Original paper

Comparison of the resistive indices obtained in the uterine artery and the ophthalmic artery in preeclamptic and normotensive patients in Doppler US

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Abstract

Introduction: Preeclampsia is a medical condition characterized by hypertension and proteinuria during pregnancy, with the symptoms generally manifesting in the 3rd trimester. Hypertension brings hemodynamic changes; it is therefore expected that arterial blood flow velocity waveforms will be different in the uterine and ophthalmic arteries in preeclampsia. Vascular changes do occur in preeclampsia, which in turn induces hemodynamic changes. **Aim:** To compare mean values of the resistive index of the ophthalmic and uterine arteries in patients with preeclampsia and normotensive individuals in Doppler US. **Methods:** In this cross-sectional observational study, ultrasound of the uterine and ophthalmic arteries was performed in 60 pregnant women in the 2nd and 3rd trimester of pregnancy to compare the resistive index of these arteries in preeclamptic and normotensive individuals. All the patients, i.e. 30 preeclamptic and 30 normotensive pregnant women, took part in this study voluntarily. The study was approved by the institutional review board (IRB) of the University of Lahore. **Results:** The mean resistive index of the uterine artery was 0.50 ± 0.08 in normotensive participants and 0.64 ± 0.09 in preeclamptic women, with the *p*-value <0.001. The mean resistive index of the ophthalmic artery was 0.70 ± 0.05 in normotensive participants and 0.63 ± 0.04 in preeclamptic women, with the *p*-value <0.001. **Conclusions:** There was a significant negative correlation between the resistive index of the uterine and ophthalmic arteries among the patients with preeclampsia and a significant positive correlation among normotensive individuals. Preeclampsia could be easily diagnosed with Doppler ultrasound based on hemodynamic changes in response to vascular changes in the ophthalmic and uterine arteries.

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Introduction

Preeclampsia is one of the leading causes of maternal morbidity throughout the world[1]. It is a pregnancy disorder characterized by high blood pressure and often a significant amount of protein in urine[2]. The incidence of preeclampsia is from 5–10%[3,4], and its prevalence is 2–8%[5]. The possible causes of preeclampsia include: an exaggerated inflammatory response by endothelial cells, which intrinsically increases the local blood supply to the affected area,[6] and the activation of monocytes[7,8] and granulocytes as the maternal inflammatory response[9]. An increase in maternal diastolic pressure during pregnancy can also lead to preeclampsia[10]. The possible interventions in preeclampsia include therapies with melatonin[11] to decrease blood pressure (BP), corticosteroids (in severe preeclampsia), anticonvulsants (to prevent seizers in severe cases) as well as bed rest, hospitalization and delivery. The recent and most popular theory suggests that severe hypertension increases the limits of cerebral autoregulation and leads to vasodilatation with breakthrough brain edema. Endothelial damage is recognized as a major feature in the pathophysiologic mechanism of preeclampsia and as a possible risk factor for posterior reversible encephalopathy syndrome. Studies suggest that posterior reversible encephalopathy syndrome associated with substantial endothelial damage may develop without a relevant increase in blood pressure[12].

This means that identification of cerebral overflow in patients with preeclampsia with the help of ophthalmic artery Doppler ultrasound may be a marker of the risk of cerebral hemorrhage and may be able to determine the severity in patients with preeclampsia[13]. On the other hand, the uteroplacental circulation is crucial for a normal pregnancy outcome. Elevated resistive index (RI), pulsatility index (PI) or systolic to diastolic (S/D) ratios and the presence of a diastolic notch are considered as abnormal uterine artery flow velocity disorders. Impaired trophoblastic invasion of the maternal spiral arteries is associated with increased risk for maternal complications of pregnancy, such as pregnancy-induced hypertension, preeclampsia, placental abruption, poor fetal outcome, intrauterine growth restriction (IUGR) and small for gestational age (SGA) infant[14]. Numerous tests, including cold pressor test, have been found to identify mothers at risk of preeclampsia[15].

Doppler ultrasound and color Doppler imaging (CDI) are non-invasive, fast and easy to perform in the evaluation of the uterine and placental blood flow[16]. Moreover, they produce highly reliable measures in the ophthalmic artery[17]. Besides, there is no evidence that diagnostic ultrasound has produced any harm to humans. Ultrasound is then neither harmful nor expensive, and produces accurate results[18]. Vascular changes do occur in preeclampsia and induce hemodynamic changes which can be easily evaluated with Doppler ultrasound. As arterial diseases are almost generalized, it has been postulated that if the uterine artery is affected by preeclampsia, the ophthalmic artery might be affected as well[19].

This study was performed to compare the resistive index of the uterine artery versus the ophthalmic artery in patients with preeclampsia in Doppler ultrasound. Doppler ultrasound used for early diagnosis of preeclampsia could contribute to reduced morbidity by enabling proper patient management.

Material and methods

This cross-sectional, observational study was conducted at the Gilani Ultrasound Clinic in Lahore, Pakistan, to compare the resistive index of the uterine artery with that of the ophthalmic artery using ultrasound in pregnant women in the 2nd and 3rd trimester. The Board of Studies and the Institutional Review Board (IRB) of the University of Lahore approved the study protocol. The sample of 60 participants was calculated with a sample power formula. For the purpose of comparison, 30 normotensive and 30 preeclamptic pregnant women were recruited. Participation was voluntary and written consent was obtained from the patients or their guardians. Patients with chronic hypertension, non-cooperative individuals, patients whose uterine arteries were not visualized due to abdominal gases or large fetus, and patients with any eye disease or impaired vision were excluded. The ultrasound machine used in the study (Toshiba Xerio) was equipped with a linear probe of 7–14 MHz for ophthalmic artery examination and with a curvilinear probe of 3–6 MHz for uterine artery assessment. The American Institute of Ultrasound in Medicine (AIUM) guidelines for obstetrics were observed during examinations[20]. The gestational age was calculated in weeks by ultrasound and from the last menstrual cycle. History regarding proteinuria, hypertension, family history and previous history of preeclampsia were taken from the patients. The uterine artery was localized in the supine position from either left or right to avoid fetal parts near the cervix. Spectral waveforms were taken in the longitudinal view, and the measurements were recorded for known preeclamptic and normotensive individuals. The ophthalmic arteries were localized, and spectral waveforms were taken with the help of a linear transducer. RI of the ophthalmic and uterine arteries was calculated, and the acquired data was evaluated with the help of the Statistical Package for the Social Sciences version 24 (SPSS 24, IBM, Armonk, NY, United States of America). Mean and standard deviation values were calculated for age as well as resistive index of the uterine and ophthalmic arteries. The data was normally distributed. Correlations of RI of the uterine and ophthalmic arteries in normal and preeclamptic patients were assessed using the Pearson's correlation.

Results

The mean age of the normotensive participants was 25.40 ± 3.8 years with the range from 19 to 35 years.

Tab. 1. *Mean and standard deviation values for age as well as resistive index of the uterine and ophthalmic arteries among 30 normotensive and 30 preeclamptic participants*

Variables	Study groups	Mean	Std. deviation
Age (years)	Preeclamptic	25.4	3.79
	Normotensive	25.8	3.33
Resistive index of uterine artery	Preeclamptic	0.65	0.09
	Normotensive	0.50	0.08
Resistive index of ophthalmic artery	Preeclamptic	0.63	0.05
	Normotensive	0.71	0.06

Tab. 2. *Pearson's correlation of the resistive index of the ophthalmic artery and the uterine artery among 30 normotensive and 30 preeclamptic pregnant women*

Correlations			RI of uterine artery	RI of ophthalmic artery
Study groups				
Preeclamptic	RI of uterine artery	Pearson Correlation	1	−0.450*
		Significant (2-tailed)		0.013
Normotensive	RI of uterine artery	Pearson Correlation	1	0.524**
		Significant (2-tailed)		0.003

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

The mean age of the preeclamptic participants was 25.9 ± 3.3 years with the range from 20 to 33 years. The mean resistive index of the uterine artery was 0.50 ± 0.08 in normotensive participants, and 0.64 ± 0.09 in preeclamptic patients, with the p-value <0.001. The mean resistive index of the ophthalmic artery was 0.70 ± 0.05 among normotensive participants and 0.63 ± 0.04 in preeclamptic patients, with the p-value <0.001; details are summarized in Tab. 1 and Tab. 2. A significant negative correlation of 0.450 with the p-value of 0.013 was found between the resistive index of the uterine and ophthalmic arteries in preeclamptic participants, and a positive correlation of 0.524 with the p-value of 0.003 was found between the resistive index of the uterine and ophthalmic arteries among normotensive patients, as shown in Tab. 2 and Fig. 1.

Discussion

Ultrasound techniques are used to predict early signs of preeclampsia by providing blood flow readings in Doppler imaging. The resistive index of the uterine artery is increased in hypertensive patients at risk of preeclampsia. Conversely, the resistive index of the ophthalmic artery is decreased in preeclamptic patients. According to a study by C A de Oliveira *et al*., conducted in 2013 to determine changes in ophthalmic artery Doppler indices in hypertensive disorders during pregnancy,[21] it was estimated that the resistive index was 0.75 ± 0.05 among normotensive pregnant women
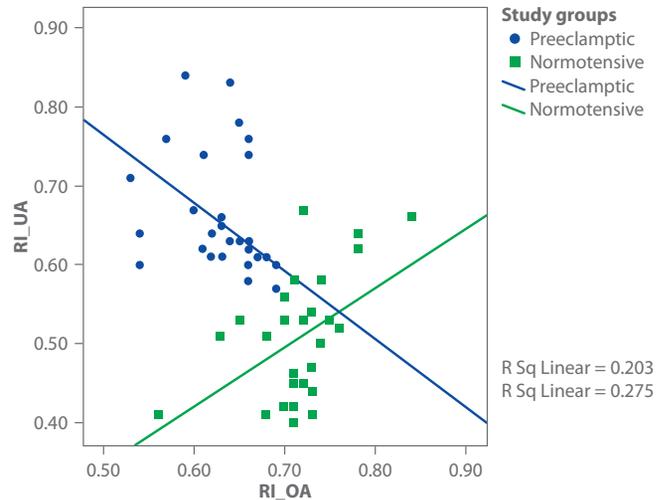

Fig. 1. *Scatter plot represents the comparison of the resistive index (RI) of the ophthalmic artery (OA) and the uterine artery (UA) in preeclamptic and normotensive pregnant women*

and 0.63 ± 0.09 in preeclamptic women. The study was conducted among seventy-three patients to confirm the status of the resistive index of the ophthalmic artery as a predictor of preeclampsia in the second trimester of pregnancy. All the patients at risk of preeclampsia were included. They were evaluated with Doppler imaging of the ophthalmic artery at 24 to 28 weeks of pregnancy and monitored until the end of pregnancy to verify the occurrence of preeclampsia. ROC curves were created to determine the predictive characteristics of the ophthalmic artery resistive index. Of the observed patients, 14 developed preeclampsia while 59 remained normotensives until delivery. The patients who developed preeclampsia had lower ophthalmic artery resistive indices (0.682 ± 0.028) than those who remained normotensive (0.700 ± 0.029; the p-value was within the range of significance: p-value = 0.044). Low resistance in the ophthalmic artery was considered a risk factor for the development of preeclampsia with the area under the curve of 0.694 and the confidence interval from 0.54 to 0.8. It was concluded that low resistance of the ophthalmic artery was related to preeclampsia[22]. In the present study, the mean resistive index of the ophthalmic artery measured in normotensive pregnant women and in preeclamptic women was very similar to that reported in the aforementioned study, as shown in Tab. 1 and Fig. 1, Fig. 2 and Fig. 3.

According to previous studies, Doppler indices for the uterine artery decreased with advancing gestational age. Ademola Joseph Adekanmi *et al*. compared Doppler indices of the uterine and umbilical arteries among healthy Nigerian women with singleton pregnancies in the second and third trimesters. The authors found that normal values of the resistive index were 0.53 ± 0.18 in the second trimester and 0.48 ± 0.20 in the third trimester[23]. In another study by H. Valensise, the resistive index of the uterine artery above 0.58 was considered abnormal[24]. In the present study, the mean resistive index of the uterine artery in normotensive
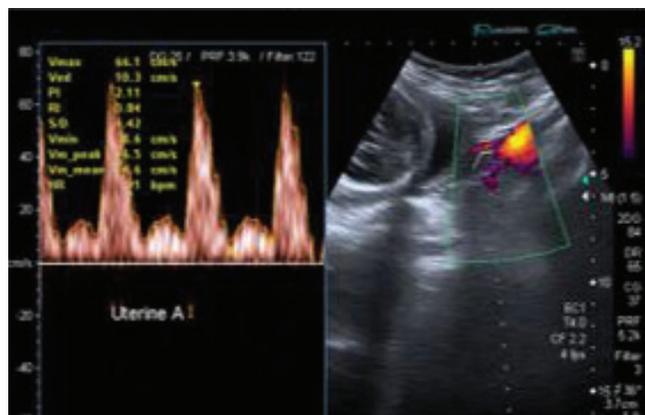
Fig. 2. *Ultrasound image of a preeclamptic female at 33 weeks of pregnancy representing high RI (0.84) of the uterine artery*
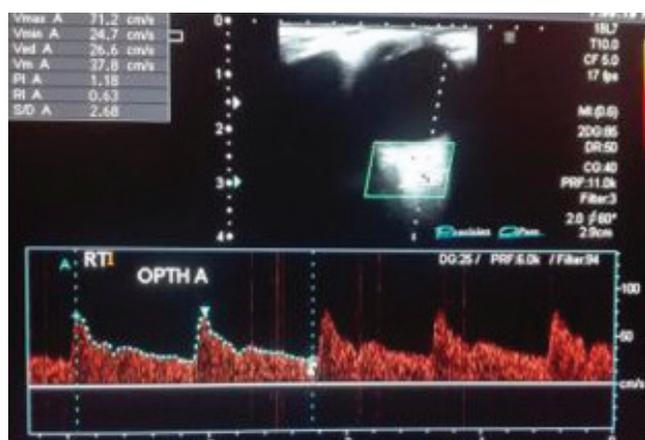

Fig. 3. *Ultrasound image of a preeclamptic female at 33 weeks of pregnancy representing low RI (0.63) of the ophthalmic artery*

pregnant women was 0.50 and in preeclamptic women: 0.64, which is in line with the results of the above-mentioned study by H. Valensise. The results of this study prove that the resistive index of the ophthalmic artery is significantly correlated with the resistive index of the uterine artery in both normotensive and preeclamptic patients. A negative linear correlation was found, i.e. the resistive index increases in the uterine artery and decreases in the ophthalmic artery in preeclampsia. Blood flow in both uterine artery and ophthalmic artery was almost equally affected by preeclampsia, except for a few cases where any of the two remained normal. Both vessels can be used to predict the severe problem like preeclampsia to reduce maternal mortality and morbidity. In pregnant women, especially in the second and third trimesters, long examinations during which the sonographer manipulates the transducer over the abdomen to locate the uterine artery, may be uncomfortable. The ophthalmic artery can be easily located with the transducer, and the readings are obtained in a short time. That is why, in this research, we decided to compare the resistive index of the ophthalmic artery in confirmed preeclamptic and normotensive individuals.

Conclusions

There was a significant negative correlation between the resistive index of the uterine and ophthalmic arteries in the patients with preeclampsia, and a significant positive correlation was found for normotensive individuals. Preeclampsia could be easily diagnosed by Doppler ultrasound due to hemodynamic changes that occur in response to vascular changes in the ophthalmic and uterine arteries.

Conflict of interest

Authors do not report any financial or personal connections with other persons or organizations, which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

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