising from abnormal NST alone. This indicates that Doppler detects early disease changes before NST, with a lead time of 5.86 days. This period is crucial for managing high-risk preterm pregnancies, as steroid prophylaxis can enhance lung maturity [22]. Not all high-risk pregnancies with abnormal Doppler require immediate termination. If the Doppler is abnormal but the NST is normal, continuous monitoring can allow time for steroid prophylaxis and planned delivery instead of an immediate cesarean. Conversely, an abnormal NST with a normal Doppler does not guarantee a positive outcome, given the high false-positive rate. Evaluating both tests together is essential to reduce unnecessary cesarean sections. However, an abnormal Doppler combined with an abnormal NST significantly raises the risk of adverse perinatal outcomes.

Preexisting diabetes leads to worse pregnancy outcomes, with three- to fourfold higher rates of perinatal complications and mortality. Additionally, GDM is common during pregnancy and is linked to adverse maternal and perinatal outcomes [26]. Studies have shown that NST can improve perinatal outcomes for patients with GDM and is recommended for fetal surveillance in diabetic patients in low-resource settings [27]. The importance of fetal Doppler ultrasound, especially for evaluating fetal well-being in high-risk pregnancies, is widely recognized [28]. Limited data exist on fetal Doppler parameters and their ability to predict adverse perinatal outcomes in pregnancies with GDM. Familiari et al. (2018) suggested that monitoring fetal Doppler parameters is essential, in addition to glycemic management, in GDM [2]. Our study of 672 high-risk pregnant women found that combining NST and CPR was the most effective at predicting adverse perinatal outcomes in those with hyperglycemia, achieving an LR (+) of 42.4. Notably, the population included women with both GDM and pre-pregnancy diabetes, who are at greater risk for complications.

Timely delivery for women with GDM is critical, as maternal and fetal outcomes are linked to glycemic control. The aim is to optimize results with minimal interventions while maintaining strict glycemic control [29]. Our results support the idea that in women with well-controlled GDM, it is safe to wait for spontaneous labor until 40 weeks, as long as fetal Doppler and NST results remain normal. In our study, all eleven neonates born to mothers with CPR and NST abnormalities faced adverse perinatal outcomes, including two neonatal deaths. This highlights the importance of combining both fetal monitoring methods in managing high-risk pregnancies, which enables timely interventions and improves neonatal outcomes.

The main strength of this study is its prospective design, which focuses on high-risk pregnancies and involves a large sample size, demonstrating the effectiveness of CRP and NST in predicting adverse perinatal outcomes. Additionally, the analysis encompassed a broad range of high-risk pregnancies and subgroups, enabling the evaluation of the two parameters across various high-risk conditions. In this study, we note that cesarean section for fetal distress was based solely on abnormal cardiotocography results and did not include a pH test of the newborn's umbilical cord blood, which may have affected the study outcomes.

In conclusion, this study shows that, besides the non-stress test, the cerebroplacental ratio is also a valuable parameter for predicting adverse perinatal outcomes in high-risk pregnancies. The non-stress test demonstrates greater predictive accuracy than the cerebroplacental ratio for adverse perinatal outcomes across different high-risk groups. Combining these two measures offers a stronger prediction of adverse perinatal outcomes. More multicenter studies are needed to evaluate the predictive value of both parameters for specific adverse outcomes, using a standardized diagnostic method for fetal distress, and to confirm these results.

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Authors contributions

N.T.H.T., V.V.T., and N.V.Q.H. designed the study. N.T.H.T. and N.T.N.H. collected the data. N.T.H.T. and N.V.Q.H. performed statistical analyses and wrote the first manuscript. N.T.H.T. and N.V.Q.H. critically revised successive drafts of the paper. All the authors have read and approved the final version of the manuscript.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The datasets used and/or analyzed in the current study are available from the corresponding author upon reasonable request.

References

[1] Miller DA, Lockwood C, Barss V. Nonstress test and contraction stress test. UpToDate. 2016. Available from: https://www.uptodate.com/contents/nonstress-test-and-contraction-stress-test

[2] Familiari A, Neri C, Vassallo C, et al. Fetal Doppler parameters at term in pregnancies affected by gestational diabetes: role in the prediction of perinatal outcomes. Ultraschall in Der Medizin-European Journal of Ultrasound. 2020;41(06):675–680.

[3] Bonnevier A, Maršál K, Brodszki J, et al. Cerebroplacental ratio as predictor of adverse perinatal outcome in the third trimester. Acta Obstet Gynecol Scand. 2021;100(3):497–503. doi: 10.1111/aogs.14031.

[4] Bhide A, Acharya G, Baschat A, et al. ISUOG Practice Guidelines (updated): use of Doppler velocimetry in obstetrics. Ultrasound Obstet Gynecol. 2021;58(2):331–339. doi: 10.1002/uog.23698.

[5] Ciobanu A, Wright A, Syngelaki A, et al. Fetal Medicine Foundation reference ranges for umbilical artery and middle cerebral artery pulsatility index and cerebroplacental ratio. Ultrasound Obstet Gynecol. Apr. 2019;53(4):465–472. doi: 10.1002/uog.20157.

[6] Obstetricians ACo, Gynecologists. Practice bulletin no. 116: management of intrapartum fetal heart rate tracings. Obstet Gynecol. 2010;116(5):1232–1240.

[7] Chandraharan E. Updated NICE Cardiotocograph (CTG) guideline: is it suspicious or pathological. J Clin Med Surgery. 2023;3(2):1129.

[8] Brown MA, Magee LA, Kenny LC, et al. Hypertensive Disorders of Pregnancy: ISSHP Classification, Diagnosis, and Management Recommendations for International Practice. Hypertension. Jul. 2018;72(1):24–43. doi: 10.1161/hypertensionaha.117.10803.

[9] Martins JG, Biggio JR, Abuhamad A. Society for Maternal-Fetal Medicine Consult Series #52: diagnosis and management of fetal growth restriction: (Replaces Clinical Guideline Number 3, April 2012). Am J Obstet Gynecol. 2020;223(4):B2–b17. doi: 10.1016/j.ajog.2020.05.010.

[10] Punya B, Mpa S. Study of post-dated and term pregnancy with fetomaternal outcome at RRMCH. Int J Obstet Gynaecol Res. 2017;4(2):179–183.

[11] McIntyre HD, Fuglsang J, Kampmann U, et al. Hyperglycemia in pregnancy and women's health in the 21st century. Int J Environ Res Public Health. 2022;19(24):16827. doi: 10.3390/ijerph192416827.

[12] Practice Bulletin No. 175: ultrasound in pregnancy. Obstet Gynecol. Dec. 2016;128(6):e241–e256. doi: 10.1097/aog.0000000000001815.

[13] Prevalence, years lived with disability, and trends in anaemia burden by severity and cause, 1990-2021: findings from the Global Burden of Disease Study 2021. Lancet Haematol. Sep. 2023;10(9):e713–e734. doi: 10.1016/s2352-3026(23)00160-6.

[14] Subramanian V, Venkat J, Dhanapal M. Which is superior, Doppler velocimetry or non-stress test or both in predicting the perinatal outcome of high-risk pregnancies. J Obstet Gynecol India. 2016;66(Suppl(S1):149–156. doi: 10.1007/s13224-015-0829-z.

[15] Chandraharan E, editor. Handbook of CTG interpretation: from patterns to physiology. Cambridge, UK: Cambridge University Press; 2017.

[16] Albert B, Cooke W, Vatish M. Performance evaluation of computerized antepartum fetal heart rate monitoring: dawes-Redman algorithm at term. Ultrasound Obstet Gynecol. 2025;65(2):191–197.

[17] Dall'Asta A, Frusca T, Rizzo G, et al. Assessment of the cerebroplacental ratio and uterine arteries in low-risk pregnancies in early labour for the prediction of obstetric and neonatal outcomes. Eur J Obstet Gynecol Reprod Biol. 2024;295:18–24. doi: 10.1016/j.ejogrb.2024.02.002.

[18] Buca D, Rizzo G, Gustapane S, et al. Diagnostic Accuracy of Doppler Ultrasound in Predicting Perinatal Outcome in Appropriate for Gestational Age Fetuses: a Prospective Study. Diagnostische Genauigkeit der Dopplersonografie zur Vorhersage des perinatalen Outcomes bei reifgeborenen Föten: eine prospektive Studie. Ultraschall Med. 2021;42(4):404–410. doi: 10.1055/a-1072-5161.

[19] de Paula CF, Ruano R, Campos JA, et al. Quantitative analysis of placental vasculature by three-dimensional power Doppler ultrasonography in normal pregnancies from 12 to 40 weeks of gestation. Placenta. Feb. 2009;30(2):142–148. doi: 10.1016/j.placenta.2008.11.010.

[20] Konwar R, Basumatari B, Dutta M, et al. Role of Doppler waveforms in pregnancy-induced hypertension and its correlation with perinatal outcome. Cureus. 2021;13(10):e18888. doi: 10.7759/cureus.18888.

[21] Sanodia G, Malviya R, Mahor S, et al. Study the role of cerebroplacental ratio in fetal growth restriction and its correlation with perinatal outcome. Eur J Cardiovasc Med. 2024;14(2):198–202.

[22] Yelikar KA, Prabhu A, Thakre GG. Role of fetal Doppler and non-stress test in preeclampsia and intrauterine growth restriction. J Obstet Gynaecol India. 2013;63(3):168–172. doi: 10.1007/s13224-012-0322-x.

[23] Nayak P, Singh S, Sethi P, et al. Cerebroplacental ratio versus nonstress test in predicting adverse perinatal outcomes in hypertensive disorders of pregnancy: a prospective observational study. Cureus. 2022;14(6):e26462. doi: 10.7759/cureus.26462.

[24] Padmagirison R, Rai L. Fetal doppler versus NST as predictors of adverse perinatal outcome in severe preeclampsia and fetal growth restriction. J Obstet Gynecol. 2006;56:134–138.

[25] Williams KP, Farquharson DF, Bebbington M, et al. Screening for fetal well-being in a high-risk pregnant population comparing the nonstress test with umbilical artery Doppler velocimetry: a randomized controlled clinical trial. Am J Obstet Gynecol. May. 2003;188(5):1366–1371. doi: 10.1067/mob.2003.305.

[26] Caughey AB, Turrentine M. ACOG PRACTICE BULLETIN: gestational diabetes mellitus. Obstet Gynecol. 2018;131(2):E49–E64.

[27] Sharma J, Goyal M. Cardiotocography and diabetic pregnancy. J Pak Med Assoc. 2016;66(9 Suppl 1):S30–S33.

[28] Elmes C, Phillips R. Systematic review evaluating the efficacy of the cerebroplacental ratio (CPR) in saving babies lives. Ultrasound. 2022;30(3):184–193. doi: 10.1177/1742271X211048213.

[29] Metcalfe A, Hutcheon JA, Sabr Y, et al. Timing of delivery in women with diabetes: A population-based study. Acta Obstet Gynecol Scand. 2020;99(3):341–349. doi: 10.1111/aogs.13761.