Original Article

Fetal Middle Cerebral to Uterine Artery Pulsatility Indices Ratios in Preeclampsia versus Normal Pregnancy

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ABSTRACT

Objectives: To assess the predictive value of MCA/uterine artery pulsatility indices (PI) ratio in the third trimester of pregnancy for anticipating adverse pregnancy outcomes in women with preeclampsia, comparing it to the CPR (MCA/umbilical artery PI ratio).

Study Design: A prospective study.

Patients and Methods: The research involved 50 preeclampsia cases and 50 healthy pregnancies or births that were more than 26 weeks old. All participants underwent comprehensive laboratory testing, comprising Urine analysis, CBC, liver function tests, and renal function testing. Additionally, ultrasonography examinations were carried out at Benha University Hospital during the study period.

Results: In the preeclampsia group, the mean MCA PI, MCA/UTA, and MCA/Umbilical artery PI were lower, while the mean uterine and umbilical artery PI were higher in contrast to control group, and these differences were statistically significant. Negative newborn results, such poor APGAR scores, preterm birth, NICU admission, SGA, and neonatal death, were all more prevalent in the preeclamptic group in contrast to control group, with significant differences variations observed. MCA/UTA ratio in pregnancies with preeclampsia demonstrated its effectiveness as a valuable predictor of adverse neonatal outcomes.

Conclusion: The Cerebro-Uterine (CU) ratio was notably different between the two groups, being less in preeclampsia cases in contrast to control group. Furthermore, it was significantly linked to poor neonatal results. in pregnancies affected by preeclampsia. The CU ratio displayed a commendable ability to predict adverse neonatal outcomes.

Key Words: Fetal middle cerebral artery, preeclampsia, pulsatility indices ratios, uterine artery.

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INTRODUCTION

Hypertensive disorders of pregnancy (HDPs) represent significant contributors to maternal morbidity and mortality on a global scale, with the greatest impact being felt in low- and middle-income countries (LMIC). Preeclampsia, eclampsia, and gestational hypertension are among several pregnancy-related diseases, manifesting as elevated blood pressure and a spectrum of multi-organ abnormalities, ranging from mild to severe[1].

A complex illness called preeclampsia is distinguished by a fast rise in blood pressure and existence of protein in the urine. or hypertension accompanied by substantial organic dysfunction occurring after the 20th week of pregnancy[2]. Preeclampsia affects a percentage ranging from 2% to 10% of pregnant women worldwide, while eclampsia affects a smaller fraction, between 0.03% and 0.05%. However, it is important to note that Preeclampsia is generally prevalent in studies, with rates ranging from 4.5 % to 23 %[3].

Doppler ultrasound serves as a valuable tool for evaluating blood flow velocity in uterine arteries, enabling the potential identification of women at an elevated risk of developing preeclampsia. Preeclampsia and unfavorable pregnancy outcomes have been linked to elevated uterine artery Doppler indices in both singleton and twin pregnancies[4].

With the onset of placental insufficiency, various alterations take place in fetal circulation, ultimately leading to a phenomenon known as "brain sparing." Blood flow is redirected in this process, giving critical organs like the brain, heart, and adrenals priority over organs like the spleen, kidneys, and peripheral circulation[5].

The ratio of the Middle Cerebral Artery's (MCA) Pulsatility Index to the Umbilical Artery (UA) yields the foetal cerebroplacental ratio (CPR)[6]. Combining the analysis of Doppler waveforms in both the MCA and UA) has been proposed as a practical clinical simplification. A decreased cerebroplacental ratio, which indicates a

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shift of cardiac output towards cerebral circulation, has been demonstrated to boost the accuracy of predicting unfavorable outcomes when compared to measuring MCA or UA Doppler alone[7].

Uterine artery Doppler assessment has been a focus of study in preeclampsia (PE) due to its role in reflecting the maternal vascular condition. This evaluation involves parameters like PI, Resistance Index (RI), and existence of an early diastolic notch (N)[8].

Furthermore, it has been demonstrated that the third trimester of high-risk pregnancies is a critical time for uterine artery Doppler examination, which offers information on placental perfusion and foetal health, while umbilical artery Doppler primarily indicates placental health[9]. It's worth noting that the cerebro-uterine (CU) ratio, which represents vascular impedance between the MCA and uterine arteries, is a relatively novel concept and hasn't been widely examined[5].

The purpose of this study was to examine the MCA/umbilical artery PI ratio and the CPR (the middle cerebral artery (MCA)/uterine artery P) ratio) for their ability to predict adverse pregnancy outcomes in pre-eclamptic women during the third trimester of pregnancy.

PATIENTS AND METHODS

Department of Obstetrics and Gynecology at Benha University carried out this prospective study. The study commenced in March 2022.

Study population

The research involved 50 cases of preeclampsia and 50 normal pregnancies at or beyond the 26th week of gestation. The participants were recruited from the obstetric clinics at Benha University Hospital during the study's duration.

Ethical consideration

An informed written consent was signed from each case that was included in the present study, Approval of ethical committee of Benha University was obtained, the aim of the study was explained to each participant before collection of data and Confidentiality of the data was assured.

Inclusion criteria

Inclusion criteria for this study require cases to meet specific conditions: maternal age within the range of 18 to 35 years, a gestational age of 26 weeks or beyond, and, for Group I, a diagnosis of preeclampsia according to well-defined criteria, including new-onset hypertension (≥140/90) along with one or more of the following: other maternal organ dysfunctions (renal insufficiency, hepatic involvement, neurological issues, haematological complications), proteinuria (≥300 mg/24 hours or a high spot urine protein/creatinine ratio), as well as uteroplacental dysfunction resulting in foetal growth limitation[10,11].

Exclusion criteria

The exclusion criteria encompass maternal systemic disorders (such as chronic hypertension, renal disease, CKD, DM, and IHD), a history of smoking, the use of medications during pregnancy except for iron supplements, and being in active labor or experiencing ruptured membranes.

Method

Laboratory tests

Laboratory investigations included a complete blood picture (CBC) assessing total leukocyte count (TLC), hemoglobin (Hb), and platelet count, along with measurements of aspartate aminotransferase (AST), serum creatinine (S.Creatinine), and serum urea (S.Urea). Urine analysis was also conducted.

Ultrasonography examinations

All cases underwent ultrasonographic examinations using the Volsun S10 machine from GE Healthcare, USA. Transabdominal sonographic assessments were carried out with a convex probe to determine fetal biometry, fetal weight, and amniotic fluid index (AFI). For the estimation of the Middle Cerebral Artery Pulsatility Index (MCA PI), an axial image of fetal head was acquired, and the circle of Willis was identified. The MCA, a significant anterolateral branch leading to the lateral orbital margin, was examined. The distance between the Doppler sample volume and its source was around 1 cm. Doppler velocity of uterine artery was measured at the location, where external iliac artery was crossed, cranial to the iliac artery's crossing point. The mean Pulsatility Index (PI) for both uterine arteries was calculated, with PI values exceeding the 95th percentile considered abnormal. The MCA to Uterine Artery (UTA) PI ratio and the MCA to Umbilical Artery (UA) ratio were determined. A score below the fifth percentile for the former was regarded abnormal, whereas a ratio of less than 1.08 suggested abnormalities or a brain-sparing impact for the latter.

Eligible cases were subjected to: For eligible cases, the evaluation encompassed a comprehensive history-taking process, covering personal history, obstetric history, past medical history, and the history of the current pregnancy. A thorough physical examination was conducted, involving the calculation of the BMI, measurement of blood pressure, assessment for signs of edema, and examination of the abdomen. Additionally, a series of investigations were performed, including abdominal ultrasonographic examinations and Doppler velocimetry studies, which involved Doppler velocimetry for the uterine artery, Doppler velocimetry for the umbilical artery, and Doppler velocimetry for the MCA.

Follow up and outcomes: Patients and controls were tracked through delivery, and the results of the perinatal outcome analysis were compared to those of the pregnancy and the newborn.

Statistical Analysis

Data were organized into tables following collection, and data analysis was conducted using SPSS version 23. Continuous parametric variables were displayed as means with their corresponding standard deviations. Categorical variables were expressed as frequencies and percents. Chi-square test used and ROC curve was also performed. Statistical significance was defined by a probability (*P*) value of ≤0.05.

RESULTS

BMI, gravidity, Age, parity, and gestational age did not significantly vary between the two groups. However, systolic and diastolic blood pressure levels differed significantly. There were no discernible variations in haemoglobin levels, mean corpuscular volume, mean corpuscular haemoglobin, or red blood cell distribution width. Nevertheless, preeclampsia group had lower haemoglobin concentrations and platelet counts while having greater levels of white blood cell count, serum glutamic pyruvic transaminase, urea, and creatinine. Persistent uterine notch was significantly more prevalent in the Pre-eclampsia group (12%). Pre-eclampsia group had a significantly lower mean amniotic fluid index (AFI).

In urine analysis, Pre-eclampsia group had significantly higher mean specific gravity and albumin level (Table 1).

In terms of pregnancy and neonatal outcomes, pre-eclampsia patients had birth weight, 5-minute Apgar scores, and gestational age at delivery that were all considerably lower than those in control group. Additionally, pre-eclampsia group had significantly higher rates of cesarean sections, perinatal death, preterm births, NICU admissions, and small-for-gestational-age infants. Furthermore, pre-eclampsia group had significantly higher rates of acidemia and assisted ventilation at birth (Table 2).

Regarding Doppler indices, significant variances were between the two groups. Umbilical and uterine artery indices were significantly greater in pre-eclampsia group in contrast to control group, but middle cerebral artery indices were significantly lower (Table 3)

Doppler ultrasound images showing normal and abnormal values of Doppler indices were illustrated in (Figures 1,2,3,4,5,6).

Regarding the association between normal and abnormal MCA/UA ratio and MCA/UTA ratio with adverse neonatal results, Sixteen Patients with preeclampsia had abnormal CP ratios and thirty-four patients had normal CP ratios. Twenty-one Patients with preeclampsia had abnormal CU ratios and twenty-nine patients had normal CP ratios. Abnormal CU ratios were greater than CP ratios in their odds ratios in prediction of perinatal death (4.558 vs 2.604) and SGA (7.897 vs 2.915) (Table 4).

ROC curves showed the predictabilities of MCA/UTA and MCA/UA ratios regarding neonatal outcomes. MCA/UTA and MCA/UA ratio both had ability to predict unfavorable outcomes according to sensitivity, specificity, PPV, NPV and accuracy (Table 5; Figures 7,8),

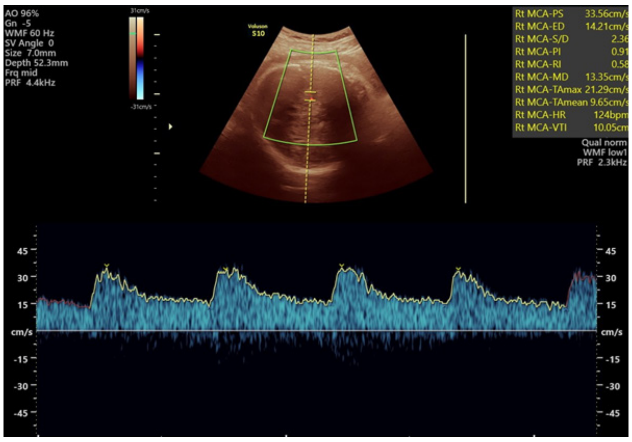

Fig. 1: Abnormal MCA Doppler, MCA PI = 0.91, MCA RI =0.5

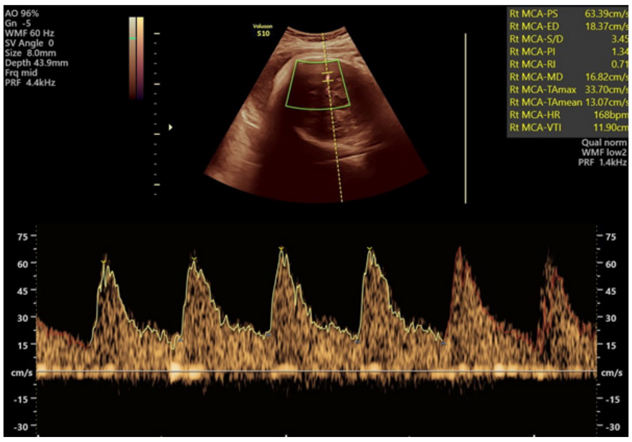

Fig. 2: Middle cerebral artery Doppler with high systolic peak velocity normal indices, MCA PI = 1.34, MCA RI =0.7

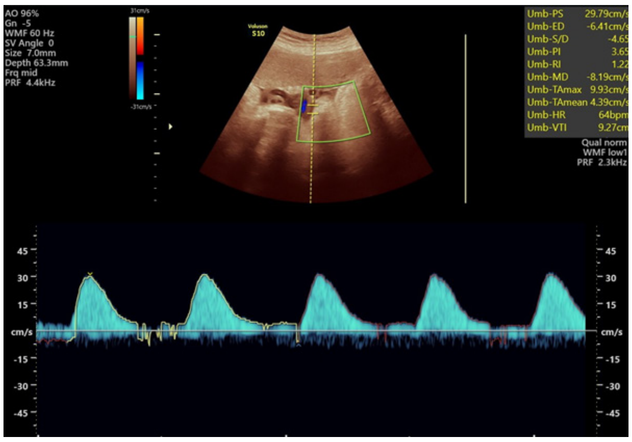

Fig. 3: Abnormal umbilical blood flow Umb-PI =3.65, Umb-RI=1.22

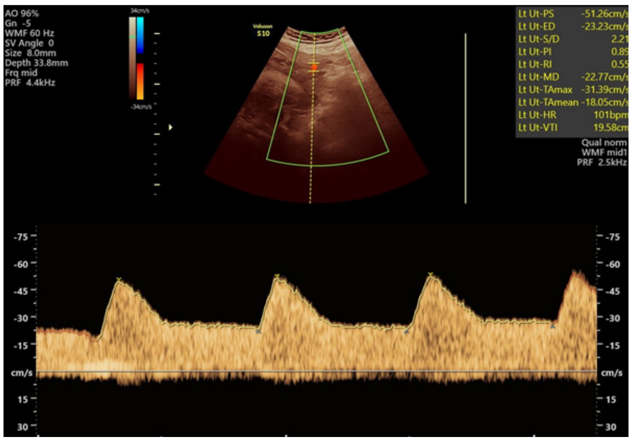

Fig. 6: Normal uterine artery Doppler. UTA-PI=0.89, UTA-RI=0.55

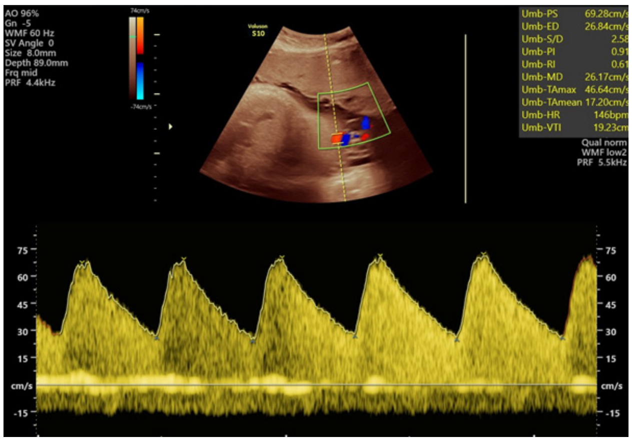

Fig. 4: Normal umblical artery Doppler with normal diastolic blood flow in 36 week gestation Umb-PI =0.91,Umb-RI=0.61

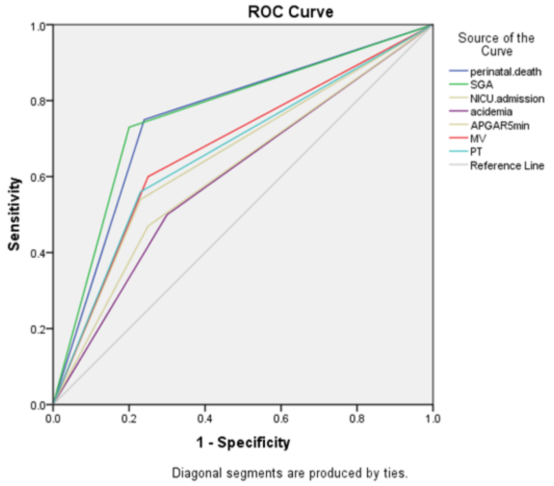

Fig. 7: Predictive ability of MCA to UA ratio in relation to neonatal outcome

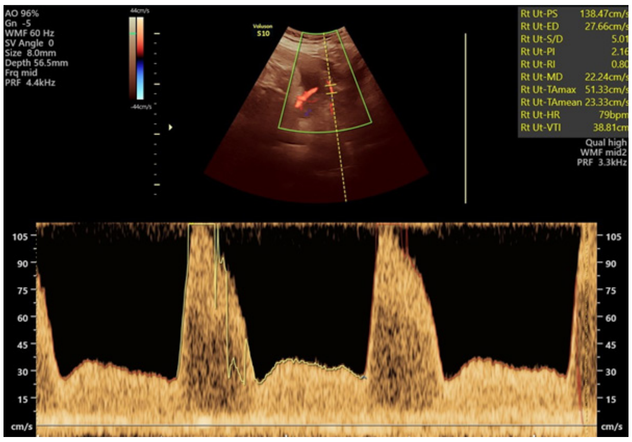

Fig. 5: Uterine artery Doppler with high PI and persistent uterine notch UTA-PI=2.16, UTA-RI=0.80

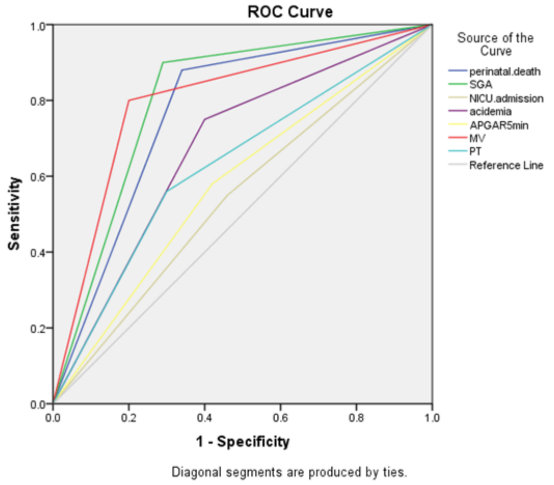

Fig. 8: ROC curve for Predictive ability of MCA to UTA ratio in relation to neonatal outcome

Table 1: Comparison between two groups regards to demographic, laboratory and ultrasonography data

	Pre-Eclampsia Group (n=50)	Control (n=50)	*P. Value*
Age (years)	27.33 ± 4.05	26.64 ± 3.02	0.33648
BMI (kg/m2)	27.38 ± 1.95	27.42 ± 1.92	0.91778
Gravidity	2.38 ± 1.01	2.34 ± 1.06	0.84719
Parity	1.34 ± 0.98	1.28 ± 1.01	0.76399
SBP (mmHg)	149.44 ± 4.20	121.2 ± 9.66	<0.0001*
DBP (mmHg)	94.76 ± 3.24	79.98 ± 6.68	<0.0001*
GA (weeks)	28.96 ± 2.45	29.20 ± 2.56	0.6351
HB gm/dl	10.76 ± 1.02	10.91 ± 0.82	0.437
HCT%	34.49 ± 1.09	35.23 ± 1.03	0.001*
MCV (fl)	80.54 ± 3.33	80.5 ± 2.37	0.946
MCH (pg)	26.64 ± 1.72	26.7 ± 1.46	0.867
RDW%	14.31 ± 0.71	14.42 ± 0.73	0.449
WBCs thousand/mm^3	10.5 ± 0.99	10.09 ± 0.71	0.020*
Platelets thousand/mm^3	227.28 ± 27.08	370.3 ± 37.32	<0.0001*
SGPT	35.96 ± 8.27	30.90 ± 8.02	0.003*
Creatinin mg/dl	0.93 ± 0.10	0.80 ± 0.09	<0.0001*
Urea mg/dl	25.44 ± 2.82	22.44 ± 2.59	<0.0001*
Presistent uterine notch	6 (12%)	0 (0%)	0.012*
AFI	6.88 ± 2.32	13.90 ± 1.96	<0.0001*
Specific gravity of Urine analysis	1.03 ± 0.02	1.01 ± 0.01	<0.0001*
Albumin Level (mg/dl)	32.48 ± 12.92	14.42 ± 5.06	<0.0001*

BMI: Body Mass Index, GA: Gestational Age. SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure. HB: Hemoglobin, HEMATOCRIT%: Hematocrit percentage, MCV: Mean Corpuscular Volume, MCH: Mean Corpuscular Hemoglobin, RDW%: Red Cell Distribution Width percentage, WBCs: White Blood Cells, pltt: Platelets, SGPT: Serum Glutamic Pyruvic Transaminase, scr: Serum Creatinine. *P<0.05 statistically significant.

Table 2: Adverse neonatal outcomes in preeclamsia and control group

		Pre-Eclampsia Group (n=50)	Control (n=50)	*P. Value*
Mode of delivery	Vaginal	12 (24%)	19 (38%)	<0.0001*
	CS	38 (76%)	31 (62%)	
GA at delivery (weeks)		35.18 ± 1.2	37.98 ± 1.22	<0.0001*
Birth weight (gm)		2259.38 ± 662.41	3285.86 ± 531.02	<0.0001*
5 min APGAR score		7.7 ± 1.27	9.2 ± 0.5	<0.0001*
Perinatal death		7 (14%)	1 (2%)	0.027*
Preterm birth		22 (44%)	3 (6%)	<0.0001*
NICU admission		18 (36%)	3 (6%)	0.0002*
SGA		11 (22%)	1 (2%)	0.002*
Acidemia		4 (8%)	0 (0%)	0.041*
Assisted ventilation		10 (20%)	1 (2%)	0.00371*

CS: Cesarean section. APGAR score: Apgar score is a system of evaluating the physical condition of a newborn infant immediately after delivery, NICU: Neonatal Intensive Care Unit, SGA: Small for Gestational Age. Acidemia: low PH in arterial blood gas, Assisted ventilation: Mechanical ventilation, *P<0.05 statistically significant.

Table 3: Comparison of Doppler parameters between preeclamptic and control group

	Pre-Eclampsia Group (n=50)	Control (n=50)	*P. Value*
MCA PI	1.21 ± 0.19	1.63 ± 0.19	<0.0001*
MCA RI	0.71 ± 0.04	0.83 ± 0.05	<0.0001*
UA PI	1.24 ± 0.34	0.92 ± 0.09	<0.0001*
UA RI	0.70 ± 0.16	0.47 ± 0.05	<0.0001*
LT UTA PI	1.12 ± 0.20	0.84 ± 0.07	<0.0001*
LT UTA RI	0.67 ± 0.07	0.64 ± 0.03	0.00255*
RT UTA PI	1.33 ± 0.17	0.86 ± 0.12	<0.0001*
Rt UTA RI	0.74 ± 0.05	0.6 ± 0.03	<0.0001*
Mean UTA PI	1.22 ± 0.15	0.85 ± 0.08	<0.0001*
MCA/UA ratio	0.97 ± 0.23	1.77 ± 0.27	<0.0001*
MCA/UTA ratio	0.99 ± 0.17	1.91 ± 0.30	<0.0001*

MCA PI: Middle Cerebral Artery Pulsatility Index, MCA RI: Middle Cerebral Artery Resistance Index, UA PI: Umbilical Artery Pulsatility Index, UA RI: Umbilical Artery Resistance Index, LT UTA PI: Left Uterine Artery Pulsatility Index, LT UTA RI: Left Uterine Artery Resistance Index, RT UTA PI: Right Uterine Artery Pulsatility Index, rt UTA RI: Right Uterine Artery Resistance Index, *P<0.05 statistically significant.

Table 4: Relationship of adverse neonatal outcomes and abnormalities in Doppler indices in preeclamptic group (n=50)

	MCA/UA ratio					MCA/UTA ratio				
	Abnormal N=16		Normal N=34		OD	Abnormal N=21		Normal N=29		OD
	N	%	N	%		N	%	N	%	
Low 5 min APGAR score	8	50	9	26.5	1.431	10	47.6	7	24.1	1.610
Perinatal death	5	31.2	2	5.8	2.604	6	28.5	1	3.4	4.558
Preterm birth	9	56.2	13	38.2	1.269	12	57.1	10	34.4	1.493
NICU admission	8	50	10	29.4	1.350	11	52.3	7	24.1	1.768
SGA	8	50	3	8.8	2.915	10	47.6	1	3.4	7.897
Acidemia	2	12.5	2	5.9	1.391	2	9.5	2	6.9	1.174
Assisted ventilation	6	37.5	4	11.8	1.875	7	33.3	3	10.3	2.167

Table 5: Overall Performance of MCA/UA ratio and MCA/UTA ratio anticipating perinatal outcome

	MCA/UA ratio					MCA/UTA ratio				
	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Perinatal death	71.4	74.4	31.1	94.1	74	85.7	65.1	28.6	96.5	68
SGA	72.7	79.5	50	91.2	78	90.9	71.8	47.6	96.5	76
Preterm birth	40.1	75	56.2	61.8	60	54.5	67.9	57.1	65.5	62
NICU admission	44.4	75	50	70.6	64	61.1	68.8	52.4	75.8	66
Acidemia	50%	69.6	12.5	94.1	68	50	58.7	9.5	93.1	58
APGAR score5 min	47.1	75.6	50.0	73.5	66	58.8	66.7	47.6	75.8	64
Assisted ventilation	60	75	37.5	88.2	72	70	65	33.3	89.6	66

DISCUSSION

Pregnant women with hypertensive disorders are often diagnosed when their systolic blood pressure is at least 140 mmHg and their diastolic blood pressure is at least 90 mmHg. These values must be validated at least twice, at least six hours apart. Gestational hypertension, pre- and eclampsia are three clinical conditions included in these illnesses. Pregnancy-induced hypertension was shown to be common (4.2%) in a prior study conducted in Egypt. Preeclampsia and eclampsia were also common (3.8%) and (0.3%), respectively[12].

Preeclampsia is closely associated with negative effects on both mother and baby, including conditions such as IUGR, placental abruption, and stillbirth[13].

In third trimester of high-risk pregnancies, Doppler indices of the UTA serve as valuable indicators for assessing both placental perfusion and fetal well-being. This makes UTA Doppler a more beneficial tool compared to umbilical artery (UA) Doppler, which primarily focuses on evaluating placental pathology[14].

Our findings indicate that when considering patient demographic data, there are no significant differences in relation to age, BMI, gravidity, parity, or gestational age between the two groups. However, a significant distinction exists in the levels of systolic and diastolic blood pressure between the two groups.

Our findings point to considerably higher systolic and diastolic blood pressure readings in the pre-eclamptic group when compared to the control group, which is in agreement with Nasr *et al*. On the other hand, they reported noticeably higher gestational age readings[15].

Other blood parameters, such as red blood cell distribution width, mean corpuscular volume, mean corpuscular haemoglobin, and haemoglobin levels, did not substantially vary between the two groups. In contrast to control group, preeclampsia group had lower hematocrit levels and platelet counts, but greater levels of white blood cell counts, serum glutamic pyruvic transaminase, urea, and creatinine.

Our results align with the results of El Nagar *et al*., who observed that levels of serum creatinine, urea, ALT, and AST were all significantly higher in the preeclampsia group [1.170.22 mg/dL, 44.887.73 mg/dL, 50.5917.83 IU/L, and 44.3619.23 IU/L, respectively] than in the control group [0.870.14 mg/dL, 11.124.68 mg/dL, 28.077.81 IU/L][16].

Our results show significant differences in Doppler indices between preeclampsia and control groups. Specifically, MCA PI, MCA resistance index, MCA/umbilical artery ratio, and MCA uterine artery ratio are lower in preeclampsia group, while umbilical artery PI, umbilical artery resistance index, left uterine artery PI, left uterine artery resistance index, and right uterine artery PI, right uterine artery resistance index are greater in preeclampsia group.

Our results support those of Eser *et al*., who found that uterine artery PI and Umbilical artery PI in preeclampsia group were significantly greater than control group but the middle cerebral PI in preeclampsia group was lower than in the control group. The MCA/umbilical artery PI ratios in preeclampsia group (mean =1.21) was lower than in control group (mean =1.89), also the MCA/uterine artery PI in preeclampsia group (mean =1.09) was lower than in the control group (mean =2.04)[17].

Our results revealed that, in relation to pregnancy and neonatal outcomes, the pre-eclampsia group had notably lower gestational age at delivery, birth weight, and 5-minute Apgar scores in contrast to control group. Conversely, the pre-eclampsia group exhibited significantly higher frequencies of cesarean sections, perinatal mortality, preterm deliveries, NICU admissions, and infants classified as small for their gestational age. Additionally, the rates of acidemia and the need for assisted ventilation at birth were significantly elevated in pre-eclampsia group in contrast to control group.

These outcomes are consistent with the findings reported by Zarean *et al*., who observed marked disparities between the two groups when it comes to unfavourable perinatal events, low birth weight, caesarean deliveries, and 5-minute Apgar scores (P 0.05). However, they also noted that certain factors, such as the incidence of perinatal mortality, NICU admissions, the existence of acidemia, and the occurrence of seizures, did not exhibit significant variations between groups ($P > 0.05$)[18].

In this study, Pre-eclampsia group had a notably greater prevalence of persistent uterine notches (12%) compared to control group, and this dissimilarity was found to be statistically significant. Furthermore, the Pre-eclampsia group displayed a significantly lower mean value for the Amniotic Fluid Index (AFI) in contrast to control group (6.88 ± 2.32 vs. 13.90 ± 1.96; $p < 0.00001$).

Our outcomes support those of El Nagar *et al*., who observed that the mean AFI in preeclampsia cases was 9.16 ± 2.42, whereas in the control group, it was 13.11 ± 5.40. These findings suggest that AFI levels were greater in control group than in the preeclampsia group. Additionally, the Pre-eclampsia group had a significantly higher proportion of persistent uterine notches (81%) in comparison to control group (8%), and this distinction was statistically significant ($p < 0.00001$)[16].

Our findings indicate that, concerning urine analysis, Pre-eclampsia group exhibited a significantly higher mean specific gravity and albumin level when compared to control group ($p < 0.0001$). It was determined that this difference was statistically significant.

Our findings, however, contrast from those of Ebrashy *et al*., who found no changes between the foetuses of women with preeclampsia and those in the control group in terms of the foetal biophysical profile, middle cerebral artery resistance index, or umbilical artery resistance index[19].

In relation to the association between normal and abnormal Cerebro-Placental ratio and Cerebro-Uterine ratio with neonatal adverse outcomes, our results revealed that OR for abnormal MCA/UTA ratio was greater than the OR of MCA/UA ratio in predicting perinatal death (4.558 vs. 2.604) and small-for-gestational-age (SGA) (7.897 vs.

2.915), indicating a greater predictability of MCA/UTA ratio over MCA/UA ratio for adverse neonatal outcomes.

Our findings are comparable to those of Eser *et al*., who also reported a higher predictability of MCA/UTA ratio compared to MCA/UA ratio for adverse neonatal outcomes[17].

In Abdelrazik *et al*.'s study, Middle cerebral artery (MCA) / umbilical artery (UA) PI ratio for prediction of NICU admission was specificity 71.43%, (NPV) 90.91% and the accuracy 70%. On the other hand prediction of low Apgar score at 5 min was 50% sensitivity and PPV 44.44%. Prediction of low UA PH was 69.05% specificity and NPV 86.57%[20].

In the investigation by Adiga *et al*., the MCA/UA ratio exhibited a sensitivity of 30.4%, specificity of 80.6%%, a PPV of 33.3%, NPV of 78.4%, and an accuracy of 68.9% in predicting the need for assisted respiration. MCA/UTA ratio exhibited MCA/UTA ratio had 52.2% sensitivity, 63.9% specificity, 31.6% PPV, 80.7% NPV and 61.1% accuracy[5].

In Eser *et al*. study, MCA/UTA exhibited prediction for SGA (sensitivity47.8%, specificity 57.9%, NPV 72.9%), While for preterm birth (sensitivity 55.1%, specificity 97%, NPV 19%, PPV 96%).

Our results indicate that the MCA/UTA ratio displayed various levels of sensitivity, specificity, PPV, NPV, and accuracy in predicting different neonatal outcomes. Notably, it showed strong sensitivity and specificity in predicting SGA and NICU admission, but the results varied for other outcomes.

Our findings align with those of Adiga *et al*.[5] who reported similar predictive values for the MCA/UTA ratio in different neonatal outcomes. In Eser *et al*.'s study, the MCA/UTA ratio exhibited sensitivity and specificity in predicting NICU admission, Apgar scores, SGA, and preterm birth[17].

Our findings are incongruent with the results obtained by Simanaviciute and her team. According to their research, a reduced MCA/uterine artery PI ratio did not demonstrate any significant association with the presence of SGA newborns in this particular scenario. Furthermore, their findings indicated that the MCA/umbilical artery PI ratio did not exhibit an independent correlation with preterm births. Moreover, neither of these ratios was found to be independently linked with operative deliveries, immediate cesarean sections, or admissions to the NICU[21].

CONCLUSIONS

The Cerebrouterine (CU) ratio shows a clear distinction between the two groups, with the preeclampsia group having a lower ratio than the control group. Furthermore, it has a considerable correlation with poor neonatal outcomes in pregnancies with preeclampsia. The CU ratio exhibits a considerable predictive ability for adverse neonatal outcomes.

CONFLICT OF INTERESTS

There are no conflicts of interest.

REFERENCES

1. Antwi E, Amoakoh-Coleman M, Vieira DL, *et al*. Systematic review of prediction models for gestational hypertension and preeclampsia. PLoS One. 2020;15(4):e0230955.

2. da Silva WA, Pinheiro AM, Lima PH, *et al*. Renal and cardiovascular repercussions in preeclampsia and their impact on fluid management: a literature review. Braz J Anesthesiol. 2021 Jul-Aug;71(4):421-428.

3. Logan G, Njoroge P, Nyabola L, *et al*. Determinants of preeclampsia and eclampsia among women delivering in county hospitals in Nairobi, Kenya. F1000Res; 2020.

4. Springer S, Polterauer M, Stammler-Safar M, *et al*. Notching and Pulsatility Index of the Uterine Arteries and Preeclampsia in Twin Pregnancies. J Clin Med. 2020 Aug 15;9(8).

5. Adiga P, Kantharaja I, Hebbar S, *et al*. Predictive value of middle cerebral artery to uterine artery pulsatility index ratio in hypertensive disorders of pregnancy. Int J Reprod Med. 2015;2015:614747.

6. Sherrell H, Clifton V, Kumar S. Predicting intrapartum fetal compromise at term using the cerebroplacental ratio and placental growth factor levels (PROMISE) study: randomised controlled trial protocol. BMJ Open. 2018 Aug 13;8(8):e022567.

7. Abd Rabou IB, Mohammed HA, Mohamed H. Correlation between Cerebroplacental ratio and umbilical artery Doppler with pregnancy outcome in postdates. Evidence Based Women's Health Journal. 2020;10(1):112-120.

8. Lopez-Mendez MA, Martinez-Gaytan V, Cortes-Flores R, *et al*. Doppler ultrasound evaluation in preeclampsia. BMC Res Notes. 2013 Nov 19;6:477.

9. Zhou S, Guo H, Feng D, *et al*. Middle Cerebral Artery-to-Uterine Artery Pulsatility Index Ratio and Cerebroplacental Ratio Independently Predict Adverse Perinatal Outcomes in Pregnancies at Term. Ultrasound Med Biol. 2021 Oct;47(10):2903-2909.

10. Tranquilli AL, Dekker G, Magee L, *et al*. The classification, diagnosis and management of the hypertensive disorders of pregnancy: A revised statement from the ISSHP. Pregnancy Hypertens. 2014 Apr;4(2):97-104.

11. Wisner K. Gestational Hypertension and Preeclampsia. MCN Am J Matern Child Nurs. 2019 May/Jun;44(3):170.

12. Amaral LM, Wallace K, Owens M, *et al*. Pathophysiology and Current Clinical Management of Preeclampsia. Curr Hypertens Rep. 2017 Aug;19(8):61.

13. Dymara-Konopka W, Laskowska M, Oleszczuk J. Preeclampsia - Current Management and Future Approach. Curr Pharm Biotechnol. 2018;19(10):786-796.

14. Ukah UV, Hutcheon JA, Payne B, *et al*. Placental Growth Factor as a Prognostic Tool in Women With Hypertensive Disorders of Pregnancy: A Systematic Review. Hypertension. 2017 Dec;70(6):1228-1237.

15. Nasr LE, Mohamed AH, Abd El Maksoud KA, *et al*. Evaluation Of Middle Cerebral/Umbilical Artery Resistance And Pulsatility Indices Ratio As Predictors Ffor Fetal Well-Being And Neonatal Outcome In Preeclampsia With Or Without Intrauterine Growth Restriction. Journal of Pharmaceutical Negative Results. 2023:2413-2426.

16. El Nagar MMM, El Sheikha KZ, Sedek AAMAE. Measurement of Third-Trimester Uterine Artery Doppler for Evaluation of Maternal Postpartum Outcome among Patients with Severe Pre-Eclampsia. International Journal of Medical Arts. 2023;5(6):3360-3372.

17. Eser A, Zulfıkaroglu E, Eserdag S, *et al*. Predictive value of middle cerebral artery to uterine artery pulsatility index ratio in preeclampsia. Arch Gynecol Obstet. 2011 Aug;284(2):307-11.

18. Zarean E, Azami N, Shahshahan Z. Predictive Value of Middle Cerebral Artery to Umbilical Artery Pulsatility Index Ratio for Neonatal Outcomes in Hypertensive Disorders of Pregnancy. Adv Biomed Res. 2022;11:46.

19. Ebrashy A, Azmy O, Ibrahim M, *et al*. Middle cerebral/umbilical artery resistance index ratio as sensitive parameter for fetal well-being and neonatal outcome in patients with preeclampsia: case-control study. Croat Med J. 2005 Oct;46(5):821-5.

20. Abdelrazik Abdelfattah AH, Mohammed Moustafa T, Mohammed Taha E-S. The value of middle cerebral to umbilical artery Doppler ratio in the prediction of neonatal outcome among women with pregnancy induced hypertension. Al-Azhar Medical Journal. 2020;49(4):1713-1722.

21. Simanaviciute D, Gudmundsson S. Fetal middle cerebral to uterine artery pulsatility index ratios in normal and pre-eclamptic pregnancies. Ultrasound Obstet Gynecol. 2006 Nov;28(6):794-801.