Central Retinal and Ophthalmic Artery Doppler Velocimetry among Hypertensives and Normotensive Adults at a Nigerian Tertiary Health Facility

Peter T. Adenigba[1], *Ademola J. Adekanmi[2,4], Olufunmilola A. Ogun[3]

[1]Department of Radiology, University College Hospital Ibadan, Nigeria. [2]Department of Radiology, College of Medicine, University of Ibadan, Nigeria. [3]Department of Ophthalmology, College of Medicine, University of Ibadan, Nigeria. [4]Institute of cardiovascular diseases, College of Medicine, University of Ibadan, Nigeria.

Abstract

Background: Haemodynamic alterations of the retrobulbar circulation are sequelae of untreated, long-standing hypertension. Early evaluation of the retrobulbar blood flow is very crucial to prevent irreversible ocular complications. The objective of this study was to evaluate the differences in central retinal artery (CRA) and ophthalmic artery (OA) haemodynamics in adult hypertensive and non-hypertensive subjects.

Methodology: This prospective, comparative cross-sectional study was conducted among 63 hypertensives and 75 normotensive controls. Using Doppler ultrasonography, the CRA and OA Doppler velocimetry parameters among cases and controls were evaluated and analysed.

Results: The CRA Peak Systolic Velocity (PSV) and End-diastolic velocity (EDV) was 7.54 ± 2.60cm/s and 2.99 ± 1.15cm/s (p<0.001) in hypertensives but 10.8 ± 2.51cm/s and 4.50 ± 1.25cm/s) p<0.001 in controls. The systolic/diastolic ratio (S/D) in cases was 2.64 ± 0.75 and 2.44 ± 0.38 p=0.045 in controls. The CRA's Pulsatility Index (PI) between cases and controls was not statistically significant, p =0.082. Furthermore, the CRA's PSV, PI, Resistivity index (RI) and S/D, were higher among subjects with stage 1 compared to stage 2 hypertension (p=0.004; p=0.027; p<0.001 and p=0.001 respectively). The OA mean EDV in hypertensives was 4.57 ± 1.97 and in controls= 5.31 ± 1.79 (p=0.022), while the OA mean RI and Peak Ratio, p=0.009 and 0.003, respectively, were higher in stage 1 hypertension.

Conclusion: The Central retinal and ophthalmic artery blood flow parameters were significantly lower among hypertensive cases. Also, hypertensive stage 2 cases had significantly lower blood flow and vascular impedance parameters in the CRA and both Central retinal and ophthalmic artery, respectively.

Keywords: Hypertension; Retinopathy; Central Retinal Artery; Ophthalmic Artery; Ultrasonography.

Introduction

Hypertension is now a major health concern associated with significant morbidity and mortality, with complications of hypertension accounting for 9.4 million death worldwide [1,2]. Africa has the highest worldwide prevalence of hypertension of 46% among adults older than 25 years3 [3] and has become a serious public health issue in sub-Saharan Africa [1,2,4-6].

Pathophysiological changes in sustained systemic hypertension may affect the retina, choroid, and optic nerve[7,8] resulting in various end-organ complications, such as retinopathy[7,9.10] and changes in retinal vessel calibre[11,13]. In the retinal circulation, the primary response of the retinal arterioles to systemic hypertension is

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Corresponding Author: *Ademola J. Adekanmi
Department of Radiology, College of Medicine, University of Ibadan, Nigeria.
Email: kanmiademola@gmail.com

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vasoconstriction which may lead to disruption of the blood - retinal barrier, increased vascular permeability, and secondary arteriosclerosis in sustained hypertension [14].

Recently, there has been a great deal of research interest in the role of retrobulbar blood flow in chronic hypertension in the aetiopathogenesis of irreversible ocular changes that may result in blindness[15,16,17]. Of the various radiological modalities, interest has been focused on ocular ultrasonography with Doppler sonography emerging as an efficient, reliable, safe, and non-invasive tool devoid of ionizing radiation that can assess the posterior segment of the eye and the blood flow alterations[11,18]. Doppler sonography is now an established imaging technique and an increasingly used tool to evaluate ocular changes associated with hypertension. The Doppler spectral analysis successfully demonstrates the changes in blood flow velocities in orbital vessels in various pathological conditions[11-13]. Previous ocular studies in Nigeria have focused extensively on the fundoscopic/ophthalmoscopic retinal vascular changes in hypertensives[19,20]. However, there is a paucity of literature on ocular Doppler changes in hypertensive individuals.

Therefore, the purpose of this study is to determine the central retinal and ophthalmic artery Doppler pattern among a cohort of hypertensive adults and to compare the same with the values obtained in a normotensive adult population in Ibadan, Nigeria.

Material and Methods

Study design and setting: This was a cross-sectional comparative study design. Cases were recruited from the outpatient cardiology clinic of a referral tertiary hospital in South-West of Nigeria, while controls were selected among normotensive, non-diabetic patients from the General outpatient's department of the same Hospital and healthy volunteers. The study period was from August 2017 to January 2018.

Study population and sampling: Cases were adults aged 18 years and above with hypertension (Blood pressure>140/90 mmHg) without symptoms and signs of Diabetes (polyuria, polydipsia, weight loss) and are normoglycemic (random plasma glucose concentration <200mg/dl (11mmmol/l); fasting (>8hours) plasma glucose<126mg/dl (7mmol.l) and 2-hour postprandial glucose <200mg/dl during oral glucose tolerance test (American Diabetes Association, 2013). While healthy normotensive, non-diabetic adults without renal or vascular diseases of similar age and socioeconomic Status were the control group.

Institutional Ethical Review Committee approval was obtained for this study. Sixty-three adults with hypertension were enrolled, according to the selection criteria. We enrolled consecutive participants until the sample size was attained. Similarly, by systematic sampling, we enrolled sixty (75) age and sex-matched control subjects (men and women) normotensive adults who met the inclusion criteria and with no past or present history or clinical evidence of cardiovascular diseases. Thus, a total of one hundred and thirty-eight (138) participants - 63 hypertensive patients and 75 controls- were recruited for this study.

Inclusion Criteria

Adults over 18 years with hypertension were included in the study group. In this study, hypertension was systolic blood pressure greater than or equal to 140 mmHg and diastolic blood pressure greater than or equal to 90mmHg or the use of antihypertensive medications by the patients. Hypertension Stage 1- Systolic pressure 140-159 mm Hg and/or diastolic 90-99 mm Hg, and Stage 2- Systolic pressure 160 mm Hg or greater and/or diastolic 100 mm Hg or greater[21]. Controls were healthy normotensive (BP <130/90mmHg), normoglycemic subjects having normal lipid profile, and body mass index.

Exclusion criteria: This study excluded participants with comorbidities such as heart failure, atrial fibrillation, renal failure, Sickle Cell Disease (SCD), vascular disorders, diabetes mellitus (Fasting Blood Sugar, FBS 7.0 mmol/l or 126mg/dl), glaucoma, or other medical disorders. In addition, we excluded all cases of previous intraocular surgery, non-consenting subjects, and healthy subjects with a history of or on medication for cardiovascular disease and those with deranged lipid profiles.

Clinical evaluation: The sociodemographic and anthropometric parameters of all patients who met the inclusion criteria and had signed the informed consent form to participate in the study were extracted into a prepared data form.

The blood pressure measurement was measured using a mercury sphygmomanometer (Acoson mercury sphygmomanometer, manufactured by Accoson, Model-Dekamet desk, Country-England). We evaluated the blood pressure (BP) while the subject was resting in a sitting position and the arm supported on a level surface. The cuff was placed around the upper arm and secured. The stethoscope bell was placed over the brachial artery in the cubital fossa to listen to pulse sounds. The cuff was slowly inflated until the pulse disappeared and then slowly deflated. Readings were based on Korotkoff first (the blood pressure reading when the pulse reappeared) and the fifth phase (the reading when the pulse disappeared), corresponding to the systolic BP and diastolic BP.

The participant's height in meters (m) was measured using a Stadiometer, and the weight in kilograms (kg) using a zero corrected Seca weighing scale, model number 755 1321994, and manufactured in 2010 by Seca GmbH & Co. Kg. in Hamburg, Germany.

An experienced ophthalmologist performed all ocular examinations. The following information; intraocular pressures, by applying a topical anesthetic drop (Tetracaine Hydrochloride 0.5%, Alcon Laboratories Inc, Texas, USA), and the tear film was stained with 2% fluoresce in dye (Omni Fluro, Ahmedabad, India), and intraocular pressure was estimated with the Goldmann Applanation Tonometer (Haag Streit, GmBH). Mean ocular perfusion pressure (MOPP) = ⅔ (mean arterial pressure − IOP), where mean arterial pressure (MAP) = DBP + ⅓ (SBP – DBP was calculated[22].

Laboratory evaluation: The fasting glucose was evaluated using a drop of capillary blood obtained by finger prick with a sterile lancet under aseptic technique and using a disposable test strip using Accu-check Active glucometer, serial number GU 21660419, manufactured by Roche in Mannheim, Germany. Fasting blood glucose was documented in mg/dl. Participants with normal fasting glucose and without evidence of hyperlipidemia, as documented in the case files, were recruited into the study. Also, similar clinical and laboratory evaluations were carried out for the controls, and we excluded those with hyperlipidemia or on medication for dyslipidemia.

Ultrasound evaluation: Ocular Color and Pulsed Wave Doppler ultrasound examination of the central retinal and ophthalmic arteries was done using a Sonic Touch ultrasound machine with a linear 5-14 MHz transducer. The ultrasound scanner serial number is SXTCH2.0-1008.0682, manufactured in 2009 by Ultrasonix Medical Corporation in Richmond, BC, Canada.

All patients were positioned supine following the technique described by Schmetterer et al[23]. Both eyes were closed, and a modest amount of standard water-soluble coupling gel was applied to the closed eyelids to provide adequate contact between the transducer and the skin and thus facilitate the transmission of the sound wave to the globe. We avoided applying excessive compression of the eyelid with the transducer was avoid mechanical force on the globe, which could increase intraocular pressure[23]. We scanned both globes in orthogonal (sagittal and transverse) planes while the participants kept the eyes straight ahead with the eyelids closed but without squeezing the eyelids. An experienced radiologist with vast experience in Doppler imaging performed the scans. Firstly B-mode scan was done to exclude orbital pathologies, such as orbital tumors, uveitis, and drusen. Next, we used the color Doppler mode to locate the retrobulbar arteries. Finally, still using the colour Doppler, we identified the ophthalmic artery at approximately 15mm from the posterior margin of the globe. The sample volume box was centered on the vessel, with the angle set parallel to the vessel to account for the Doppler angle[28]. The CRA and OA also were assessed with the optic nerve taken as a reference. Blood flow velocities in the CRA were measured within the optic nerve head shadow 3-5 mm behind the posterior margin of the globe.

For this study, the Doppler wall filter was set at 50Hz, the pulse repetition frequency for the CRA and OA set at 2.5 kHz and 3.3 kHz, respectively, and the Doppler sample volume adjusted to 2mm.

The value of PSV, EDV, RI, and PI from three (3) consecutive spectral waveforms of the assessed vessels taken for every participant, and the average of 3 readings recorded. In addition, each participant had both eyes examined, and the mean values of the two were calculated and documented in the datasheet. The average duration of the ultrasound procedure was about twenty (20) minutes.

Data management and analysis: The sociodemographic, anthropometric, clinical information from the patient's case files, ophthalmological, and retrobulbar Doppler data collected documented in a datasheet. The data was entered and analyzed using Statistical Package for Social Sciences (SPSS Inc. Chicago, IL USA), version 23.

The Doppler parameters (PSV, EDV, PI, and RI) and the sociodemographic characteristics of the population were described using means and standard deviations, proportions, frequencies, and charts.

We used the student's t-test to compare the mean ages of hypertensive and control subjects. A Chi-square test was used to compare the sociodemographic characteristics between hypertensive and control subjects. Analysis of variance was used to compare anthropometric, laboratory, and clinical characteristics between hypertensive subjects with retinopathy, those without retinopathy, and controls and compare the retrobulbar arterial blood flow Doppler indices between the study groups. Where the ANOVA revealed significant differences, we performed post-hoc analyses (Sidak post hoc test, or Games Howell post hoc test used as appropriate) to determine where the difference(s) lay, especially with the Doppler blood flow parameters.

Using Spearman's rank test, we determined the correlation between the duration of hypertension and Doppler parameters and between Doppler parameters and grades of hypertensive retinopathy. Statistical significance was set at $p<0.05$.

Results

The mean age of the hypertensive patients was 50.4 ± 9.69 years, with a minimum and maximum age of 29 and 70 years, this was not statistically significantly different from the mean age of 47.5 ± 10.5 years, with a minimum and maximum age of 27 years and 70 years respectively in the controls, p=0.097. The majority of the participants were females in both the hypertensive patients (58.7%) and controls (57.3%), respectively p=0.868. Educational Status was significantly associated with hypertension p=0.003. Hypertensive patients were majorly patients with tertiary education (47.6%) compared to (74.7%) among the control with tertiary as shown in table 1.

Table 1: Sociodemographic characteristic of the study population

Variables	Hypertensive (%)	Controls (%)	p-value
Age#	50.4 ± 9.69	47.5 ± 10.5	0.671
Gender			
Male	26 (41.3)	32 (42.7)	0.868
Female	37 (58.7)	43 (57.3)	
Ethnicity			
Yoruba	61 (96.8)	67 (89.3)	0.163
Others	2 (3.2)	8 (10.7)	
Religion			
Christian	37 (58.7)	55 (73.3)	
Muslim	26 (41.3)	20 (26,7)	0.070
Occupation			
Unemployed	2 (3.2)	6 (8.0)	
Waged employed	22 (34.9)	38 (50.7)	0.085
Self-employed	34 (54.0)	26 (34.7)	
Retired	5 (7.9)	5 (6.7)	
Educational Status*			
Uneducated	3 (4.8)	1 (1.3)	
Primary	15 (23.8)	5 (6.7)	
Secondary	15 (23.8)	13 (17.3)	0.003
Tertiary	30 (47.6)	43 (74.7)	
Positive history of smoking*			
No	60 (95.2)	74 (98.7)	0.331
Yes	3 (4.8)	1 (1.3)	

* *Fisher's exact test (X^2), #student independent t test (Mean±SD)*

There was a significant difference in the mean systolic blood pressure between patients with hypertension (163.0 ± 35.2) and controls (115.5 ± 11.6) $p<0.001$. There was also a significant difference in the mean diastolic blood pressure between patients with hypertension (98.4 ± 23.7) and controls (73.2 ± 7.81) $p<0.001$.Similarly, there was a statistically significant difference in the average MAP between patients with hypertension (119.9 ± 26.3) and controls (87.3 ± 7.78) $p<0.001$.

However, the intraocular pressure and the cup to disc ratio on fundoscopy showed no significant difference between the cases and the control.

The intraocular pressure in both eyes shows no statistical differences in their mean, as displayed in table 2.

Table 2: Relationship between hypertensive retinopathy and anthropometric characteristics

Variables	Hypertensive Mean ± SD	Control Mean ± SD	P-value
Body weight	73.4 ± 15.1	71.8 ± 12.0	0.491
Height	1.65 ± 0.07	1.62 ± 0.08	0.074
BMI	27.0 ± 5.60	27.3 ± 4.76	0.771
Systolic BP	163.0 ± 35.2	115.5 ± 11.6	<0.001
Diastolic BP	98.4 ± 23.7	73.2 ± 7.81	<0.001
MAP	119.9 ± 26.3	87.3 ± 7.78	<0.001
FBS	88.3 ± 9.90	85.5 ± 14.3	0.202
IOP in Right eye (mmHg)	14.9 ± 2.92	15.1 ± 2.44	0.612
IOP in Left eye (mmHg)	14.9 ± 2.71	15.0 ± 2.42	0.887
Right eye cup to disc ratio	0.29 ± 0.10	0.26 ± 0.09	0.145
Left eye cup to disc ratio	0.28 ± 0.10	0.27 ± 0.09	0.269

BMI =Body mass Index, BP = Blood pressure, MAP = Mean arterial blood pressure, IOP = Intraocular pressure, SD = standard deviation.

However, the mean ocular perfusion pressure was significantly higher in hypertensive cases and stage 2 disease than normal controls and cases with stage 1 disease(Table 3).

Table 3: Intraocular pressure and mean ocular perfusion pressure among the study population

Variables	Hypertensive	Control	P-value
IOP in Right eye (mmHg)	14.9 ± 2.92	15.1 ± 2.44	0.612
IOP in Left eye (mmHg)	14.9 ± 2.71	15.0 ± 2.42	0.887
MOPP	70.2 ± 18.0	49.0 ± 4.65	<0.001
	Hypertension Severity		
MOPP	STAGE 1	STAGE 2	
	54.5 ± 9.2	82.9 ± 12.4	<0.001
Right eye cup to disc ratio	0.29 ± 0.10	0.26 ± 0.09	0.145
Left eye cup to disc ratio	0.28 ± 0.10	0.27 ± 0.09	0.269

MOPP = Mean ocular perfusion pressure, and IOP = Intraoccular pressure.

The Doppler parameters shows that there was a significant difference in the CRA mean PSV between hypertensive patients (7.54 ± 2.60) and controls (10.8 ± 2.51) p<0.001. Likewise, there was a statistically significant difference in the CRA mean EDV between hypertensive (2.99 ± 1.15) and controls (4.50 ± 1.25) p<0.001. Also, a significant difference in the CRA's mean S/D ratio between hypertensive patients (2.64 ± 0.75) and controls (2.44 ± 0.38) p=0.045. On the other hand, the difference in the CRA mean PI between hypertensive patients (1.02 ± 0.28) and controls (0.95 ± 0.17) was not statistically significant, p =0.082.

In the ophthalmic artery, there was a statistically significant difference in the mean EDV between hypertensive (4.57 ± 1.97) and controls (5.31 ± 1.79) p=0.022(Table 4).

Table 4: Relationship between hypertension and retrobulbar arterial flow Doppler changes.

Variables	Hypertensive group Mean ± SD	Control group Mean ± SD	P-value
	CENTRAL RETINAL ARTERY		
PSV	7.54 ± 2.60	10.8 ± 2.51	<0.001
EDV	2.99 ± 1.15	4.50 ± 1.25	<0.001
PI	1.02 ± 0.28	0.95 ± 0.17	0.082
RI	0.58 ± 0.10	0.57 ± 0.06	0.556
S/D ratio	2.64 ± 0.75	2.44 ± 0.38	0.045
	OPHTHALMIC ARTERY		
PSV	14.3 ± 6.67	16.1 ± 6.25	0.102
EDV	4.57 ± 1.97	5.31 ± 1.79	0.022
PI	1.25 ± 0.41	1.26 ± 0.39	0.878
RI	0.66 ± 0.09	0.65 ± 0.08	0.322
S/D ratio	3.27 ± 1.08	3.10 ± 0.90	0.313
PEAK ratio	0.61 ± 0.11	0.62 ± 0.09	0.654

PSV =Peak systolic volume, EDV = End diastolic volume, PI = Pulsatility index, RI = Resistivity Index, S/D = Systolic-Diastolic ratio and SD = Standard Deviation.

Most hypertensive patients, 35 (55.6%), had stage 2 hypertension—Figure 1

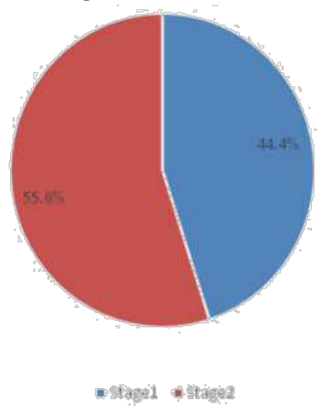

Figure 1: Proportion of Hypertension Severity Among Hypertensive Patients

We noted a significant difference in the CRA mean PSV between subjects with stage 1 hypertension (8.57 ± 2.19) and those with stage 2 hypertension (6.71 ± 2.63) p=0.004. Likewise, there was also a significant difference in the CRA mean PI between subjects with stage 1 hypertension (1.10 ± 0.30) and those with stage 2 hypertension (0.95 ± 0.25) p=0.027. Similarly, the difference in CRA RI between subjects with stage 1 hypertension (0.63 ± 0.09) and those with stage 2 hypertension (0.54 ± 9) P<0.001. Finally, there was a statistically significant difference in the CRA mean SD ratio between subjects with stage 1 hypertension (2.96 ± 0.84) and those with stage 2 hypertension (2.40 ± 0.55) P=0.001.

In the ophthalmic artery, there was a statistically significant difference in the mean RI between subjects with stage 1 hypertension (0.70 ± 0.08) and those with stage 2 hypertension (0.63 ± 0.09) P=0.009. Likewise, there was a statistically significant difference in the ophthalmic mean peak ratio between subjects with stage 1 hypertension (0.57 ± 0.10) and those with stage 2 hypertension (0.65 ± 0.10) P=0.003 (Table 5).

Table 5: Relationship between hypertension severity and retrobulbar arterial flow Doppler changes.

	Stage 1 (Mean ± SD)	Stage 2 (Mean ± SD)	*P-value*
	CENTRAL RETINAL ARTERY		
PSV	8.57 ± 2.19	6.71 ± 2.63	0.004
EDV	3.08 + 0.99	2.92 + 1.27	0.607
PI	1.10 ± 0.30	0.95 ± 0.25	0.027
RI	0.63 ± 0.09	0.54 ± 0.09	<0.001
SD ratio	2.96 ± 0.84	2.40 ± 0.55	0.002
	OPHTHALMIC ARTERY		
PSV	15.3 ± 6.00	13.5 ± 7.15	0.284
EDV	4.44 ± 1.59	4.68 ± 2.24	0.639
PI	1.33 + 0.41	1.19 + 0.40	0.202
RI	0.70 + 0.08	0.63 + 0.09	0.009
S/D ratio	3.57 + 1.04	3.04 + 1.07	0.051
PEAK ratio	0.57 + 0.10	0.65 + 0.10	0.003

PSV =Peak systolic volume, EDV = End diastolic volume, PI = Pulsatility index, RI = Resistivity Index, S/D = Systolic-Diastolic ratio and SD = Standard Deviation.

In the CRA, there was a negative correlation between MAP and PSV (r= -0.635, p<0.001), EDV (r= -0.401, p=0.001), PI (r= -0.307, p=0.014), RI (r= -0.385, p=0.002) and S/D ratio (r= -0.290, p=0.021). In the OA, there was a negative correlation between MAP and PSV (r= -0.267, p=0.034), RI (r= -0.291, p=0.021), S/D ratio (r= -0.290, p=0.021) and PEAK ratio (r= 0.309, p=0.016) respectively (Table 6).

Table 6: Correlation between Mean Arterial blood pressure (MAP) and retrobulbar arterial flow Doppler velocimetry

Variables	Mean arterial blood pressure (MAP)	
	Correlation coefficient	p-value
	CENTRAL RETINA ARTERY	
PSV	-0.635	<0.001
EDV	-0.401	0.001
PI	-0.307	0.014
RI	-0.385	0.002
S/D ratio	-0.290	0.021
	OPHTHALMIC ARTERY	
PSV	-0.267	0. 034
EDV	-0.048	0.709
PI	-0.153	0.231
RI	-0.291	0.021
S/D ratio	-0.290	0.021
PEAK ratio	0.309	0.016

PSV =Peak systolic volume, EDV = End diastolic volume, PI = Pulsatility index, RI = Resistivity Index, S/D = Systolic-Diastolic ratio and SD = Standard Deviation.

Discussion

The ophthalmic examination in this study showed no statistical difference in the intraocular pressure and cup to disc ratio of both eyes among the hypertensive cases and the controls, all indicating that none of the cases had glaucoma. Expectedly, the mean ocular perfusion pressure is significantly higher in the hypertensive cases than in controls, being a mathematical expression derived from the patient's MAP [22].

This present study observed that the central retinal artery PSV, EDV, and the ophthalmic artery EDV in hypertensive subjects were statistically lower in the hypertensive patients than in the controls, similar to the findings of some previous studies among hypertensive subjects [24,25]. At the same time, the PI and RI were not significantly different in the hypertensive subjects from the controls. Our observation was in agreement with the findings of a study conducted among 60 geriatric patients with hypertension and 30 healthy subjects which also reported no statistical difference in CRA and OA between the hypertensive and the control group [24]. However, Ahmetoglu et al. in a study among 22 hypertensive patients off medication (with a mean age of 58 years) and 15 controls (mean age of 56 years), also reported that RI of the OA and CRA show a significant increase among hypertensive patients compared to the control group, and the treatment of hypertensive patients with candesartan significantly decreased their RI values [25]. The differences between this study and our present study maybe due to differences in population dynamics, the sample size and the study design.

In contrast to the studies with older hypertensive patients, a study of acohort of 100 young hypertensive patients and 50 age and gender-matched healthy controls reported a significantly higher PSV, EDV, PI, and RI of both CRA and OA in the hypertensive group than in the control [26]. This may suggest that age differences between cases and controls may significantly affect the Doppler parameters.

Generally, we would have expected a unidirectional pattern in the Doppler velocimetry parameters in the CRA and the OA among the hypertensive cases. The fact that some patients' blood pressure had been well controlled on anti-hypertensive medications, we believed could be responsible for the observed non-unidirectional Doppler velocimetry pattern.

In addition, this present study also showed that the mean PSV, PI, and RI of CRA and the ophthalmic artery mean RI were significantly reduced in patients with stage 2 hypertension compared with those with stage 1 hypertension. In contrast, the ophthalmic artery peak ratio significantly increased in patients with stage 2 hypertension than those with stage 1 hypertension. Although to our knowledge, there were no studies to compare our observations with regards to retrobulbar Doppler velocimetry and hypertension stages with. de Oliveira et al., in a study to compare the ophthalmic artery Doppler indices, howbeit among women with pregnancies complicated by hypertension, reported that the ophthalmic artery peak ratio increased significantly in women with severe preeclampsia than those with mild preeclampsia, chronic hypertension, and healthy pregnancy respectively. They also observed a significant reduction in the ophthalmic artery RI and PI among the pregnant women. Hence, we deduced that the OA peak ratio increases as hypertension worsens.

We further observed in the correlation test that as the mean arterial pressure increases, there was an inverse reduction in the CRA's PSV, EDV, PI and S/D, and Ophthalmic artery PSV, RI and S/D, in agreement with the known atherosclerosis, arteriolosclerosis effect of hypertension and loss of the retrobulbar autoregulation as blood pressure increases. However, the increase in OA Peak ratio as the MAP increases would suggest that the OA peak ratio increases with the blood pressure, in tandem with the findings of de Oliveira et al., although among pre-eclamptic women.

This study is not without limitations. First, hypertensive cases recruited were not newly diagnosed antihypertensive drug-naive subjects for ethical reasons. Second, the hypertensive cases studied were already on medications, and some cases had their blood pressure well controlled. This could have reflected on the mean Doppler parameters recorded in this study.

Conclusion

Compared to normotensive controls, the Central retinal and ophthalmic artery blood flow is significantly reduced among hypertensive cases. Also, hypertensive stage 2 cases had significantly lower blood flow in the CRA and lower vascular impedance parameters in the Central retinal and ophthalmic arteries.

The findings of this study would sensitize ophthalmologists and other Physicians to include retrobulbar Doppler scans in the workup protocol to look out for early blood flow changes and institute appropriate therapy to avoid irreversible ocular changes.

A multi-center study is suggested in the future to determine the cutoff of central retinal and ophthalmic artery blood flow and vascular resistance at which irreversible ocular changes could occur.

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