

**COMPARATIVE EVALUATION OF OPHTHALMIC ARTERY DOPPLER INDICES IN PRE-ECLAMPTIC AND NORMOTENSIVE PREGNANT WOMEN IN KANO, NIGERIA****Hussaini Dede<sup>1</sup> Anas Ismail<sup>2</sup>, Yusuf Lawal<sup>2</sup>**<sup>1</sup>Department of Radiology, College of Medical Sciences Yobe State University, Damaturu, Nigeria<sup>2</sup>Department of Radiology, Bayero University Kano, Nigeria.**Corresponding Author:** *Hussaini Dede*, **Email:** [dedehussaini@yahoo.com](mailto:dedehussaini@yahoo.com)Received: **30-Mar-2026**Accepted: **21-Apr-2026**Published: **30-Apr-2026****Abstract**

**Background:** Hypertensive disorders in pregnancy are widely acknowledged as among the most severe complications, significantly impacting maternal as well as neonatal morbidity and mortality rates globally. Pre-eclampsia (PE) is the most important gestational condition associated with hypertension. Maternal ophthalmic artery Doppler velocimetry enables the identification of pregnant women with increased cerebral blood flow who are at risk of developing severe PE and eclampsia.

**Objectives:** To sonographically determine the ophthalmic artery Doppler velocimetric indices among patients with pre-eclampsia and compare with that of match normotensive pregnant controls.

**Methods:** - This cross sectional study was carried out in a tertiary health care facility in Nigeria. Eighty pre-eclamptic patients an equal number of normotensive matched pregnant controls were recruited for the study. A comprehensive history of hypertension was obtained, and an obstetric scan was conducted to assess the gestational age. The ophthalmic artery peak ratio, pulsatility index, and resistive index of both groups were obtained (and compared) using high resolution ultrasound Doppler examination.

**Results:** The key hemodynamic finding was a significantly lower ophthalmic artery peak systolic velocity (PSV) and relatively higher end diastolic velocity (EDV) in pre-eclamptic subjects compared to controls ( $P < 0.001$ ). This resulted in significantly lower resistive index (RI) and pulsatility index (PI), alongside a higher peak ratio (PR) in the pre-eclamptic group- a pattern of reduced vascular resistance and increased blood flow.

**Conclusion:** Ophthalmic artery Doppler ultrasonography can be useful in distinguishing pre-eclamptic from normotensive pregnant women through characteristic low-resistance, high-flow hemodynamic profiles.

**Key Words:** - Doppler, Ophthalmic artery, pre-eclampsia, velocimetry

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## INTRODUCTION

Hypertension is the most prevalent disorder affecting pregnancies worldwide.<sup>1</sup> Maternal mortality continues to pose a significant challenge on a global scale, as it is estimated that approximately 810 women lose their lives on a daily basis due to complications related to pregnancy or childbirth.<sup>1</sup> Classically, the American College of Obstetrics and Gynaecology (ACOG) defines pre-eclampsia as the presence of hypertension and proteinuria occurring after 20 weeks of gestation in a previously normotensive patient.<sup>2,3</sup> However, a significant proportion of women develop systemic manifestations of PE such as low platelets or elevated liver enzymes before the hallmark of proteinuria is detectable resulting in delayed diagnoses.<sup>4</sup> In Nigeria, about 34% of pregnant women receive no antenatal care, putting them at higher risk of maternal mortality.<sup>5</sup> A recent, nationwide cross-sectional survey found that PE and eclampsia are the leading causes of maternal mortality in Nigeria and is responsible for 28.2% of maternal deaths; the other main contributors to maternal mortality are haemorrhage (24.4%) and pregnancy-related infection/sepsis (14.2%).<sup>5</sup> Ranging in severity, hypertensive disorders of pregnancy include: chronic hypertension, defined as systolic blood pressure (BP)  $\geq 140$  mm Hg or diastolic BP  $\geq 90$  mm Hg that predates the onset of pregnancy; gestational hypertension, defined as hypertension diagnosed after 20 weeks of gestation without concurrent proteinuria; pre-eclampsia is classically defined as new-onset hypertension with new-onset proteinuria; and chronic hypertension with superimposed PE which is defined as chronic hypertension with new-onset proteinuria or other signs/symptoms of PE after 20 weeks or chronic proteinuria with new onset hypertension.<sup>6</sup>

The high morbidity and mortality associated with PE arouse interest for new methods to better identify risk in pre-eclamptic patients.<sup>7</sup> The ophthalmic artery, which is the first

branch of the internal carotid artery and has embryological, anatomical and functional similarities with the intracranial vasculature, is an easily accessible vessel for Doppler assessment that provides information on the less accessible intra-cranial circulation.<sup>8</sup>

Uterine artery and several peripheral vessels Doppler indices have been investigated as a potential marker for the development of pre-eclampsia, among which is ophthalmic artery Doppler (OAD). Evaluating ophthalmic artery with Doppler sonography is easy using standard ultrasound equipment and is unaffected by adiposity. Furthermore, the Doppler velocimetric indices have constant reference ranges throughout trimesters of pregnancy.<sup>10,9</sup>

There are few studies in Nigeria regarding the ophthalmic artery velocimetric indices in patients with pre-eclampsia. This study is aimed at evaluating the parameters of the ophthalmic artery Doppler velocimetry in patients with PE and compare them with those of normotensive pregnant controls.

### Aim and objectives

#### Broad

To sonographically determine the ophthalmic artery Doppler velocimetric indices among patients with pre-eclampsia and compare with that of match normotensive pregnant controls.

#### Specific

1. To sonographically determine ophthalmic artery resistive index (RI), pulsatility index (PI) and peak ratio (PR) among patients with pre-eclampsia and their matched controls.
2. To compare resistive index, pulsatility index and peak ratio between pre-eclamptic patients and matched normotensive pregnant controls.

### Materials and methods

This observational cross sectional study was carried out in Aminu Kano Teaching Hospital (AKTH). It is a tertiary care facility in Kano, Nigeria. Using a systematic random sampling technique, 80 pregnant women

being managed for pre-eclampsia at the obstetrics and gynaecology department of AKTH, and an equal number of matched normotensive pregnant women as controls were recruited into the study. The two groups were matched in terms of maternal age, gestational age and parity.

Pregnant women who were not-consenting, smokers, having multiple pregnancies, orbital pathologies and maternal conditions before pregnancy, such as diabetes mellitus, chronic hypertension, and HIV infection, were excluded from both groups.

Informed consents were obtained from the study and control groups. Data were obtained using structured data collection sheet. The maternal age, blood pressure (BP), gestational age and estimated foetal weight (by ultrasound scan) of study group were obtained. Similar information were obtained from the control group. The ophthalmic artery peak ratio (PR), pulsatility index (PI), and resistive index (RI) were obtained for both study and control groups.

Ultrasound scanning was performed using HYVission V5 Panascope digital ultrasound machine, equipped with 6.8-15MHz transducer. An acoustic coupling gel was applied on the transducer which was then placed directly and gently on the closed eyelid with the gaze directed at the ceiling.<sup>11</sup> The examiner's hand was rested on the orbital margin to minimize the applied pressure to the globe and the orbit. The insonation angle was kept below  $20^{\circ}$  with high-pass filter set to its minimum value.<sup>12</sup> Real time grey scale and colour Doppler scanning was then performed in longitudinal and transverse planes of both globes. The hypoechoic stripe of the optic nerve was then identified with the ophthalmic artery just medial to it.<sup>13</sup> Using colour Doppler, the ophthalmic artery was further identified by its direction of flow (toward probe) and pulsatility at about 15 millimetres from the optic disc (on the medial aspect of the optic nerve). Pulsed-wave Doppler was then applied, with sample volume placed around 15mm behind optic disc, medial to optic

nerve; sample volume was about 2mm in length.<sup>12</sup>

The Doppler sample gate ( $\leq 2$  mm) was placed at the centre of the detected vessel to image the spectral pattern. Pulse repetition frequency (PRF) was set at 125 kHz and adjusted as appropriate.<sup>11</sup>

The spectral waveform (figure 1) as well as the velocimetric indices which include, Resistive index (RI), Pulsatility Index (PI) and peak ratio (PR) were obtained from the ultrasound machine which has the manufacturer calibrated automatic calculator for RI and PI. While the PR was calculated manually by dividing the second peak systolic velocity (P2) with the peak systolic velocity (PSV). Both ophthalmic arteries were insonated and measurement taken three times on both right and left side, and average of each of the three reading were recorded.

Data generated were analysed using IBM statistical product and service solutions (SPSS) statistics software version 22.0 New York, USA. Mean  $\pm$  standard deviation was used to summarize quantitative variables. T-test was used to compare continuous with group/categorical variables with two levels. Findings were then presented numerically, graphically and in tabular forms. A p-value of 0.05 or below was considered to be statistically significant.

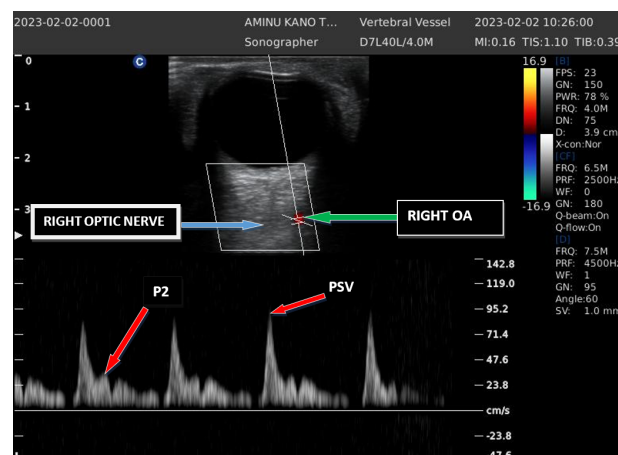


Figure 1: - Triplex transverse ultrasonogram showing the colour filled right ophthalmic artery (green arrow) and its spectral waveform (red arrows). PSV= peak systolic velocity, P2= second peak systolic velocity, OA = ophthalmic artery.

## Results

This study was conducted over a period of 8 months from December 2023 to July 2024. A total of 160 subjects were recruited into the study, comprising 80 pre-eclamptic subjects and equal number of normotensive pregnant controls.

### Socio-demographics of the study subjects

The age range of pre-eclamptic subjects was 19 – 38 years with a mean age of  $28 \pm 3.86$  years while that of the normotensive pregnant control subjects was 18 – 37 years with a mean of  $27.52 \pm 4.36$  years. The mean age difference between the two groups was not

statistically significant ( $p = 0.444$ ). The highest number of the respondents were found in the age range of 25 – 29 years comprising of 37 individuals (46.3%) in both the pre-eclamptic subjects and normotensive pregnant control groups as shown in **Table 1**.

The gestational age of the pre-eclamptic group ranges from 28 – 38 weeks with a mean gestational age of  $33.24 \pm 2.89$  weeks, while that of the normotensive pregnant control subjects was 25 – 40 weeks with a mean of  $33.41 \pm 3.72$  weeks. There is no statistically significant difference between the mean gestational ages of the two groups ( $P = 0.74$ ) as shown in the **Table 1** below.

**Table 1: Socio-demographic Characteristics of pre-eclamptic and normotensive pregnant control Subjects:**

Variables	Pre-eclamptic subjects n=80 (%)	Normotensive pregnant control n=80 (%)	Total n=160	P-value
<b>Age (Years)</b>				
<20	2 (2.5)	2 (2.5)	4	
20-24	12 (15.0)	12 (15.0)	24	
25-29	37 (46.3)	37 (46.3)	74	
30-34	23 (28.8)	23 (28.8)	46	
35-40	6 (7.5)	6 (7.5)	12	
<b>Mean <math>\pm</math> SD</b>	<b><math>28 \pm 3.82</math></b>	<b><math>27.54 \pm 4.32</math></b>		<b>P = 0.444</b>
<b>Gestational age (weeks)</b>				
20 - 24	0	0	0	
25 - 29	9 (11.3)	9 (11.3)	18	
30 - 34	37 (46.3)	37 (46.3)	74	
35 - 40	34 (42.5)	34 (42.5)	68	
<b>Mean <math>\pm</math> SD</b>	<b><math>33.19 \pm 2.88</math></b>	<b><math>33.42 \pm 3.68</math></b>		<b>P = 0.740</b>

### Ophthalmic artery Doppler velocimetric indices in the pre-eclamptic and normotensive control subjects.

The ophthalmic artery PSV, EDV, RI PI, P2 and PR ranges for pre-eclamptic and

normotensive control subjects are shown in **Table 2**.

The mean PSV, EDV, RI PI, P2 and PR values on the right and left sides showed no statistically significant difference ( $P = 0.99$ ), as shown in **Table 3**

The mean ophthalmic artery PSV, EDV, RI, PI, P2 and PR for the pre-eclamptic subjects were  $55.78 \pm 20.4$ cm/s,  $22.36 \pm 8.94$ cm/s,  $0.58 \pm 0.09$ ,  $0.89 \pm 0.29$ ,  $41.80 \pm 15.9$ cm/s and  $0.78 \pm 0.08$  on the right side. The corresponding values for the left eye were  $55.81 \pm 20.11$ cm/s,  $22.81 \pm 9.03$ cm/s,  $0.57 \pm 0.09$ ,  $0.88 \pm 0.28$ ,  $42.03 \pm 15.85$  and  $0.75 \pm 0.08$ . Similarly, the mean ophthalmic artery PSV, EDV, RI, PI, P2 and PR values for the normotensive control subjects were  $69.59 \pm 15.47$ cm/s,  $17.94 \pm 6.60$ cm/s,  $0.74 \pm 0.08$ ,  $1.56 \pm 0.35$ ,  $40.06 \pm 9.71$ cm/s and  $0.59 \pm 0.12$

in the right eye. The corresponding values on the left were  $69.18 \pm 14.77$ cm/s,  $17.94 \pm 6.55$ cm/s,  $0.73 \pm 0.08$ ,  $1.56 \pm 0.34$ ,  $40.24 \pm 9.65$  and  $0.59 \pm 0.11$  (**Table 4**).

The mean PSV, RI and PI values among the pre-eclamptic subjects were lower than those of the normotensive control subjects, while the EDV and PR values of the pre-eclamptic subjects were higher on both the right and left sides ( $P < 0.001$ ). The P2 values for the pre-eclamptic and normotensive controls showed no statistically significant difference ( $P = 0.400$ ), as shown in **Table 3**.

**Table 2: The range of ophthalmic artery Doppler velocimetric indices between pre-eclamptic and normotensive control subjects.**

Doppler Parameters	Pre-eclamptic subjects		Normotensive control subjects	
	RIGHT EYE	LEFT EYE	RIGHT EYE	LEFT EYE
PSV (cm/s)	12.00 – 88.50	13.00 – 88.00	43.13 - 96.70	43.33 - 96.50
P2 (cm/s)	8.69 – 69.9	8.70 – 69.20	23.8 -65.44	23.9 – 65.5
EDV (cm/s)	3.32 – 40.16	3.4 – 40.60	6.70 - 34.20	7.00 - 34.00
RI	0.35 – 0.79	0.34 – 0.78	0.56 – 0.91	0.56 - 90
PI	0.38 – 1.81	0.36 – 1.80	1.00 – 2.37	0.98 – 2.36
PR	0.52 – 0.85	0.52 – 0.86	0.31 – 0.79	0.32 – 0.79

**Table 3: Comparison of means of Doppler velocimetric indices of pre-eclamptic and normotensive control subjects for the right and left side.**

Doppler parameters	Pre-eclamptic (cases)		P-value	Normotensive (controls)		P-value
	Mean	SD		Mean	SD	
RIGHT_PSV	55.78	20.4	<b>0.99*</b>	69.59	15.47	<b>0.99*</b>
LEFT_PSV	55.81	20.11		69.18	14.77	
RIGHT_EDV	22.36	8.94	<b>0.99*</b>	17.94	6.60	<b>0.99*</b>
LEFT_EDV	22.81	9.03		17.94	6.55	
RIGHT_RI	0.58	0.09	<b>0.99*</b>	0.74	0.08	<b>0.99*</b>
LEFTT_RI	0.57	0.09		0.73	0.08	
RIGHT_PI	0.89	0.29	<b>0.99*</b>	1.56	0.35	<b>0.99*</b>
LEFTT_PI	0.88	0.28		1.56	0.34	
RIGHT_P2	41.80	15.95	<b>0.99*</b>	40.06	9.71	<b>0.99*</b>
LEFT_P2	42.03	15.85		40.24	9.65	
RIGHT_PR	0.75	0.08	<b>0.99*</b>	0.59	0.12	<b>0.99*</b>
LEFT_PR	0.75	0.08		0.59	0.11	

\*Statistically significant at  $p \leq 0.05$

**Table 4: Comparison of means of Doppler velocimetric indices of pre-eclamptic and normotensive control subjects.**

DOPPLER PARAMETERS	Pre-eclamptic (CASES)		Normotensive (CONTROLS)		P-value
	Mean	SD	Mean	SD	
RIGHT_PSV	55.78	20.4	69.59	15.47	<b>&lt;0.002*</b>
LEFT_PSV	55.81	20.11	69.18	14.77	<b>&lt;0.003*</b>
RIGHT_EDV	22.36	8.94	17.94	6.60	<b>&lt;0.003*</b>

LEFT_EDV	22.81	9.03	17.94	6.55	<0.001*
RIGHT_RI	0.58	0.09	0.74	0.08	<0.001*
LEFTT_RI	0.57	0.09	0.73	0.08	<0.001*
RIGHT_PI	0.89	0.29	1.56	0.35	<0.001*
LEFTT_PI	0.88	0.28	1.56	0.34	<0.001*
RIGHT_P2	41.80	15.95	40.06	9.71	0.402*
LEFT_P2	42.03	15.85	40.24	9.65	0.383*
RIGHT_PR	0.75	0.08	0.59	0.12	<0.001*
LEFT_PR	0.75	0.08	0.59	0.11	<0.001*

\*Statistically significant at  $p \leq 0.05$

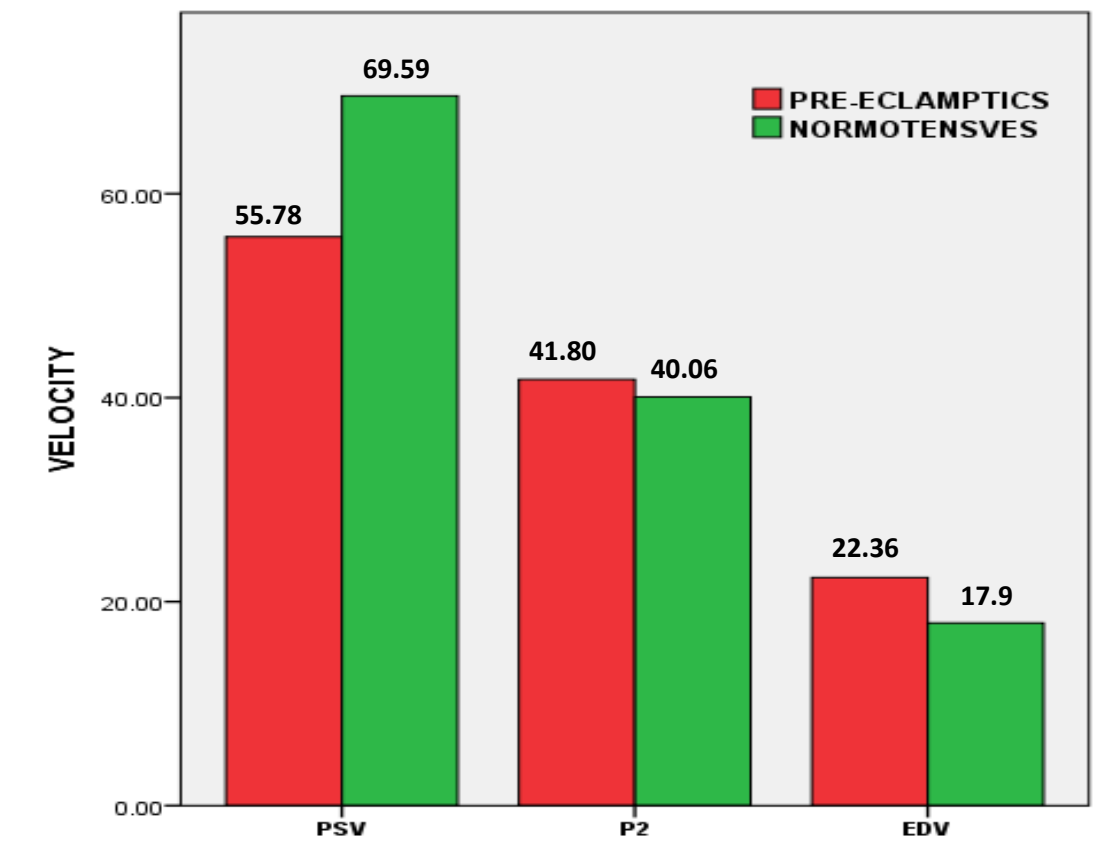


Figure 2: Bar chart showing means of PSV, P2 and EDV of the ophthalmic arteries of the right eyes for the pre-eclamptic and normotensive group.

## Discussion

Pre-eclampsia (PE) is a complication of pregnancy that is associated with substantial maternal and foetal morbidity and mortality. Maternal endothelial dysfunction due to circulating factors of foetal origin from the placenta is a hallmark of pre-eclampsia.<sup>14</sup> The occurrence, development, and intensity of PE can vary significantly in a natural context, with unpredictable timing, intensity, and severity. The commonly cited explanation for the observed pathology is that inadequate transformation of spiral arteries and excessive oxidative stress in the placenta leads to a systemic inflammatory reaction, characterized by extensive damage to the endothelium, where the placenta is considered the primary pathogenic agent in this process.<sup>1</sup>

This study examined ophthalmic artery Doppler velocimetric indices in both normotensive pregnant women and those diagnosed with PE.

A total of 80 pre-eclamptic subjects were evaluated in this study with equal number of normotensive pregnant control group summing up to 160 participants. The mean age of  $28 \pm 3.86$  years with an age range of 19 – 38 years for the pre-eclamptic subjects was similar, to that of the control group with a mean of  $27.52 \pm 4.36$  years and a range 18 – 37. The modal age for both the study and control groups is 25 – 29 years. The difference between the mean age of the study and control groups was not statistically significant (P- value = 0.444), because they were matched. The mean age obtained in this study ( $27.52 \pm 4.36$  years) was similar to that derived by *Mustapha et al*<sup>15</sup> in North-western Nigeria at  $27.24 \pm 4.16$ . However, *Olatunji et al*<sup>12</sup> obtained higher mean age in a study in southwestern Nigeria where found a mean age of  $32.4 \pm 4.7$  years. This difference was likely due to socio-cultural variation in terms of time of marriage between the two regions.

The mean gestational age of the pre-eclamptic group at  $33.24 \pm 2.89$ , was similar to that of the control group ( $33.41 \pm 3.72$  weeks). The modal gestational age for the

two groups was 25 – 29 weeks. There was no statistically significant difference between the gestational age of pre-eclamptic subjects and their normotensive control groups (P value = 0.74). The modal gestational age presented in this study was similar to what was found by *Olatunji et al*<sup>12</sup> in southwestern Nigeria where gestational age of less 30 weeks was reported. The mean gestational age of the pre-eclamptic group was also similar to what was recorded by *Mustapha et al*<sup>15</sup> in North-western Nigeria at  $33.20 \pm 3.74$  weeks

The mean ophthalmic artery peak systolic velocity (PSV) value among the pre-eclamptic subjects was lower than that of the normotensive control subjects, and the difference was statistically significant (P < 0.001). Conversely, the end diastolic velocity (EDV) of pre-eclamptic subjects was higher than those of the normotensive controls on both the right and left sides (P < 0.001). The mean second peak systolic velocity (P2) value was slightly higher in the pre-eclamptic subject compared to that of the normotensive controls, however, not statistically significant (P= 0.400). This explained the statistically significant (P < 0.001) lower mean resistive index (RI) and pulsatility index (PI) values, with a higher peak ratio seen in the pre-eclamptic subjects. This pattern of reduced resistance with increase blood flow was explained by *Belfort et al*<sup>16</sup> in the United States. They stated that pre-eclampsia as a placental disease is associated with increase placental vascular resistance and in order to improve placental perfusion, it may be hypothesized that there is compensatory production of vasodilator substances by the placenta. These circulating factors, as a secondary effect, dilate vessels in multiple organs, including aorta, myometrium and intracranial circulation compared to normotensive controls groups. *Pollyanna et al*<sup>10</sup> in a systemic review of 14 studies and *Olatunji et al*<sup>12</sup> in Southwestern Nigeria reported similar pattern of low resistance among the pre-eclamptic subjects. They revealed that the mean RI, PI, and PSV were significantly lower in pre-eclamptic patients

than in the normotensive pregnant controls. While Mean P1, EDV, and PR were significantly higher in the pre-eclamptic group.

This study found no statistically significant difference between the mean PSV, EDV, RI PI, P2 and PR values on the right and left side ( $P = 0.99$ ). This is in agreement with what was recorded by *Mustapha et al*<sup>15</sup> in North-western Nigeria and *Olatunji et al*<sup>12</sup> in Southwestern Nigeria in their respective studies.

The mean ophthalmic artery PSV and EDV recorded in this study among the pre-eclamptic subjects were  $55.78 \pm 20.4$  cm/s and  $22.36 \pm 8.94$  cm/s respectively in the right eye and  $55.81 \pm 20.11$  cm/s and  $22.81 \pm 9.03$  cm/s respectively in the left eye. This was in agreement with what was obtained by *Kumari et al*<sup>17</sup> in India. However, *Olatunji et al*<sup>12</sup> in Southwestern Nigeria recorded a lower mean PSV value, presumably due smaller sample size of 42 compared with 80 in this study. The mean ophthalmic artery PSV and EDV recorded in this study among the normotensive control was  $69.59 \pm 15.47$  cm/s and  $17.94 \pm 6.60$  cm/s on the right side, and  $69.18 \pm 14.77$  cm/s and  $17.94 \pm 6.55$  cm/s on the left side. The pattern of higher PSV and lower EDV among the control group compared to the study group was reported by *Kumari et al*<sup>17</sup> in India and *Olatunji et al*<sup>12</sup> in Southwestern Nigeria.

**Limitations of the study:** Being a study conducted at a single centre, highlights the potential for selection bias due to its limited geographic scope. While the findings regarding ophthalmic artery Doppler parameters are significant, the results may not fully represent the broader population. Secondly the study is limited by lack of longitudinal follow-up, absence of diagnostic accuracy analysis and potential confounding variables.

**Conclusion:** Ophthalmic artery Doppler parameters showed significant differences between pre-eclamptic and normotensive pregnant subjects, and may serve as a useful adjunct in the evaluation of pre-eclampsia. Given its non-invasive nature, it holds

promise as an adjunctive tool for the evaluation and monitoring of pre-eclampsia, though larger, multi-centre studies are recommended to establish normative thresholds and refine its clinical utility.

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