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Original Research Article

A Comparative Study of Antepartum Fetal Surveillance using Cerebroplacental Ratio vs Non-Stress Test in Predicting Perinatal Outcome in Hypertensive Disorders of Pregnancy

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Abstract:

Introduction: Antepartum fetal surveillance is of immense importance for detecting fetal compromise in utero in high-risk pregnancies. The non-stress test (NST), contraction stress test (CST), biophysical profile (BPP), modified BPP (MBPP), and Doppler velocimetry are among the various tests used to evaluate high-risk pregnancies. This study was conducted to compare the diagnostic efficacy of the cerebroplacental ratio (CPR) and the non-stress test (NST) in predicting fetal compromise in hypertensive disorder of pregnancy (HDP).

Methods: This is a prospective study in which 110 pregnant women between 32 and 37 weeks of gestation with hypertensive disorder of pregnancy were evaluated by Doppler ultrasound and non-stress testing. In the study, the final ultrasound and Doppler indices prior to delivery were taken into account. The outcome of pregnancy was recorded according to Group A (n = 67, CPR and NST normal), Group B (n = 9, CPR normal and NST abnormal), Group C (n = 26, CPR abnormal and NST normal), and Group D (n = 8, CPR and NST both abnormal). The perinatal outcome was measured in terms of admission to the NICU, LBW, Apgar <7 at 5 minutes, MSL, and stillbirth. Qualitative variables were correlated using the Chi-square test or Fisher exact test. Sensitivity, specificity, NPV, and PPV were calculated, and a p-value <0.05 was considered statistically significant. Data analysis was done using social sciences (SPSS) licensed version 21.0.

Results: The sensitivity of Doppler (68.57%) was better than that of NST (34.28%), while the specificity of NST (93.33%) was better than that of Doppler (86.66%) in predicting perinatal outcomes. When both CPR and NST were abnormal, there was a larger fetal compromise in terms of APGAR scores, NICU admissions, birth weight, and other metrics.

Conclusion: CPR had greater diagnostic accuracy in terms of higher sensitivity than NST in predicting adverse perinatal outcomes in women with hypertensive disorders of pregnancy; however, both tests are complementary to each other, and both tests must be performed to identify a range of foetuses that are compromised at different stages of women with HDP.

Introduction

Hypertensive disorders of pregnancy (HDP) are an important cause of maternal and perinatal morbidity and mortality worldwide, complicating about 3–10% of pregnancies [1–3]. In a cross-sectional hospital-based survey of 313,030 women admitted to 357 medical facilities in 29 countries in Africa, Asia, Latin America, and the Middle East, the World Health Organisation (WHO) Multicountry Survey on Maternal and Newborn Health found that 0.29% of the women had chronic hypertension [4], 2.2% had pre-eclampsia, and 0.28% had eclampsia [5]. Approximately 30,000 maternal and 500,000 perinatal deaths are attributed to the HDP annually [2, 6]. With the advent of electronic fetal monitoring, the fetal universe, which was hitherto hidden from scientific study, was instantly accessible to newer technology. In our practice, identifying and closely monitoring high-risk pregnancies has become essential. Both NST and ultrasound Doppler are non-invasive procedures. Doppler flow studies give us vital information regarding fetal circulation before the clinical features have set in.

Antepartum fetal surveillance is currently done using modalities like electronic fetal monitoring, ultrasound, colour Doppler, and the non-stress test (NST). These days, antenatal fetal surveillance is commonly performed using Doppler ultrasonography velocimetry of the uteroplacental umbilical and fetal veins, which enables the non-invasive evaluation of fetal circulation. It includes an assessment of the uterine artery, middle cerebral artery, umbilical artery, and ductus venosus. By far the most common vessels evaluated by Doppler ultrasound are the umbilical arteries (UA). The umbilical arterial circulation is normally a low-impedance circulation, with an increase in the amount of end-diastolic flow with advancing gestation [7].

The middle cerebral artery (MCA) is the most accessible cerebral vessel to ultrasound doppler imaging in the fetus and carrying more than 80% of cerebral blood flow [8]. The cerebral circulation is normally a high-impedance circulation [9]. The brain-sparing effect, which is a central redistribution of blood flow that happens when fetal hypoxemia is present, is crucial for the fetus's response to oxygen deprivation [9, 10].

Doppler investigation of a middle cerebral artery in combination with an umbilical artery seems to improve the prediction of adverse outcomes in near-term pregnancies [11]. Fetal hypoxemia can be detected by the Cerebroplacental Ratio (CPR), which is the ratio of the pulsatility index (PI) of the MCA to that of the UA. There are two ways in which this might happen: increased placental resistance and decreased MCA (brain-sparing effect) resistance [12]. The cerebroplacental ratio (MCA/UA PI) is postulated to be a better predictor of adverse perinatal outcomes, with higher diagnostic accuracy, sensitivity, and positive predictive value [12]. The cerebroplacental ratio abnormal values have been variably described as less than an absolute measure of 1.08 [13, 14]. The cerebroplacental ratio is considered to be a marker of centralization of fetal blood flow as an adaptation to placental insufficiency, such as that seen in pre-eclampsia [15]. CPR has been shown to be correlated with adverse perinatal outcomes and impaired long-term neonatal cognitive development [16]. The non-stress test (NST) is the most common method of surveillance in the antenatal ward. The NST has a high sensitivity for detecting fetal distress, although the specificity of a non-reassuring NST is poor [17].

The present study has been undertaken to evaluate the efficacy of the cerebroplacental ratio as a predictor of perinatal outcome in comparison to NST, which is an easy-to-perform and widely used method of fetal surveillance, especially in low-resource settings, for the hypertensive disorder of pregnancy.

Material and Methods

Study design and settings: This study was conducted over 18 months in the Department of Obstetrics and Gynaecology of Dr. Baba Saheb Ambedkar Medical College & Hospital, Sector-6, Rohini, New Delhi. Scientific and ethical committee clearance was obtained before the study.

Inclusion and Exclusion Criteria: Women with a single, live fetus in cephalic presentation and a period of gestation between 32 and 37 weeks diagnosed with hypertension peculiar to pregnancy (pre-eclampsia, eclampsia, and gestational hypertension) were included in the study. Women with chronic hypertension, multiple pregnancies, fetal anomalies, dead foetuses, diabetes mellitus, severe anaemia, or a Rh-negative pregnancy were excluded from the study. The study by Smitha et al. (2014) observed that the sensitivity and specificity of the cerebroplacental ratio for predicting adverse perinatal outcomes were 94.42% and 82.65%, respectively [18]. Taking these values as a reference, the minimum required sample size with a desired precision of 10%, 80% power of study, and 5% level of significance is 93 patients. To reduce the margin of error, the total sample size taken is 110.

Study Protocol: The study was started after approval by the ethical and scientific committees. Pregnant women attending antenatal OPD, admitted in the antenatal ward and labour room of the department of obstetrics and gynaecology with the fulfilment of inclusion and exclusion criteria, were recruited for the study. Every eligible patient provided written informed consent. Demographic profiles, including age, parity, and booked/unbooked, were noted. Detailed menstrual history, obstetric history, and dietary history were taken. A complete general, systemic, and obstetric examination was performed. Patient blood pressure and lab investigations, including a complete blood count, liver function test, kidney function test, and coagulation profile, were divided into gestational hypertension, pre-eclampsia, severe pre-eclampsia, and eclampsia. The relevant data was recorded in the standard-prepared proforma.

The sonographic assessment was done in recruited patients using a Samsung Medison (EVN4-9) ultrasound machine using a 3.5 MHz transabdominal probe measuring the complete biometric parameters: biparietal diameter (BPD), abdominal circumference (AC), head circumference (HC), and femur length (FL). UA Doppler waveforms were obtained from a free-floating portion of the umbilical cord during minimal fetal activity. Three similar consecutive waveforms were obtained, and the mean PI of these waveforms was used for UA PI analysis. For MCA, the colour Doppler was used to identify the circle of Willis. The pulsed-wave Doppler gate was positioned in the proximal third portion of the proximal and distal middle cerebral arteries, close to its origin from the circle of Willis.

Pulsatility Index (PI) = Peak Systolic Velocity (S) - End Diastolic Velocity (D)

Mean Velocity (M)

The cerebroplacental ratio was obtained using the following ratio: mean PI MCA / mean PI UA. As in some previous studies, a single cut-off value (1.08) was used in the present study, above which velocimetry was considered normal and below which it was considered abnormal [13,14].

NST was performed with a cardiotocography machine, and fetal heart rate and uterine contractions were recorded for 20 minutes. NST was reactive if the graph showed 2 or more accelerations of fetal heart rate of 15 beats/minute amplitude and of 15-second duration observed over 20 minutes.

The study was non-blinding, as both the obstetrician and the patient were aware of the results of the scan. All patients with HDP were managed according to standard institutional protocol. NST and USG were done weekly. Patients with normal Doppler were followed every 2 weeks. Patients with abnormal Doppler were followed biweekly. The fetal surveillance was continued until the decision to deliver was made. The study took into account the Doppler indices and the final ultrasound before delivery. The mode of delivery was at the discretion of the primary obstetrician, either by vaginal delivery or caesarean section. The patients were followed till delivery, and the following adverse perinatal outcomes were recorded: low birth weight (birth weight < 2.5 kg), APGAR at 1 and 5 minutes (APGAR< 7), meconium-stained liquor (MSL), NICU admission, and stillbirth.

According to the most recent NST and CPR, the recruited women were split into the following four groups: Group A had both normal NST and CPR; Group B had abnormal NST but normal CPR; Group C had normal NST but abnormal CPR; and Group D had abnormal NST and abnormal CPR. The age of the patient, obstetrics score, gestational age at delivery, mode of delivery, and adverse perinatal outcome of patients in groups A, B, C, and D were calculated.

Statistical Analysis: The Statistical Package for Social Sciences (SPSS) version 21.0 was used for the final analysis after the data was entered into a Microsoft Excel spreadsheet. The categorical variables were presented in the form of numbers and percentages (%). On the other hand, the quantitative data were presented as the mean ± standard deviation (SD) and as the median with the 25th and 75th percentiles (interquartile range). The chi-square test was utilised to evaluate the comparison of the qualitative variables. If any cell had an expected value of less than 5, then Fisher's exact test was used. For quantitative data comparison, the ANNOVA test was used except for birth weight, where the Kruskal-Wallis H test was used. A p-value of less than 0.05 was considered statistically significant.

Results

Table 1: Study population in each group. (NST – non stress test, CPR– cerebroplacental ratio)

Group	Characterstics	Study Subjects (Total 110)
A	Both CPR and NST were normal	67 (60.90%)
B	CPR was normal but NST was abnormal	9 (8.18%)
C	CPR was abnormal but NST was normal	26 (23.63%)
D	Both CPR and NST were abnormal	8 (7.27%)

Table 2 : Baseline characteristics of study subjects

	Group A (n=67)	Group B (n=9)	Group C (n=26)	Group D (n=8)	P value
Mean age in years	25.33±3.25 (n=67)	24.11±4.01 (n=9)	28.19±3.99 (n=26)	30.88±5.41 (n=8)	**<0.01*** **
Age group*					
20-24 years	35 (52.2%)	7 (77.8%)	7 (26.9%)	1 (12.5%)	**0.03****
25-29 years	23 (34.3%)	1 (11.1%)	8 (30.8%)	3 (37.5%)	
30 years and above	9 (13.4%)	1 (11.1%)	11 (42.3%)	4(50%)	
Obstetric score*					
Primigravida	47 (70.1%)	6(66.67%)	10 (38.5%)	3 (37.5%)	**<0.01****
Multigravida	20 (29.9%)	3(33.33%)	16 (61.5%)	5 (62.5%)	
Gestational age*					
Preterm	16 (23.9%)	3(33.3%)	16 (61.53%	5 (62.5%)	**0.001****
Term	51 (76.1%)	6 (66.7%)	10 (38.47%)	3 (37.5%)	
Gestational hypertension*	26 (38.8%)	2 (22.2%)	3 (11.6%)	0	**<0.01****
Preeclampsia*	35 (52.2%)	2 (22.2%)	5 (19.2%)	1(12.5%)	**<0.01****

Severe preeclampsia*	6 (9%)	3 (33.3%)	7 (26.9%)	3 (37.5%)	**0.001****
Eclampsia*	0	2 (22.2%)	11 (42.3%)	4(50%)	**<0.001****

*Significant at p<0.05, **CHI SQUARE TEST, ***ANNOVA TEST

Table 3: Mode of delivery & neonatal outcome of the study population

	Group A (n=67)	Group B (n=9)	Group C (n=26)	Group D (n=8)	P value
Mode of delivery*					
NVD	49 (73.1%)	5 (55.6%)	7 (26.93%)	2 (25%)	**<0.001****
Vaginal instrumental	3 (4.5%)	0	0	0	
LSCS	15 (22.4%)	4 (44.4%)	19(73.07%)	6 (75%)	
Perinatal outcome					
Low birth weight (<2.5 kgs)*	3 (4.5%)	1 (11.1%)	18 (69.2%)	6 (75%)	**<0.001******
Mean birth weight (kgs)*	2.93±0.25	2.65±0.12	2.25±0.44	1.92±0.27	**<0.001******
APGAR at 1 min*	8.67±1.41	7.67±1.58	6.15±1.64	5.75±2.18	**<0.001*****
APGAR at 5 min*	9.64±0.98	9.11±1.05	7.77±1.70	7.25±2.12	**<0.001*****
APGAR at 1 min <7*	5 (7.46%)	4(44.44%)	17(65.38%)	6 (75%)	**<0.001****
APGAR at 5 min <7*	3 (4.47%)	0(0%)	8 (30.76%)	4 (50%)	**<0.001****
MSL	17 (25.4%)	1 (11.1%)	8 (30.8%)	4 (50%)	0.31**
NICU admission*	6 (9%)	5 (55.6%)	17 (65.4%)	7 (87.5%)	**<0.01****
Still birth/perinatal death*	0	0	3 (11.5%)	1 (12.5%)	**0.02****

*Significant at p<0.05

Table 4: Sensitivity, specificity, PPV, NPV

	Sensitivity	Specificity	PPV	NPV
USG Doppler (CPR)	68.57 %	86.66%	70.58 %	85.52 %
NST	34.28 %	93.33 %	70.58%	75.26 %

PPV – positive predictive value
NPV – negative predictive value

Discussion

Normal fetal growth requires a healthy fetal circulation. The fetal, placental, and maternal vasculatures undergo extraordinary alterations to enable this. The fetal, placental, and maternal vasculatures undergo extraordinary alterations to enable this. In pregnancies with HDP, there is chronic fetal hypoxia, the blood volume in the fetal circulation is redistributed in favour of vitally important organs, i.e., the heart, kidneys, and brain. When the diastolic flow through the MCA increases due to vasodilatation, the PI of the MCA decreases. The resulting hyperperfusion is considered pathological. This 'brain-sparing effect' is associated with an abnormal CPR (CPR less than 1.08) [13,14]. . However, if hypoxia persists, fetal acidemia or brain edema may develop [19]. Abnormal CPR is the second earliest change to occur after abnormal MCA Doppler in the temporal sequence of fetal Doppler abnormalities, while abnormal NST is the second last change to occur [20].

This prospective study was conducted on 110 women with hypertension during pregnancy. The groups were similar in their characteristics except for the mean maternal age, which was significantly higher in group D (30.88 years), which may represent an independent association of maternal age with adverse perinatal outcomes. Similar findings are also seen in the study conducted by Nayak et al., where in group D, the mean age was highest (30.56 years) and there was a poor perinatal outcome [21]. There is a weaker adaptation of maternal cardiovascular function and impaired vascular functioning as maternal age advances, which could be an important pathogenesis of poor perinatal outcomes [22]. The impaired systemic and uterine arteries have direct consequences for lower uteroplacental perfusion, leading to a higher rate of perinatal complications [23]. The variations between population-based and hospital-based research may account for some of the variations found in this study and other investigations. Another reason could be the inclusion of mothers from lower and middle socioeconomic status groups who came to this hospital.

Similar to the study conducted by Yelikar et al., it was seen that the women with the most compromised fetuses such as severe preeclampsia and eclampsia, belonged to Group D, which necessitated a delivery at an earlier gestational age than Group A, which had a greater proportion of mild preeclamptic women who continued till term [24]. Considering the mode of delivery, women with abnormal Doppler in Group C and Group D had the majority of caesarean sections. This may represent the subset of babies with undiagnosed FGR in groups C and D. Group D was considered to have the most compromised fetuses of all and was not allowed to go into labor. In order to promote lung maturity, all of the newborns received prenatal steroids before delivery. They were taken for caesarean sections, and hence, the maximum number of caesarean sections occurred in the Group D population (75%). This is also seen in a study conducted by Yelikar et al., where 66.7% of women in group IV delivered by caesarean sections [24]. The difference in the number of caesarean deliveries in our study for Group B (44.4%) and Group C (73.07%) was statistically significant, suggesting that LSCSs increased when CPR was abnormal compared to only NST being abnormal. Hypertension in pregnancy is associated with FGR in 30–40% [21], and in these cases, the use of CPR allows the assessment of blood flow abnormalities in the maternal-fetal-placental unit. CPR identifies clinically undetected fetal impairment and reflects early fetal tolerance to persistent hypoxia [21].

In this study, the Group D population, where both CPR and NST were abnormal, had a maximum number of preterm deliveries (62.5%) with a mean birth weight of 1.92 kg. The maximum number of neonates from Groups C and D had meconium staining, APGAR < 7 at 1 minute, and NICU admissions. A similar observation was made in the study conducted by Yelikar et al., where Group IV, where both tests were abnormal, had the least mean birth weight, averaging 1,378 ± 230 g, thus detecting a deficient intrauterine environment [24]. In a study conducted by Nayak et al., there were 39 (62.9%) neonates with low birth weight (LBW), with the highest number of LBW babies in group D (88.9%), and the lowest in group A (45.5%) [21] is also comparable to our study, where Group D has the highest number of LBW babies (75%), and Group A has the lowest number of LBW babies (4.5%). This represented a significant statistical difference. In the study by Nayak et al., mean birth weight was highest in group A (2720.32 g) and lowest in group D (1468 g), which is comparable to our study and is also statistically significant [21].

This study showed that the highest percentage of perinatal complications in terms of NICU admission occurred in women with both an abnormal NST and an abnormal Doppler (87.5%). In Group C, where only Doppler was abnormal, 65.4% had NICU admission, whereas, in Group B, where there was only abnormal NST, 55.6% had NICU admission. Group A, where both NST and Doppler were normal, had the least NICU admissions, similar to the study conducted by Malhotra K et al. for a different high-risk collective with pregnancies affected by PIH [25]. The results of our study are also consistent with the study conducted by Choudhary N et al., which showed that patients with both NST and Doppler waveform abnormalities (group D) had the highest percentage of neonatal complications, NICU admissions, and perinatal deaths [26]. Even those patients whose NST was normal but whose Doppler velocimetry was abnormal had comparatively higher neonatal complications [26]. Similarly, a previous study from India by Nayak et al. reported that CPR had a high sensitivity (93.3%), specificity (74.47%), PPV (53.85%), and NPV (97.22%) for the prediction of NICU admission in hypertensive disorders of pregnancy [21].

In this study, in terms of NICU admission, the sensitivity of CPR was 68.57%, the specificity was 86.66 %, the positive predictive value (PPV) was 70.58%, and the negative predictive value (NPV) was 85.52%. The sensitivity of NST was 34.28 %, specificity was 93.33 %, positive predictive value (PPV) was 70.58%, and negative predictive value (NPV) was 75.26% in terms of NICU admission. The study by Malik N et al. observed a statistically significant correlation between abnormal CPR and NICU admission (68.75%) with a sensitivity of 78.57%, a specificity of 86.11%, a PPV of 68.75%, and an NPV of 91.18% [27].

In comparing the APGAR scores and NICU admissions of Group A with Group C and Group D in our study, there was a statistically significant difference, which points to the fact that babies in Group C and Group D were more compromised. In a study by Yelikar et al., similar findings were observed. When the babies of women with only an abnormal Doppler (group C) were compared to those of women with only an abnormal NST (group D), it was seen that Group B had a better perinatal outcome than Group C, again suggesting that deranged CPR is a better indicator of perinatal morbidity and mortality. This study had 4 perinatal deaths, 3 occurring in patients with abnormal CPR only, and 1 where both CPR and NST were abnormal.

In recent years, the focus in prenatal diagnosis was set on establishing CPR and NST as standard prediction markers for assessing adverse perinatal outcomes to determine the optimal timing of birth. Our main test results for the predictive accuracy of CPR were consistent with the values previously published in Coenen et al. that deranged Doppler was associated with adverse pregnancy outcomes, including preterm delivery and APGAR score below [28]. Similar findings were published by Nayak et al., who concluded that in their research population, CPR was a better predictor of unfavourable newborn outcomes than the standard NST [21]. Our study quantifies the diagnostic accuracy of CPR versus NST across the spectrum of HPD in predicting adverse perinatal outcomes.

Conclusion

To detect a spectrum of foetuses compromised at different phases in women with HDP, it is imperative to employ both CPR and NST. When both the Doppler and NST were abnormal, there was a larger fetal compromise. Furthermore, the foetuses were in a worse state when CPR was abnormal than when NST alone was abnormal. CPR had greater sensitivity and NPV than NST for predicting NICU admission in women with HDP. We can conclude that both tests are complementary to each other in fetal surveillance of high-risk pregnancies.

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