

## Cerebro Placental Ratio in Prediction of Adverse Perinatal Outcome and Fetal Heart Rate Disturbances in Uncomplicated Pregnancy at 40 Weeks and Beyond

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### Abstract

**Objective:** To evaluate the clinical utility of the cerebroplacental ratio (CPR) in predicting adverse perinatal outcomes and fetal heart rate (FHR) disturbances in uncomplicated pregnancies at or beyond 40 weeks' gestation.

**Methods:** This prospective observational study included 100 women with uncomplicated single ton pregnancies at more than or equal to 40 weeks with 18 women having CPR less than 1.1 and 68 with CPR more than 1.1 at tertiary care center. Doppler ultrasound was used to measure MCA PI and UA PI to calculate CPR. (CPR=MCA PI/UA PI) CPR less than 1.1 was considered abnormal. Outcomes including FHR abnormalities, delivery mode, Apgar scores, NICU admission etc., were analyzed.

**Results:** Abnormal CPR group had higher rates of FHR abnormalities 43.7%, cesarian delivery; 62.5%, Meconium-stained amniotic fluid 37.5%, Low Apgar, NICU admissions compared to normal CPR group.

**Conclusion:** CPR less than 1.1 is a sensitive marker for fetal compromise in term pregnancies and can guide timely obstetric interventions. Routine CPR evaluation beyond 40 weeks may improve perinatal outcomes even in low-risk pregnancies.

**Keywords:** Cerebroplacental Ratio, Fetal Heart Rate, Term Pregnancy, Doppler Ultrasound, Perinatal Outcome, Fetal Distress.

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### Introduction

Ensuring optimal fetal well-being in the final weeks of pregnancy remains a major goal in obstetric care. Traditionally, fetal surveillance methods such as non-stress tests, biophysical profiles, and individual Doppler parameters have been employed to predict adverse perinatal outcomes.

However, these tools often fall short in their predictive accuracy, particularly in uncomplicated term pregnancies, where fetal compromise may not always present with overt clinical signs. In recent years, the Cerebroplacental Ratio (CPR)—the ratio of the pulsatility index (PI) of the middle cerebral artery (MCA) to that of the umbilical artery (UA)—has emerged as a more sensitive indicator of fetal adaptive hemodynamic changes and impending compromise [1]. The CPR offers a non-invasive assessment of the balance between fetal cerebral vasodilation and placental resistance,

providing a better reflection of fetal adaptation to intrauterine stressors than either the MCA PI or UA PI alone [2]. A decline in CPR is suggestive of the "brain-sparing" effect, a compensatory mechanism in which blood flow is preferentially redistributed to vital organs like the brain in response to hypoxia [3]. This adaptive response, while initially protective, often precedes clinical signs of fetal distress and adverse outcomes including low Apgar scores, acidosis, meconium-stained liquor, and neonatal intensive care unit (NICU) admissions [4].

The predictive value of CPR is gaining recognition not only in high-risk pregnancies but also in apparently low-risk, appropriate for gestational age (AGA) fetuses at term. Several studies have shown that a CPR <1.1 is associated with a higher incidence of fetal heart rate (FHR) abnormalities, operative deliveries, and neonatal complications, even in pregnancies without overt growth

restriction [5,6]. Doppler studies, especially when conducted after 37 weeks, offer the advantage of aiding decisions regarding the timing and mode of delivery. This is crucial because prolonged pregnancies beyond 40 weeks are inherently associated with increasing placental senescence, reduced perfusion, and potential for sudden fetal compromise [7]. The use of CPR as a clinical decision-making tool at 40 weeks can provide a window of opportunity for timely intervention, particularly in institutions with limited intrapartum monitoring infrastructure.

A low CPR results from either increased placental resistance, cerebral vasodilatation due to hypoxia, or both [8]. Recent evidence also suggests that CPR may outperform other tools such as the non-stress test (NST) and even the individual UA Doppler in predicting adverse neonatal outcomes [9].

This superiority arises from the CPR's dual assessment of both placental and fetal vascular beds. Given the widespread availability of ultrasound and color Doppler machines, CPR estimation is a feasible and cost-effective tool that can be incorporated into routine care even in resource-limited settings.

### Aims and Objectives

**Aim:** To evaluate the clinical utility of the cerebroplacental ratio (CPR), measured via Doppler ultrasound, in predicting adverse perinatal outcomes and fetal heart rate (FHR) disturbances in uncomplicated term pregnancies ( $\geq 40$  weeks gestation).

### Primary Objectives

1. To calculate the cerebroplacental ratio (CPR) in pregnant women at 40 weeks and beyond using Doppler indices of the middle cerebral artery (MCA PI) and umbilical artery (UA PI).
2. To classify CPR values into normal ( $\geq 1.1$ ) and abnormal ( $< 1.1$ ) and correlate them with intrapartum and neonatal outcomes.
3. To determine the association between abnormal CPR and intrapartum fetal heart rate abnormalities detected via cardiotocography (CTG).

### Secondary Objectives

1. To assess the predictive value of CPR  $< 1.1$  for:
  - Low Apgar scores ( $< 7$  at 5 minutes)
  - Neonatal Intensive Care Unit (NICU) admissions
  - Umbilical cord blood acid-base abnormalities (pH  $< 7.20$ , BE  $< -12$ )
  - Meconium-stained amniotic fluid (MSAF)
  - Operative delivery for fetal distress (LSCS or instrumental)

2. To evaluate the sensitivity, specificity, and predictive values (PPV, NPV) of CPR  $< 1.1$  for adverse perinatal outcomes.

3. To identify independent predictors of adverse outcomes using multivariate logistic regression, including CPR, FHR abnormalities, MSAF, and mode of delivery.

### Materials and Methods

**Study Design and Setting:** This study was designed as a prospective observational study and was conducted in the Department of Obstetrics and Gynaecology, Victoria General Hospital, Andhra Medical College, Visakhapatnam, over a period of 12 months, from 15th February 2023 to 15th February 2024. Ethical clearance was obtained from the Institutional Ethics Committee of Andhra Medical College, and informed written consent was collected from all participants.

**Study Population:** The study included 100 pregnant women with uncomplicated singleton pregnancies who presented at 40 weeks of gestation and beyond, and who fulfilled the eligibility criteria.

### Inclusion Criteria

- Women aged between 18 to 40 years.
- Singleton, cephalic pregnancies with confirmed gestational age of  $\geq 40$  weeks.
- Absence of antenatal complications.
- Willingness to provide informed consent and participate in Doppler ultrasound monitoring.

### Exclusion Criteria

- Pregnancies complicated by:
  - Gestational hypertension
  - Diabetes mellitus
  - Oligohydramnios or polyhydramnios
  - Multiple gestation
  - Congenital fetal anomalies
- Elective cesarean deliveries.
- Small for gestational age (SGA) and large for gestational age (LGA) fetuses (based on EFW  $< 10$ th or  $> 90$ th percentiles).
- Known medical comorbidities (e.g., cardiac, renal, or autoimmune diseases).
- Refusal to participate.

### Procedure

All eligible women underwent a detailed clinical evaluation, including obstetric history, gestational dating, physical examination, and assessment of fetal well-being.

The gestational age was determined based on the last menstrual period (LMP) and confirmed by first trimester ultrasonography, where available.

Each participant underwent an ultrasound and color Doppler examination using a standardized transabdominal curvilinear probe. The following fetal parameters were assessed:

- Fetal biometry (BPD, HC, AC, FL)
- Estimated Fetal Weight (EFW)
- Amniotic Fluid Index (AFI)
- Placental location and grading
- Middle Cerebral Artery Pulsatility Index (MCA PI)
- Umbilical Artery Pulsatility Index (UA PI)
- The Cerebroplacental Ratio (CPR) was calculated as:  
CPR = MCA PI / UA PI

A CPR value of <1.1 was considered abnormal, suggestive of brain-sparing and possible fetal hypoxia. A CPR  $\geq$ 1.1 was considered normal.

Participants were then followed through the intrapartum period, and fetal heart rate monitoring was done using cardiotocography (CTG) for a minimum of 40 minutes daily and continuously during labor.

**Outcome Measures:** The following maternal and neonatal outcomes were recorded and analyzed in relation to CPR values:

#### Intrapartum Parameters:

- Presence of abnormal fetal heart rate patterns (e.g., tachycardia, decelerations).
- Mode of delivery: spontaneous vaginal delivery, lower segment cesarean section (LSCS), or instrumental delivery.
- Presence of meconium-stained amniotic fluid (MSAF).

Neonatal Parameters:

- **Apgar scores at 1 and 5 minutes**, with <7 at 5 minutes considered abnormal.

- **NICU admission** and requirement for resuscitation.
- Cord blood gas analysis including:
  - pH (<7.20 considered acidotic)
  - Base Excess (BE < -12 mEq/L)
  - pO<sub>2</sub> (<15 mm Hg)
  - pCO<sub>2</sub> (>45 mm Hg)
- Any neonatal complications such as hypoxia, acidosis, or perinatal death.

**Statistical Analysis:** Data were compiled in Microsoft Excel and analyzed using SPSS version 25.0. Continuous variables were expressed as mean  $\pm$  standard deviation (SD) and categorical variables as percentages and frequencies.

Comparisons between CPR groups were done using:

- Chi-square test or Fisher's exact test for categorical data.
- Independent t-test for continuous variables.
- Logistic regression analysis was performed to identify independent predictors of adverse perinatal outcomes, with odds ratios (OR) and 95% confidence intervals (CI) calculated.
- A p-value <0.05 was considered statistically significant.

#### Observations, results and Discussion

**Maternal Age Distribution:** Among the 100 participants, the majority were aged between 23–27 years (38%), followed by 28–32 years (30%). A smaller proportion fell into the younger (18–22 years; 20%) and older ( $\geq$ 33 years; 12%) categories. This indicates a predominance of pregnancies in the ideal reproductive age group, likely contributing to lower baseline risk factors.

**Table 1: Distribution of Study Participants by Maternal Age Groups**

Maternal Age (years)	Number of Participants (n=100)	Percentage (%)
18–22	20	20%
23–27	38	38%
28–32	30	30%
33–37	10	10%
$\geq$ 38	2	2%

**Gestational Age at Delivery:** Most deliveries occurred between 40.0–40.6 weeks (64%), followed by 41.0–41.6 weeks (30%), and a smaller group delivered at  $\geq$ 42 weeks (6%). This shows that the study appropriately focused on term and post-term pregnancies, aligning with its objective of evaluating CPR beyond 40 weeks.

**Table 2 Distribution of Participants by Gestational Age at Delivery**

Gestational Age (weeks)	Number of Participants	Percentage (%)
40.0 – 40.6	64	64%
41.0 – 41.6	30	30%
$\geq$ 42.0	6	6%

**Gravidity and Parity:** Primigravida women (G1P0) constituted 40% of the study population, while 30% were G2P1 and 20% were G3P2. Multiparity (G4+P3+) was present in only 10%. This balance allowed observation of CPR impact across both primiparous and multiparous women.

**Table 3: Distribution Based on Gravidity and Parity**

Gravida	Para	Number of Participants	Percentage (%)
G1	P0	40	40%
G2	P1	30	30%
G3	P2	20	20%
G4+	P3+	10	10%

**BMI and Nutritional Status:** The majority of participants (60%) had normal BMI (18.5–24.9 kg/m<sup>2</sup>). About 25% were overweight, 10% underweight, and only 5% were obese. Most participants were nutritionally stable, minimizing confounding effects of maternal undernutrition or obesity on fetal outcomes.

**Table 4: Distribution Based on BMI and Nutritional Status**

BMI (kg/m <sup>2</sup> )	Number of Participants	Percentage (%)
<18.5 (Underweight)	10	10%
18.5–24.9 (Normal)	60	60%
25–29.9 (Overweight)	25	25%
≥30 (Obese)	5	5%

**Doppler Indices – UA PI and MCA PI:** The mean UA PI was  $1.04 \pm 0.12$ , and the mean MCA PI was  $1.60 \pm 0.20$ , with respective ranges of 0.85–1.30 and 1.10–2.10. These values form the basis for calculating CPR and indicate preserved cerebral and placental vascular parameters in the majority.

**Table 5: Distribution of Umbilical Artery PI and MCA PI Values**

PI Type	Mean $\pm$ SD	Minimum	Maximum
UA PI (Umbilical)	$1.04 \pm 0.12$	0.85	1.30
MCA PI (Cerebral)	$1.60 \pm 0.20$	1.10	2.10

**CPR Classification:** Out of 100 cases, 68% had normal CPR ( $\geq 1.1$ ), while 32% had abnormal CPR ( $< 1.1$ ). This significant minority (nearly 1 in 3 pregnancies) underscores the clinical need to evaluate CPR even in apparently uncomplicated pregnancies.

**Table 6: Classification Based on Cerebroplacental Ratio (CPR)**

CPR Value Range	Number of Participants	Percentage (%)
$\geq 1.1$ (Normal)	68	68%
$< 1.1$ (Low/Abnormal)	32	32%

**Fetal Heart Rate Abnormalities:** Only 2 of the 68 women with normal CPR showed FHR abnormalities, whereas 14 out of 32 in the abnormal CPR group had abnormal FHR, highlighting a strong correlation between low CPR and fetal heart rate disturbances.

**Table 7: Fetal Heart Rate (FHR) Abnormalities by CPR Category**

CPR Group	Normal FHR	Abnormal FHR	Total
$\text{CPR} \geq 1.1$	66	2	68
$\text{CPR} < 1.1$	18	14	32

**Mode of Delivery:** Among those with normal CPR, 79.4% delivered vaginally, while only 31.2% of those with  $\text{CPR} < 1.1$  had vaginal delivery. Cesarean deliveries were significantly more common in the abnormal CPR group (62.5%), mainly due to fetal compromise.

**Table 8: Mode of Delivery in Relation to CPR**

CPR Group	Vaginal Delivery	LSCS	Instrumental	Total
$\text{CPR} \geq 1.1$	54	12	2	68
$\text{CPR} < 1.1$	10	20	2	32

**Meconium-Stained Amniotic Fluid (MSAF):** MSAF was observed in 12 out of 32 cases with low CPR (37.5%), compared to only 5 cases (7.4%) among those with normal CPR, suggesting a greater risk of fetal stress in low CPR pregnancies.

**Table 9: Meconium-Stained Amniotic Fluid (MSAF) in Different CPR Groups**

CPR Group	MSAF Present	MSAF Absent	Total
CPR $\geq$ 1.1	5	63	68
CPR $<$ 1.1	12	20	32

**Apgar Scores:** In the abnormal CPR group, 18.7% had Apgar scores  $<$ 7 at 5 minutes, whereas only 1.4% in the normal CPR group had such scores. This indicates a clear association between low CPR and poor neonatal adaptation.

**Table 10: Apgar Scores at 1 and 5 Minutes According to CPR**

CPR Group	Apgar $<$ 7 (5 min)	Apgar $\geq$ 7 (5 min)	Total
CPR $\geq$ 1.1	1	67	68
CPR $<$ 1.1	6	26	32

**Umbilical Cord Blood Gas Parameters:** Neonates with CPR  $<$ 1.1 had significantly lower pH (7.18 vs. 7.26) and higher pCO<sub>2</sub> levels (47.2 mmHg vs. 39.8 mmHg). Their base excess and pO<sub>2</sub> values also reflected worse metabolic profiles, supporting CPR as a biochemical predictor of fetal hypoxia.

**Table 11: Umbilical Cord Blood Parameters by CPR Category**

Parameter	CPR $\geq$ 1.1 (Mean $\pm$ SD)	CPR $<$ 1.1 (Mean $\pm$ SD)
pH	7.26 $\pm$ 0.05	7.18 $\pm$ 0.06
Base Excess	-7.2 $\pm$ 2.3	-13.5 $\pm$ 3.1
pO <sub>2</sub> (mm Hg)	24.0 $\pm$ 4.1	13.5 $\pm$ 2.2
pCO <sub>2</sub> (mm Hg)	39.8 $\pm$ 5.3	47.2 $\pm$ 4.5

**NICU Admissions and Neonatal Complications:** NICU admissions were markedly higher in the abnormal CPR group (12/32, 37.5%) compared to only 3 out of 68 (4.4%) in the normal group. Neonatal complications followed a similar trend, reinforcing CPR's prognostic role.

**Table 12: NICU Admission and Neonatal Complications by CPR**

CPR Group	NICU Admission	Neonatal Complications	Total Cases
CPR $\geq$ 1.1	3	2	68
CPR $<$ 1.1	12	10	32

**Adverse Neonatal Outcomes:** Among low CPR cases, 56.2% experienced adverse outcomes, whereas only 5.8% in the normal CPR group did. This demonstrates a statistically significant association between CPR  $<$ 1.1 and poor perinatal outcomes.

**Table 13: Correlation between CPR and Adverse Neonatal Outcomes**

CPR Category	Adverse Outcome Present	No Adverse Outcome	Total
CPR $\geq$ 1.1	4	64	68
CPR $<$ 1.1	18	14	32

**Predictive Value of CPR  $<$ 1.1:** CPR  $<$ 1.1 showed excellent diagnostic ability with 81.8% sensitivity, 82.1% specificity, 56.3% PPV, and a high NPV of 94.1%, indicating its utility in ruling out adverse outcomes when normal.

**Table 14: Predictive Value of CPR  $<$ 1.1 for Adverse Outcomes**

Statistical Measure	Value (%)
Sensitivity	81.8%
Specificity	82.1%
Positive Predictive Value (PPV)	56.3%
Negative Predictive Value (NPV)	94.1%

**Logistic Regression – Risk Predictors:** Multivariate analysis revealed that CPR  $<$ 1.1 was the strongest independent predictor of adverse outcomes (OR = 6.5,  $p <$  0.001). FHR abnormality and MSAF also emerged as significant predictors, whereas LSCS alone was not independently predictive ( $p = 0.29$ ).

**Table 15: Logistic Regression – Predictors of Adverse Perinatal Outcome**

Predictor Variable	Odds Ratio (OR)	95% CI	p-value
CPR $<$ 1.1	6.5	2.3 – 18.3	$<$ 0.001
FHR Abnormality	5.1	1.8 – 14.2	0.002
MSAF	2.4	1.0 – 6.0	0.048
Mode of Delivery (LSCS)	1.7	0.6 – 4.8	0.29

Neonates born to mothers with a cerebroplacental ratio (CPR)  $<1.1$  exhibited a significantly higher incidence of adverse outcomes compared to those with normal CPR ( $\geq 1.1$ ).

Birth asphyxia (Apgar score  $<7$  at 5 minutes) occurred in 18.7% of the low CPR group versus only 1.4% in the normal group ( $p = 0.001$ ). Meconium-stained amniotic fluid with meconium aspiration syndrome was seen in 15.6% of neonates with abnormal CPR, compared to 2.9% in the normal group ( $p = 0.017$ ). Metabolic acidosis,

defined by cord blood pH  $<7.2$ , was significantly more prevalent in the abnormal CPR group (31.2%) than in the normal CPR group (4.4%) ( $p < 0.001$ ). Additionally, low birth weight (LBW) was noted in 28.1% of the low CPR group, contrasting with 5.8% in the normal CPR group ( $p = 0.002$ ).

These results confirm that a CPR  $<1.1$  is a strong predictor of adverse neonatal outcomes and underscores the importance of using CPR as a routine surveillance tool for timely obstetric decision-making.

**Table 16: Distribution of Specific Adverse Neonatal Outcomes by CPR Category**

Outcome	CPR $\geq 1.1$ (n=68)	CPR $<1.1$ (n=32)	p-value
Birth Asphyxia (Apgar $<7$ at 5 min)	1 (1.4%)	6 (18.7%)	0.001*
MSAF with MAS	2 (2.9%)	5 (15.6%)	0.017*
Metabolic Acidosis (pH $<7.2$ )	3 (4.4%)	10 (31.2%)	$<0.001^*$
Low Birth Weight ( $<2.5$ kg)	4 (5.8%)	9 (28.1%)	0.002*

\*Statistically significant at  $p < 0.05$

### Summary and Conclusion

The present study was conducted to evaluate the utility of the cerebroplacental ratio (CPR) in predicting adverse perinatal outcomes and fetal heart rate abnormalities in uncomplicated singleton pregnancies at or beyond 40 weeks of gestation. Despite being clinically categorized as low-risk, a significant proportion of these pregnancies (32%) demonstrated abnormal CPR ( $<1.1$ ), highlighting the presence of silent fetal compromise not detectable through routine surveillance tools such as NST or clinical examination.

Doppler velocimetry, particularly the combined assessment of umbilical artery (UA PI) and middle cerebral artery (MCA PI) via CPR, provides a non-invasive yet physiologically meaningful measure of placental resistance and fetal adaptation [10].

This study demonstrated strong associations between abnormal CPR and multiple adverse outcomes, including:

- Increased incidence of non-reassuring fetal heart rate patterns
- Higher rates of cesarean delivery for fetal distress
- Greater likelihood of meconium-stained liquor
- Low Apgar scores, cord blood acidosis, and NICU admissions

The statistical analysis showed that CPR  $<1.1$  had a sensitivity of 81.8%, specificity of 82.1%, and a negative predictive value of 94.1%, confirming its value as a screening tool for ruling out adverse outcomes in term pregnancies.

Importantly, logistic regression confirmed that CPR  $<1.1$  was the strongest independent predictor of adverse neonatal outcomes, even when accounting for other variables like meconium-stained fluid and fetal heart rate abnormalities. This underscores

CPR's clinical value in anticipating fetal decompensation before it manifests intrapartum, thus enabling timely interventions.

### Conclusion

The findings of this study support the integration of CPR assessment into routine fetal surveillance protocols for term and post-term pregnancies. Given its high predictive accuracy, non-invasiveness, and ease of use, CPR serves as a clinically meaningful marker for fetal well-being. Its role is particularly important in detecting subclinical placental insufficiency in low-risk populations that may otherwise go unnoticed.

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