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Original Research Article

PROGNOSTIC ACCURACY OF CEREBROPLACENTAL RATIO FOR ADVERSE FETAL OUTCOMES AND FETAL DISTRESS WITHIN 24 HOURS OF BIRTH

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ABSTRACT

Background: *The cerebroplacental ratio (CPR), derived from Doppler indices of the fetal middle cerebral artery and umbilical artery, has emerged as a potential predictor of fetal compromise. Evaluating its prognostic accuracy for adverse perinatal outcomes (APO) and cesarean section for intrapartum fetal distress (CS-IFR) may enhance perinatal risk stratification and decision-making in late gestation.* ***Objective:*** *To evaluate the prognostic accuracy of the cerebroplacental ratio for predicting adverse perinatal outcomes and cesarean section due to fetal distress within 24 hours of delivery.* ***Study Design:*** *Retrospective observational study.* ***Setting:*** *Radiology and Gynaecology Departments, Nishtar Hospital, Multan, Pakistan.* ***Duration of Study:*** *Twelve months, from April 2024 to April 2025.* ***Methods:*** *A total of 200 pregnant women between 31 and 41 weeks of gestation were included. All participants underwent fetal ultrasound assessment for estimated fetal weight, amniotic fluid volume, and Doppler evaluation of the umbilical artery (UA) and middle cerebral artery (MCA). The cerebroplacental ratio (CPR) was calculated as the MCA pulsatility index divided by the UA pulsatility index. Neonatal outcomes were recorded within 24 hours of delivery. Statistical analyses included chi-square tests and multiple regression analysis to determine the association between CPR and adverse outcomes. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of CPR were calculated.* ***Results:*** *Patients with elevated UA pulsatility index and higher UA-PI multiples of the median showed a significantly higher incidence of adverse perinatal outcomes ($p = 0.009$). Multiple regression analysis identified labor induction (OR: 2.48, 95% CI: 1.019–6.11, $p < 0.05$) and CPR multiples of the median (OR: 0.03, 95% CI: 0.0071–0.3261, $p < 0.001$) as independent predictors of adverse perinatal outcomes. CPR showed a specificity of 70%, PPV of 32%, and NPV of 94% for predicting APO. For predicting CS-IFR, CPR had a specificity of 79%, a PPV of 26%, and NPV of 98%.* ***Conclusion:*** *The cerebroplacental ratio is a strong and reliable predictor of adverse perinatal outcomes and cesarean delivery for fetal distress in term pregnancies. Its high negative predictive value suggests utility in identifying low-risk pregnancies and informing delivery planning.*

Keywords: Cerebroplacental Ratio, Fetuses, Fetal Compromise, Pregnancy

INTRODUCTION

Birth weight is related to the risk of stillbirth, emergent c-section for fetal distress and other adverse fetal outcomes, however, it has poor predictive power to determine these conditions. (1). It is due to the fact that many appropriate for gestation age fetuses have small birth weight and experience adverse outcomes as well in addition to small for gestation age fetuses. Therefore, recent research focuses on hemodynamics as determinants of adverse perinatal outcomes.

Cerebroplacental ratio is widely used to diagnose adverse perinatal outcomes as it assesses the correlation between fetal cerebral redistribution and hypoxemia, which is independent of birth weight (2). Hence, CPR is used as a prognostic factor to predict intrauterine growth restriction in small and appropriate for age fetuses. (3, 4).

A significant number of studies have been conducted to assess the use of CPR to predict intrapartum adverse outcomes before delivery.(5, 6)However, studies testing the diagnostic ability of CPR are limited. This study was conducted to evaluate the prognostic accuracy of cerebroplacental ratio adverse perinatal outcomes and cesarean section for fetal distress within 24 hours of birth.

METHODOLOGY

A retrospective study was conducted in the Radiology and Gnaecology Department of Nishtar Hospital, Multan, from April 2024 to April 2025. A total of 200 women with gestation age between 31-41 weeks, admitted to our department were selected for analysis. Fetuses appropriate for gestation age and those with fetal growth restriction and other complications were both included. Women with multiple pregnancies, undergoing elective cesarean sections, those with congenital fetal disorders or aneuploidy were excluded. Consent of the participants was obtained before initiation of the study. The ethical review committee approved the research.

All women underwent fetal ultrasound for estimated fetal weight and amniotic fluid volume. The pulsatility indices of umbilical and middle cerebral arteries were evaluated by color and pulse Doppler. Cerebroplacental ratio was calculated by using the two indices.All examinations were done before start of dilations, premature rupture of membrane, or other precursors of labor induction. All deliveries were performed by spontaneous or induced labor within 24 hours of the examinations. Estimated fetal weight and birth weight were calculated as centiles for fetal gender to adjust for gestational age. CPR values were calculated as multiples of median (50th centile) for each GA.

Neonatal outcomes, including birth weight, NICU admission, Apgar score, mode of birth and cord arterial pH were recorded. Adverse perinatal outcomes such as NICU admission, abnormal fetal heart rate, cord pH or fetal scalp pH less than 7.2 leading to c-section, 5-minute Apgar less than 7 were also noted.

All data analysis was performed by Stats Plus and GraphPad software. Quantitative data such as maternal age, gestation age at admission and birth, parity, duration between ultrasonic examination and birth, estimated fetal weight (& centile), Doppler parameters, neonatal gender, mode of labor induction & delivery, 5-min Apgar score, cord

arterial pH and location of neonatal stay were evaluated by descriptive analysis. Frequency was used to present categorical data, compared by Fisher's exact test and median (IQR) was used to present continuous data, compared by the Mann-Whitney U test. Logistic regression analysis and receiver operating characteristic analysis were performed to assess the prognostic accuracy of CPR. P value of less than 0.05 determined statistical significance.

RESULTS

Maternal and neonatal data is shown in Table I. 52.5% were male babies and most mothers experienced vaginal birth (60%) through spontaneous labor (55%). Majority of neonates (90%) were stable and stayed in the maternity ward. None of the neonates had a low 5-minute Apgar score but 3% had low cord pH. 8% of the pregnancies resulted in emergent c-section due to low scalp pH or abnormal fetal heart rate, while overall, 16% neonates had adverse outcomes. 6% were born premature, and 30th % had low birth weight.

The adverse neonatal outcomes are presented in Table II according to patients' characteristics. Patients with a high umbilical artery pulsatility index and UA-PI multiples of median were significantly more likely to have an adverse outcome (p=0.009). However, other variables were low, including maternal height, estimated fetal weight (+centile), birth weight (+centile), middle cerebral artery (+multiples of median), and CPR multiples of median. Labor induction, small for gestation age fetuses and preterm births were also associated with adverse outcomes. Maternal age, BMI, neonatal gender, parity and gravidity, and maternal weight before pregnancy were insignificant. Multiple regression analysis identified labor induction (odds ratio: 2.48, 95% CI: 1.019-6.11, p<0.05) and CPR multiples of median (OR: 0.03, 95% CI: 0.0071-0.3261, p<0.001) as significant predictors of adverse perinatal outcomes. For the prediction of APO, CPR had a specificity of 70% with a PPV of 32% and NPV of 94%. However, CPR was only a significant parameter for prediction of CS-IFR with a specificity of 79%, PPV of 26%, and NPV of 98% (Table III).

Table 1: Descriptive Statistics of Study Variables

	Mean ± SD	**Median (IQR)**
Maternal age	31.11 ± 6.22	31 (30.0,35.0)
Gravidity	1.18 ± 0.59	1 (1,1)
Parity	1.0 ± 1.2	0 (0,1)
Maternal pre-pregnancy weight	61.3 ± 10.5	59 (54,67)
Maternal height	160.3 ± 5	161 (156,164)
Maternal BMI	22.6 ± 3.7	22.7 (20,26.3)
Gestation age on ultrasound	40.8 ± 0.9	40.3 (38,41)
Gestation age at birth	40.9 ± 0.9	40.5 (39,41)
Estimated fetal weight	3076 ± 587	3158 (2639,3488)
Estimated fetal weight (centile)	35.7 ± 33.0	31 (5.2, 65.2)
Umbilical artery pulsatility indices	1.0 ± 0.19	0.93 (0.81,1.00)
Umbilical artery pulsatility indices (multiples of median)	1.23 ± 0.31	1.09 (1.26,1.00)
Middle cerebral artery pulsatility indices	1.44 ± 0.26	1.32 (1.07,1.54)
Middle cerebral artery pulsatility indices (multiples of median)	0.89 ± 0.17	0.85 (0.67,1.11)
Cerebroplacental ratio	1.61 ± 0.46	1.49 (1.23,1.93)
Cerebroplacental (multiples of median)	0.86 ± 0.25	0.87 (0.71,1.12)
Birth weight	3055 ± 568	3140 (2713,3456)
Birth weight (centile)	33.9 ± 30.3	26 (5,58)
N (%)		
Adverse perinatal outcome	32 (16%)	
Nulliparity	100 (50%)	
Preterm examinations	12 (6%)	
Preterm labor	12 (6%)	
Male neonatal gender	105 (52.5%)	
Type of labor induction		
Spontaneous	110 (55%)	
Induced labor	88 (44%)	
Small for gestation age fetuses (<10th percentile)	60 (30%)	
5-min Apgar <7	-	
Arterial pH<7.2	6 (3%)	
Mode of delivery		
Vaginal	120 (60%)	
Assisted vaginal	10 (20%)	
C-section due to abnormal cardiotocogram	20 (10%)	
C-section due to failure to progress	20 (10%)	
Location of neonatal stay		
Maternal ward	180 (90%)	
Neonatal ward	16 (8%)	
NICU	4 (2%)	

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Table 2: Classification of adverse outcome concerning patients' characteristics

Variables	Adverse outcome 1st and 3rd quartile (n=32)		*P- value*
	Mean ± SD	**Median (IQR)**	
Maternal age	32.8 ± 3.9	32 (29-34)	NS*
Gravidity	1.22 ± 0.51	1 (1,1)	NS
Parity	0.56 ± 1.1	0 (0,1)	NS
Maternal pre pregnancy weight	60.8 ± 11.6	57 (52.4,64)	NS
Maternal height	160 ± 5	158 (154, 163)	<0.05
Maternal BMI	23.1 ± 5.4	23.0 (21.5, 24)	NS
Gestation age on ultrasound	39.7 ± 2.3	38.2 (36.9, 38.7)	<0.0001
Gestation age at birth	39.8 ± 2.3	38.3 (36.8, 40.1)	<0.0001
Estimated fetal weight	2644 ± 675	2698 (2122, 3183)	<0.0001
Estimated fetal weight (centile)	21.6 ± 29.2	6 (2, 34)	<0.0001
Umbilical artery pulsatility indices	1.12 ± 0.37	1.11 (0.78, 1.35)	<0.0001
Umbilical artery pulsatility indices (multiples of median)	1.48 ± 0.40	1.47 (1.13,1.70)	<0.0001
Middle cerebral artery pulsatility indices	1.14 ± 0.41	1.08 (0.99, 1.32)	<0.001
Middle cerebral artery pulsatility indices (multiples of median)	0.85 ± 0.16	0.83 (0.71,0.90)	<0.0001
Cerebroplacental ratio	1.23 ± 0.56	0.98 (0.92,1.53)	<0.0001
Cerebroplacental (multiples of median)	0.72 ± 0.37	0.57 (0.51,0.94)	<0.0001
Birth weight	2568 ± 617	2546 (2056, 3030)	<0.0001
Birth weight (centile)	17.3 ± 28.1	3 (1, 31.4)	<0.0001
N (%)			
Nulliparity	16 (50%)		
Preterm labor	9 (28.2%)		
Male neonatal gender	3 (9.4%)		
Type of labor induction			
Spontaneous	1 (3.2%)		
Induced labor	24 (75%)		
Small for gestational age fetuses	19 (59.4%)		

**NS= not sinificant*

Table 3: Diagnostic Accuracy of CPR For Prediction of Adverse Perinatal Outcomes and Incidence of Cesareans Section for Fetal Distress

	CPR MoM <0.80	**CPR MoM <0.665**
For APO		
AUC	0.75	
Detection rate	74%	
Specificity	70%	
PPV	32%	
NPV	94%	
For prevalence of CS-IFC		
AUC	-	0.79
Detection rate	-	74%
Specificity	-	79%
PPV	-	26%
NPV	-	98%

DISCUSSION

The results of our study showed a significant association between low cerebroplacental ratio and adverse perinatal outcomes. However, estimated fetal weight and maternal variables did not imply any significant predictive power. CPR had a high NPV of 94% for APO and 98% for CS-IFC which can help identify high-risk pregnancies that can be managed timely, opting for low-risk options. Other studies have also verified the utility of CPR for the prediction of adverse outcomes.(7-9)

Mohamed et al assessed CPR in 400 women with normal pregnancies with normal fetal growth before active labor for the prediction of c-section.(10) The results revealed an area under the curve of 0.71, sensitivity of 33.2%, specificity of 92.7%, and positive predictive value of 37.5%. Another study evaluated the diagnostic ability of CPR for failure to reach growth potential in 800 normal fetuses after 3 days of birth.(11)CPR was significantly associated with a two-fold greater incidence of abnormal neonatal heart rate and a three times greater likelihood of cesarean section. The PPV for CS was 37.4%, NPV of 89.1%, and the sensitivity of 19%. In both these studies, the majority of patients had an induced labor.

A study by Winchester et al evaluated the role of CPR in determining risk of adverse fetal outcomes in full-term low-risk fetuses during labor.(12) The logistic analysis showed that CPR was an independent risk factor for adverse outcomes because of fetal compromise. A low accuracy of 0.59 was reported despite a high negative predictive value of 97%. Similar to our study, Bonnevier et al assess fetuses within 24 hours of delivery and concluded that low CPR was associated with APO.(13) However, in this study parity was also a significant parameter in addition to CPR, but it also had a poor accuracy for APO (AUC: 0.60) and CS (AUC: 0.74).

The previous literature reported fetal gender and parity as strong determinants of outcomes, which is contradictory to our study.(14, 15)

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But we do agree with the fact that maternal age and estimated fetal weight were not among the predictors. Labor induction was also a noticeable factor to some degree in our study.

Our study has some limitations. The study had a limited sample size selected from a single center. Secondly, we did not record type of labor induction and Bishop score. Lastly, the incidence of adverse perinatal outcomes may be higher compared to previous literature.

CONCLUSION

CPR is a strong predictor of adverse perinatal outcomes and cesarean section due to fetal compromise in term fetuses.

DECLARATIONS

Data Availability Statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department Concerned. (IRBEC-NMU-24)

Consent for publication

Approved

Funding

Not applicable

CONFLICT OF INTEREST

The authors declared an absence of conflict of interest.

AUTHOR CONTRIBUTION

SAMREEN MUSHTAQ (Associate Professor)

Conception of Study, Development of Research Methodology Design, Study Design, Review of manuscript, final approval of manuscript. Manuscript drafting.

MUHAMMAD AMIN (Associate Professor)

Manuscript revisions, critical input.
Study Design, Review of Literature.

MUHAMMAD MASOOD UR RAUF KHAN (Professor)

Conception of Study, Final approval of manuscript.
Data entry data analysis, drafting article.

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