ORIGINAL ARTICLE

A Prospective Analysis of the Association Between Antepartum Cerebroplacental Ratio and Risk of Adverse Fetal Outcomes in Full-Term Pregnancies at Tertiary Care Setting, Sahiwal, Pakistan

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ABSTRACT

Objective: To evaluate the association of cerebroplacental ratio, Doppler ultrasound, and risk of adverse fetal outcomes in normal-term pregnancies.

Study Design: A prospective cohort study.

Place and Duration of Study: This study was conducted at the Department of Gynecology and Obstetrics and Radiology, Sahiwal Medical College and Teaching Hospital, Sahiwal, Pakistan from 1st April 2024 to 30th March 2025.

Methods: A total of 250 pregnant women with singleton pregnancies and gestation age between 37 and 41 weeks, admitted to the hospital during latent labor, were included in the study. The cerebroplacental ratio was calculated as the middle cerebral artery pulsatility index divided by the umbilical cord pulsatility index. All measurements were classified by gestational age percentile into specific groups. Adverse fetal outcomes included fetal death, meconium-stained amniotic fluid, Apgar score <7 at 5 minutes, stillbirth, NICU admission, and need for ventilator, sepsis, hypothermia, non-invasive ventilation, hypoglycemia, and necrotizing enterocolitis.

Results: The incidence of abnormal heart rate was higher in fetuses with cerebroplacental ratio (CPR) <5th percentile in comparison with CPR >5th percentile (54.5% vs 30%). Similar results were recorded in both groups with CPR <1 (60% vs 30%, *P*=0.04). A cerebroplacental ratio (CPR) <5th percentile had a positive predictive value of 24% and a negative predictive value of 90% for abnormal fetal heart rate. However, the positive predictive value of cerebroplacental ratio (CPR)<1 and 1.08 for both parameters was 5% and 7%, respectively. The cerebroplacental ratio (CPR) >95th percentile had a negative predictive value of 98% and 99%, respectively.

Conclusion: A low cerebroplacental ratio is a predictor of fetal distress requiring operative delivery and abnormal fetal heart rate, with low positive predictive value and high negative predictive value. A cerebroplacental ratio (CPR) <5th percentile, however, was only correlated to abnormal fetal heart rate.

Keywords: *Placental Insufficiency, Pregnancy, Ultrasound.*

How to cite this: *Jamal Y, Shaukat M, Irum R. A Prospective Analysis of the Association Between Antepartum Cerebroplacental Ratio and Risk of Adverse Fetal Outcomes in Full-Term Pregnancies at Tertiary Care Setting, Sahiwal, Pakistan. Life and Science. 2025; 6(4): 547-552. doi: http://doi.org/10.37185/LnS.1.1.943*

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Received: May 19, 2025; 1st Revision Received: Jul 10, 2025
2nd Revision Received: Sep 06, 2025; Accepted: Sep 10, 2025

Introduction

Placental insufficiency is a common condition in which insufficient blood flow and nutrients are delivered to the placenta due to maternal lifestyle factors, medications, or disorders. It can increase the risk of fetal morbidity and mortality by causing intrauterine growth restriction and perinatal asphyxia.[1] It is common in small-for-gestational-age fetuses but can appear appropriate for gestational

age in older fetuses.[2,3] These late gestation fetuses are very likely to suffer from comorbid conditions as the placental sufficiency remains undiagnosed.

Antepartum Doppler ultrasound serves as the primary method to monitor the fetus, especially those with growth restriction effectively.[4] Placental insufficiency can be detected by an increase in placental resistance and a consequent decrease in cerebral resistance. Cerebroplacental ratio is calculated to assess fetal oxygenation. In typical cases, CPR is >1 because placental resistance is always lower than cerebral resistance. However, in cases of fetal growth restriction, CPR ≤1 because cerebral resistance decreases and placental resistance increases.

Abnormal CPR before birth is a significant predictor of adverse fetal outcomes in fetuses with early-onset growth restriction and is appropriate for gestational age.[5] It is associated with complications including fetal distress, low Apgar score at 5 minutes after birth, and NICU admission. Abnormal CPR cut-off values include >1, >1.08, >0.67 multiples of the median, and >5 or 10% of gestation age. Various studies have validated the diagnostic accuracy of these values.[6,7]

Most of the literature focuses on the antenatal period, and on CPR, not on the late pregnancy or postpartum period. Since there is scarce data concerning the utility of CPR during childbirth, this study aims to evaluate the association of CPR, Doppler ultrasound, and the risk of adverse fetal outcomes in normal-term pregnancies.

Methods

A prospective cohort study was conducted at the Gynecology and Obstetrics and Radiology Department of Sahiwal Medical College and Teaching Hospital, Sahiwal, Pakistan from 1st April 2024 to 30th March 2025. A total of 250 pregnant women with singleton pregnancies and gestation age between 37 and 41 weeks, admitted to the hospital during latent labor, were included in the study by consecutive sampling. The sample size was calculated to achieve 0.80 power in the study, a 0.5 statistical significance level, an estimated ratio of distressed fetuses requiring operative delivery of 1:7, and an estimated variability in CPR values between fetuses depending on the occurrence of adverse effects, according to Monteith C et al. Patients undergoing planned c-sections, with fetal death or congenital deformities, maternal fever, meconium-stained premature rupture of membranes, and maternal/ fetal instability requiring urgent intervention were excluded.[8] Informed consent was obtained from all patients. The Ethical Review Board of the hospital approved the study vide letter no: 131/IRB/SLMC/SWL, dated: 26th March 2024.

Patients' demographic details were collected from their medical records after admission. Ultrasound was performed to assess Doppler indices, fetal biometry, and amniotic fluid index by a 2-5 MHz transabdominal transducer. The velocities of the middle cerebral artery and the umbilical artery were measured by Pulse wave Doppler for at least three waveforms during fetal rest at an angle <30 degrees.

The cerebroplacental ratio was calculated as the middle cerebral artery pulsatility index divided by the umbilical cord pulsatility index. All measurements were classified according to gestational age percentile into specific groups for reference ranges at the 2.5th, 5th, 10th, 25th, 50th, 75th, 90th, 95th, and 97.5th percentiles. All women received intrapartum standard care and were attended by a physician. Fetal heart rate was monitored regularly, and neonatal outcomes, including fetal distress requiring operative delivery and category II and III fetal heart rate tracing, were recorded. Adverse fetal outcomes included fetal death, meconium-stained amniotic fluid, Apgar score <7 at 5 minutes, stillbirth, NICU admission, and need for ventilator, sepsis, hypothermia, non-invasive ventilation, hypoglycemia, and necrotizing enterocolitis.

Data analysis was done by SPSS version 21. Quantitative data were presented as mean ± SD, and median. Wilcoxon rank test and unpaired t-tests were performed to compare continuous variables. The proportions were compared by the Chi-square test or Fisher's exact test. Statistical significance was determined at $P<0.05$.

Results

A total of 250 pregnant women were included in the analysis. The mean age of patients was 30 years. 18 (72%) were nulliparous with no evident gynecological disorder. 80 (32%) fetuses had an

abnormal heart rate, and 35 (14%) experienced distress that required an operation. No fetal deaths or stillbirths were recorded among the participants. The median duration from CPR measurement to delivery was 7 hours. Women who had fetal distress and underwent operative delivery had significantly lower MCA-PI and CPR (1.3 and 1.4, respectively) as compared to those without fetal distress (1.4 and 1.7, respectively) (P<0.01). However, UA levels were similar between the two groups. The maternal characteristics, neonatal outcomes, and ultrasound findings are shown in Table 1.

Table 1: Maternal parameters and ultrasonic findings

Variables	**N= 250**
Maternal age	30 (25-34) years
Nulliparity	180 (72%)
Gestation age	280 (275-284) days
BMI	22.2 (20.5-25)
Obstetric complications	
Gestational diabetes	20 (8%)
Maternal heart disease	10 (4%)
Chronic hypertension	8 (3.2%)
Maternal thyroid disease	5 (2%)
Severe preeclampsia	5 (2%)
Fetal growth restriction	3 (1.2%)
Intrapartum features	
Abnormal fetal heart rate	80 (32%)
Meconium-stained amniotic fluid	45 (18%)
Fetal distress requiring operative delivery	35 (14%)
Mode of delivery	
Vaginal	90 (36%)
Cesarean section	110 (44%)
Ultrasound findings (CPR)	
<5th percentile	35 (14%)
<1	5 (2%)
<1.08	15 (6%)
Amniotic fluid index	8.1 (4.6-11)
Oligohydramnios	70 (28%)
Birth weight	3170 (2869-3438) grams
Birth weight percentile	
<5	3 (1.3%)
5-<10	3 (1.3%)
10-<50	70 (28%)
50	35 (14%)
>50-90	110 (44%)
>90	40 (16%)
Low birth weight	15 (6%)
Apgar <7	1 (0.004%)
NICU admission	5 (2%)
Respiratory distress	10 (4%)

Table 2: Adverse neonatal outcomes at cerebroplacental ratio reference ranges

	<5th percentile (N=35)	Chi Square value	t-test value	*P* value	<1 (N=10)	t-test value	*P* value	<1.08 (N=20)	Chi Square value	*P*-value
Meconium-stained amniotic fluid	5 (14.3%)	38.1		0.39	4 (40%)		0.05	5 (25%)		0.47
Abnormal fetal heart rate	19 (54.5%)	21.0		<0.01	6 (60%)		0.04	10 (50%)	23.6	0.18
Fetal distress requiring operative delivery	7 (20%)	32.1		0.28	3 (30%)		0.09	5 (25%)		0.33
Oligohydramnios	16 (45.8%)	>26.5		0.10	3 (30%)		1	9 (45%)		0.61
Birth weight	3042 ± 441		2.44	0.02	3077 ± 440	0.70	0.49	3089 ± 398		0.39
Birth weight <10th percentile	-			0.10	-		0.88	-		0.62
Apgar <7	-			1	-		1	-		1
NICU admission	2 (5.8%)			0.21	1 (10%)		0.20	1 (5%)		0.30

**Chi-squared test, ***t-test*

There was no significant difference between perinatal outcomes across all three CPR cut-off values, as shown in Table 2, except for abnormal fetal heart rate and mean birth weight. The incidence of abnormal heart rate was higher in fetuses with CPR <5th percentile in comparison with CPR >5th percentile (54.5% vs 30%). Similar results were recorded in both groups with CPR <1 (60% vs 30%, *P*=0.04). A lower mean birth weight was observed at CPR <5th percentile (3042 ± 441 g) as compared to the other group (3189 ± 431 g) (*P*<0.01).

The predictive value of the CPR cut-off was also assessed for fetal distress and abnormal fetal heart rate. A CPR <5th percentile had a positive predictive value of 24% and a negative predictive value of 90% for abnormal fetal heart rate. The following values were 20% and 88%, respectively, for fetal distress. However, the positive predictive value of CPR <1 and 1.08 for both parameters was 5% and 7%, respectively. And the CPR >95th percentile had a negative predictive value of 98% and 99%, respectively.

Discussion

The results of the present study showed that fetuses that required operative delivery due to fetal distress had significantly lower CPR and MCA-PI, indicating that they were associated with adverse perinatal outcomes. Previous studies have also reported the same correlations with CPR reference cut-off values.[9-11] This conclusion backs the brain sparing during hypoxia, which can significantly increase the risk of non-reassuring fetal status. The pulsatility index for the umbilical artery was similar between fetuses in distress and without distress. The existing literature confirms these results and indicates that UA-PI cannot be considered an individual validity tool for predicting fetal compromise risk.[12,13]

Research shows that a low antepartum CPR can be a predictive factor for emergent c-sections or operative vaginal delivery due to fetal distress in full-term pregnancies that are small for gestational age or without it.[14] A study conducted on appropriate gestation age fetuses reported that fetuses with lower intrapartum CPR were at higher risk of requiring an operative delivery due to fetal compromise, but this finding was not statistically significant due to a limited number of patients or variable time for CPR measurement.[15] We assume that the reason for this is that uterine stress during labor may have a similar effect as uteroplacental insufficiency, due to which it isn't easy to differentiate between fetuses.

A low antepartum CPR value was also significantly correlated to abnormal fetal heart rate. Karge et al. A also reported that a low CPR value during labor was associated with a 5-times increased risk of fetal compromise, and a CPR >90th percentile predicted a low risk.[16] Previous studies also report a high incidence of low birth weight, NICU admission, low Apgar, meconium-stained amniotic fluid, and neonatal comorbidities in fetuses with low CPR.[17] However, the present study did not detect a relationship between adverse perinatal outcomes and CPR, due to the low incidence of adverse perinatal outcomes.

For the prediction of fetal compromise, a low positive predictive value of 20% was noted for CPR <5th percentile, with a high negative predictive value of 88%. The same pattern was reported for other cut-off values, i.e., CPR <1 and 1.08. However, this does not comply with other studies where CPR was reported to be an accurate determinant of fetal distress, but these studies focused on patients with FGR. Still, women in our study had normal full-term pregnancies.[18,19] In addition, fetuses with CPR <95th percentile had a negative predictive value of 98% for fetal compromise, indicating a low risk. These findings are similar to those of Gupta A et al. where a CPR <10th percentile in normal pregnancies had a high negative predictive value of 92% for fetal distress and a low positive predictive value.[20]

Our study has a limitation: the low frequency of fetal adverse outcomes, which prevented us from establishing an association with a low CPR value. A larger sample size may be required to achieve the desired results.

Conclusion

A low cerebroplacental ratio is a predictor of fetal distress requiring operative delivery and abnormal fetal heart rate, with low positive predictive value and high negative predictive value. A CPR <5th percentile, however, was only correlated to abnormal fetal heart rate.

Acknowledgement: None

Conflict of Interest: The authors declare no conflict of interest

Grant Support and Financial Disclosure: None

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Author Contributions

YJ: Conception and design of the work, writing the original draft, proofreading, and approval for final submission

MS: Manuscript writing for methodology design and investigation, revising, editing, and supervising for intellectual content

RI: Data acquisition, curation, and statistical analysis, validation of data, interpretation, and write-up of results