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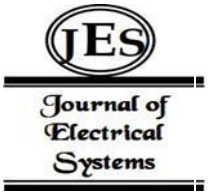
Fetal Renal Artery and Middle Cerebral Artery Indices in Pregnant Mothers with Pre-Eclampsia



***Abstract:* - Introduction and purpose**: Pregnancy is always associated with risks, and high blood pressure disorders are not a rare problem during pregnancy, which puts the mother and fetus at risk and sometimes causes life-long complications. Gestational hypertension is diagnosed when only systolic blood pressure (BP) ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg occurs after 20 weeks of gestation.
Methods: This cross-sectional, descriptive, analytical study was conducted during one year at Ba'ath Hospital of the Army Medical Sciences University on 50 pregnant mothers, 26 of whom with pre-eclampsia and 24 of whom were healthy, and Doppler ultrasound criteria were evaluated in these people.
Findings: In this study, the mean MCA.RI of the renal artery in healthy pregnant mothers was equivalent and the mean MCA.RI of the renal artery in preeclampsia mothers was equivalent. The mean MCA.PI of the renal artery in healthy pregnant mothers was equivalent and the mean MCA.PI of the renal artery was equivalent in preeclampsia mothers. Statistically, there was no significant difference between the two groups in the mean MCA.RI of the renal arteries (P>0.05).
Discussion and conclusion: In this study, it was shown that there was no significant difference in Doppler ultrasound parameters of middle cerebral and renal arteries in preeclampsia and healthy mothers.

Keywords: renal artery, Doppler, middle cerebral artery

I. INTRODUCTION

Pregnancy is always associated with risks, and high blood pressure disorders are not a rare problem during pregnancy, which puts the mother and fetus at risk and sometimes causes life-long complications. Gestational hypertension is diagnosed by systolic blood pressure (BP) ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg that occurs after 20 weeks of gestation. (1).

When this hypertension is accompanied by proteinuria, thrombocytopenia, renal failure, liver failure, pulmonary edema, and cerebral/visual symptoms, it is called preeclampsia (2), which occurs in 46% of pregnant women with gestational hypertension. (3) In general, 5-7% of all pregnant women suffer from preeclampsia, causing more than 500,000 fetal deaths and 70,000 maternal deaths worldwide each year (4). In addition, pre-eclampsia increases the risk of maternal and fetal mortality, severe maternal and fetal complications, admission to the maternal intensive care unit, premature delivery, cesarean section, and admission to the neonatal intensive care unit (4-6).

In fact, the mechanism of preeclampsia is not fully understood, but due to the reduction of symptoms when the placenta is removed, the placenta can play a major role in preeclampsia (7). The only definitive treatment for preeclampsia is delivery of the baby and the placenta (8). Hypoxia may play an important role in preeclampsia. Uterine hypoxia caused by abnormal implantation in the early stages of pregnancy is common in pregnancies

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complicated by preeclampsia (9, 10). According to some studies, the amount of glomerular filtration (12) and maternal kidney resistance and systolic/diastolic ratio (S/D) have decreased in pregnant women with preeclampsia (13, 14). In addition, the level of thromboxane increases while the level of prostaglandins decreases in the blood and placenta of these mothers (15). In fact, pre-eclampsia has many effects on maternal health during and after pregnancy. In patients with pre-eclampsia, the risk of chronic hypertension, cardiovascular diseases (16), chronic kidney failure (17) and even ESRD (18) is higher than that of healthy mothers. Fetuses of these mothers will experience pulmonary, cardiovascular and metabolic diseases and obesity. (19-21)

Studies on animal models of pre-eclampsia have shown that intrauterine hypoxia increases the risk of abnormal kidney development and causes a decrease in glomerular filtration rate, disruption of renal vascular tone and activation of the renin-angiotensin-aldosterone system. In the physiological conditions of the fetus of a healthy mother, the activity of the renin-angiotensin system is high in early pregnancy, so the contraction in the renal arteries increases and urine production decreases. Later, the activity of the renin-angiotensin system decreases and subsequently renal vasoconstriction decreases, resulting in increased urine output, especially after 34 weeks. The fetal renin level is higher than the maternal level and has nothing to do with maternal and placental renin levels. (9, 22)

Children of mothers with preeclampsia face various problems after birth and throughout their lives. Due to blood pressure imbalance, fetal kidneys are affected by maternal preeclampsia. (23)

Pre-eclampsia affects the kidneys of the fetus and the number of nephrons decreases following blood pressure imbalance. Due to placental hypoxia, the development of kidney nerves is disturbed and leads to blood pressure imbalance throughout life. (19). Doppler ultrasound is one of the most appropriate examination methods to show vascular resistance abnormalities in fetal kidneys due to preeclampsia, because it does not contain ionizing radiation and is a non-invasive method. The values of resistance index (RI) and pulsatility index (PI), which means high values measured by Doppler test, indicate an increase in resistance in the vascular bed, is the best indicator of resistance in the vascular bed. (24)

So far, limited Doppler studies of fetal kidney and middle cerebral artery in pre-eclamptic mothers have been investigated and they have obtained different results.

II. MATERIAL AND METHOD:

This study was conducted from July 2022 to July 2023 on patients referred for pre-eclampsia pregnancy ultrasound and healthy pregnant women to Besat Army Hospital.

Inclusion criteria were: 1- New/known case of pre-eclampsia 2- Absence of fetal growth restriction (IUGR) 3- Absence of previously known diseases in the fetus including cardiac, renal and fetal anomalies 4- Consent to participate in the study and exclusion criteria were: 1- The patient's lack of consent to continue the study 2- The unavailability of information during childbirth. At first, the type of study, its importance and steps, and the confidentiality of the information were explained to the patient, and if the patient consents to participate in the study, a written consent form was given. All the patient's information was coded without mentioning the name and surname in a checklist including: demographic variables (age of mother and fetus and sex of the fetus). Patients were divided into two groups with pre-eclampsia and healthy. All patients were underwent ultrasound examination by an expert radiologist with more than one thousand anomaly scan experience. Ultrasound examination was done using a curve probe with 3-5 MHz and RI, PI, and S/D indexes were measured and recorded in the middle cerebral arteries and fetal kidneys.

Variables were presented as mean (SD), median (interquartile range) or number (percentage) as appropriate. All statistical analyzes were performed using SPSS Inc. For continuous variables, independent T test or Mann Whitney U test was used, and for nominal values, $\chi 2$ test was used.

III. RESULTS:

In this study, 24 healthy mothers and 26 preeclampsia mothers were studied. The mean age of healthy mothers was 26.92±3.933 years and the mean gestational age in weeks was 34.08±1.5 weeks. Also, 7 people were under 25 years old, 5 people were over 30 years old, and the rest were between 25-30 years old.

The mean age of mothers with preeclampsia was 25.65 ± 4.79 years and the mean gestational age was 34.69 ± 1.49 weeks. Also, 3 cases were under 25 years old and 3 cases were over 30 years old, and the rest were between 25-30 years old.

Two groups were matched with each other in terms of mother's age and there was no statistically significant difference (p=0.3).

There was no statistically significant difference between the two groups in terms of gestational age (p=0.125).

Table1. demographic characteristics in two groups

		Control N(%)	**Case N(%)**	**p-value**
Age groups(y)	<25	7(29.2)	12(46.2)	0.125
	25-30	12(50)	11(42.3)	
	>30	5(20.8)	3(11.5)	
Gender	male	10(41.7)	12(46.2)	0.85
	female	13(54.2)	14(53.8)	

In the group of healthy mothers, 13 fetuses (54.2%) were boys and 10 fetuses (41.7%) were girls and in the group of preeclamptic mothers, 14 fetuses (53.8%) were boys and 12 fetuses (46.2%) were girls.

Gender were analyzed in two groups using chi-square test, which showed that there was no significant difference between the two groups (p=0.85).

Table 2. Doppler variables in two groups

	CONTROL		**CASE**		**P-VALUE**
	Mean± SD	median	Mean± SD	median	
MCA.RI	0.82± 0.07	0.81	0.83 ±0.07	0.82	0.56
MCA.PI	1.9 ±0.04	1.84	1.9 ±0.28	1.9	0.08
MCA. S/D	6.9 ±3.45	5.1	7.07 ±5.1	5.95	0.57
RENAL.RI	0.84± 0.06	0.84	0.83 ±0.06	0.84	0.73
RENAL .PI	1.98± 0.39	2.03	2.13 ±0.38	2.04	0.44
RENAL .S/D	7.2 ±3.3	6.05	6.99 ±1.89	6.96	0.57

Mean MCA. RI in healthy people was 0.82. Also, the mean MCA.PI in healthy mothers was 1.9 and the S/D ratio was 6.9. The meanrenal RI in healthy people was 0.84 and the mean Renal PI was 1.98 and the S/D ratio was 7.2.

Mean MCA. RI in pregnant mothers with preeclampsia was 0.83. Also, the mean MCA.PI in healthy mothers was 1.9 and the S/D ratio was 7.07. The mean renal RI in mothers with preeclampsia was 0.83 and the mean Renal PI was 2.13, S/D ratio was 6.99.

The relationship between RI and PI variables in renal and MCA arteries was evaluated using independent t-test and it was shown that none of the RI and PI variables in renal and MCA arteries were significantly different between the two groups.

The correlation of S/D variables in renal arteries and MCA was evaluated using Mann-Whitney test and it was shown that none of the S/D variables in renal arteries and MCA were significantly different in two groups.

Table3. correlation between maternal variables and Doppler values in all of the participant(n=50)

		MCA			Renal		
		RI	PI	S/D	RI	PI	S/D
Maternal age	Pearson Correlation	0.12	-0.13	0.09	-0.08	-0.09	-0.21
	p-value	0.37	0.36	0.51	0.58	0.52	0.13
Gestational age	Pearson Correlation	0.16	-0.06	0.07	-0.19	-0.29	-0.33
	p-value	0.91	0.63	0.62	0.18	0.03	0.01

Correlation of ultrasound and demographic variables was investigated using Pearson's test in all participant. The relationship between maternal age variable and MCA. RI had a correlation coefficient of 0.127, which seems with increasing the age of the mother, the amount of MCA. RI increases, but this relationship was not statistically significant (p=0.37).

Also, the variable relationship of mother's age with MCA. PI had a correlation coefficient of -0.131, which seems with increasing the age of the mother, the level of MCA. PI decreases, but this relationship was not statistically significant (p=0.36).

The correlation coefficient of two variables, gestational age and renal PI was -0.294, which was statistically significant, that is, with increasing gestational age, the renal artery PI variable decreases with a negative slope. (P=0.03)

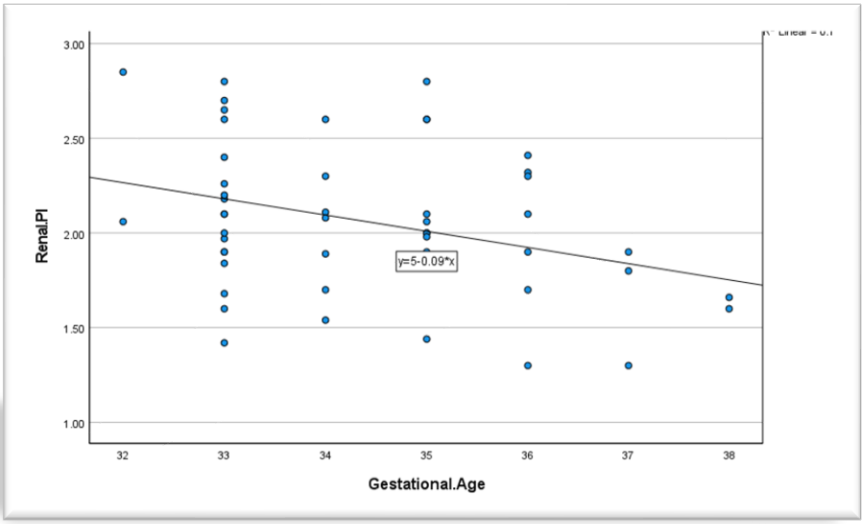

Diagram1. Correlation of renal PI and gestational age in all participants

Also, the correlation coefficient between the two variables of gestational age and renal S/D was equal to 0.33, which was statistically significant, that is, with increasing gestational age, the variable S/D of the renal artery decreases with a negative slope (P=0.01).

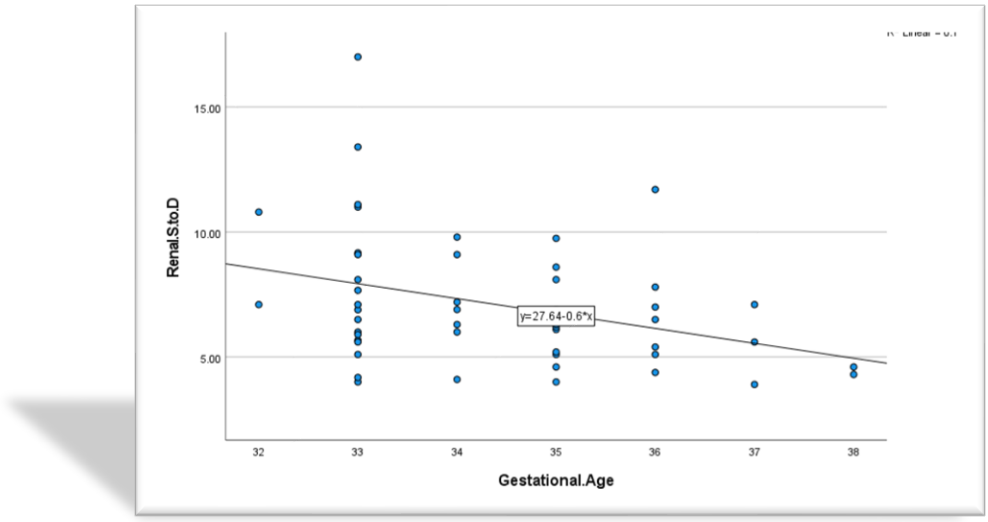

Diagram2. Correlation of renal S/D and gestational age in all participants

The relationship between fetal gender and Doppler variables was investigated using independent t-test and it was shown that fetal gender had no significant relationship with any of the Doppler criteria.

IV. DISCUSSION:

In this study, we investigated the Doppler ultrasound variables in pregnant mothers with preeclampsia and compare them with healthy mothers.

Due to the involvement of different organs of the body, preeclampsia increases morbidity and mortality in the mother and fetus and manifests itself with proteinuria, thrombocytopenia, kidney and liver disorders, lung edema, brain and vision symptoms. There is no definitive treatment for preeclampsia, and usually delivery and separation of the placenta from the mother, which seems to play a major role in the occurrence of preeclampsia, is the main treatment option.

In addition to the fetus, preeclampsia in the mother is also associated with the risk of chronic higher blood pressure, cardiovascular diseases, chronic kidney diseases and kidney failure after delivery. The fetuses of preeclamptic mothers have a higher risk throughout their lifetime in terms of the occurrence of pulmonary and cardiovascular and metabolic diseases and being obese.

Doppler ultrasound is one of the ways to evaluate fetal kidney vascular anomalies.

RI, PI and S/D indices indicate impedance and resistance in the vascular bed.PI expresses the total wave flow while RI and S/D are calculated based on two points in the maximum flow curve so some studies have mentioned PI as a reliable index in renal Doppler evaluations.

In this study, the two groups were not significantly different in terms of maternal age, gestational age, and fetal gender. It was also shown that the mean RI, PI, and S/D variables were not significantly different in patients with preeclampsia and healthy mothers.

The variables of maternal age and gestational age were directly related to RI and S/D ratio in the MCA artery, and these variables also increased with increasing age, but they were not statistically significant.

The important finding of this study was that with increasing gestational age, PI and S/D levels in the renal artery decreased, which was statistically significantly.

In a study conducted in 2021 in Turkey (26), the mean RI and S/D of the renal artery in the preeclamptic group were 0.85 and 9.9, respectively, in the control group, 0.85 and 11.8, and there was no statistically significant difference between the two, which is similar to our study. In the Turkish study, the mean PI of the renal artery in the preeclampsia group was 2.93 and in the control group was 2.28, which had a significant difference. In the present study, the mean PI of renal arteries was lower in the control group, but there was no statistical difference

between the two groups. It seems that the small number of the current study can be one of the causes of this difference, which needs to be further investigated with a study with larger data. In the animal study conducted by Boubred et al., it was shown that the PI in the renal arteries of the pre-eclamptic group was higher than the control group, which seems that the increase in PI can be due to the imbalance between vasoconstrictor and vasodilator factors, including the renin-angiotensin system and the renal sympathetic system. (27)

In a study conducted by Kaya et al., it was shown that the PI, RI, S/D of the renal artery in alcohol-eclamptic fetuses was significantly lower than the control group (28), which was also confirmed in Afsari et al.'s study. 20 In the study of Maayeh et al., the RI and S/D indices were significantly lower in the preeclamptic group than in the normal group, but the PI was not significantly different. (29)

In a study conducted by Williams et al., MCA artery Doppler parameters were investigated in preeclamptic and HELLP patients. In this study, the average RI in the preeclamptic group was 0.85 and the other group was 0.75, which was statistically significant. (30) In another study conducted by Ozeren et al. the mean MCA-RI in the healthy, hypertensive, and preeclamptic groups was 0.6, 0.59, and 0.51, respectively, and there was a significant difference between the healthy and preeclamptic groups. Also, the mean MCA PI was1, 0.95,0.75 respectively which was significant between the healthy and preeclamptic groups. In the above study, 7 pre-eclamptic patients and 380 healthy individuals were evaluated, and the number of samples was less than the study. It seems that the difference in the results of our study and this study is related to the heterogeneity of the population and the smaller number of samples in Ozeren's study.

As mentioned, different studies have shown many differences with each other, so the detailed evaluation and comparison of the results of the present study is limited.

V. CONCLUSION:

In this study, we tried to investigate and compare the Doppler sonographic differences of renal arteries and MCA of preeclamptic and healthy fetuses. In this study, it was shown that with the increase in gestational age, renal PI and S/D variables decreased significantly in two groups, but due to the lack of a similar study, it was not possible to compare similar cases. Also, in patients with preeclampsia, the Doppler criteria of renal arteries and MCA There was no significant difference with the control group. Taking into account that previous studies had significant differences from each other in terms of results, there were limitations in examining the results with similar studies.

* All the authors of this article are researchers and educators and not employed by a government agency that has a primary function of research or education.

Data statement: The authors declare that they had full access to all of the data in this study and the authors take complete responsibility for the integrity of the data and the accuracy of the data analysis

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