www.jmscr.igmpublication.org
Impact Factor 5.84
Index Copernicus Value: 71.58
ISSN (e)-2347-176x ISSN (p) 2455-0450
crossref DOI: https://dx.doi.org/10.18535/jmscr/v5i9.94

IGM Publication
Journal Of Medical Science And Clinical Research
An Official Publication Of IGM Publication

Doppler Evaluation of Ocular Vessels in Primary Open Angle Glaucoma Patients

Authors
Dr Lekha C.S[1], Dr Mini P.A[2], Dr Josey Verghese T[3]
[1]Junior Resident, Department of Radiodiagnosis, Govt. T.D. Medical College, Alappuzha
[2]Additional Professor, Department of Ophthalmology, Govt. T.D. Medical College, Alappuzha
[3]Professor, Department of Radiodiagnosis, Govt. T.D. Medical College, Alappuzha
Corresponding Author
Dr Mini P.A.
Additional Professor, Department of Ophthalmology, Govt. T.D. Medical College, Alappuzha, Kerala state
Ph: 9447304075 Email: *drminipantony@gmail.com*

ABSTRACT

Background: *Primary Open-Angle Glaucoma (POAG), is sometimes called "the silent thief of sight" because in the early stages of the disease there are no warning signs — no pain or vision loss. The trabecular meshwork in the angle of anterior chamber where the aqueous exits the eye become blocked. Hence the pressure inside the eye, ie, intraocular pressure (IOP) increases. The fact that the optic nerve head perfusion is directly related to retrobulbar circulation, which is directly accessible to ultrasound study, makes Colour Doppler imaging (CDI) a prime tool for the evaluation of early changes in vascular flow related to glaucoma. The use of CDI has been validated already in the evaluation of moderate and advanced glaucoma patients, consistently detecting flow velocity alterations and increased resistivity index in these patients in comparison with healthy individuals.*

Aim: *Primary objective is to assess the blood flow in ocular vessels namely Central Retinal Artery, Short Posterior Ciliary Arteries and Ophthalmic Artery in patients with established Primary Open Angle Glaucoma (POAG) with visual field defects compared with patients of the same disease without visual field defects in standard automated perimetry. The present study search alteration in ocular blood flow indices in POAG and to assess if reduced retro-ocular blood flow is associated with disease progression. Circulatory alteration early in the disease, might be used to know if given treatment could normalize circulatory alterations and on the basis of this, to predict chances of having further increase in damage to optic nerve in glaucoma patients. Hence treatment modalities might be changed in future with emphasis directed more on normalization of circulatory alteration rather than just IOP.*

Materials and Methods: *This is a descriptive study with diagnostic test evaluation. 64 patients, above 40 years of age, attending the weekly glaucoma clinic in the Ophthalmology outpatient department and referred to the Department of Radio diagnosis of T.D. Medical College Alappuzha, who are clinically diagnosed to have Primary open angle glaucoma constituted the study group. PSV, EDV and RI of Ophthalmic, central retinal and short posteroir ciliary arteries are studied. Analysis of The diagnostic performance of RI of Ophthalmic artery, Central retinal artery and Short posterior ciliary arteries was evaluated using Receiver Operating Characteristic (ROC) curve analysis, keeping perimetry based classification of visual field defect as the base. ROC curves were also used to compare the diagnostic performance of the three RI values. The data analysis*

was done in IBM SPSS statistics version 23 and MED CALC version 16.8.4.
Results: *Mean intraocular pressure and cup-disc ratio were found statistically significant among the two groups with and without field defects. The study showed significantly lower velocities (PSV and EDV) of ophthalmic artery and central retinal artery in POAG patients having visual field defects in comparison with those without visual field defects. There was no statistically significant difference in the PSV of short posterior ciliary artery among the 2 subgroups of the sample. The resistivity index (RI) was significantly higher in all the three ocular vessels in POAG patients having visual field defects, when compared with those having a stable visual field. The diagnostic capability of RI of ocular vessels- ophthalmic artery, central retinal artery and short posterior posterior ciliary arteries in patients with and without field defects were compared using the ROC curves, which showed statistically significant area under curve in all the above mentioned vessels.*
Conclusion: *In view of the statistically significant differences in the Doppler indices of ocular vessels among the POAG patients with and without visual field defects, further research is required in this field to establish the usefulness of colour Doppler imaging in POAG.*

INTRODUCTION

Glaucoma[1] is one of the leading causes of blindness world-wide, second only to cataract. It is broadly classified as open or closed angle glaucoma. An imbalance in the production and drainage of aqueous humour that fills the anterior chamber of eye occurs, more often the trabecular meshwork in the angle of anterior chamber where the aqueous exits the eye become blocked. Hence the pressure inside the eye (intraocular pressure /IOP) increases. As IOP increases, the pressure pushes harder against the nerve fibres of the optic nerve. This deprives the optic nerve of oxygen and nutrients. Over time, high eye pressure can cause irreversible nerve damage[2,3] and vision loss. Vision loss occurs from Primary open angle glaucoma starts in the peripheral [4]field and slowly moves centrally. Nerve damage causing peripheral loss of vision, is not perceived by the patient until the disease has progressed[5] significantly. Hence Primary Open Angle Glaucoma requires close monitoring throughout life.

The fact that the Optic nerve head perfusion is directly related to retrobulbar circulation,[6] which is directly accessible to ultrasound study, makes Colour Doppler imaging (CDI) a prime tool for the evaluation of early changes in vascular flow related to glaucoma. Altered ocular haemodyn-amics has been implicated in disease progression. Optic nerve head is perfused by the Short Posterior Ciliary Arteries (PCA), and the Central Retinal Artery (CRA), which are branches of Ophthalmic artery (OA). Colour Doppler Imaging (CDI) visualizes all these arteries and hence can be used for the routine monitoring of Primary open angle glaucoma.

VASCULAR ANATOMY AND COLOUR DOPPLER STUDY OF ORBIT

The first branch of the internal carotid artery is the ophthalmic artery (OA), the only extracranial branch of the internal carotid artery.[7] The ophthalmic artery continues to run inferiorly to the optic nerve and enters the orbit through the optic canal. While in the orbit, the OA crosses superior to the ON and moves nasally and anteriorly. The OA terminates after giving off the central retinal artery (CRA) and the posterior ciliary arteries, and branches to the extraocular muscles.

The central retinal artery supplies the inner two-thirds of the retina, the anterior segment of the optic nerve head and areas of the retrolaminar optic nerve. It penetrates the optic nerve approximately 10–15mm behind the globe to run adjacent to the central retinal vein in the middle of the ON. The medial and lateral posterior ciliary arteries then branch off the ophthalmic artery.The short posterior ciliary artery supply the peripapillary and posterior choroid, while the long posterior ciliary artery and the anterior ciliary arteries (branches of the muscular arteries) supply the anterior choroid. These retrobulbar vessels provide the majority of the blood to the eye.

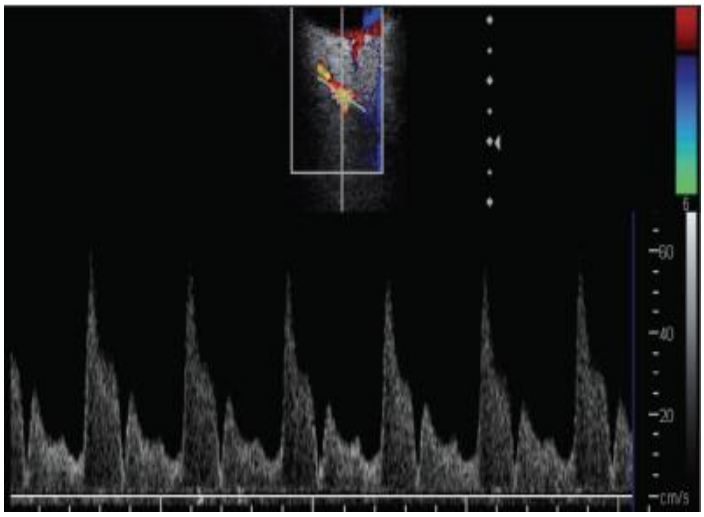
Therefore, the hemodynamic parameters of the ophthalmic artery, central retinal artery and short posterior ciliary arteries reflect local blood supply conditions in the optic disc. Colour Doppler

imaging is done to assess the relation of vascular factors in the pathogenesis of glaucomatous optic neuropathy and the key position of the OA, CRA and short PCA in the orbital vascular anatomy and in the optic nerve blood supply. The prognostic aid of Colour Doppler imaging in patients with glaucoma supports the use of this method for monitoring the occurence and progression of optic nerve damage in glaucoma patients.

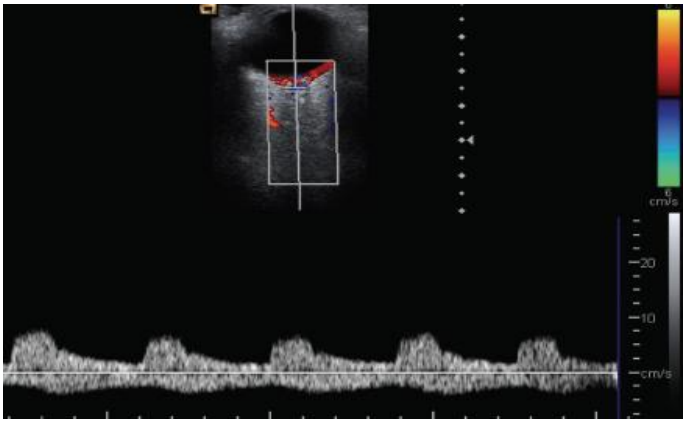
COLOUR DOPPLER IMAGING

Doppler indices Doppler imaging can provide information about blood flow in both large and small vessels. Doppler indices used to characterise the peripheral resistance are based on the Peak Systolic Velocity (PSV), End Diastolic Velocity (EDV), Mean frequency (M), Resistivity Index (RI) and Pulsatility Index (PI).

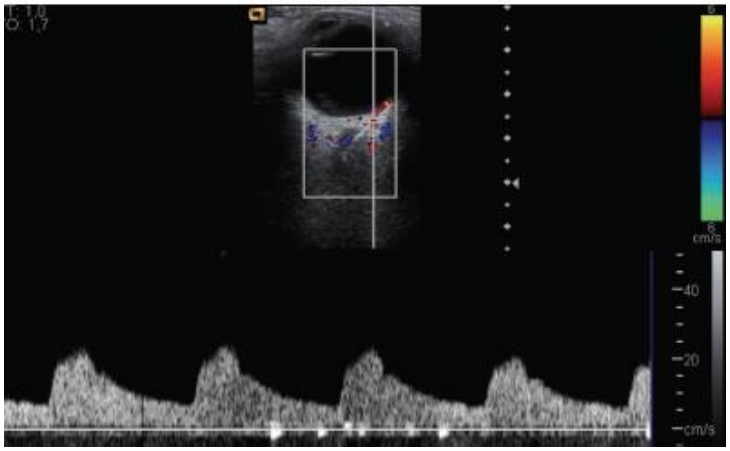
A) Transverse Colour Doppler image shows the site of the ophthalmic artery (OA), medial to the optic nerve and the typical OA waveform obtained by pulsed Doppler shows a sharp systolic peak, a dicrotic notch, and a relatively little flow in diastole.



B) Transverse CDI showing the central retinal artery (CRA) and central retinal vein (CRV) in the centre of optic nerve. Waveforms for central retinal vessels showed, CRA curve above the zero axis with rounded systolic peak and continuous flow in diastole, the CRV is seen below the zero axis and of low and continuous flow.



C) Transverse CDI demonstrates the short posterior ciliary arteries (PCAs) in the retrobulbar fat. Typical short posterior ciliary artery waveform obtained by pulsed Doppler shows a blunted systolic peak and a low to moderate flow velocity during diastole.



Various Studies on Doppler evaluations in Primary open angle glaucoma

A study[8] conducted in India by Sharma and Bangia found that based on CDI value, in a group of glaucoma patients those who eventually had more progressive visual field loss, diastolic velocities were significantly lower and resistivity index were significantly higher compared with stable patients.

A study[9] by Nanameng Ping zhang in China suggested that blood flow velocities were reduced and RI was increased in all retro bulbar vessels in POAG eyes. Changes of ocular blood flow are important in the development of Primary open angle glaucoma and CDI is therefore a potential diagnostic tool for this condition.

Zahida Butt,[10] Colm O'Brien and Paul Allen from Scotland inferred that there was an increased resistance to blood flow in the Central retinal artery of untreated patients with POAG and also in the ophthalmic artery of patients with POAG. The Ophthalmic artery Peak systolic velocity was elevated in untreated patients with POAG.

Recent study[11] in Nigeria in 2013 by Dr Odunlami Olufemi Adeyinka, Ayoola Olugbenga, Onakpoya Oluwatoyin Helen indicated that ocular blood flow alterations including reductions in PSV, EDV and increase in the RI of the OA and CRA were present in black skinned Africans with POAG.

Another study done by Dr.Suprasanna[1] Charudutt M Shetty and Rajagopal Kadvigare in India in 2014 concluded that Peak systolic velocity and EDV were lower and RI was higher in the ocular vessels of eyes with POAG. In the OA and medial posterior ciliary arteries, RI was higher and the OA EDV was lower in glaucomatous eyes with progressive than with stable visual field loss.

A study conducted by Fatima Jimenez-Aragon, Elena Garcia-Martin, Raquel Larrosa[12] Lopez, J.M, Artigas-Martín, Pilar Seral-Moral, and Luis E. Pablo Miguel Servet University Hospital, Zaragoza, Spain in August 2013 showed significant differences for some orbital CDI parameters between both groups. A combination of decrease in flow velocities and increase in pulsatility and resistive indices obtained by orbital CDI, was registered in progressing glaucoma patients compared to those who remained stable.

Fernando Galassi, Andrea sodi, Francisca Ucci in their study[13] on Ocular hemodynamics and glaucoma prognosis-a colour doppler imaging, inferred that patients with a stable visual field had a higher diastolic velocity and a lower RI in the ophthalmic artery compared with those with a deteriorating visual field.

AIM AND OBJECTIVE

To assess the blood flow in ocular vessels namely Central Retinal Artery, Short Posterior Ciliary Arteries, and Ophthalmic Artery in patients with established Primary Open Angle Glaucoma (POAG) with visual field defects compared with patients of the same disease without visual field defects.

MATERIALS AND METHODS

This is a descriptive study with diagnostic test evaluation done in between January 2015 to June 2016 in Glaucoma clinic of Department of Ophthalmology outpatient department and Department of Radio diagnosis, Govt. T.D. Medical College Alappuzha in Kerala which is a tertiary care centre. Most of the suspected cases of glaucoma in the district and surrounding rural areas are referred to this hospital.

Inclusion criteria 1.Patients with normal Standard Automated Perimetry (SAP) that is a normal Humphrey Swedish Interactive Threshold Algorithm (SITA) 24-2 standard visual field with mean deviation (MD), and pattern standard deviation (PSD) within 95% limits of the normal reference, but having glaucoma risk factors based on the features of the optic disc (as determined by clinical assessment of the Optic Nerve Head (ONH)), or the presence of ocular hypertension (IOP ≥21mmHg), constituted the first group. 2.Patients with glaucomatous (abnormal) visual field loss with PSD, or glaucoma hemifield test outside normal limits ($P < 0.05$ and $P < 1\%$, respectively) in a consistent pattern on both qualifying visual fields in conjunction with C/D ratio > 0.6 or a vertical C/D ratio greater than the fellow eye by > 0.2 and raised IOP (>21 mmHg) was considered as the second group. They also had ONH changes such as diffuse or localized rim thinning, disc (splinter) haemorrhage, or a notch in the rim detected on baseline dilated fundus examination.

Sample size: 64 Patients with Primary open angle glaucoma having visual field defects and 64 patients of the same disease without field defects during the study period, who satisfied the Inclusion criteria.

Procedure: Prior approval was obtained from The Ethics Committee of our institution and written

consent was received from the patients.In our study PSV, EDV, and RI are measured in the Ophthalmic Artery (OA), Central-Retinal Artery (CRA), and short Posterior Ciliary Arteries (PCA).

GE machine Logiq F8 with linear array probe of frequency (6- 12HZ) was used for performing the ocular imaging, eye with the worst field loss was chosen for CDI measurements of the Study group. During the examination, patients were advised to assume supine position and ultrasound probe was applied over ipsilateral common carotid artery and blood flow velocity was seen to rule out any carotid artery disease. Only those patients with normal carotid waveforms were taken in the study. Then the probe was placed over the supero-temporal part of closed eye lids using sterile coupling gel and pointed towards the orbital apex by tilting it approximately 20-30º to sagittal plane. The examination was carried out with avoidance of undue manual pressure on the globe. The colour Doppler window was localized over the retro bulbar area and flow in the Ophthalmic, Central Retinal and Short Posterior Ciliary arteries were visualised. The Ophthalmic artery was identified approximately 17mm back from the optic nerve head, where it lies parallel and lateral to the optic nerve before giving off its major branches. The Central Retinal Artery was identified at the optic nerve head. The Short Posterior Ciliary arteries begin as trunks approximately 10–20 mm behind the globe, before they form multiple branches surrounding the optic nerve in its retro bulbar portion. They pierce the sclera around the optic nerve and supply the choroid. Because of the high variability of the course, we chose the first point behind the globe where they could be measured and showed characteristic Doppler spectra at the point to get the best reproducibility. After the gray-scale examination, the Colour Doppler Imaging of the vessels were performed. Spectral waveforms and quantitative informations were obtained using the minimum sized Doppler gate(1.5 mm X 1.5 mm), appropriate Doppler frequency with an angle under 30°. A low to medium flow setting was chosen for slow flow (especially central retinal artery and short posterior ciliary artery), a medium to high flow setting was chosen in fast flow (for ophthalmic artery). Using a cross-hair calliper, Peak Systolic Velocity (PSV) and End Diastolic Velocity (EDV) were measured in centimetres/ second and the RI was calculated using Pourcelot's formula 20: The Doppler variables (PSV, EDV, RI) for OA, CRA and short PCA were measured and mean, standard deviation calculated. p values were calculated to determine the statistical significance of blood flow velocities and RI of the ocular vessels in Primary open angle glaucoma patients.

Data Analysis: data was done in IBM SPSS statistics version 23 and MED CALC version 16.8.4. The profile of the sample (demographics) was examined with frequencies, cross tabulations and appropriate graphical tools. The study variables were analysed using descriptive statistics, and; normality of the variables was examined with K-S and S-W tests. The differences in the average of the relevant study variables among the subgroups were examined using parametric (Independent sample t test) and non-parametric (Mann Whitney U) tests.

The diagnostic performance of RI of Ophthalmic artery, Central retinal artery and Short posterior ciliary arteries was evaluated using Receiver Operating Characteristic (ROC) curve analysis, keeping perimetry based classification of visual field defect as the base. ROC curves were also used to compare the diagnostic performance of the three RI values.

RESULTS AND INTERPRETATION

Analysis of Doppler indices of ophthalmic artery

Table : Descriptive Statistics of PSV, EDV, RI of Ophthalmic artery among the Groups With and Without Visual Field Defects.

	Perimetry									
	Without Visual Field Defect					With Visual Field Defect				
	Min	Max	Range	Mean	SD	Min	Max	Range	Mean	SD
PSV	24.70	34.30	9.60	30.55	2.01	21.60	29.40	7.80	24.84	1.74
EDV	5.29	8.90	3.61	7.56	0.64	4.50	6.40	1.90	5.22	0.51
RI	0.718	0.794	0.076	0.753	0.015	0.766	0.810	0.044	0.790	0.010

Table shows the descriptive statistics including mean & SD of PSV, EDV & RI of Ophthalmic artery separately for two levels of visual field.

Analysis of normality in the distribution of the variables: The normality in the distribution of the variables PSV, EDV and RI was examined using Kolmogorov-Smirnov and Shapiro-Wilk test. Parametric test can be applied on these variables only if the normality is found in their distribution.

Table: Tests of Normality for PSV, EDV and RI of Ophthalmic artery.

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
PSV	0.169	128	0.000	0.930	128	0.000
EDV	0.173	128	0.000	0.913	128	0.000
RI	0.154	128	0.000	0.941	128	0.000

The normality tests (both of them) show that the variables are not following normal distribution since the p values are 0.000 which is less than the cut off value of 0.05. For a variable to follow normal distribution, its p value should be greater than0.05

Analysis of Doppler indices of Central Retinal artery

Table : Descriptive Statistics of PSV, EDV, RI of Central retinal artery among the Groups With and Without Visual Field Defects.

	Perimetry									
	Without Visual Field Defect					With Visual Field Defect				
	Min	Max	Range	Mean	SD	Min	Max	Range	Mean	SD
PSV	7.50	10.80	3.30	9.20	0.68	6.90	9.80	2.90	8.37	0.72
EDV	1.88	3.00	1.12	2.43	0.23	1.40	2.40	1.00	1.82	0.20
RI	0.693	0.786	0.093	0.736	0.017	0.753	0.805	0.052	0.783	0.012

Analysis of normality in the distribution of the variables : The normality in the distribution of the variables PSV, EDV and RI of CRA was examined using Kolmogorov-Smirnov and Shapiro-Wilk test. Parametric test can be applied on these variables only if the normality is found in their distribution.

Table : Tests of Normality for PSV, EDV and RI of Central retinal artery.

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
PSV	0.068	128	0.200	0.984	128	0.145
EDV	0.141	128	0.000	0.967	128	0.003
RI	0.154	128	0.000	0.944	128	0.000

The normality tests show that the variable, PSV is following normal distribution since its significance level was found greater than 0.05 in both KS test and SW test. But for the other variables EDV and RI normality tests failed since the p values are 0.000 which is less than the cut off value of 0.05. They do not follow normal distribution.

Analysis of Doppler indices of Posterior Ciliary artery

Table : Descriptive Statistics of PSV, EDV, RI of Short posterior ciliary arteries among the Groups without and with Visual Field Defects.

	Perimetry									
	Without Visual Field Defect					With Visual Field Defect				
	Min	Max	Range	Mean	SD	Min	Max	Range	Mean	SD
PSV	12.70	19.20	6.50	16.19	1.15	13.30	17.80	4.50	16.19	0.96
EDV	3.55	5.70	2.15	4.88	0.43	3.70	5.20	1.50	4.39	0.22
RI	0.669	0.741	0.072	0.699	0.014	0.701	0.738	0.037	0.728	0.009

Analysis of normality in the distribution of the variables of PCA

Table : Tests of Normality for PSV, EDV and RI of PCA.

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
PSV	0.202	128	0.000	0.925	128	0.000
EDV	0.175	128	0.000	0.955	128	0.000
RI	0.137	128	0.000	0.926	128	0.000

The normality tests (both of them) show that the variables are not following normal distribution since the p values are 0.000 which is less than the cut off value of 0.05

Comparison of diagnostic capability of RI of ocular vessels

The diagnostic capabilities of RI of all 3 ocular vessels were compared using the ROC curves.

ROC curve of RI of ophthalmic artery –Showed an area under curve of 0.974 (95% CI: 0.929-0.994)

ROC curve of RI of central retinal artery - Showed an area under curve of 0.986 (95% CI: 0.947-0.999)

ROC curve of RI of short posterior ciliary artery - Showed an area under curve of 0.964 (95% CI: 0.916 -0.989)

DISCUSSION

Our study is to evaluate the relation of vascular factors in the pathogenesis of glaucomatous optic neuropathy and the key position of the OA, CRA and short PCA in the orbital vascular anatomy and in the optic nerve blood supply.64 Patients with Primary open angle glaucoma having visual field defects and 64 patients of the same disease without field defects were evaluated by Color Doppler Imaging. Difference in mean age was found statistically not significant for the two groups as p value of the difference in means was 0.115. The study population was constituted by 79 males (61.7%) and 49 females (38.3%), out of which 48.1% males and 53% females had visual field defects.

Ophthalmic artery

The mean PSV, EDV & RI values of patients of those without visual field defect were 30.55cm/sec, 7.56 cm/sec and 0.753 respectively. Mean PSV, EDV & RI values of those with visual field defect were 24.84 cm/sec, 5.22cm/sec and 0.790 respectively. Thus, the mean velocities (PSV and EDV) showed statistically significant decrease with an increase in the RI in those with visual field defects. (All showed statistically significant p value of 0.000).

In a clinical Study, "Role of Color Doppler Imaging in Early Diagnosis and Prediction of Progression in Glaucoma" conducted by Fatima Jimenez-Aragon et al in 2013, the mean PSV, EDV & RI values were respectively 30.7cm/sec, 7.32cm/sec and 0.75 for those POAG patients without progression of the disease and 25.68 cm/sec, 5.29 cm/sec and 0.79 for those with progression. Significant differences were found between the EDV and RI parameters of both groups, consistent with our study results. Unlike our results, they didn't obtain a statistically significant difference in the PSV of ophthalmic artery, though a lower mean PSV was noted for those with visual field changes.

Central Retinal artery

The mean PSV, EDV & RI values of patients of without visual field defect were 9.20cm/sec, 2.43cm/sec and 0.736 respectively. Mean PSV, EDV & RI values of those with visual field defects were 8.37cm/sec, 1.82cm/sec and 0.783 respectively. Thus, the mean velocities - PSV and EDV showed statistically significant decrease with an increase in the RI in those with visual field defects (All showing statistically significant p value of 0.000).

The study conducted by Fatima Jimenez-Aragon et al found the mean PSV, EDV & RI values of CRA to be 9.56 cm/sec, 2.41 cm/sec and 0.73 respectively for those without progression of the disease and 8.79 cm/sec, 1.88cm/sec and 0.77 for those with progression. Significant differences were found between the EDV and RI parameters

defect were 16.19cm/sec, 4.88cm/sec and 0.699 respectively. Mean PSV, EDV & RI values of those with visual field of both groups, consistent with our study results. Similar to ophthalmic artery, the PSV didn't show a statistically significant difference, though a lower mean was noted for those with visual field changes.

Short Posterior Ciliary artery

The mean PSV, EDV & RI values of patients without visual field defects were 16.19cm/sec, 4.39cm/sec and 0.728 respectively. The mean PSV of both groups were same with no significant difference, consistent with the study conducted by Fatima Jimenez-Aragon et al. The mean EDV showed statistically significant decrease with an increase in the RI in those with visual field defects (Both showing statistically significant p value of 0.000). The study conducted by Fatima Jimenez-Aragon et al in 2013 showed no significant statistical differences for all three CDI parameters between both groups. However, there were lower flow velocities and higher mean RI in the progression group.

Comparison of diagnostic capability of RI of ocular vessels

The diagnostic capabilities of RI of all 3 ocular vessels were compared using the ROC curves.

ROC curve of RI of ophthalmic artery –Showed an area under curve of 0.974 (95% CI: 0.929-0.994)

ROC curve of RI of central retinal artery - Showed an area under curve of 0.986 (95% CI: 0.947-0.999)

ROC curve of RI of short posterior ciliary artery - Showed an area under curve of 0.964 (95% CI: 0.916 -0.989)

A high area under curve was obtained in all 3 cases (above 0.5) with a maximum value for central retinal artery.

The comparison of all three curves showed cut-off points with a specificity of 75.37% and a sensitivity of 100% in the OA, a specificity of 64.55% with a sensitivity of 93.75% in the CRA and a specificity of 68.79, sensitivity of 90.62% in the short PCA. Pair-wise comparison of RI of the three ocular vessels were done, which showed no significant statistical difference between them. All three obtained p values were above 0.05.

Hence, statistically significant differences were found in the Doppler indices of ophthalmic artery, central retinal artery and short posterior ciliary artery among the primary open angle glaucoma patients with and without visual field defects, except the PSV of short posterior ciliary artery, where there was no statistically significant difference

CONCLUSION

- The study showed significantly lower velocities (PSV and EDV) of ophthalmic artery and central retinal artery in POAG patients having visual field defects in comparison with those without visual field defects.
- There was no statistically significant difference in the PSV of short posterior ciliary artery among the 2 subgroups of the sample.
- The resistivity index (RI) was significantly higher in all the three ocular vessels in POAG patients having visual field defects,

when compared with those having a stable visual field.

- Since the resistivity indices (RI) are a ratio of velocities and are angle independent, they are more reliable parameters than flow velocities within the small vessels.
- The diagnostic capability of RI of ocular vessels-ophthalmic artery, central retinal artery and short posterior ciliary arteries in patients with and without field defects were compared using the ROC curves, which showed statistically significant area under curve in all the above mentioned vessels.
- In view of the statistically significant differences in the Doppler indices of ocular vessels among the POAG patients with and without visual field defects, further research is required in this field to establish the usefulness of colour Doppler imaging in POAG.

REFERENCES

1. K. Suprasanna, Chandra Kant, M. Shetty, S. Charudutt, Rajagopal Kadavigere, Doppler evaluation of ocular vessels in patients with primary open angle glaucoma, DOI: 10.1002/jcu.22175, 2014.
2. S. Resnikoff, D. Pascolini, D. Etya'ale et al. "Global data on visual impairment in the year 2002," Bulletin of the World Health Organization, vol. 82, no. 11, pp. 844–851, 2004. View at Google Scholar·
3. H. A.Quigley and A. T. Broman, "The number of people with glaucoma worldwide in 2010 and 2020," British Journal of Ophthalmology, vol. 90, no. 3, pp. 262–267, 2006. · View at Google Scholar ·
4. A. Tuulonen, J. Lehtola, and P. J. Airaksinen, "Nerve layer defects with normal visual fields: do normal optic disc and normal visual field indicate absence of glaucomatous abnormality?" Ophthalmology, vol. 100, no. 5, pp. 587–598, 1993. View at Google Scholar ·
5. T. G. Zeyen and J. Caprioli, "Progression of disc and field damage in early glaucoma," Archives of Ophthalmology, vol. 111, no. 1, pp. 62–65, 1993.View at Google Scholar ·
6. S. S. Hayreh, I. H. Revie, and J. Edwards, "Vasogenic origin of visual field defects and optic nerve changes in glaucoma," British Journal of Ophthalmology, vol. 54, no. 7, pp. 461–472, 1970. View at Google Scholar·
7. Harris A, Jonescu-Cuypers CP, Kagemann L et al.Atlas of Ocular Blood Flow: Vascular Anatomy, Pathophysiology, and Metabolism. Butterworth Heineman Publishers,PA,USA2003.
8. NC Sharma, D Bangiya: Comparative Study of Ocular Blood Flow Parameters by Color Doppler Imaging in Healthy and Glaucomatous Eye, 2006. Udaipur, Rajasthan.
9. Nana Meng, Ping Zhang, Huadong Huang, Jinlan Ma, Yue Zhang, Hao Li, Yi Qu, Jinan: Colour Doppler Imaging Analysis of Retro bulbar Blood Flow Velocities in Primary Open-Angle Glaucomatous Eyes: A Meta-Analysis, China.
10. Zahida Butt Colm O'Brien Graham McKillop, Peter Aspinall and Paul Allan: Colour Doppler Imaging in Untreated High- and Normal Pressure Open-Angle Glaucoma.
11. Odunlami Olufemi Adeyinka, Ayoola Olugbenga, Onakpoya Oluwatoyin Helen, Adetiloye Victor Adebayo, Arogundade Rasheed: Ocular Blood Flow Velocity in Primary Open Angle Glaucoma – A Tropical African Population Study, 2013.
12. Fatima Jimenez-Aragon, Elena Garcia-Martin, Raquel Larrosa Lopez, JoseM. Artigas-Martín, Pilar Seral-Moral, and Luis E. Pablo, Role of CDI in Glaucoma early diagnosis and progression, Miguel

Servet University Hospital, Zaragoza, Spain August 2013.

13. Fernando Galassi, Andrea Sodi, Francisca Ucci, Gialia Renicri, Benedetta Pieri, Michela Baccini. Ocular hemodynamics and Glaucoma prognosis-a colour doppler imaging.arch ophthalmol.2003;121;1711-1715.