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Research Article

A STUDY ON ASSOCIATION OF SYSTOLIC BLOOD PRESSURE, DIASTOLIC BLOOD PRESSURE, AND PULSE PRESSURE WITH INTRAOCULAR PRESSURE IN RELATION TO PRIMARY OPEN-ANGLE GLAUCOMA

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ABSTRACT

Objective: This study aims to probe the relationship among pulse pressure (PP), systolic blood pressure (SBP) and diastolic blood pressure (DBP), and the intraocular pressure (IOP) in normal persons and primary open-angle glaucoma (POAG) patients. Design: This was an institution-based observational study.

Methods: This study was conducted on 240 patients attending the ophthalmology department and glaucoma clinic of a tertiary hospital. Included subjects were asked about their ocular and systemic problems and undergone detailed examination of eyelids, conjunctiva, cornea, anterior chamber by slit lamp, visual acuity, refraction, and fundus examination. IOP was measured by Goldmann applanation tonometer. Blood pressure was measured by sphygmomanometer.

Results: In this study, we found that SBP, DBP, PP, and IOP – both eyes were found to be higher in subjects with POAG than normal control subjects. Among these, differences in mean SBP, DBP, and IOP – both eyes between subjects with POAG and normal subjects were statistically significant. IOP was found to be positively correlated with SBP, DBP, and PP both in subjects with POAG as well as in normal subjects.

Conclusion: Although involving a limited number of eyes, the key findings of the study suggest that IOP is positively correlated with PP, SBP, and DBP. This opens up the possibility of early detection of glaucoma patients with raised PP, SBP, and DBP.

Keywords: Primary open-angle glaucoma, Systolic Blood pressure, Diastolic Blood pressure, Pulse pressure.

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INTRODUCTION

Glaucoma is not a single entity; rather it is a group of disorders that is characterized by typical optic nerve head (ONH) alterations which are associated with characteristic visual field changes where a raised intraocular pressure (IOP) is clearly a risk factor. It is one of the main causes of irreversible blindness worldwide [1]. Among the various glaucoma entities, primary open-angle glaucoma (POAG) is the most common type of glaucoma seen in most parts of the world [2-4]. In 2010, almost 45 million people were affected by POAG worldwide; 4.5 million (10%) of whom were estimated to be blind [5]. POAG has earned itself the sobriquet of "the silent thief of vision" because the patient often remains unaware of his deteriorating vision until a very late stage. POAG is often asymptomatic early on [6]. Although plenty of clinical and experimental studies have been undertaken, the precise mechanism that leads to the development and thereafter the progression of POAG has not been elucidated [7]. The pathophysiology of open-angle glaucoma (OAG) is an enigma. There are many risk factors associated with OAG, out of which raised IOP is a clear risk factor for glaucoma and the only parameter that we can measure to know the progression of the disease [8]. However, multiple studies have shown that not all patients with abnormal IOP have glaucoma, and conversely, not all patients with glaucoma have abnormal IOP. Although IOP reduction continues to be the mainstay of successful treatment to reduce the progression of glaucoma [9], many patients with apparent IOP control and adequate IOP reduction still present with steady vision loss [10]; hence, the need to identify risk factors other than IOP, which can be used for identifying and treating patients with glaucoma, assumes a vital significance. Raised IOP exerts a deleterious effect on the ONH, besides this, other factors, especially vascular ones have been implicated as risk factors [11]. These factors can lead to reduced perfusion of the ONH and may thus play an important role in both pathogenesis as well as a steady progression of POAG [12]. Systemic hypertension assumes an important role in bringing about increases in IOP. High blood pressure (BP) is presumed to lead to an increase in IOP by augmenting the production of aqueous humor. High BP leads to an elevated ciliary blood flow and capillary pressure. It also decreases aqueous outflow due to an elevated episcleral venous pressure [13,14]. Conversely, however, low BP, whether spontaneous or due to antihypertensive therapy, can reduce ocular perfusion pressure, leading to ischemic damage of the optic nerve [14,15]. This might explain why some patients go on to develop normal-tension glaucoma, that is, glaucoma despite IOP within the normal range, and why glaucomatous patients sometimes deteriorate despite well-controlled IOP. However, in the absence of any proven scientific evidence, the relationship between glaucoma and BP continues to be debatable. While some studies show systemic hypertension to be a risk factor for glaucoma paradoxically others report low systemic BP to be one for the development and progression of glaucoma. An irrefutable direct and clear relationship between glaucomatous changes and progressive damage and BP level has not yet been established [15,16].

METHODS

The study was conducted on subjects who volunteered to be a part of this study and who subsequently agreed to an informed written consent. Demographic, ocular, and medical history data were obtained through an interviewer-administered detailed questionnaire. Information relevant to this study such as history of any disease in the past such as angina, myocardial infarction, heart failure, diabetes, hypertension, and any surgeries was included in the questionnaire. A special note was made if participants had a history of glaucoma or

any other ocular disease and whether they had been, anytime in the past, or were currently being treated with medications or laser or incisional surgery. Every participant was made to undergo a complete ophthalmic examination that included visual acuity measurement, refraction, and slit lamp examination. In this study, cases were selected based on the evaluation of optic disc, gonioscopy, visual field analysis by automated perimetry, and applanation tonometry. In this study, POAG was diagnosed by the presence of glaucomatous cupping, visual field defects, optic disc damage, and open angles on gonioscopy, with or without raised IOP, after the exclusion of other possible causes. For every participant, the demographic data, history, examination findings, and IOP readings were meticulously recorded in the case record form. IOP of both eyes was recorded by an applanation tonometer attached to a slit lamp under topical anesthesia within a 2-h window period starting 10 am to 12 pm. BP of the brachial artery was measured alongside by a single observer. BP reading of the right brachial artery of the arm with the mercury column approximately in level with the heart was taken with a sphygmomanometer in a sitting position. This study followed the American Heart Association BP measurement recommendations. Systolic blood pressures (SBP) as well as diastolic blood pressures (DBP) were recorded, and pulse pressure (PP) measurements were arrived at by calculating the difference between systolic BP and diastolic BP.

Statistical analysis

The data were studies using Microsoft Excel software and analyzed using SPSS (Version 24). Independent t-test and Pearson's correlation were used for the data analysis and statistical calculations. $p \leq 0.05$ was considered to be significant statistically.

RESULTS

In this study, we found mild visual impairment, or normal vision, in 87% of POAG cases and 97% of controls. Among POAG cases, 8% had moderate visual impairment, 1% had severe visual impairment, and 4% were blind, compared to only 3% of controls with moderate visual impairment and none with severe visual impairment or blindness. The mean SBP difference between cases and controls is 4.83 with p=0.019. A difference (statistically significant) exists in the mean SBP between the groups. The mean DBP difference between cases and controls is 3.61 with p=0.002; a difference exists in the mean DBP between the groups and it is statistically significant. The mean PP difference between cases and controls is 3.05 with p=0.001 which also is statistically significant. In this study among cases, the relation between IOP with SBP, DBP, and PP shows, there is a positive correlation between SBP and IOP in both eyes: Right eye (r: 0.320) and left eye (r: 0.189), respectively, positive correlation between DBP and IOP-right eye (r: 0.228) and left eye (r: 0.307), respectively, positive correlation between PP and IOP-right eye(r: 0.414) and left eye (r: 0.204). Results of correlations between variables in cases have been tabulated in Tables 1 and 2 based on the laterality of the eyes. All these correlations between different variables in the right eye and left eye of cases are statistically significant. The present study among control relation between IOP with SBP, DBP, and PP shows, there is positive correlation between SBP and IOP right eye (r: 0.321) and left eye (r: 0.295), a positive correlation between DBP and IOP in the right eye (r: 0.344) and left eye (r: 0.375), positive correlation between PP and IOP right eye (r: 0.211) and left eye (r: 0.182). Results are presented below in Table 3 and Table 4, respectively. All these correlations between different variables in the right eye and left eye of controls are statistically significant.

DISCUSSION

This study titled "A study on the association of SBP, DBP, and PP with IOP in relation to primary OAG" was done in the department of ophthalmology at a medical college hospital, in Eastern India. A total of 240 patients were enrolled for this study, 120 cases and 120 controls. Patients with POAG (known cases or recently diagnosed) in the age group of 40–80 years of both sexes and with or without a family history of glaucoma were included as cases.

All non-glaucoma patients aged 40–80 years of both sexes were taken as controls. In this study, we found mild visual impairment, or normal vision, in 87% of POAG cases and 97% of controls. Among POAG cases, 8% had moderate visual impairment, 1% had severe visual impairment, and 4% were blind, compared to only 3% of controls with moderate visual impairment and none with severe visual impairment or blindness. The mean SBP difference between cases and controls is 4.83 with p=0.019, (statistically significant) difference. The mean DBP difference between cases and controls is 3.61 with p=0.002, (statistically significant) difference. The mean PP difference between cases and controls is 3.05 with p=0.101 which is statistically insignificant. The IOP-right eye is found to be positively correlated with SBP, DBP, and PP in subjects with primary OAG and SBP, DBP, and PP in normal subjects. The IOP-left eye is found to be positively correlated with SBP, DBP, and PP in subjects with primary OAG and SBP, DBP, and PP in normal subjects**.** Studies by Zhao *et al.* [13] show a positive correlation between high BP and raised IOP. Large-scale epidemiologic studies have been undertaken that have attempted to probe this relationship, most of them have thrown up conflicting reports. Several studies reported an inverse relationship between elevated BP and glaucoma [17,18]. whereas other studies pointed to a direct association between elevated BP and POAG using

Table 1: Correlation between different variables in the right eye of cases

Groups	Correlation between	Pearson's Correlation (r)	Interpretation	p-value
Cases	SBP and IOP-Right eye	0.320	Positive correlation	0.000*
	DBP and IOP-right eye	0.228	Positive correlation	0.042*
	PP and IOP-right eye	0.414	Positive correlation	0.000*

Table 2: Correlation between different variables in the left eye of cases

Groups	Correlation between	Pearson's correlation (r)	Interpretation	p-value
Cases	SBP and IOP-left eye	0.189	Positive correlation	0.038*
	DBP and IOP-left eye	0.307	Positive correlation	0.002*
	PP and IOP-left eye	0.204	Positive correlation	0.026*

Table 3: Correlation between different variables in the right eye of controls

Groups	Correlation between	Pearson's Correlation (r)	Interpretation	p-value
Controls	SBP and IOP-right eye	0.321	Positive correlation	0.000*
	DBP and IOP-right eye	0.344	Positive correlation	0.000*
	PP and IOP-right eye	0.211	Positive correlation	0.021*

Table 4: Correlation between different variables in the left eye of controls

Groups	Correlation between	Pearson's Correlation (r)	Interpretation	p-value
Controls	SBP and IOP-left eye	0.295	Positive correlation	0.001*
	DBP and IOP-left eye	0.375	Positive correlation	0.002*
	PP and IOP-left eye	0.182	Positive correlation	0.047*

IOP: Intraocular pressure, PP: Pulse pressure, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

Studies examining the relation between blood pressure and POAG with adjustment for intraocular pressure

References	Country	Sample	Study design	Exposure	Outcome	Association
Our Study	India	240	Institution-based observational study	SBP, DBP, PP	POAG	Positive
Blue mountain eye study [17]	Australia	3654	Population-based survey	HTN	OAG	Positive
Singapore Malay eye study[18]	Singapore	3280	Cross-sectional Population-based study	SBP, DBP, HTN	POAG	Positive
The Rotterdam study[19]	Netherlands	5317	Cross-sectional prospective population-based study	SBP, DBP	POAG	Positive
Los Angeles Latino eye study [20]	USA	6130	Cross-sectional population-based study	SBP, DBP	OAG	Positive
The Thessaloniki eye study [21]	USA	232	Cross-sectional population-based study	DBP	OAG	Negative
The Barbados eye study [22]	West Indies	3222	Population-based survey	SBP	POAG	Negative

PP: Pulse pressure, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, POAG: Primary open-angle glaucoma, OAG: Open-angle glaucoma

cross-sectional data [19-22]. Chung *et al*. [23] reported that both high BP as well as low systemic BP was associated with increased incidence of POAG albeit with different mechanisms at play. Their study brought out a unique relation of BP with POAG. They concluded that the relation between BP and POAG is "U" shaped. Nonetheless, it is complex and poorly understood.

CONCLUSION

It can be said that an increase in BP is associated with an elevated IOP, which in turn can increase the risk of glaucoma. In addition, the microangiopathy of hypertension can damage the retina and optic nerve. Hypertension needs to be treated because it happens to be one of the most important risk factors for renal, cardiovascular morbidity, and mortality. In this study, we found that SBP, DBP, PP, and IOP are found to be higher in subjects with primary OAG than normal control subjects. Among these, differences in mean SBP, DBP, and IOP between subjects with primary OAG and normal subjects are statistically significant.

Our study was made to find out the relationship between SBP, DBP, PP, and IOP in POAG. Although involving a limited number of eyes, the findings of this study suggest that IOP is positively related with PP, SBP, and DBP. Hence, it could be recommended that patients with high BP be screened for glaucoma, and as a corollary patients with glaucoma be screened for arterial hypertension. Such a strategy could result in the early detection of more POAG patients and the prevention of significant loss of vision in such patients. Furthermore, patients with coexisting glaucoma and high BP should be under close supervision and more frequent ophthalmologic examinations.

AUTHOR CONTRIBUTION

Preparation of this manuscript and all correspondence by Dr. Arkendu Chatterjee (Corresponding author), Study design, supervision, and guidance Dr. Sudeshna Roy, Collection of patient data, administration of the questionnaire, and statistical analysis was done by Dr. Debalina Ghanta and Dr. Shamim Ahamed.

CONFLICTS OF INTERESTS

The authors declare that they have no conflicts of interest whatsoever conducting this study.

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