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Diagnostic Accuracy of Middle Cerebral Artery to Umbilical Artery Resistance Index Ratio in Predicting Adverse Perinatal Outcomes

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Abstract

Background: Despite evidence supporting the use of MCA/UA Doppler ratios in detecting fetal compromise, most studies have focused on high-risk pregnancies or specific populations, with limited data from broader clinical settings, particularly in Bangladesh; therefore, the purpose of the study was to evaluate the diagnostic accuracy of the Middle Cerebral Artery to Umbilical Artery Resistance Index Ratio in predicting adverse perinatal outcomes. ***Aim of the study:*** The aim of the study was to evaluate the diagnostic accuracy of the Middle Cerebral Artery to Umbilical Artery Resistance Index Ratio in predicting adverse perinatal outcomes. ***Methods:*** A prospective cohort study of 106 pregnant women at 29–38 weeks gestation was conducted at the Department of Obstetrics and Gynecology, BIRDEM General Hospital, Dhaka (Nov 2022–Feb 2024). Maternal and fetal outcomes were recorded, C/U ratio was assessed, participants were grouped by a 1.01 cut-off, and data were analyzed using SPSS v26.0 ($p < 0.05$). ***Results:*** The C/U ratio predicted adverse perinatal outcomes with an ROC AUC of 0.827 (95% CI: 0.749–0.905; $p < 0.0001$). At a cut-off of 1.01, sensitivity was 77.8%, specificity 84.6%, PPV 46.2%, NPV 95.7%, and accuracy 83.6%. Low C/U (<1.01) was associated with higher rates of complicated outcomes (84.0% vs 21.4%), 5-min APGAR <7 (68.0% vs 19.6%), NICU admission (74.0% vs 21.4%), respiratory distress (60.0% vs 12.5%), and FGR (18.0% vs 0.0%) compared to C/U ≥1.01 (P <0.05). ***Conclusion:*** A C/U ratio below 1.01 reliably predicts adverse perinatal outcomes, supporting its use for early identification of at-risk fetuses.

Keywords: Diagnostic Accuracy, Cerebroplacental Ratio, Perinatal Outcomes.

INTRODUCTION

Pregnancy-induced hypertension (PIH) is a leading contributor to both maternal and neonatal complications, affecting approximately 5–10% of pregnancies, with a reported incidence of around 5% at Hatyai Hospital [1,2]. Fetal growth restriction (FGR) is another frequent concern in obstetrics, occurring when a fetus does not reach its expected growth potential, thereby increasing the risk of perinatal morbidity and mortality [3,4]. Additionally, these growth-restricted fetuses are at heightened risk for long-term health issues, including adult hypertension, atherosclerosis, type 2 diabetes, and metabolic disorders [5,6].

Although FGR can lead to a complicated perinatal course, timely antenatal detection and monitoring of intrauterine growth restriction (IUGR) can improve fetal outcomes. Accurate identification of a compromised IUGR fetus is therefore a critical goal of prenatal care, allowing for prompt intervention [7]. Doppler ultrasound is a noninvasive technique that assesses fetal hemodynamics and evaluates fetoplacental and uteroplacental circulation [7]. It is safe for repeated

use during pregnancy and serves as a sensitive tool for the early identification of fetal compromise, enabling timely clinical action to prevent adverse outcomes.

Doppler ultrasound provides a reliable method for evaluating uteroplacental and fetoplacental blood flow. Studies have demonstrated the utility of fetal vascular Doppler measurements, including umbilical artery (UA) indices, middle cerebral artery (MCA) indices, and the cerebroplacental (MCA/UA) ratio, in predicting uteroplacental insufficiency and perinatal mortality [8-10]. Research indicates that the MCA/UA ratio often has higher sensitivity and specificity for assessing fetal prognosis compared with umbilical artery velocimetry alone. This ratio not only reflects placental circulatory insufficiency, as evidenced by changes in the umbilical S/D ratio, but also captures compensatory alterations in cerebral blood flow reflected in the middle cerebral S/D ratio [11-13]. MCA Doppler evaluation has therefore been recommended as an effective method for detecting fetal hypoxia and identifying fetuses at risk of adverse perinatal outcomes [14].

Despite evidence supporting the use of MCA/UA Doppler ratios in detecting fetal compromise, most studies have focused on high-risk pregnancies or specific populations, with limited data from broader clinical settings, particularly in Bangladesh. Additionally, variations in optimal cut-off values and their predictive accuracy for adverse perinatal outcomes remain inconsistently reported. Therefore, further research is needed to validate the diagnostic performance of the MCA/UA ratio in predicting perinatal complications across diverse populations. The purpose of the study was to evaluate the diagnostic accuracy of the Middle Cerebral Artery to Umbilical Artery Resistance Index Ratio in predicting adverse perinatal outcomes.

OBJECTIVE

- To evaluate the diagnostic accuracy of the Middle Cerebral Artery to Umbilical Artery Resistance Index Ratio in predicting adverse perinatal outcomes.

METHODOLOGY & MATERIALS

This prospective cohort study was conducted in the Department of Obstetrics and Gynecology, BIRDEM General Hospital, Dhaka, Bangladesh, between November 2022 and February 2024. A total of 106 pregnant women at 29–38 weeks of gestation were enrolled based on the following criteria.

Inclusion criteria

- Pregnant women of 29–38 weeks of gestation who underwent at least one third-trimester ultrasonography with color Doppler.
- Pregnant women with diabetes mellitus, gestational diabetes mellitus, chronic hypertension, pre-eclampsia, or pregnancy-induced hypertension.

Exclusion criteria

- Uncertain last menstrual period.
- Multiple pregnancies.
- Pregnancy with congenital anomalies.
- Intrauterine fetal death.
- Severe comorbidities (cardiac failure, hepatic failure, renal failure, or sepsis).

The study assessed maternal outcomes (gestational age at delivery, mode and cause of delivery) and fetal outcomes (birth weight, APGAR score, respiratory distress, and fetal growth restriction). The middle cerebral artery to umbilical artery (C/U) resistance index ratio was the independent variable. Standard clinical definitions were used for hypertensive and diabetic disorders in pregnancy.

All participants underwent at least one third-trimester Doppler ultrasound to assess fetal biometry, biophysical profile, amniotic fluid, and C/U ratio. All scans were performed by a single examiner to minimize observer variability. Pregnancies were followed until delivery, and perinatal outcomes were recorded. Based on receiver operating characteristic (ROC) analysis, a C/U ratio of 1.01 was used as the cut-off to categorize participants into two groups (<1.01 vs ≥ 1.01).

Data were collected using a structured proforma, entered into SPSS version 26.0, and analyzed using descriptive and inferential statistics. A p-value <0.05 was considered statistically significant. Ethical clearance was obtained from the Institutional Review Board of BIRDEM, and written informed consent was obtained from all participants.

RESULTS

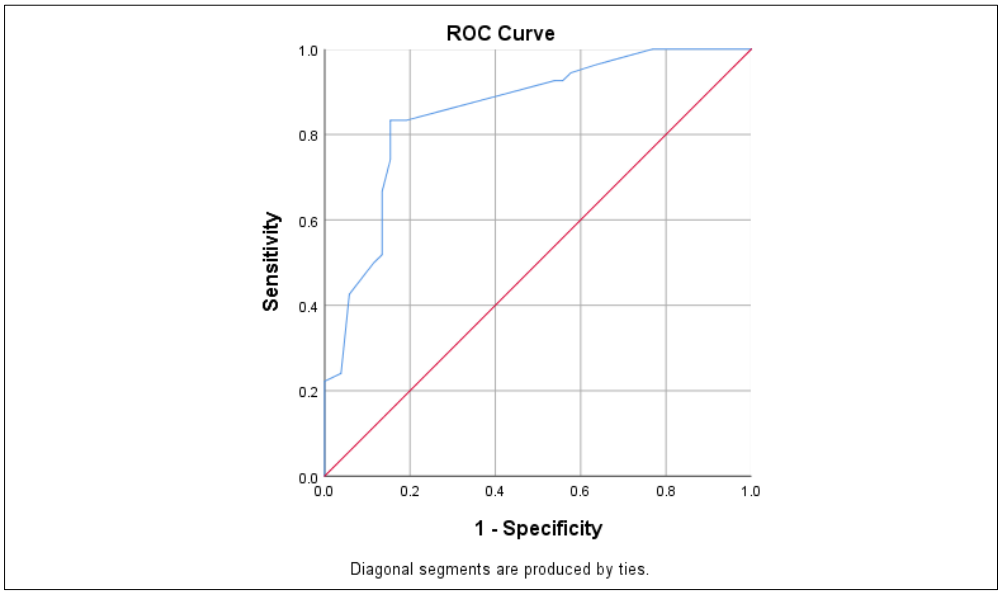

Figure 1: Receiver Operating Characteristic (ROC) Curve Of C/U Ratio for Predicting Adverse Perinatal Outcomes

The ROC curve analysis of the C/U ratio was performed to determine the optimal cut-off for predicting adverse perinatal outcomes. The area under the curve (AUC) was 0.827 (95% CI: 0.749–0.905; SE = 0.040; p < 0.0001), indicating that the C/U ratio is a fair predictor.

Table 1: Sensitivity And Specificity at Different C/U Ratio Cut-Off Values (ROC Curve Coordinates)

Cut-off value	Sensitivity	Specificity	1 – Specificity	Youden's Index (YI)
-0.2400	0.000	1.000	0.000	0.000
0.9050	0.241	0.962	0.038	0.202
0.9150	0.389	0.942	0.058	0.331
0.9250	0.463	0.885	0.115	0.348
0.9650	0.685	0.846	0.154	0.531
0.9750	0.722	0.846	0.154	0.568
1.0150	**0.778**	**0.846**	**0.154**	**0.624**
1.0700	0.778	0.827	0.173	0.605
1.0950	0.778	0.808	0.192	0.585
1.1150	0.889	0.462	0.538	0.350
1.2500	1.000	0.231	0.769	0.231
1.3500	1.000	0.135	0.865	0.135
1.5500	1.000	0.077	0.923	0.077
2.7000	1.000	0.000	1.000	0.000

The table presents sensitivity, specificity, 1 – specificity, and Youden's Index for different C/U ratio cut-off values. The ROC analysis identified 1.01 as the optimal cut-off, providing 77.8% sensitivity and 84.6% specificity for predicting adverse perinatal outcomes, demonstrating good diagnostic performance.

Table 2: Comparison of Perinatal Outcomes and Complications Between Two Groups

Perinatal Complications		C/U ratio < 1.01 (n=50)	C/U ratio ≥ 1.01 (n=56)	P value
Perinatal outcome	Complicated	42 (84.0%)	12 (21.4%)	<0.0001[a]
	Uncomplicated	8 (16.0%)	44 (78.6%)	
APGAR Score (at 5th min)	≥ 7	16 (32.0%)	45 (80.4%)	<0.0001[a]
	< 7	34 (68.0%)	11 (19.6%)	
NICU Admission	Needed	37 (74.0%)	12 (21.4%)	<0.0001[a]
	Not needed	13 (26.0%)	44 (78.6%)	
Respiratory Distress	Present	30 (60.0%)	7 (12.5%)	<0.0001[a]

Perinatal Complications		C/U ratio < 1.01 (n=50)	C/U ratio ≥ 1.01 (n=56)	P value
	Absent	20 (40.0%)	49 (87.5%)	
FGR	Present	9 (18.0%)	0 (0.0%)	0.003[c]
	Absent	41 (82.0%)	56 (100.0%)	

The table compares perinatal outcomes and complications between the two C/U ratio groups. Majority (84.0%) of respondents in the C/U < 1.01 group experienced complicated perinatal outcomes, whereas in the C/U ≥ 1.01 group, this percentage was significantly lower at 21.4% (P < 0.0001). Adverse perinatal complications were also significantly higher in the C/U < 1.01 group, including low APGAR scores at 5th minute (68.0% vs 19.6%), NICU admissions (74.0% vs 21.4%), respiratory distress (60.0% vs 12.5%), and fetal growth restriction (18.0% vs 0.0%), compared to the C/U ≥ 1.01 group (all P values < 0.05).

Table 3: Diagnostic Accuracy Of C/U Ratio in Predicting Adverse Perinatal Outcomes

Diagnostic test (C/U ratio)	Perinatal outcome	
	Complicated (Bad)	**Uncomplicated (Good)**
C/U < 1.01	42 (77.8%) – TP	8 (15.4%) – FP
C/U ≥ 1.01	12 (22.2%) – FN	44 (84.6%) – TN
Statistic	**Value (95% CI)**	
Sensitivity	77.8% (64.4 – 87.9)	
Specificity	84.6% (71.9 – 93.1)	
Positive Predictive Value	46.2% (30.8 – 62.2)	
Negative Predictive Value	95.7% (93.1 – 97.4)	
Accuracy	83.6% (75.2 – 90.1)	

The diagnostic performance of the C/U ratio in predicting adverse perinatal outcomes is shown in the table. Using a cut-off of 1.01, the C/U ratio demonstrated a sensitivity of 77.8%, specificity of 84.6%, positive predictive value of 46.2%, negative predictive value of 95.7%, and overall accuracy of 83.6%, indicating that a C/U ratio below 1.01 is strongly associated with complicated perinatal outcomes while effectively identifying uncomplicated cases.

DISCUSSION

The diagnostic performance of the Middle Cerebral Artery to Umbilical Artery (C/U) Resistance Index Ratio in predicting adverse perinatal outcomes among pregnancies at a tertiary care hospital in Bangladesh. Abnormal C/U ratios, indicative of fetal hemodynamic compromise, pose significant risks to both maternal and neonatal health, necessitating timely detection and intervention. The findings highlight the strong association between low C/U ratios and complications such as low APGAR scores, NICU admissions, respiratory distress, and fetal growth restriction. These results emphasize the importance of using Doppler assessment as part of routine antenatal surveillance to identify at-risk fetuses and optimize perinatal outcomes.

The present study evaluated the diagnostic accuracy of the middle cerebral artery to umbilical artery (C/U) resistance index ratio in predicting adverse perinatal outcomes. ROC curve analysis demonstrated that different C/U ratio cut-offs yielded varying sensitivity and specificity, with the optimal threshold at 1.015, producing a sensitivity of 77.8% and specificity of 84.6%. These findings are consistent with previous studies assessing Doppler ratios as predictive tools. Shahinaj *et al.,*[15] reported high sensitivity and specificity of the MCA/UA pulsatility index in predicting stillbirth and adverse perinatal outcomes, emphasizing the strong discriminative power of such ratios. Similarly, Mhaske *et al.,*[16], in a prospective cohort of 30 growth-restricted fetuses, found that the MCA:UA PI ratio achieved the highest sensitivity (95%) and good specificity (77%) compared to UA PI or MCA PI alone, supporting the use of the ratio for early detection of fetuses at risk. The trend observed in the current study, where sensitivity increases with higher cut-off values while specificity varies moderately, further validates the clinical utility of the MCA/UA resistance index ratio as a reliable predictor of adverse perinatal outcomes in high-risk pregnancies.

Furthermore, a C/U ratio below 1.01 was strongly associated with adverse perinatal outcomes, with 84.0% of cases in the low C/U group experiencing complications compared to 21.4% in the higher C/U group (P < 0.0001). Low C/U ratios were also linked to significantly higher rates of low APGAR scores at the 5th minute (68.0% vs 19.6%), NICU admissions (74.0% vs 21.4%), respiratory distress (60.0% vs 12.5%), and fetal growth restriction (18.0% vs 0.0%), highlighting the predictive value of this Doppler index. These results align with Lakhkar *et al.,*[17], who reported that the MCA/UA systolic/diastolic ratio was the most sensitive index for predicting major perinatal adverse outcomes (83% sensitivity, 75% specificity), and Kamalarani *et al.,*[18], who emphasized that the cerebro-umbilical (C/U) ratio is a reliable predictor with high specificity (96%) for ratios below 1.08, demonstrating its role in

confirming perinatal complications when Doppler findings are abnormal.

The diagnostic performance of the C/U ratio in this study was reinforced by its sensitivity (77.8%), specificity (84.6%), positive predictive value (46.2%), negative predictive value (95.7%), and overall accuracy (83.6%). These findings are consistent with Bhardwaj *et al.,*[19], who reported that abnormal cerebroplacental (CPR) or its inverse (UCR) ratios were strongly associated with low APGAR scores, NICU admissions, neonatal hypoglycemia, and ventilatory support, with AUCs ranging from 0.76 to 0.85 for gestational age-adjusted scores. Likewise, Das *et al.,*[20] found that an MCA/UA ratio below 1 had a sensitivity of 72.97%, specificity of 95.24%, and high predictive values, concluding it was the best predictor among multiple Doppler parameters for adverse perinatal outcomes. Together, these studies and the current results underscore the reliability of the C/U ratio as a non-invasive and robust tool for early identification of fetuses at risk, enabling timely obstetric interventions and improved neonatal care.

Limitations of the study

The study had a few limitations:

- The study was conducted with a relatively small sample size, which may limit the generalizability of the findings to the broader population.
- As a single-center study based in one hospital in Dhaka, the results may not fully represent the national population or reflect variations in other regions.

CONCLUSION

The Middle Cerebral Artery to Umbilical Artery (C/U) resistance index ratio is a reliable predictor of adverse perinatal outcomes. A C/U ratio below the optimal cut-off of 1.01 was strongly associated with complicated perinatal outcomes, low APGAR scores, NICU admissions, respiratory distress, and fetal growth restriction. These findings support its use as a non-invasive tool for early identification of at-risk fetuses, facilitating timely intervention and improved neonatal care.

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