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Ophthalmic Artery Doppler Indices Changes in Preeclampsia

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ABSTRACT

Background & Objective: Preeclampsia (PE) is a major complication of pregnancy worldwide. Doppler ultrasound of maternal arteries, including uterine and ophthalmic arteries (OA), plays an important role in determining individuals progressing PE. The aim of this study is to compare OA indices in pregnant women with a diagnosis of PE and women without it.

Materials & Methods: This study evaluated pregnant women who had delivery in Shariati Hospitals, Tehran, Iran between January 2021 and March 2022. The maternal OA Doppler waves were obtained in preeclamptic and non-preeclamptic women at 35 to 37 weeks of gestation by a maternal-fetal medicine specialist. OA Doppler parameters including first and second PSV, second to first PSV ratio (Peak ratio, PR) and PI were obtained for each eye and also average between the eyes.

Results: Out of 148 included participants, 48 cases progressed to PE at 35 to 37 weeks of gestation and 100 cases did not have PE at the same gestational age. All OA parameters including (First and second peak systolic velocities (PSV), second to first PSV Ratio (PR) and Pulsatility Index (PI) in each eye; as well as, the average of these indices in both eyes) were assessed. PR and PI between the two eyes were statistically different in those with PE.

Conclusion: OA Doppler indices change in pregnant women with PE. These changes could help to earlier and better diagnosis of PE and prevention of maternal and fetal sequelae.

Keywords: Preeclampsia, Ophthalmic Artery, Doppler Indices, Pregnancy Complication

Introduction

Preeclampsia (PE) is a major complication of pregnancy with adverse effects on mother and fetus. It is one of the important causes of maternal mortality. It is defined as follows, acute onset of maternal hypertension and proteinuria after 20th weeks of gestational age **(1)**. There are several methods for predicting PE, including the following: maternal characteristics, uterine arteries (UtA) and ophthalmic arteries (OA) Doppler indices, and serum biomarkers. Impaired blood flow in maternal arteries may be observed in pregnant women before the onset of PE and at the time of diagnosis and it could be detected by Doppler ultrasound **(2)**. Doppler study is a safe and accessible method and can be done in the least time and also in a portable way. In this study, we have assessed the changes of OA Doppler indices in pregnant women with PE.

Methods

This study evaluated pregnant women who had delivery in Shariati Hospitals, Tehran, Iran between January 2021 and March 2022. The maternal OA Doppler waves were obtained in preeclamptic and non-preeclamptic women at 35 to 37 weeks of gestation by a maternal-fetal medicine specialist. All cases gave written informed consent to participate in this study and it was approved by the Research Ethics Committee at Tehran University of Medical Sciences.

The inclusion criteria were singleton pregnancies examined at 35 to 37 weeks of gestation. We excluded pregnant women with type 1 and 2 diabetes mellitus (DMI, II), chronic hypertension (HTN), autoimmune diseases, and those with fetal aneuploidy or abnormality. 48 cases progressed to PE at 35 to 37 weeks of gestation, and 100 cases did not have PE at the same gestational age were included in the study.

PE defined as follows: high blood pressure measurements (systolic blood pressure [SBP] ≥140mmHg and/or diastolic pressure [DBP] ≥90

mmHg) that was associated with acute-onset proteinuria (≥ 1+ protein on a dipstick analysis or ≥ 300 mg in urine 24 hours). Severe PE was defined as PE with severe hypertension (SBP ≥160 mmHg and/or DBP ≥110 mmHg) or signs or symptoms of end-organ damage.

Ophthalmic artery (OA) waveforms were obtained with a 7-15 MHz linear transducer that was placed horizontally on the upper eyeball. Pulsed-wave Doppler was recorded medial to the optic nerve and three to five waveforms were obtained. OA Doppler parameters including first and second PSV, second to first PSV ratio (Peak ratio, PR) and PI were obtained for each eye and also average between the eyes (Figure 1). Finally, all analyses were performed in SPSS (version 26) and P-values less than 0.05 were defined as statistically significant.

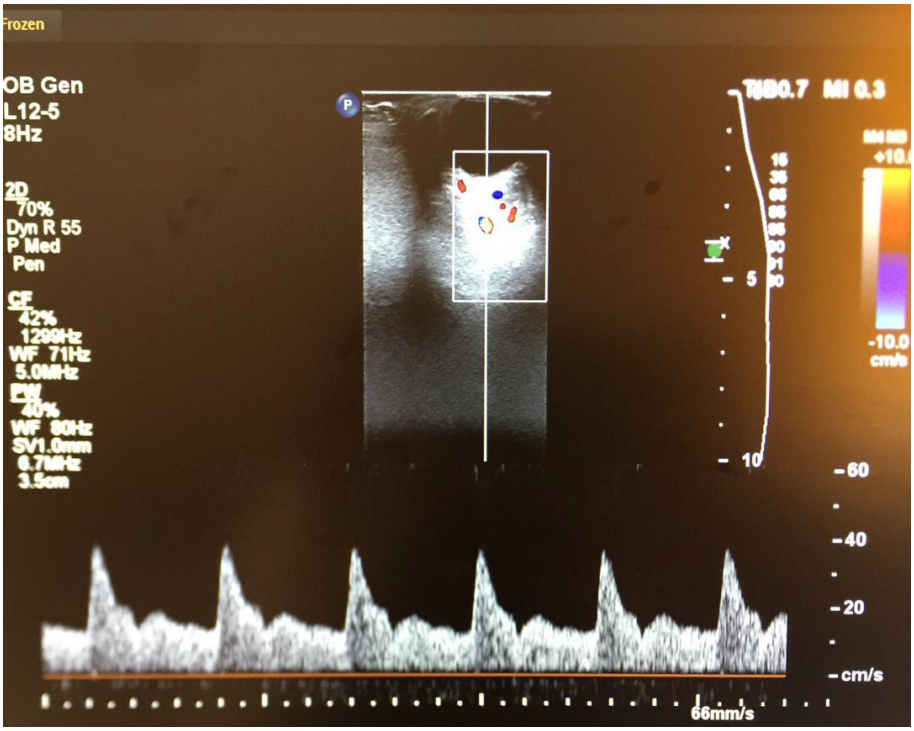

Figure 1. A sample of ophthalmic artery Doppler waveforms

Results

A total of 148 pregnant women were included in the study. The population contained 100 normal cases and 48 pregnancies with PE (42 cases of mild PE and 6 cases of severe PE). This study showed that the following variables were higher in preeclamptic pregnancies compared to those without PE: Right (Rt.) and left (Lt.) second PSV, average (Av.) of second PSV between the eyes, Rt. PR, Lt. PR, and Av. of PR between the eyes (Table 1). The area under curve (AUC) values (95% CI) of three OA Doppler indices, including Rt. PR (0.96, 0.94 – 0.98), Lt. PR (0.96, 0.94 – 0.99) and Av. of PR between the eyes (0.97, 0.94 – 0.99) were higher than 0.90 (Table 2). Lt. PR, Rt. PR, Av. of PR and Av. of PI between the eyes had the most important changes in PE.

Table 1. Ophthalmic artery Doppler indices of study population of 148 pregnancies, according to development of mild and severe preeclampsia (PE)

Characteristics	Normal (n=100)	PE (n=48)			P*	P#	p†
		Total (n=48)	Mild PE (n=42)	Severe PE (n=6)			
Right First PSV	31.4 (25.5, 38.4)	24.5 (20.2, 27.4)	24.2 (20.5, 27.4)	27.0 (16.2, 31.6)	<0.001	<0.001	0.838
Right Second PSV	17.3 (13.6, 20.6)	21.3 (18.5, 26.0)	21.3 (18.5, 23.8)	25.0 (14.6, 29.3)	<0.001	<0.001	0.451
Right ophthalmic artery PI	2.0 (1.8, 2.3)	1.2 (1.0, 1.6)	1.2 (1.0, 1.6)	1.3 (1.0, 1.5)	<0.001	<0.001	0.949

Characteristics	Normal (n=100)	PE (n=48)			P*	P#	p†
		Total (n=48)	Mild PE (n=42)	Severe PE (n=6)			
Left First PSV	32.0 (25.6, 38.5)	24.4 (20.3, 27.5)	24.0 (20.5, 27.5)	27.2 (16.1, 31.6)	<0.001	<0.001	0.816
Left Second PSV	17.4 (14.0, 21.0)	21.3 (18.4, 26.4)	21.2 (18.4, 24.4)	25.1 (14.7, 29.5)	<0.001	<0.001	0.442
Left ophthalmic artery PI	2.0 (1.8, 2.3)	1.2 (1.0, 1.6)	1.2 (1.0, 1.6)	1.3 (1.1, 1.6)	<0.001	<0.001	0.997
Average PR between two eyes	53.7 (48.4, 60.3)	84.6 (76.0, 96.2)	84.0 (76.0, 94.6)	91.8 (79.8, 98.5)	<0.001	<0.001	0.220
Average of first PSV between two eyes	31.7 (25.6, 38.4)	24.4 (20.2, 27.5)	24.1 (20.5, 27.5)	27.1 (16.2, 31.6)	<0.001	<0.001	0.827
Average of second PSV between two eyes	17.4 (13.8, 20.6)	21.3 (18.5, 26.2)	21.2 (18.5, 24.1)	25.1 (14.7, 29.4)	<0.001	<0.001	0.446
Average of ophthalmic artery PI between two eyes	2.0 (1.8, 2.3)	1.2 (1.0, 1.6)	1.2 (1.0, 1.6)	1.3 (1.0, 1.6)	<0.001	<0.001	0.976
Right PR	53.8 (48.3, 60.5)	84.5 (74.7, 96.2)	84.0 (74.7, 94.6)	91.1 (79.0, 98.5)	<0.001	<0.001	0.257
Left PR	53.8 (48.3, 60.3)	84.6 (77.3, 96.1)	84.1 (77.0, 94.5)	92.4 (80.5, 98.6)	<0.001	<0.001	0.189

Table 2. **The diagnostic measures of ophthalmic artery Doppler indices in PE**

Variables	AUC (95% CI)	Best Cut point
Right First PSV	0.75 (0.64, 0.86)	0.06
Right Second PSV	0.70 (0.56, 0.84)	0.06
Right ophthalmic artery PI	0.87 (0.78, 0.97)	0.06
Left First PSV	0.75 (0.64, 0.86)	0.06
Left Second PSV	0.70 (0.57, 0.84)	0.06
Left ophthalmic artery PI	0.88 (0.79, 0.97)	0.06
Average PR between two eyes	0.97 (0.94, 0.99)	0.07
Average of first PSV between two eyes	0.75 (0.64, 0.86)	0.06
Average of second PSV between two eyes	0.70 (0.57, 0.84)	0.06
Average of ophthalmic artery PI between two eyes	0.88 (0.78, 0.97)	0.07
Right PR	0.96 (0.94, 0.98)	0.07
Left PR	0.96 (0.94, 0.99)	0.07

Discussion

PE is responsible for more than 16% of maternal mortalities worldwide **(3)**. Screening and early diagnosis of PE are very important issues in obstetrics medicine, especially in high-risk pregnancies **(1, 4)**. Fetal and maternal complications of PE are serious **(5)**. Therefore, it is necessary to study markers for early prediction and diagnosis of PE. Recently, researches have evaluated cerebrovascular changes in preeclamptic women and some of them have evaluated OA Doppler indices in prediction and diagnosis of PE.

It is important to know more about maternal arteries Doppler changes before progressing to PE or at the time of PE.

The ophthalmic artery (OA) is the first branch of the internal carotid artery and has embryological, anatomical and functional similarities with the intracranial vasculature. Its branches supply the orbit, meninges, face, and upper nose **(6)**. This artery is easily accessible for ultrasound and can have useful information from the cerebral circulation that is not easily accessible for evaluation. Therefore, in some studies, ultrasonographic examination of OAs has been used to predict neurological consequences. Although, computed tomography (CT) and magnetic resonance imaging (MRI) are more difficult methods because of less access, high cost, and risks to mothers with high blood pressure during transportation, but OA Doppler can be performed in the shortest possible time and on a portable basis. Figure 2 shows OA Doppler analysis.

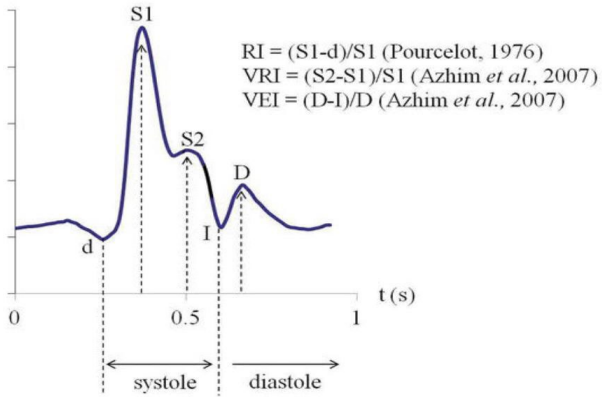

Figure 2. Shows OA Doppler indices (7). The first PSV wave is peak velocity S1, it represents the maximum velocity during systole and is as an ejection parameter in cardiac systole and augmentation of S2 is related to reflection of pressure wave. The peak diastolic velocity, (D), is the maximum velocity which rises due to vascular elastic recoil during cardiac diastole, and (d), the end diastolic velocity, represents the minimum velocity.

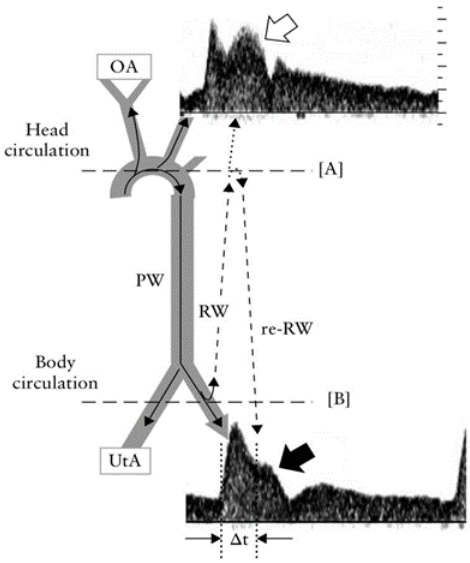

Figure 3. Shows pulse wave (PW) reflection and transmission between OA and UtA. Reflection will increase with vasoconstriction and vascular tone (8). Therefore, the reason for the increase in second PSV in OA Doppler assessment in PE is well shown in this figure. Also, the relationship between OA Doppler indices changes and PE may be related to hemodynamic adaptation to the pregnancy (9).

Most studies have shown that PR in the OA Doppler indices was the best predictor of PE and had the most important changes in PE **(10, 11)**. Our study showed that Av. of PR between the two eyes had the significant change in PE. In some studies, both OA PI and PSV were reported higher in PE while others have shown a significant elevation in normal pregnancies **(12-20)**. Unlike PR, first and second PSV changes of the OA are unreliable indices in prediction and diagnosis of PE. Therefore, it suggests against first and second PSV indices use as routine markers for prediction and early diagnosis of PE **(11, 21-23)**.

The strengths of this study were a higher sample size compared to other studies. OA Doppler ultrasound is especially helpful in prediction and also early diagnosis of PE. Facilitating earlier diagnosis of PE can help prevent serious maternal and fetal complications, especially maternal neurological sequelae **(24)**.

Conclusion

This study assessed the OA Doppler indices changes in pregnant women with PE and showed that these changes could help to earlier and better diagnosis of PE and prevention of maternal and fetal sequelae.

Acknowledgments

None.

Conflict of Interest

The authors declare no known conflicts of interest.

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