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Prediction of Fetal and Neonatal Outcome in Preeclamptic Women by Middle Cerebral to Uterine Artery Pulsatility Index Ratio

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Abstract

Background: Preeclampsia presents substantial dangers to the health of both mother and child, calling for accurate indicators of potential negative consequences. Using the middle cerebral to uterine artery pulsatility index ratio, this research sought to predict foetal and neonatal outcomes in women with preeclampsia. The purpose of this prospective study was to examine the relationship between foetal and neonatal outcomes and pulsatility index ratios in fifty preeclamptic patients utilising Doppler tests and other evaluations. To find out if there was a correlation between normal and abnormal ratio cases and factors like foetal weight, gestational age, intrauterine growth restriction (IUGR), preterm labour, caesarean section (CS), Apgar scores, and admissions to the Neonatal Intensive Care Unit (NICU), statistical analyses were performed. The results showed that in preeclampsia cases, around 40.4% had aberrant middle cerebral to umbilical artery ratios (<1.58) and about 38.3% had abnormal middle cerebral to uterine artery pulsatility index ratios (<2.3). Lower foetal weight ($p < 0.05$), reduced gestational age at examination and delivery ($p < 0.05$), higher rates of intrauterine growth restriction (IUGR) ($p < 0.05$), preterm birth ($p < 0.05$), and increased central semen (CS) ($p < 0.05$) were all substantially linked with abnormal ratios. Nevertheless, no discernible disparities were seen in Apgar scores below 7 at 5 minutes or in the admission to the NICU ($p > 0.05$). Results: Abnormal ratios of the middle cerebral artery to the umbilical artery pulsatility index were associated with lower foetal weight, earlier gestational age, increased rates of intrauterine growth restriction (IUGR), and preterm birth. These findings suggest that these indexes may be useful as predictive markers for adverse outcomes in preeclampsia.

Keywords: Preeclampsia; Topics covered include: Doppler studies, foetal outcomes, neonatal outcomes, intrauterine growth restriction, predictive markers, and the pulsatility index ratio.

1. Introduction

Preeclampsia is a major cause for worry during pregnancy; it affects between 5–10% of pregnant women and poses a serious risk to the health of the mother and the unborn child. Perinatal morbidity and death rates are greatly impacted by its enormous impact on maternal mortality worldwide. The precise processes that induce preeclampsia are still unknown, despite continuous investigation [1].

But our knowledge is expanding to show that endothelial cell dysfunction after placentation is a major factor in its development. An early element in its formation is the poor invasion of trophoblasts, which leads to placental ischemia as a result of insufficiently dilated uterine spiral arteries. Impaired foetal hemodynamics and reduced uterus-placental perfusion are two ways in which preeclampsia is worsened by vascular endothelial injury and the subsequent vasospasm [2].

Preeclampsia has far-reaching consequences that affect the health of the foetus, not only the mother. A compensatory reaction known as the "foetal brain-sparing effect" is triggered when this situation causes foetal hypoxia. This system prioritises the blood supply to the heart, brain, and adrenal glands during pregnancy, at the expense of the kidneys, intestines, and lower extremities. Fetal physiology reacts complexly to reduced placental blood flow, as shown in animal and human investigations of this adaptive response [3].

Antepartum monitoring can distinguish the clinical signs of preeclampsia, which may progress to IUGR, oligohydramnios, and placental abruption, among other problems. In order to manage preeclamptic pregnancies and reduce the risk of severe difficulties and intrauterine foetal death, the timing of the delivery is crucial. It is crucial to identify the fraction of foetuses who are at risk of being born with a failing growth potential, which is indicated by intrauterine growth restriction (IUGR). Uteroplacental insufficiency is one of the potential causes of this disorder, which is the pathological analogue of small for gestational age (SGA) babies [4].

Noninvasive Doppler ultrasonography provides invaluable information about foetal circulation, making it an indispensable tool for the evaluation and management of complex pregnancies. In high-risk instances in particular, it helps in predicting unfavourable perinatal outcomes. Prenatal monitoring techniques that use Doppler velocimetry of the umbilical, foetal, and uteroplacental veins and capillaries are well-established. These methods help with differential diagnosis and therapeutic intervention planning by allowing early detection of impaired foetuses [5].

Doppler ultrasonography is useful for evaluating the foetal state and any problems by analysing the blood flow patterns in various arteries, including the umbilical arteries and the middle cerebral artery (MCA). Preeclampsia and gestational hypertension are indicators of placental pathology and adaptive alterations in foetal circulation that may be used to predict newborn outcomes when the ratio of the pulsatility indices (PI) of the MCA and umbilical artery is high enough [6].

Using the middle cerebral to uterine artery pulsatility index ratio, this research sought to predict foetal and neonatal outcomes in women with preeclampsia.

2. Subjects and Approaches

Patients:

Fifty pregnant patients admitted to Benha University Hospital on a prospective basis between 2022 and 2024 were included in the research. Preeclampsia, with or without intrauterine growth restriction, was a complicating factor in these pregnancies (IUGR). Following the birth, clinical data and the results of the pregnancy were retrieved from the hospital records. Dates of menstruation or ultrasound performed during the first trimester verified the gestational age.

The Research Ethical Committee of Benha University gave its support to the project.

I followed the criteria laid down by the Helsinki Declaration and was a member of the medical faculty. Each participant gave their informed permission before blood samples were taken. Patients were able to discontinue participation in the trial at any moment without penalty, and the confidentiality of their information was preserved throughout the whole process. All of the data that was gathered was utilised just for this research.

Methods:

A battery of tests and evaluations were administered to the subjects of the study:

Participating pregnant women were asked to verbalise their agreement. As part of a comprehensive medical history, we verified the patient's age, gestational age, and parity. During the first 28–40 weeks of gestation, cases were chosen at random. Medical evaluations, including obstetric and general health checks, were carried out. Comprehensive blood work, testing for liver and kidney function, and analysis of urine were all part of the laboratory inquiry.

The following parameters were measured: gestational age, foetal biometry, biophysical profile, amniotic fluid index, and intrauterine growth rate (IUGR) using ultrasound and doppler investigations.

Doppler tests assessed pulsatility in the umbilical, uterine, and middle cerebral arteries, among others. Blood pressure and proteinuria levels were the main indicators used to diagnose preeclampsia.

Conditions such as gestational diabetes, chromosomal abnormalities, and twin pregnancies were used to exclude participants. Until delivery, the participants were observed at regular intervals using Doppler flow measurements. In order to determine the foetal and uterine health, the Doppler examination used specialised methods to measure blood flow in different arteries.

These Doppler scans were linked to pregnancy and neonatal outcomes including birth weight, delivery method, Apgar scores, small-for-gestational-age babies, and NICU hospitalisation (NICU). Also, in order to make sure that the measurements and evaluations were precise, foetal ultrasonography and Doppler examinations were carried out utilising specified procedures and equipment.

At 1 and 5 minutes after birth, the neonate's vitals (heart rate, breathing rate, facial expressions, and overall look) were assessed using the Apgar score. Certain criteria were used to identify adverse newborn outcomes, such as an Apgar score below 7 at 5 minutes, admission to the neonatal intensive care unit (NICU), or death of the neonate, whether it happened during pregnancy or soon after delivery. The goal of these evaluations was to look at the effects of Doppler results on the baby and the pregnancy in depth.

A statistical analysis:

The data is reported either as the number of instances or as the mean plus or minus the standard deviation. The Chi-square (X^2) test was used to compare proportions, whereas the independent t-test was used to compare means. When relevant, the Fisher's exact test was used. How well a test can detect sick people (its sensitivity) and how well it can identify healthy people (its specificity) are two different metrics (true negative rate). The Positive Predictive Value (PPV) is the percentage of actual positive instances, whereas the Negative Predictive Value (NPV) is the percentage of actual negative cases that are accurately detected. The Statistical Package for the Social Sciences was used to perform the statistical analysis (SPSS, version 15). To determine significance, a P-value less than 0.005 was used as the limit.

3. Findings

With a standard variation of ±4.23, the maternal age shows an average of 26.23 years. Primiparous (29 people) and multiparous (60 people) individuals make up the group (21 individuals). The standard deviations for moderate preeclampsia (143 mmHg) and severe preeclampsia (149 mmHg) are ±12.64 and ±16.89, respectively, as shown by the systolic blood pressure. Differentiating moderate preeclampsia (91.67 mmHg) from severe preeclampsia (97.67 mmHg) is also shown by diastolic pressure, with ±6.99 and ±11.04 standard deviations, respectively. With a standard variation of ±1.61, the average gestational age during examination is 29.4 weeks.

Therefore, out of the total instances of preeclampsia, 19 (or 38.3%) had an abnormal (<2.3) MCA/uterine artery PI ratio and 31 (or more than 2.3) were considered normal. A total of 30 instances were considered normal, whereas 20 cases with preeclampsia showed an abnormal MCA/umbilical artery PI ratio (<1.58), accounting for 40.4% of the cases.**Table 1**

Table (2): Case comparisons based on PI (MCA/umbilical artery ratio and PI (MCA/uterine artery ratio)), PI (MCA/uterine artery proportion) and PI (MCA/umbilical artery proportion) distribution

	Cases						
	Mean		**±SD**	**t**		**P**	**Sig.**
PI (MCA/umbilical artery ratio	1.62		±0.34	16.47		<0.001	HS
PI (MCA/uterine artery ratio	1.82		±0.31	12.54		<0.001	HS
Groups	**Percentiles**						
	1	4	5	3	4	2	31
Pre-eclampsia	1.28	1.43	1.48	1.82	2.02	2.25	2.40
	5	10	5	12	7	3	8
Pre-eclampsia	1.02	1.16	1.43	1.63	1.77	1.95	2.40

Using Student's t test, a ratio of less than 2.3 for the MCA/uterine artery PI and less than 1.58 for the MCA/umbilical artery PI were considered abnormal.

There Regarding the distribution of aberrant PI MCA/uterine artery and PI MCA/umbilical artery ratios, there was no statistically significant difference between moderate and severe preeclampsia (P > 0.05). Unfortunately, the correlation between severe preeclampsia and aberrant PI was not statistically significant (P = 0.18). Second Table

Table 2: Ratios of PI MCA to uterine and umbilical arteries, as compared to moderate and severe preeclampsia

		Pre-eclampsia						
		Mild (25)		**Severe (25)**		χ^2	**P**	**Sig.**
		N	**%**	**N**	**%**			
PI MCA/uterine artery ratio	**Normal (27)**	19	70.0%	8	53.3%	1.76	0.18	NS
	Abnormal (23)	7	30.0%	16	46.7%			
PI MCA/umbilical artery ratio	**Normal (29)**	20	66.7%	9	46.7%	2.44	0.12	NS
	Abnormal (21)	9	33.3%	11	53.3%			

A chi-square test is used.

Table 3 compares the groups of normal and abnormal cases according to factors such as foetal weight, gestational age, intrauterine growth restriction (IUGR), preterm labour, caesarean section, Apgar score greater than 7 at 5 minutes, severe preeclampsia, and neonatal intensive care unit (NICU) status, in connection to the MCA/Uterine artery PI ratio.

Fetal weight and gestational age at examination and delivery were both found to be considerably lower in cases with abnormal MCA/UT PI ratios. They showed a greater incidence of intrauterine growth restriction (IUGR), preterm delivery, and caesarean section as compared to cases with normal ratios (P < 0.05). Nevertheless, with regards to Apgar scores <7 at 5 minutes, severe preeclampsia, and NICU hospitalisation, no statistically significant difference was seen between abnormal ratio patients and normal ratio cases (P > 0.05).

The foetal weight, gestational age at examination, rates of intrauterine growth restriction (IUGR), preterm birth, and caesarean section (CS) were all significantly lower in preeclampsia cases with abnormal MCA/UT PI ratios compared to normal ratio cases (P < 0.05), and the rates of IUGR, preterm birth, and CS were all higher in these cases (P < 0.05). However, when it came to Apgar scores less than 7 at 5 minutes or admission to the NICU, no statistical significance was discovered between the normal and abnormal ratio instances (P > 0.05). Third Table

Case outcomes related to the foetal middle cerebral artery/ut pulsatility index ratios are shown in Table 3.

	Normal (27)		Abnormal MCU(23)		P	Sig.
	Mean	**±SD**	**Mean**	**±SD**		
Fetal weight*	2923.41	±683.33	2418.09	±1074.81	0.03	S
GA at examination*	33.59	±0.90	32.57	±2.23	0.01	S
	N	**%**	**N**	**%**		
IUGR	9	24.3%	13	56.5%	0.01	S
Preterm	19	51.4%	21	91.3%	0.002	S
CS	24	64.9%	19	82.6%	0.01	S
Apgar <7 at 5min (n %)	3	8.1%	1	4.3%	>0.99	NS
NICU admission	9	24.3%	9	39.1%	0.22	NS

A chi-square test and a student's t test.

Table 4 compares instances depending on factors such as foetal weight, gestational age, intrauterine growth restriction (IUGR), preterm labour, caesarean section, Apgar score more than 7 at 5 minutes, and neonatal intensive care unit (NICU), in connection to ratios of placental to umbilical artery perfusion (PI).

Infant birth weight, gestational age at assessment, and abnormal MCA/UA PI ratios were all much lower. In comparison to patients with normal ratios, they demonstrated an increased incidence of SGA, preterm delivery, and CS (P < 0.05). No statistically significant difference was found between patients with normal and abnormal ratios in relation to severe preeclampsia, nulliparous women, NICU hospitalisation, Apgar scores <7 at 5 minutes, or any other factor (P > 0.05).

Fetal weight and gestational age at assessment were considerably lower in preeclampsia patients with aberrant ratios compared to normal ratio cases (P < 0.05). The rates of intrauterine growth restriction (IUGR), preterm delivery (P < 0.05), and caesarean section (CS) were also substantially greater in PE patients with aberrant MCA/UA PI ratios (P < 0.05). Apgar scores less than 7 at 5 minutes and admission to the neonatal intensive care unit (NICU) did not vary significantly between cases with normal and abnormal ratios (P > 0.05). Chapter 4

Table (4) Fetal Outcome in Context of Middle Cerebral Artery/Umbral Pulsatility Index Ratios in Case Studies

	Normal (29)		Abnormal MCA/umbilical (21`)		P	Sig
Fetal weight	2924.00	±702.12	2475.62	±1031.82	0.04	S
GA at examination	29.5	±0.93	32.73	±2.15	0.04	S
IUGR	6	17.6%	16	61.5%	0.001	S
Preterm	22	64.7%	22	84.6%	0.02	S
CS	18	45.0%	22	55.0%	0.01	S
Apgar <7 at 5min (n %)	2	50.0%	2	50.0%	>0.99	NS
NICU admission	7	38.9%	11	61.1%	0.07	NS

A chi-square test and a student's t test.

There While the MC/umbilical artery ratio was superior at predicting IUGR, the other ratios showed comparable predictive potential for poor outcomes. Five-Area Table

Fig. 5: Umbilical ratios and middle cerebral artery/uterine pulsatility index for prediction accuracy

	sensitivity	Specificity	PPV	NPV	p	OR (95% CI)
MCA/uterine artery PI ratio						
IUGR	59.09	73.68	56.52	75.68	0.01	**4.04(1.33-12.34)**
Preterm	37.00	73.00	91.00	18.92	0.04	0.81(0.69-0.95)
CS	50.00	85.00	86.96	45.95	0.01	5.67(1.43-22.41)

Apgar <7 at 5min (n %)	25.00	60.71	4.35	91.89	>0.99	0.52(0.05-5.27)
NICU admission	55.56	69.05	43.48	78.38	0.09	2.79(0.89-8.69)
MCA/umbilical artery PI ratio						
IUGR	72.73	73.68	61.54	82.35	0.001	**7.47(2.29-24.39)**
Preterm	52.00	74.00	92.00	20.59	0.02	0.79(0.67-0.94)
CS	55.00	80.00	84.62	47.06	0.01	4.89(1.39-17.24)
Apgar <7 at 5min (n %)	50.00	57.14	7.69	94.12	>0.99	1.33(0.18-10.15)
NICU admission	61.11	64.29	42.31	79.41	0.07	2.83(0.91-8.83)

The PPV is the positive predictive value and the NPV is the negative predictive value; the corresponding p-values represent the significance level of the rate difference between the two groups.

4. Discussion

Preeclampsia, has a major impact on maternal and perinatal mortality, impacting 2% to 5% of pregnancies. An increased resistance in the uterine arteries due to defective trophoblastic invasion of the mother's spiral arteries has been linked to preeclampsia, according to studies [7]. Inadequate uteroplacental blood flow is the root cause of this disorder, which is often associated with intrauterine growth limitation. New developments in Doppler ultrasonography, especially in the foetal intracranial arteries, have shed light on potential indicators of preeclampsia and growth limitation [8].

Findings from studies examining the uterine Doppler arteries have shown that an early diastolic notch or an elevated pulsatility index (PI) may identify pregnant women who are at high risk of developing preeclampsia [9]. Research highlights the importance of measuring the uterine arteries' higher impedance at mid-gestation as a reliable indicator of severe early-onset preeclampsia in newborns that are small for gestational age (SGA). When compared to late-onset preeclampsia, this screening strategy is better at predicting severe early-onset illness, which has a major influence on when to deliver for the best possible result [9, 10].

The mean value of the bilateral uterine artery indices was collected for every patient in a 2003 research by Sterne G., which was conducted once for every subject older than 28 weeks. Women who went on to have preterm deliveries had higher values across the board [11].

Two vessels were similar in predicting unfavourable result, according to research by G hosh G and Gudmundsson (2009). We looked at 251 women individually who had normal umbilical artery Doppler results. Doppler abnormalities in the uterine arteries were detected in sixty-one (24.3%) of these individuals [12].

While previous research by Sibai (2009) and others found that abnormal velocirmetry of the foetal middle cerebral artery and uterine artery in the third trimester increases the likelihood of distress requiring a caesarean section, our results corroborate those of other studies showing that increased pulsatility in the Doppler wave forms of the foetal arteries indicates uteroplacental insufficiency. Fetal adaptation to hypoxia may be indicated by decreased pulsatility of the middle cerebral artery, however there is limited association with foetal distress. Emergency caesarean sections are 85 percent more likely to occur when both vascular districts have a change at the same time [13].

While umbilical velocimetry is a useful tool for assessing placental function, it does not always provide a clear indication of foetal condition; yet, oligohydramias, low birth weight, and NICU hospitalisation were all more common in foetuses with aberrant Doppler velocimetry [14].

Compared to MCA indices alone, the MCA/umbilical artery ratio is more sensitive, and researchers have shown that it is a stronger predictor of neonatal mortality and other negative outcomes than the umbilical artery alone, especially before 34 weeks of gestation [15].

So far, there has been no assessment of the vascular impedance ratios between the uterine arteries and the foetal MCA. Thus, we set out to determine the typical range of MCA/uterine artery PI and MCA/umbilical artery PI in order to evaluate its usefulness in foretelling the unpleasant result.

The foetal prognosis is poorer in foetuses with aberrant MCA/UA Doppler ratios. No matter how far along in the pregnancy a woman is, the diastolic component of her cerebral arteries is always less than that of her umbilical arteries [15].

Although a drop in MCAPI values would not prove placental vascular resistance, they would reveal hypoxia due to placental insufficiency. The results show that it is not as effective as the Doppler indices for the umbilical artery in predicting foetal distress [16].

In 2010, Muhammad T. Eighty pregnant women between the ages of 28 and 34 were enrolled in the study. To determine whether or not these eighty women were pregnant, doctors used transabdominal ultrasonography and a Doppler examination. The purpose of this investigation was to determine if trans abdominal ultrasonography and Doppler studies are useful for predicting pregnancy outcomes that are adverse and, if so, which Doppler indices are most predictive [17].

The foetal middle cerebral artery, uterine artery, and umbilical artery wave forms were analysed using PI ratios in this study. Additionally, subgroups of patients at high risk for foetal growth restriction and severe neonatal morbidity were predicted using MCA PI/UAPI and MCAPI/UTPI, respectively, in line with that of [14].

The current study involved 50 pregnant women; a low MCAA/uterine artery PI ratio was deemed abnormal when it was less than 2.3. Out of the 50 cases with preeclampsia, 19 (38.0%) had a low MCAA/uterine artery PI ratio, while 31 (61.7%) had a normal ratio. A low MCA/umbilical artery PI ratio was deemed abnormal when it was less than 1.58. Thus, 20 instances (40.4 percent) of preeclampsia patients were abnormal, and 30 (59.6 percent)

When it came to predicting intrauterine growth retardation, the ratio of the foetal middle cerebral artery pulstility index to the umbilical artery pulstility index was 47.6 with an 88.6 specificity rate; for preterm labour, it was 61.8% with a 50% specificity rate; for predicting the Apgar score, it was 42.9 with a 75.5 specificity rate; for predicting the presence of a neonatal intensive care unit, it was 31.4% with 76.9% specificity, and for C.S., it was 32.5 with a sensitivity of 32.5%.

In terms of predicting negative pregnancy outcomes, the accuracy of the MCA/UT (PI) ratio is almost identical to that of the MCA/UA(PI) ratio, with the exception of IUGR prediction, where the MCA/UA PI ratio performs better, which is in line with our findings.

Doppler ultrasonography tests of foetal circulation were compared in 231 pregnancies (Alanis MC, et al., 2008). 115 antenatal forty-five weeks' gestational diabetes serious preeclampsia Our research compared 231 pregnancies, 115 of which were preeclamptic, and found that the MCA/uterine artery and MCA/umbilical artery PI ratios were equally good predictors of the unfavarable pregnancy outcome. Consistent with our findings, both ratios outperform indicators of elevated vascular impedance in the umbilical uterine arteries in predicting the pregnancy's fate [18].

5. Finally

An aberrant result is highly linked to newborn morbidity, while a normal MCA/UA (PI) and MCA/uterine (PI) ratio substantially predicts a normal foetal fate, according to the current research. There is a strong association between these two ratios and neonatal outcome. Comparable to the MCA/UA ratio, the UT (PI) ratio of MCA has predictive power (PI)

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