

Ocular Perfusion Pressure in Primary Open Angle

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ABSTRACT

Purpose: To determine the correlation of Mean Ocular Perfusion Pressure (MOPP) with Mean Arterial Pressure (MAP) in primary open angle glaucoma (POAG) and normal tension glaucoma.

Study Design: Cross sectional study.

Place and Duration of Study: Khyber Teaching hospital, Peshawar from July, 2017 to December, 2019.

Methods: A total of 375 patients with POAG were admitted in the hospital. Patients with variable blood pressure (BP) on admission or history of blood pressure or using anti-hypertensive drugs were selected. Patients with secondary Glaucoma, Primary Angle closure Glaucoma, patients with Diabetes mellitus and age below 40 years were excluded. Finally, 200 patients were recruited by convenience sampling. Forty-eight hours monitoring of MAP and Intra ocular pressure (IOP) phasing were done. MAP, MOPP and peak IOP were charted.

Results: MAP and MOPP variability was observed in 53% of patients with POAG. The Pearson co-relation coefficient for those patients in which intervention had yet not been done was -0.460 suggesting a moderate negative correlation between MOPP and IOP ($p < 0.01$). In IOP controlled patients, the coefficient was -0.346 ($p < 0.01$). The results showed a negative correlation between the two values in both data sets. The correlation co-efficient for MAP and IOP in both pre-admission and controlled IOP patients showed strong positive correlation (0.816 and 0.854 respectively for two tailed tests with 0.01 significance).

Conclusion: MOPP, MAP and IOP are correlated and their determination is important in all Primary Open Angle Glaucoma particularly in Normal Tension Glaucoma.

Key Words: Primary Open Angle Glaucoma, Normal Tension Glaucoma, Mean Arterial Pressure, Ocular Perfusion Pressure, Mean Ocular Perfusion Pressure.

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INTRODUCTION

Glaucoma is one of the leading causes of irreversible visual impairment leading to blindness. The number of glaucoma patients is more than 60 million people worldwide.¹ Despite improvements in investigation and treatment, blindness caused by glaucoma in one eye is reported to be 26.5% and in both eyes is 5.5%

after 10 years and increased to 38.1% and 13.5% in 20 years.²

POAG is an ocular disease characterized by progressive optic neuropathy with loss of retinal ganglion cells (RGC), retinal nerve fiber layer (RNFL) and visual field defect with gonioscopically open angles with or without IOP.³ Non IOP related factors associated with POAG included vascular, mechanical and genetic leading to RGC death and vision loss.⁴

Glaucoma experts did not include IOP in the definition but did consider it as the most important risk and a modifiable risk factor. If POAG is associated with elevated IOP (more than 21 mmHg); it is labeled as high-pressure glaucoma while with normal IOP it is

labelled as Normal tension glaucoma (NTG). The NTG Comprises 20%-90% of all POAG patients with variable ethnicity.⁵

The normal physiological cup disc ratio is 0.3. This cup area has no axonal neurons. This physiological cupped area is surrounded by neuroretinal tissue called neuroretinal rim. Loss of RGC causes widening and deepening of cup disc ratio called pathological cupping. This loss of RGC and RNFL is caused by raised IOP (mechanical damage) and ischemia (hypoperfusion) or neurotoxin.^{6,7} The neuroretinal rim and RNFL thickening or thinning, and its progression are detected by optical coherent tomography (OCT). While functional damage is detected by decreased sensitivity test on Perimetry. Thus, OCT is a measurement of RNFL thickness and Perimetry is measurement of decreased light sensitivity especially in central 30 degree of VF.

MAP is the average arterial pressure throughout in each cardiac cycle, systole and diastole. Normal MAP is 93 mmHg or ranges from 70 to 100 mmHg. Ophthalmodynamometry is the proper method to measure the MAP in central retinal artery (CRA). As ophthalmodynamometry method is very inconvenient in CRA, an alternative method based on mean Brachial artery blood pressure (MAP) is used.⁸

$MAP = \text{Systolic BP} + 2(\text{Diastolic BP})/3$ or $1/3 \text{ Systolic BP} + 2/3 \text{ Diastolic BP}$ or $\text{Systolic BP} + 2(\text{Diastolic BP})/3$. For example, a person with BP of 120/80 will have MAP of $120 + 2 \times 80 / 3 = 93$ mmHg. Whereas, mean ocular perfusion pressure (MOPP) is equal to $2/3 \text{ MAP} - \text{IOP}$. In the above example, person with IOP 21 mmHg will have MOPP; $2/3 \times 93 - 21 = 41$ mmHg. So, the normal MOPP is considered to be more than 40 mmHg. Any reduction in MAP or elevation of IOP will lead to ischemic damage of optic nerve and RNFL in POAG.

In this study we will present correlation of MAP, MOPP and IOP in POAG.

METHODS

After getting approval by ethical committee, a total of 375 patients with POAG were admitted in the hospital. Sampling size was calculated using 95% confidence level, 5% margin of error 5% and population size of 300. It was 191 patients. Patients with variable blood pressure (BP) on admission or history of blood pressure or using anti-hypertensive drugs were selected. Patients with secondary Glaucoma, Primary

Angle closure Glaucoma, patients with Diabetes mellitus and age below 40 years were excluded. Two hundred patients satisfied the inclusion criteria. Detailed ophthalmological examination including Visual acuity, Perimetry, Pachymetry for Central corneal thickness (CCT), fundus photograph for cupped disc ratio, Gonioscopy to record open angle and OCT for RNFL thickness were performed. IOP phasing was performed every 6 hours for 72 hours. Twenty-four hours monitoring of MAP was done. Peak values of IOP and lowest value of MAP were especially focused. The MOPP was calculated using the formula mentioned in introduction. Anti-hypertensive medication and anti-glaucoma medication were adjusted to achieve normal MOPP. Co-relation between MOPP and IOP was calculated using SPSS version 26.

RESULTS

Out of 375 patients, 200 patients (53%) had MAP variation; 130 (34.6%) had POAG and 70 (18.7%) had NTG. Details of MAP and MOPP are shown in table 1 and 2. MOPP and status of Glaucoma after antiglaucoma therapy and anti-hypertensive treatment is depicted in table 3.

The Pearson co-relation coefficient for those patients in which intervention had yet not been done came out to -0.460 suggesting a moderate negative correlation between MOPP and IOP on a two tailed test with a p value <0.01. Similarly, in IOP controlled patients the coefficient was -0.346 with a p value of <0.01. These results showed a negative correlation between the two values in both data sets. The

Table 1: Distribution of MAP in the study participants at admission.

MAP	No.	Percentage
>100 mm Hg.	70	35
90 to 99 mm Hg.	50	25
<90 mm Hg.	80	40
Total	200	100

Table 2: MOPP and status of glaucoma at admission (IOP uncontrolled).

MOPP (mm Hg)	No. of Cases	Percentage	Glaucoma Status
>40	15	7.5	POAG
40-36	35	17.5	POAG
35-30	55	27.5	POAG
<30	95	48.5	NTG

Table 3: MOPP and glaucoma status at follow up (IOP controlled).

MOPP mm Hg)	No. of Cases	Glaucoma Status	
		Stable n (%)	Unstable
41 or more	130	118 (90.7%)	12 (9.3%)
40 to 35	45	43 (95.5%)	2 (4.5%)
30 or 35	15	0	15 (100%)
Absent	10	NA	

correlation co-efficient for MAP and IOP in both pre-admission and controlled IOP patients showed strong positive correlation (0.816 and 0.854 respectively for two tailed-test with 0.01 significance).

DISCUSSION

In this study we have observed the relation between MAP, MOPP, IOP and POAG. Several other studies have also shown the relationship between systolic BP, diastolic BP, MAP and POAG.⁹⁻¹² In our study, 200 cases of POAG out of 375 patients (53.3%) had a history of variable BP/MAP. In Pakistan, frequency of hypertension is estimated to be 26.3% in Urban areas and 21.3% in Rural areas.¹³ In India, the prevalence was 47.3% in POAG patients.¹⁴ These studies confirm a higher association of vascular disease in glaucoma patients.

The MOPP is important factor in POAG. According to the calculation formula of MOPP, normal MOPP is 41 mmHg or more when IOP is within normal range of 21mmHg or less. If MAP is less or IOP is more, the MOPP will be lower and so glaucomatous progression will occur. In hypertension, an increased ciliary blood flow leads to hypersecretion of aqueous out flow and raised episcleral vein pressure causing decreased aqueous out flow. These changes lead to a raised IOP so consequently, MOPP will be less.⁶ To achieve normal MOPP, antihypertensive drugs are used to bring MAP to normal and anti-glaucoma drugs indicated to control IOP which are successful in controlling damage caused by glaucoma. On other hand hypotension due to anti-hypertensive therapy will decrease spontaneous blood flow to optic nerve. This will lead to ischemic damage to RNFL, despite a normal IOP.^{15,16} In such cases adjustment of anti-hypertensive drugs must be considered. In our study we adjusted antihypertensive and anti-glaucoma drugs to achieve MOPP of more than 40 mmHg in all cases.

The association between MAP and POAG has been found in several studies. The IOP up to 21 mmHg

was considered as safe, but now a days many patients are seen, having glaucomatous optic neuropathy and visual field defect with IOP less than 21 mmHg. In Japanese, POAG were seen in 92% of cases where IOP was 21 mmHg or less.¹⁷ These cases were labeled as NTG. In another study progression of glaucomatous optic neuropathy was noted in 12% eyes treated for NTG.¹⁸ In our study 70 cases (18.7%) of NTG were treated with antiglaucoma and adjustment of antihypertensive drugs to achieve normal MOPP.

In this study we did IOP phasing, to measure the maximum peak of IOP. After IOP phasing, POAG was classified as POAG with raised IOP >21 mmHg or NTG if IOP was <21 mmHg. On presentation after IOP phasing, 130 cases (34.6%) were diagnosed as POAG with raised IOP and 70 cases (18.7%) as NTG with IOP within normal range. The IOP phasing not only helps to classify glaucoma but also helps to manage it by considering MOPP.

In Asia, more than 70% of POAG are NTG as the IOP is in normal range while the OPP is less than 40 mmHg.¹⁹ The study of Chen et al, proved that improving ocular perfusion is beneficial for normal tension glaucoma.²⁰

Our study supports the results of Zheng Y et al where 32.1% patients had MOPP of less than 46 mmHg.⁸ In our study 92.5% cases had low MOPP on admission while after treatment the number reduced to 30%.

It has been seen in many studies that glaucomatous optic neuropathy progresses even with normal IOP. One of the important phenomena in such cases was variable BP/MAP. Although there is no direct relation between BP/MAP and POAG but MOPP below normal was associated with POAG.¹⁰

The study has several limitations that should be acknowledged to understand its findings within the appropriate context. The cross-sectional nature of the study limits the ability to infer causation. The use of convenience sampling can introduce selection bias and exclusion of patients with secondary glaucoma, primary angle-closure glaucoma, diabetes mellitus, and those under 40 years old means that the findings cannot be generalized to these groups. Without longitudinal follow-up, it is challenging to understand how changes in MAP, MOPP, and IOP over time impact the progression of glaucoma or patient outcomes. There may be other confounding variables that were not controlled for in the study, such as

lifestyle factors, other medications, or coexisting medical conditions, which could impact the relationships between MAP, MOPP, and IOP. Conducting the study in a single hospital (Khyber Teaching Hospital) limits the external validity. Results might differ in other settings with different patient populations and clinical practices.

These limitations suggest that while the study provides valuable insights into the correlation between MAP, MOPP, and IOP in POAG, its findings should be interpreted with caution. Further research with more robust designs and larger, more diverse populations is necessary to confirm these findings and explore their implications for clinical practice.

CONCLUSION

MOPP determination is important in all Primary Open Angle Glaucoma particularly in Normal Tension Glaucoma. Keeping the MOPP above 40 can prevent retinal ganglion cell death and prevent the deterioration of visual health in patients.

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Patient's Consent: Researchers followed the guidelines set forth in the Declaration of Helsinki.

Conflict of Interest: Authors declared no conflict of interest.

Ethical Approval: The study was approved by the Institutional review board/Ethical review board (688/DME/KMC).

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