

Correlation between Cerebroplacental Ratio and Perinatal Outcomes in Pregnancy Affected by Hypertensive Disorder

Dr. Muskan Gupta¹, Dr. Suman Budania²

¹Post Graduate Student, Sardar Patel Medical College and Associated Group of P.B.M. Hospitals, Bikaner (Rajasthan), India

²Professor, Obstetrics and Gynaecology, Sardar Patel Medical College and Associated Group of P.B.M. Hospitals, Bikaner (Rajasthan), India

Abstract: Background: Hypertensive disorders of pregnancy are major contributors to adverse maternal and perinatal outcomes. Cerebroplacental ratio is a Doppler parameter calculated as the ratio of middle cerebral artery pulsatility index to umbilical artery pulsatility index. It reflects both placental resistance and fetal cerebral redistribution. Aim: To assess the correlation between cerebroplacental ratio and perinatal outcomes in pregnancies affected by hypertensive disorders. Materials and Methods: This prospective observational study was conducted in the Department of Obstetrics and Gynaecology, S.P. Medical College and P.B.M. Hospitals, Bikaner, from November 2025 to April 2026. A total of 85 singleton pregnancies between 28 and 40 weeks with gestational hypertension, pre-eclampsia or superimposed pre-eclampsia were included. Doppler ultrasound was performed and CPR was calculated as MCA PI/UA PI. CPR ≥ 1.0 was considered normal and CPR < 1.0 was considered abnormal. Perinatal outcomes including birth weight, gestational age at delivery, Apgar score, NICU admission, mode of delivery, IUGR and perinatal mortality were analyzed. Results: Among 85 participants, 45 had normal CPR and 40 had abnormal CPR. Abnormal CPR was significantly associated with lower gestational age at Doppler assessment, lower MCA PI, higher UA PI and lower mean CPR. Mean birth weight was significantly lower in the abnormal CPR group than in the normal CPR group (2150 $\pm$ 380 g vs 2850 $\pm$ 420 g; $p < 0.001$). Abnormal CPR was also associated with earlier delivery, low Apgar score, NICU admission, IUGR, emergency cesarean section, respiratory support and perinatal mortality. Abnormal CPR showed good predictive accuracy for NICU admission, low birth weight and IUGR. Conclusion: Cerebroplacental ratio is a useful non-invasive Doppler marker for predicting adverse perinatal outcomes in pregnancies complicated by hypertensive disorders. Abnormal CPR identifies fetuses at increased risk and may help guide surveillance, delivery planning and neonatal preparedness.

Keywords: Cerebroplacental ratio; Hypertensive disorders of pregnancy; Pre-eclampsia; Doppler ultrasound; Perinatal outcome; NICU admission; IUGR.

1. Introduction

Hypertensive disorders of pregnancy are among the most important causes of maternal and perinatal morbidity and mortality. They include gestational hypertension, pre-eclampsia, eclampsia and superimposed pre-eclampsia. These disorders are associated with abnormal placentation, maternal endothelial dysfunction and increased uteroplacental vascular resistance. As a result, fetal oxygen and nutrient supply may be compromised, leading to fetal growth restriction, preterm delivery, fetal distress, low Apgar score, neonatal intensive care unit admission and perinatal mortality.

Doppler ultrasound provides a non-invasive method for assessing fetoplacental circulation. Umbilical artery pulsatility index reflects placental resistance, while middle cerebral artery pulsatility index reflects fetal cerebral vascular response. In fetal hypoxia, cerebral vasodilatation occurs as part of the brain-sparing phenomenon, resulting in a fall in middle cerebral artery resistance. The cerebroplacental ratio is calculated as the ratio of middle cerebral artery pulsatility index to umbilical artery pulsatility index. It combines placental resistance and fetal cerebral redistribution in a single parameter and is therefore considered a more integrated marker of fetal compromise than either Doppler index alone.

In pregnancies affected by hypertensive disorders, placental insufficiency may occur even before overt fetal growth restriction becomes clinically evident. Hence, timely identification of fetuses at risk is essential for planning surveillance, deciding timing of delivery and anticipating neonatal care. A low CPR has been associated with adverse perinatal outcomes such as low birth weight, emergency cesarean section, low Apgar score, NICU admission and perinatal mortality. Therefore, the present study was conducted to evaluate the correlation between cerebroplacental ratio and perinatal outcomes in pregnancies complicated by hypertensive disorders.

2. Aim and Objectives

Aim

To assess the correlation between cerebroplacental ratio and perinatal outcomes in pregnancies affected by hypertensive disorders.

Objectives

- 1) To measure cerebroplacental ratio using Doppler ultrasound in pregnant women diagnosed with hypertensive disorders of pregnancy.
- 2) To compare maternal and Doppler parameters between normal CPR and abnormal CPR groups.
- 3) To evaluate perinatal outcomes including birth weight, gestational age at delivery, Apgar score, NICU

admission, mode of delivery, IUGR and perinatal mortality.

- 4) To determine the predictive value of abnormal CPR for adverse perinatal outcomes.

3. Materials and Methods

This prospective observational study was conducted in the Department of Obstetrics and Gynaecology, Sardar Patel Medical College and Associated Group of P.B.M. Hospitals, Bikaner, Rajasthan, over a period of six months from November 2025 to April 2026. The study population included pregnant women with singleton pregnancies between 28 and 40 weeks of gestation diagnosed with gestational hypertension, pre-eclampsia or superimposed pre-eclampsia.

A total of 85 eligible participants were included in the study by simple random sampling. Women with multiple pregnancy, congenital fetal anomaly, intrauterine fetal demise at recruitment, chronic medical disorders other than hypertension, incomplete Doppler assessment or loss to follow-up were excluded. Written informed consent was obtained from all participants after explaining the study objectives.

All participants underwent routine obstetric evaluation and Doppler ultrasound examination. Middle cerebral artery pulsatility index and umbilical artery pulsatility index were measured using color Doppler ultrasound. Cerebroplacental ratio was calculated as MCA PI divided by UA PI. A CPR value of ≥ 1.0 was considered normal and < 1.0 was considered abnormal. Maternal variables including age, parity, gestational age at Doppler assessment, type of hypertensive disorder, blood pressure and proteinuria were recorded.

Perinatal outcomes studied included gestational age at delivery, birth weight, Apgar score at 1 and 5 minutes, NICU admission, duration of NICU stay, mode of delivery, intrauterine growth restriction, respiratory support and perinatal mortality. Data were entered in Microsoft Excel

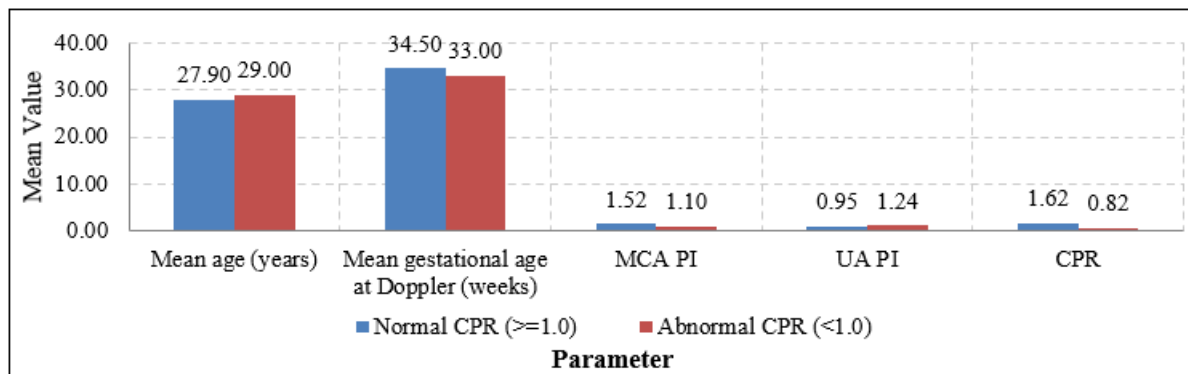
and analyzed using appropriate statistical methods. Continuous variables were expressed as mean $\pm$ standard deviation and categorical variables as number and percentage. Chi-square test, t-test and correlation analysis were applied where appropriate. A p-value less than 0.05 was considered statistically significant.

4. Results

A total of 85 pregnant women with hypertensive disorders were included. Among them, 45 women had normal CPR (≥ 1.0) and 40 women had abnormal CPR (< 1.0). Most participants were aged 26-30 years, and the mean age was 28.4 ± 4.2 years. The mean gestational age at Doppler assessment was significantly lower in the abnormal CPR group compared with the normal CPR group (33.0 ± 3.0 weeks vs 34.5 ± 2.5 weeks; $p=0.012$). The abnormal CPR group showed significantly lower MCA PI and higher UA PI, resulting in lower mean CPR. Mean CPR was 1.62 ± 0.28 in the normal group and 0.82 ± 0.14 in the abnormal group ($p<0.001$). Increasing maternal blood pressure was associated with decreasing CPR values, with a negative correlation between CPR and blood pressure severity. Adverse perinatal outcomes were significantly more common in the abnormal CPR group. Mean birth weight was lower in the abnormal CPR group (2150 ± 380 g) compared with the normal CPR group (2850 ± 420 g; $p<0.001$). Low birth weight and very low birth weight were also more frequent in the abnormal CPR group. The mean gestational age at delivery was significantly lower in the abnormal CPR group (34.8 ± 1.6 weeks) compared with the normal CPR group (38.2 ± 1.4 weeks; $p<0.001$). Mean Apgar scores at 1 and 5 minutes were significantly lower in the abnormal CPR group. Low Apgar score at 1 minute was observed in 70.0% of abnormal CPR cases compared with 13.3% of normal CPR cases. NICU admission was required in 80.0% of newborns in the abnormal CPR group compared with 17.8% in the normal CPR group. Emergency cesarean section, IUGR, respiratory support and perinatal mortality were also more frequent among women with abnormal CPR. Abnormal CPR showed good predictive accuracy for NICU admission, low birth weight, IUGR and low 5-minute Apgar score.

Table 1: Baseline and Doppler Characteristics

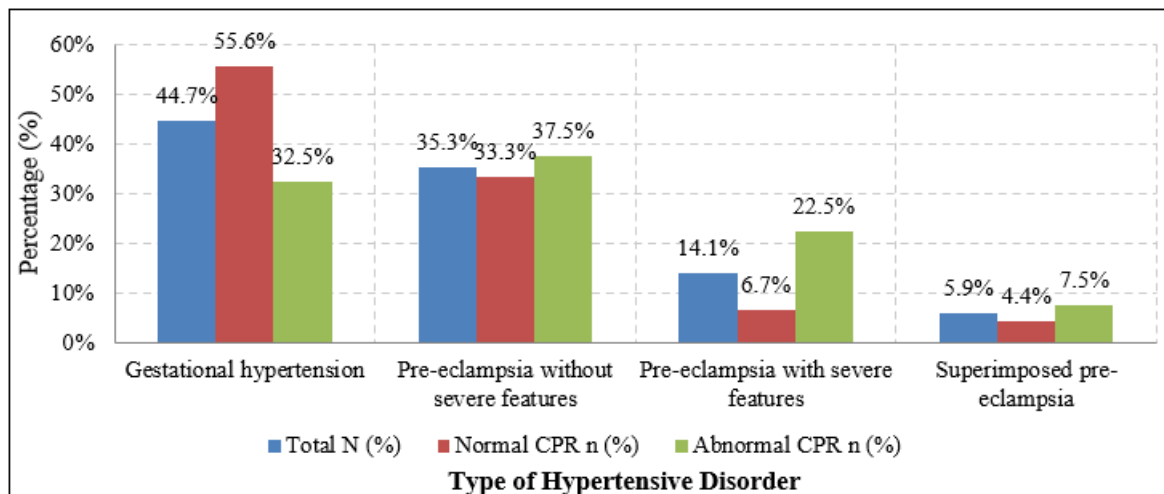
Parameter	Normal CPR (≥ 1.0)	Abnormal CPR (< 1.0)	p-value
Number of cases	45	40	-
Mean age (years)	27.9 ± 4.0	29.0 ± 4.5	0.234
Mean gestational age at Doppler (weeks)	34.5 ± 2.5	33.0 ± 3.0	0.012*
MCA PI	1.52 ± 0.22	1.10 ± 0.18	$<0.001^*$
UA PI	0.95 ± 0.20	1.24 ± 0.35	$<0.001^*$
CPR	1.62 ± 0.28	0.82 ± 0.14	$<0.001^*$



Graph 1: Baseline and Doppler Characteristics

Table 2: Distribution by Type of Hypertensive Disorder

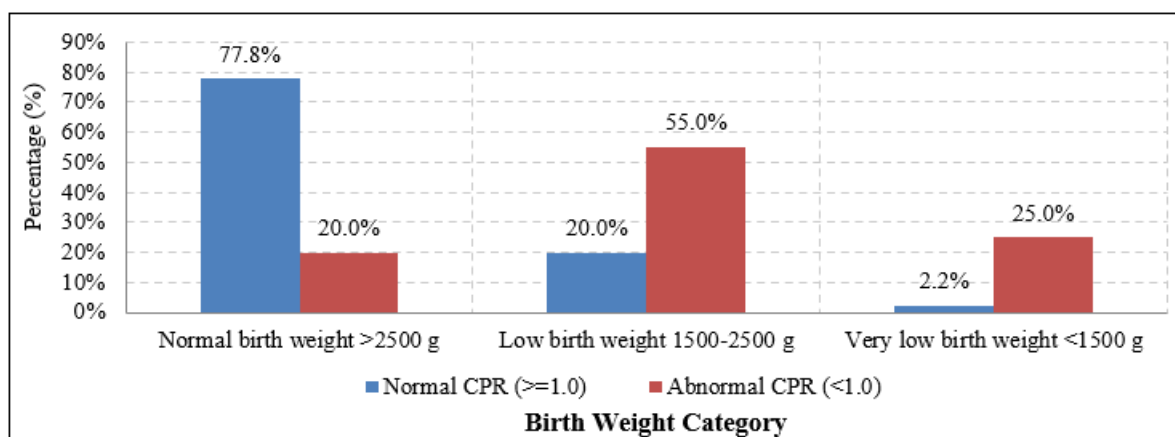
Type of hypertensive disorder	Total N (%)	Normal CPR n (%)	Abnormal CPR n (%)
Gestational hypertension	38 (44.7%)	25 (55.6%)	13 (32.5%)
Pre-eclampsia without severe features	30 (35.3%)	15 (33.3%)	15 (37.5%)
Pre-eclampsia with severe features	12 (14.1%)	3 (6.7%)	9 (22.5%)
Superimposed pre-eclampsia	5 (5.9%)	2 (4.4%)	3 (7.5%)



Graph 2: Distribution by Type of Hypertensive Disorder

Table 3: Birth Weight and Gestational Outcome by CPR Status

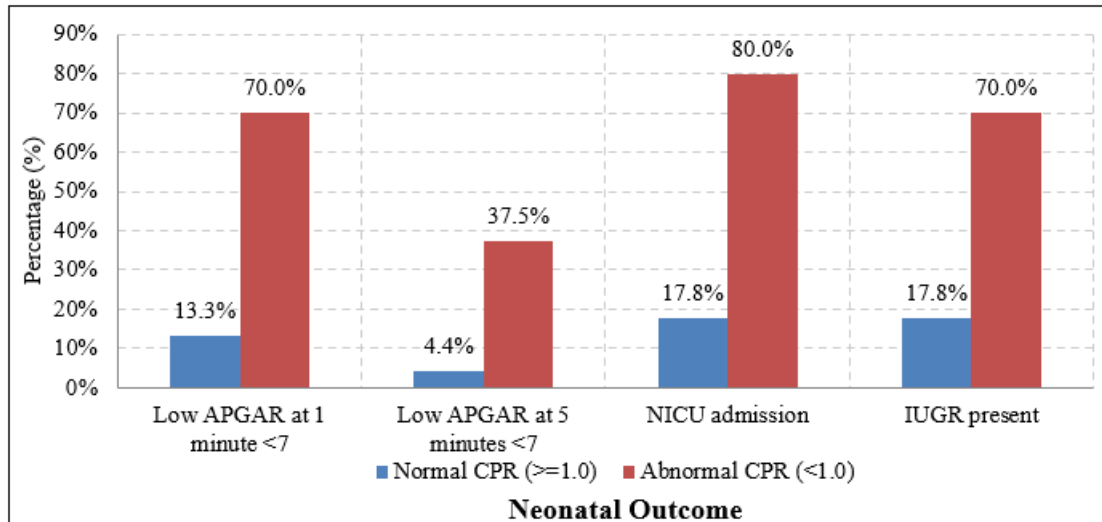
Outcome	Normal CPR (≥ 1.0)	Abnormal CPR (< 1.0)	p-value
Mean birth weight (g)	2850 $\pm$ 420	2150 $\pm$ 380	$< 0.001^*$
Normal birth weight > 2500 g	35 (77.8%)	8 (20.0%)	$< 0.001^*$
Low birth weight 1500-2500 g	9 (20.0%)	22 (55.0%)	$< 0.001^*$
Very low birth weight < 1500 g	1 (2.2%)	10 (25.0%)	0.002*
Mean gestational age at delivery (weeks)	38.2 $\pm$ 1.4	34.8 $\pm$ 1.6	$< 0.001^*$



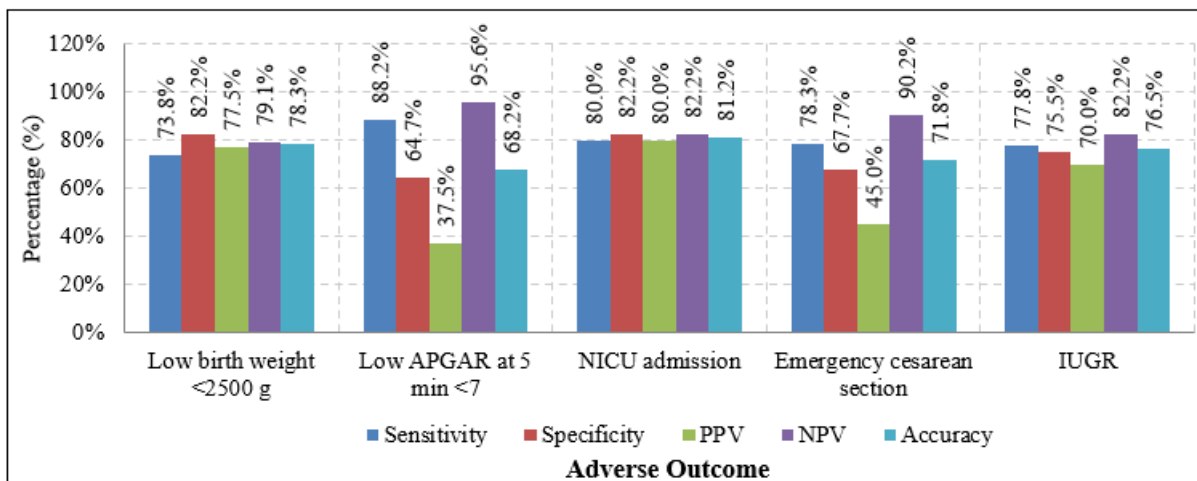
Graph 3: Birth Weight and Gestational Outcome by CPR Status

Table 4: Neonatal Outcomes by CPR Status

Outcome	Normal CPR (≥ 1.0)	Abnormal CPR (< 1.0)	p-value
Mean APGAR at 1 minute	7.8 $\pm$ 1.1	5.6 $\pm$ 1.4	$< 0.001^*$
Mean APGAR at 5 minutes	8.9 $\pm$ 0.8	7.2 $\pm$ 1.2	$< 0.001^*$
Low APGAR at 1 minute < 7	6 (13.3%)	28 (70.0%)	$< 0.001^*$
Low APGAR at 5 minutes < 7	2 (4.4%)	15 (37.5%)	$< 0.001^*$
NICU admission	8 (17.8%)	32 (80.0%)	$< 0.001^*$
IUGR present	8 (17.8%)	28 (70.0%)	$< 0.001^*$

**Graph 4:** Neonatal Outcomes by CPR Status**Table 5:** Predictive Value of Abnormal CPR for Adverse Outcomes

Adverse outcome	Sensitivity	Specificity	PPV	NPV	Accuracy
Low birth weight < 2500 g	73.8%	82.2%	77.5%	79.1%	78.3%
Low APGAR at 5 min < 7	88.2%	64.7%	37.5%	95.6%	68.2%
NICU admission	80.0%	82.2%	80.0%	82.2%	81.2%
Emergency cesarean section	78.3%	67.7%	45.0%	90.2%	71.8%
IUGR	77.8%	75.5%	70.0%	82.2%	76.5%

**Graph 5:** Predictive Value of Abnormal CPR for Adverse Outcomes

5. Discussion

The present study demonstrated a strong correlation between abnormal cerebroplacental ratio and adverse perinatal outcomes in pregnancies complicated by hypertensive disorders. Abnormal CPR was observed in 47.1% of participants, indicating a high burden of fetal hemodynamic compromise in this high-risk population. The abnormal CPR group had significantly lower gestational age at Doppler assessment, lower MCA PI, higher UA PI and markedly

reduced mean CPR, reflecting increased placental resistance with fetal cerebral redistribution.

The association between low CPR and severity of hypertensive disorder was clinically important. Women with severe pre-eclampsia showed lower mean CPR and a higher proportion of abnormal CPR compared with those having gestational hypertension. This supports the concept that worsening maternal disease severity is associated with

progressive uteroplacental insufficiency and fetal compromise.

Perinatal outcomes were significantly poorer in the abnormal CPR group. These women delivered earlier and had babies with lower mean birth weight, higher rates of low birth weight, very low birth weight and IUGR. The finding that abnormal CPR was associated with lower Apgar scores at both 1 and 5 minutes suggests that impaired fetal circulation before delivery may translate into poor neonatal adaptation after birth. NICU admission was markedly higher in the abnormal CPR group, and these neonates also required longer NICU stay and more respiratory support.

The present findings are consistent with previous studies reporting that CPR is a better predictor of adverse neonatal outcome than MCA PI or UA PI alone. CPR integrates placental resistance and fetal cerebral response, thereby providing a more complete assessment of fetal wellbeing. The predictive value analysis in this study showed good sensitivity, specificity and accuracy for outcomes such as NICU admission, low birth weight and IUGR. Thus, CPR may be useful as a simple, non-invasive Doppler marker for antenatal surveillance and delivery planning in hypertensive pregnancies.

6. Conclusion

The present study concludes that cerebroplacental ratio is significantly correlated with perinatal outcomes in pregnancies affected by hypertensive disorders. Abnormal CPR was associated with higher maternal blood pressure, severe pre-eclampsia, lower birth weight, earlier delivery, low Apgar score, increased NICU admission, IUGR, respiratory support and perinatal mortality.

A CPR value below 1.0 was a strong marker of fetal compromise and showed good predictive ability for adverse outcomes, particularly NICU admission, low birth weight and IUGR. Since CPR combines information from both placental resistance and fetal cerebral redistribution, it appears to be more useful than individual Doppler indices alone.

Routine assessment of CPR in hypertensive pregnancies may help in early identification of fetuses at risk, timely obstetric intervention and better preparation for neonatal care. Therefore, CPR should be considered as an important component of fetal surveillance in pregnancies complicated by hypertensive disorders.

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