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RESEARCH ARTICLE

A comparative study of intraocular pressure and ocular perfusion pressure changes in prehypertensive individuals

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ABSTRACT

Background: According to the WHO, glaucoma is the second leading cause of blindness in the world. Ocular perfusion pressure (OPP), an important determinant of ocular blood flow, represents the balance between the opposing forces of blood pressure (BP) and intraocular pressure (IOP). Alterations in OPP play a significant role in pathogenesis of glaucoma. Although systemic hypertension has been proved to be a potential risk factor for glaucoma, there is a paucity of literature regarding the vascular effects of prehypertension on optic disc. **Aims and Objectives**: This study aims to study the effects of prehypertension on IOP and OPP. **Materials and Methods**: A total of 102 voluntary participants in the age group of 20–50 years were selected. The study group comprised 51 subjects with prehypertension and control group included 51 age and sex-matched normotensives. Basal IOP and BP were recorded in sitting position using rebound tonometer and sphygmomanometer, respectively. Mean OPP was calculated. **Results:** There was significant increase in the IOP and OPP of both the eyes in prehypertensives when compared with normotensives. **Conclusion:** Elevated IOP levels in prehypertensive individuals are deleterious to optic disc. Raised OPP observed in prehypertensives could be due to effective autoregulation, which could be compromised if there is further increase in BP. Hence, early detection of prehypertension and measures to reduce the BP must be taken to prevent the development of glaucoma.

KEY WORDS: Blood Pressure; Intraocular Pressure; Ocular Perfusion Pressure; Prehypertension

INTRODUCTION

According to the WHO, glaucoma is the second leading cause of blindness in the world, which can affect the quality of life significantly.[1] Intraocular pressure (IOP), the pressure exerted by intraocular fluids on the coats of the eyeball, is a significant and modifiable risk factor for glaucoma.[2] Ocular perfusion pressure (OPP) is an important determinant of ocular blood flow, and it reflects the vascular status of the optic disc. It represents the balance between the opposing forces of blood pressure (BP) and IOP and expressed as the difference between these two forces.[3] Alterations in ocular perfusion could cause reduced ocular blood flow, leading to ischemia and poor irrigation of nervous tissues, thus having deleterious effects on the optic disc. These effects could be especially relevant for the increasing incidence and progression of glaucoma.[4]

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The exact pathophysiological mechanism of optic nerve damage in glaucoma is complex and not fully understood. Raised IOP is one of the major risk factors for the development of glaucoma due to its mechanical effect on the optic nerve head. Along with this, several vascular factors such as vasospasm, atherosclerosis, and systemic hypertension

have also been implicated as potential risk factors in the pathogenesis of glaucoma.[5] Prehypertension, a precursor of clinical hypertension, is defined as above - optimal systolic BP (SBP) and diastolic BP (DBP) of 120–139 or 80–89 mmHg, respectively, according to JNC 7, the WHO classification.[6] This is further classified as elevated hypertension and Stage I hypertension by American College of Cardiology and American Heart Association.[7]

Although prehypertension is an asymptomatic silent killer that is associated with subclinical atherosclerosis, and target-organ damage,[8] there is little information available in the literature regarding its vascular effects on ocular perfusion.

Understanding the relationship between BP, IOP, and OPP in prehypertensives is important to determine their effects in the development of glaucoma. Hence, the objective of this study was to substantiate the effects of prehypertension on IOP and OPP.

MATERIALS AND METHOD

A total of 102 voluntary participants were recruited from the ophthalmology clinic in Mysuru in the age group of 20–50 years. They were categorized into two groups based on their BP. The sample size was calculated according to Ngo *et al*.[9] to be 51 in each group. The study group comprised subjects with prehypertension (SBP of 120–139 mmHg or DBP of 80–89 mmHg). Control group included age- and sex-matched normotensives with BP <120/80 mmHg. Subjects with conjunctivitis, glaucoma, contact lens users, smokers, alcoholics, hypertensives, and individuals with a history of diabetes mellitus and chronic kidney diseases were excluded from the study. Institutional ethical clearance was obtained for this study.

After obtaining informed written consent and explaining the details of the procedure, subjects were asked to rest for 15 min following which basal IOP and BP were recorded in sitting position using rebound tonometer and sphygmomanometer, respectively. All the recordings were done between 11 am and 1 pm to reduce the effects of diurnal variations on IOP.[10]

Mean arterial pressure (MAP) and mean OPP (MOPP) were calculated using the following formulas:

MAP=Diastolic BP+1/3(SBP-DBP).

MOPP=(2/3) MAP–IOP.[10]

Statistical Analysis

Data collected were entered into MS Excel 2010 and analyzed using SPSS version 23. Descriptive statistical measures such as percentage, arithmetic mean, and standard deviation were applied. Inferential statistical tests such as unpaired *t*-test and Pearson's correlation were applied. Differences and correlation were interpreted as statistically significant at $P < 0.05$.

RESULTS

This study comprised 102 participants with the mean age of 30 years. The MAP in the prehypertensives was 11.9 mmHg higher than controls. The mean right IOP and left IOP values showed a statistically significant increase of 4.25 mmHg and 4.33 mmHg, respectively, in prehypertensives when compared with normotensives. The mean OPP values in the right and left eyes also showed a marginal increase of 2.47 mmHg and 2.41 mmHg, respectively, in prehypertensive cases [Table 1]. The IOP values of both the eyes were positively correlated with the BP parameters [Table 2]. A positive correlation was also observed between OPP and BP values [Table 3].

DISCUSSION

The relationship between glaucoma and BP is complex and poorly understood. IOP and OPP are the important risk factors in the pathogenesis of glaucoma. To determine this relationship, one should understand the complex interplay between BP, IOP, and OPP which was the objective of this study. It was observed in our study that the IOP was significantly higher in prehypertensive individuals when compared with normotensive individuals ($P < 0.001$). Positive correlation was also observed between MAP

Table 1: Comparison of study variables between cases and controls

Parameters (mmHg)	Prehypertensives (*n*=51) mean±SD	Normotensives (*n*=51) mean±SD	*t* value	*P* value
SBP	126.29±5.8	110.90±6.2	12.9	0.001
DBP	80.98±2.8	73.53±4.2	10.6	0.001
MAP	96.08±2.7	85.99±4.1	14.6	0.001
R-IOP	18.37±0.9	14.12±1.0	21.8	0.001
L-IOP	18.31±1.0	13.98±1.1	20.7	0.001
R-OPP	45.68±2.1	43.21±2.7	5.2	0.001
L-OPP	45.75±2.2	43.34±2.8	4.8	0.001

SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial pressure, R-IOP: Right intraocular pressure, L-IOP: Left intraocular pressure, R-OPP: Right ocular perfusion pressure, L-OPP: Left ocular perfusion pressure, SD: Standard deviation

Table 2: Pearson's correlation between IOP and BP parameters

BP parameters	Right IOP		Left IOP	
	r value	*P* value	value	*P* value
SBP	0.785	0.001	0.764	0.001
DBP	0.656	0.001	0.630	0.001
MAP	0.782	0.001	0.757	0.001

BP: Blood pressure, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial pressure, IOP: Intraocular pressure

Table 3: Pearson's correlation between OPP and BP parameters

BP parameter	Right OPP		Left OPP	
	r value	*P* value	*r* value	*P* value
SBP	0.706	0.001	0.687	0.001
DBP	0.832	0.001	0.818	0.001
MAP	0.839	0.001	0.821	0.001

BP: Blood pressure, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial pressure, IOP: Intraocular pressure

and IOP in prehypertensive subjects. Subjects with prehypertension had marginally higher OPP compared to normotensives.

Few studies have shown significant associations between high BP and glaucoma,[5,11] whereas some studies have demonstrated a low risk of glaucoma in subjects with elevated BP.[12,13] A relationship between increased IOP and glaucoma development and progression is noted in many clinical trials as well.[14,15] LALES study conducted on hypertensive individuals also showed a positive correlation between MAP and IOP.[16] Multiple mechanisms are responsible for raised IOP in systemic hypertension. It may be due to excessive ultrafiltration and reduced outflow of aqueous humor with the increase in BP.[17] Elevated levels of IOP in prehypertensive subjects could probably be due to an increase in sympathetic tone in blood vessels which have been proved by some of the studies conducted on hypertensive patients.[18] While reduced OPP is considered to be one of the risk factors for the development of glaucoma,[16] its exact mechanism is unclear and controversial. Increase in OPP as noted in our study could be explained by the protective effects of autoregulation in the prehypertensives despite increase in their BP and IOP values. Autoregulation is the ability of the vascular bed to maintain constant blood flow in spite of changes in perfusion pressure.[19] With the disruption in these autoregulatory mechanisms, as seen in hypertensives, elevated IOP might impede the ocular blood flow.[5] Another study also states that in a non-autoregulated vascular bed, small changes in perfusion pressure may lead to changes in ocular blood flow.[20]

However, IOP elevation not only affects the vascular supply but also produces mechanical stress on retinal neurons which is independent of OPP.[11] Furthermore, the real physiological status of ocular perfusion may not be reflected by the calculation of MOPP using theoretical formula. This could be the limitation in our study. Hence, increased IOP levels are more reliable risk factor for the development of glaucoma and further studies have to be done to know the exact vascular changes in the optical nerve head using Doppler optical coherence tomography. Since we have observed raised IOP in prehypertension itself, which is a high-risk group for developing hypertension, regular monitoring of IOP and OPP levels is essential to prevent the incidence and progression of glaucoma.

CONCLUSION

In our study, IOP and OPP levels were significantly higher in prehypertensive individuals when compared with normotensive controls. This complex relationship between BP, IOP, and OPP should be considered while assessing the association between glaucoma and prehypertension. Hence, early detection of prehypertension and measures such as regular exercise regimen, salt-restricted diet, and other lifestyle modifications to reduce BP is recommended. This can prevent their progression to systemic hypertension and thus reduce the risk of developing glaucoma.

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