

Original Research Article

Ocular doppler imaging: opening a new window in decoding glaucoma

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ABSTRACT

Background: In the aetiopathogenesis of multifactorial glaucoma autoregulation of ocular blood flow plays an important role as failure of autoregulation may lead to progression of disease. Aim of this study to understand this better this study was designed to investigate the quantum of these abnormalities and their likely role in pathogenesis and prognosis of primary open angle glaucoma(POAG).

Methods: This is a case control study design which involved 67 POAG patients and 67 matched controls. The parameters assessed includes peak systolic velocity(PSV), end diastolic velocity(EDV) and resistive index(RI) of ophthalmic artery(OA) and central retinal artery(CRA) of patients having POAG with age and sex matched healthy subjects. The data obtained was statistically analysed using IBM SPSS 21.

Results: The study showed decreased PSV of 31.7 cm/s vs 42.7 cm/s($p=0.0001$) and EDV 11.7 cm/s vs 19.8 cm/s($p=0.002$) with increased RI 0.63 vs 0.53($p=0.000$) in OA and PSV of 15.2 cm/s vs 21.4 cm/s($p=0.001$) and EDV 4.7 cm/s vs 11.7 cm/s($p=0.003$) with increased RI 0.69 vs 0.45($p=0.000$) in CRA in both eyes in POAG patients as compared to healthy controls.

Conclusion: The study has shown the promising application of ocular Doppler in evaluating POAG patients. However, more such studies are needed with larger study sample and on follow up basis for better understanding glaucoma hemodynamics and applicability of ocular Doppler in management of glaucoma.

Keywords: Colour doppler, Glaucoma, Ocular blood flow, Primary open angle glaucoma

INTRODUCTION

Globally 57.5 million people (95% CI 46.4 to 73.1 million) were affected by POAG in 2015 which will rise to 65.5 million (95% CrI 52.8, 83.2 million) by 2020.¹ Seeing the rising trend in disease prevalence there will be requirement of effective management protocol because despite treatment many patients continue to have progressive visual loss. The mainstay of treatment in current scenario is to target modifiable risk factor i.e.

lower IOP. Despite lowering IOP many patients continue to show disease progression with worsening vision. This stimulated search for other modifiable factors which could be targeted to halt disease progression and save diminishing vision. The search for other risk factors has led to the identification of a number of vascular alterations in patients with glaucoma, especially the ones with an otherwise normal IOP (normal tension glaucoma or NTG). Patients with glaucoma have been found to have a state of systemic vascular dysfunction with an increased incidence

of peripheral migraine, vasospasm, systemic hypotension and silent organ ischemia, in what has been suggested to be signals of a systemic vascular dysfunction.²⁻⁴

Colour Doppler imaging(CDI) of orbit is a convenient and safe method of assessing ocular blood flow in glaucoma patients and monitoring the response to anti-glaucoma treatment. The examination of patient is simple without needing mydriasis and multiple readings can be taken in a short time interval. CDI can be undertaken even if the dipoteric media of eye is not transparent. Colour Doppler Imaging (CDI) uses the principle of Doppler shift in frequency, in Hertz, to measure the blood flow velocity in cm/sec. The trans ocular reading of PSV, EDV and RI are taken of Ophthalmic artery (OA) and central retinal artery(CRA) in both orbits. RI is one parameter which is not altered by the angle of Doppler since it is a ratio. Hence, RI can be a useful measure to study the difference between various groups of patients and also avoid any inter-observer bias.⁵ In our study authors have taken two readings of each parameters in both eyes and average of those parameters are taken to obviate measurement related errors.

In the literature, few studies have shown reduction in PSV and EDV with elevated RI in both OA and CRA in glaucoma patients as compared to healthy volunteers.

METHODS

This study was conducted in a tertiary care research hospital for a duration of one year (April 2017 to Mar 2018). We had enrolled total of 150 patients in our study which comprised of 75 POAG patients and 75 healthy volunteers who were age and sex matched controls. After applying the exclusion criteria 06 patients were excluded from study as during initial work up, they turned to be hypertensive. Two more patients were excluded as they underwent LASIK surgery for refractive error correction. Total of 08 POAG patients were excluded from the study. So the final study sample comprised 134 persons of which 67 were POAG patients and 67 age and sex matched healthy volunteers. The study design was “matched case control observational study”. Prior to inclusion in the study a written informed consent was taken from patients and controls. The study was cleared by institutional ethics committee prior to its initiation.

Patients with evidence of ocular diseases like ocular inflammation, intraocular surgery or laser treatment and systemic hypertension were not included in the study. Only after confirming the diagnosis of POAG by diurnal variation of IOP, fundus examination, automated perimetry and gonioscopy patients were subjected to CDI.

The CDI imaging was carried out using Philips HD5 scanner using high frequency probe(10-12 Hz). In each eye, Peak systolic Velocity(PSV), End Diastolic Velocity (EDV) and Resistivity index (RI) of OA and CRA. RI

was calculated using the formula $RI = \frac{PSV - EDV}{PSV}$. The results were compiled and analysed using IBM SPSS Version 21.

RESULTS

Total study sample comprised of 134 patients with 67 cases of confirmed POAG and 67 age and sex matched controls. The mean age of patients in our study was 55.4 years. The total number of males in study is 90 (45 cases and 45 controls) and females is 44 (22 cases and 22 controls) with a male to female ratio of approximately 2:1.

PSV of ophthalmic artery in POAG patients was 31.7cm/s as compared to normal control population of 42.7 cm/s with p value 0.0001 which is highly significant statistically. EDV of POAG patients is 11.7cm/s as compared to 19.8 cm/s in control with p=0.002 which is again a highly significant statistically. RI value in ophthalmic artery of POAG patients is 0.63 as compared to 0.53 in control population with p value falling in statistically highly significant category with p value of 0.000.

Table 1: Colour doppler indices in ophthalmic artery.

	PSV	EDV	RI
POAG	32.6±2.6	11.7±1.4	0.63±0.04
Control	42.6±2.1	19.8±1.8	0.53±0.03
p-value	0.0001	0.002	0.000

PSV of CRA in POAG patients is 15.2cm/s as compared to 21.4 cm/s in controls. EDV in POAG patients is 4.7cm/s as compared to 11.7 cm/s in controls. RI value in CRA of POAG patients is 0.69 as compared to 0.45 in control population. Statistically p values in all the variables is highly significant with p values of PSV, EDV and RI being 0.001, 0.003 and 0.000 respectively.

Table 2: Colour Doppler Indices in central retinal artery.

	PSV	EDV	RI
POAG	15.2±2.1	4.7±1.1	0.69±0.03
Control	21.4±1.5	11.7 1.3	0.45±0.04
p-value	0.001	0.003	0.000

The mean velocities of Ophthalmic artery and CRA were statistically analysed using “unpaired t test” to find statistical significance and p value.

DISCUSSION

Glaucoma also known as kala motia remains either asymptomatic or has mild symptoms before they present with advanced visual loss. With increasing research in the field of a etiopathogenesis of glaucoma and more and more studies over the last twenty years round the globe has shown that vascular factors may play an important

role in glaucoma pathogenesis due to an failure of autoregulation in intra orbital blood flow.^{6,7} Although, elevated IOP is a well-known major risk factor for glaucoma, it has been demonstrated that there are numerous patients in whom glaucoma progressed despite adequate control of IOP with therapy thereby indicating less reliability on IOP as a progression marker for glaucoma.^{8,9}

In the present study statistically significant results were obtained in velocity indices of CDI between patients of POAG and matched healthy controls.

There is decrease in flow velocities of Ophthalmic artery and central retinal artery and increase resistive indices obtained by orbital CDI, in POAG patients as compared to matched control sample. The results suggest that orbital hemodynamics studied by CDI may represent an important biomarker to discriminate POAG patients with higher risk for progression. Doppler US may thus help to institute a more aggressive clinical management in conflicting cases with higher progression risk. Although the current data does not allow us to establish hard velocity parameters to define the threshold between normal and pathologic dynamics, however it does show a recognizable and statistically significant difference in the mean velocities of the two groups. However, a cohort study done by Calvo et al.¹⁰ determined that an RI value higher than 0.75 in the ophthalmic artery was associated with risk of glaucoma progression in patients with high risk of developing glaucoma.

CDI has been recognized in many studies as a useful modality to assess alteration in orbital blood flow dynamics.¹¹⁻¹³ Authors have analysed flow indices in ophthalmic artery and CRA. The posterior ciliary arteries are small caliber vessels and due to their direction, variable intonation angles are usually required for their analysis. Furthermore, the wide variability in their measurements is higher than in other vessels and has been suggested previously. Due to these factors we have not included indices of posterior ciliary arteries in our protocol. On the other side, the larger size and more accessible locations of the ophthalmic artery and the CRA make their measurements easier and more reproducible with CDI.

In our study authors have found significant differences in some CDI parameters, as previous authors have reported. RI has some advantages over other parameters because it includes systolic and diastolic velocity values and is the most reproducible parameter in Doppler ultrasound.¹⁴

The orbital hemodynamics studied by CDI, may be used as a useful biomarker for predicting the probability of glaucoma progression, especially for early stages for whom the adoption of more prudent therapeutic measures may lead to better outcome.

There are certain limitations to our study, glaucoma is a chronic disease with a long period of evolution, for which the follow-up is needed. So follow up cohort studies may help to assume enteropathogenic correlations and long-term predictions.

The strength of the study being double measurement of each parameter in both eyes to obviate measurement errors and inclusion of matched controls.

CONCLUSION

This study suggests that understanding orbital hemodynamics by monitoring blood flow indices in OA and CRA may be useful in management of glaucoma. However, more studies with a larger population over a period of time and follow up during anti glaucoma medication will add to the existing knowledge about a etiopathogenesis of glaucoma and will help in evolving better management protocol for glaucoma.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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