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Original Article

Physiology Section

Correlation Between the Intraocular Pressure and the Blood Pressure in Different Age Groups

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ABSTRACT

Introduction and Aim: Elevated Intra-ocular Pressure (IOP) is one of the major risk factors for developing glaucoma or glaucomatous optic neuropathy and its progression. Glaucoma is a common ophthalmic disease in India and worldwide and it is a significant cause of visual impairment and blindness. Blindness leads not only to a reduced economical and social status, but it may also result in premature death. Hence, this work was undertaken to study the relationship between IOP and Blood Pressure (BP), so that the prediction of ocular hypertension and its consequences could be forecasted by using more common systemic parameters, i.e., BP.

Methods and Material: 300 apparently healthy subjects who were aged between 25 - 64 years were examined to find out the relationship between IOP and BP. The BP was recorded with the subjects in the supine position. The IOP was recorded by using Schiotz's tonometer.

Results: The IOP was found to increase with age in both men and women and it was statistically significant. The systolic BP and the diastolic BP were positively and significantly correlated with the IOP.

Conclusion: As a person's IOP increases along with his/her BP; the subjects with hypertension should be monitored for ocular hypertension. Advancing age was positively associated with the IOP. Hence, in older people, screening needs to be done for high IOP. By symmetry, persons with an elevated IOP suggest that periodic BP monitoring may be indicated for these patients. Hence, a population based screening for elevated IOP and its control could reduce the number of people who are at the greatest risk of glaucoma, which is the second commonest cause for blindness and visual impairment in India and also worldwide.

Key Words: Intra-ocular Pressure, Blood Pressure, Age

INTRODUCTION

Human aging is characterized by the progressive constriction of the homeostatic reserve of every organ system. This decline, which is often defined as homeostenosis, is evident by the third decade of life and is gradual and progressive [1].

This decreased physiologic reserve in the eye and the cardiovascular system can be manifested by the changes in the intraocular pressure (IOP) and the blood pressure (BP) with increasing age respectively.

The intra-ocular pressure (IOP) is maintained by an equilibrium between the aqueous production from the ciliary body and its drainage via the trabecular complex. The mean IOP varies between 10 and 21 mm Hg (mean 16 ± 2.5) [2].

Any abnormalities in the IOP may result in the dysfunction of the eye, which in turn may affect the vision. The IOP is affected by various systemic parameters like age, gender and BP. The IOP tends to increase with the age of a person and a change in BP is directly associated with a change in the IOP [3,4]. A medical intervention can bring the BP back to normal, hence preventing the consequences of hypertension.

An elevated IOP is one of the major risk factors for developing glaucoma or glaucomatous neuropathy and its progression [5,6]. Glaucoma is a common ophthalmic disease worldwide and a significant cause of visual impairment and blindness. It is the second leading cause of blindness which is responsible for 23% of all the blindness cases [6]. Blindness leads not only to a reduced economical and social status, but it may also result in premature death [7]. The World Health Organization has estimated that India has a 1% prevalence of blindness. Of the estimated 8.9 million blind persons in India, 12.8% of the blind cases are caused by glaucoma. The problem is expected to reach alarming proportions by the turn of the century [8].

The World Population Projection for 2010 and 2020 derived that by 2020, India would become second in having the maximum number of glaucoma cases, surpassing Europe. From 2010 to 2020, the most detectable change in glaucoma worldwide will be its increase in India. As the proportion of those above 40 years of age increases, the proportional increase in glaucoma will challenge our resources and ingenuity [9].

If ocular hypertension or glaucoma are detected early and treated appropriately, their progression and blindness can be prevented. Yet, in the physiologic arena, the detailed variation of the IOP and the BP with reference to different age groups affecting the visual functioning is still not available completely.

Hence, this work was undertaken to study the relationship between the IOP and the BP in different age groups, so that the prediction of ocular hypertension and its consequences could be forecasted by using more common systemic parameters, i.e., BP and age.

MATERIALS AND METHODS

The present study was conducted at Davangere, Karnataka, India, after getting the approval of the institutional ethical committee. Three hundred individuals of Davangere city are randomly selected, who were of the age group of 25 to 65 years. Normotensive and newly diagnosed hypertensive (systolic BP upto 160 mmHg and diastolic BP upto 100 mmHg) subjects who were not on any medication and who were asymptomatic were recruited for the study. These were the asymptomatic patients who were found to have hypertension when their BP was checked for screening purposes. After the examination of the IOP, these patients were referred to the Medicine OPD for the management of their BP.

Persons with known hypertension who were on treatment were not included in the study. A gonioscopic examination (by using a Goldmann three mirror gonioscope) was done to rule out angle closure glaucoma. Persons with diabetes and any other medical or surgical illness, who were on medication, were not recruited for the study. Also, those who were blind and those with any history of eye surgery were excluded from the study.

The written informed consent of the subjects was obtained. After taking a brief history and after a clinical examination, the anthropometric and blood pressure recording was done in with the subjects in the supine position after a 5 min rest, with a mercury sphygmomanometer, in the right upper limb by both the palpatory and the auscultatory methods.

The IOP was recorded by using a Schiotz's indentation tonometer. The instrument was calibrated before each use by placing it on a polished metal sphere and checking it to be sure that the scale reading was 'zero'. If the reading was not zero, it was readjusted to zero. The patient was laid in the supine position and he/she was asked to look straight upwards on an over head target or on a mark on the ceiling with a fixed gaze.

The cornea was anaesthetized with 2–3 drops of 4% topical lignocaine. The tonometer tip and the footplate were wiped carefully with an alcohol swab and they were allowed to air dry. The subject's eye lids were retracted gently with the left hand without placing tension on the globe. The footplate of the tonometer was placed directly over the cornea by holding its handle with the right hand. The handle of the tonometer was lowered to a position midway between the top and the footplate of the cylinder.

Thus, the instrument would act independently by its own weight. The reading on the scale was recorded as soon as the needle became steady. The scale of the Schiotz's Indentation tonometer is calibrated in such a fashion that each scale unit represents a 0.05 mm protrusion of the plunger. The recording of the IOP was started with a 5.5 gram weight; however, if the scale reading was less than three, an additional weight was added to the plunger to make it 7.5 gram or 10 gram as indicated.
The IOP measurement was repeated until three consecutive readings agreed within the 0.5 scale units. The average scale reading and the plunger weight were then converted into the IOP in mmHg by using a conversion chart, the Friedenwald Nomogram.

After each use, the tonometer plunger and the footplate were rinsed with water, followed by alcohol and then they were wiped dry by using a lint–free material. After the procedure, a prophylactic antibiotic, Ciprofloxacin eye drops was instilled in both the eyes to prevent infections.

STATISTICS:

The results were presented as mean ± standard deviation (SD). The Student's t test was used for comparing means of the two groups. Correlation and regression analyses were performed to assess the relationship between the different variables. A 'p' – value of 0.05 or less was considered for a statistical significance.

RESULTS

The ages of the subjects ranged between 25 to 64 years. The distributions of the subjects in the different age groups are shown in [Table/Fig-1].

The mean IOP in men and women in the different age groups is shown in [Table/Fig-2]. The IOP increased with the age in both men and women. After controlling the systolic BP and the diastolic BP, the age was found to be positively related to the IOP. As the age increased, the IOP of the subject also increased [Table/Fig-3], [Table/Fig-4].

Age groups (Years)	Men	Women	Total
25 – 34	39	37	76
35 – 44	33	41	74
45 – 54	40	36	76
55 – 64	36	38	74
Total	**148**	**152**	**300**

[Table/Fig-1]: Age and gender wise distribution

Gender	Age (Years)	Number of subjects	Intraocular Pressure (mmHg)	
			Mean	S.D.
Men	25 – 34	39	14.2	1.6
	35 – 44	33	14.7	2.0
	45 – 54	40	15.9	2.3
	55 – 64	36	16.3	2.5
Women	25 – 34	37	15.1	2.0
	35 – 44	41	15.9	1.9
	45 – 54	36	16.2	1.5
	55 – 64	38	16.5	2.0

[Table/Fig-2]: Variation of IOP with gender and Age

Age Group (Years)	Number of subjects	Systolic BP (mmHg)	Intraocular Pressure (mmHg)	
			Mean	S.D.
25 – 34	25	< 120	13.7	1.4
	26	120 – 139	14.6	1.6
	25	140 – 160	15.7	2.1
35 – 44	20	< 120	13.9	1.9
	17	120 – 139	15.5	1.7
	37	140 – 160	16.1	1.8
45 – 54	15	< 120	15.0	1.8
	32	120 – 139	16.1	1.7
	29	140 – 160	16.4	2.1
55 – 64	10	< 120	15.6	2.9
	28	120 – 139	16.4	2.0
	36	140 – 160	16.7	2.2

[Table/Fig-3]: Mean IOP for specified levels of systolic BP and Age

Age Group (Years)	Number of subjects	Diastolic BP (mmHg)	Intraocular Pressure (mmHg)	
			Mean	S.D.
25 – 34	25	< 80	13.7	1.4
	26	80 – 90	14.6	1.6
	25	90 – 100	15.7	2.1
35 – 44	20	< 80	13.9	1.9
	17	80 – 90	15.5	1.7
	37	90 – 100	16.1	1.8
45 – 54	15	< 80	15.0	1.8
	32	80 – 90	16.1	1.7
	29	90 – 100	16.4	2.1
55 – 64	10	< 80	15.6	2.9
	28	80 – 90	16.4	2.0
	36	90 – 100	16.7	2.2

[Table/Fig-4]: Mean IOP for specified levels of diastolic BP and Age

Relationship of IOP with	Correlation Coefficient		Regression Coefficient	IOP Estimation (mmHg)
	r	P		
Age (Men)	+0.39	< 0.001	0.08	IOP = 12.0 + 0.08 (Men Age)
Age (Women)	+0.25	< 0.001	0.04	IOP = 14.2 + 0.04 (Women Age)
SBP	+0.35	< 0.001	0.05	IOP = 8.8 + 0.05 (SBP)
DBP	+0.36	< 0.001	0.08	IOP = 8.9 + 0.08 (DBP)
MAP	+0.36	< 0.001	0.05	IOP = 8.7 + 0.07 (MAP)
PP	**+0.28**	**< 0.001**	**0.11**	IOP = 10.7 + 0.11 (PP)

[Table/Fig-5]: Correlation of IOP with all parameters

A correlation analysis was performed to assess the relationship between the age, systolic BP, diastolic BP, the pulse pressure, the mean arterial pressure and the IOP and this relationship were statistically significant (P < 0.001) [Table/Fig-5].
By the correlation analysis study, the IOP of the subjects could be predicted from their age and Blood pressure by using the following formulae:

In males: IOP in mmHg = 12.0 + 0.08 (Age in years)

In females: IOP in mmHg = 14.2 + 0.04 (Age in years)

IOP = 7.53 + 0.05 (Age) + 0.07 (MAP) – 0.01 (PP)

DISCUSSION

Glaucoma is the commonest cause of irreversible blindness worldwide and the second most common cause of blindness overall, after cataract. It affects approximately 70 million people and among them, 7 million are blind [10].

Glaucoma or glaucomatous optic neuropathy is characterized by a chronic, slowly progressive loss of the retinal ganglion cells and their neurons. An elevated IOP is one of the major risk factors for developing glaucomatous optic neuropathy [11]. Open angle glaucoma is a leading cause of visual impairment and blindness [12,13]. Ocular hypertension is a predisposing factor for open angle glaucoma or glaucomatous optic neuropathy. The knowledge of their cause, their natural history and the risk factors of these disorders is incomplete. The IOP is widely regarded as the most important modifiable risk factor which is associated with the development of glaucomatous optic neuropathy [14-18]. Therefore, the factors that influence the IOP and its measurement are of great relevance in understanding the pathogenesis of the disease and in reducing the burden of blindness.

The correlates of this measurement include other physiologic parameters that may be needed to be considered in investigating the determinants of the IOP. We briefly investigated and described the relationship between age, BP, gender and IOP. In the present study, the IOP correlated positively with age in both men and women. The increase in the IOP with age was statistically significant. Old age has been reported as a risk factor for the development of glaucoma in patients with ocular hypertension, in multiple progression studies [16,18].

Several population based studies have found that the incidence of open angle glaucoma increased with the older age groups [18] In a study, there was a strong evidence that old age was an independent risk factor for the progression of ocular hypertension and glaucoma [18].

In elderly individuals, the onset of the structural changes in the trabecular meshwork results in a reduction in the trabecular outflow facility and the uveoscleral outflow and hence an elevated IOP in the older age group [19-21]. Aging is associated with a modest elevation of the IOP and it is also linked to a progressive decline in the cerebral and the ocular perfusion [22]. Older patients with glaucoma may have dysfunction of the ocular blood flow auto regulation [22].

Other possible risk factors for the development of ocular hypertension or glaucoma in old age are : local vasospasm, sleep apnoea, abnormalities of the connective tissue of the lamina cribrosa, primary ganglion cell degeneration, systemic hypertension and atherosclerosis [22,23]. An increased age may reflect the cumulative effects of some other factors that cause the aging optic nerve head to be more vulnerable to the elevated IOP and even sometimes to the normal range of the IOP [15].

The findings from our study indicated that systolic BP, diastolic BP, PP and MAP were positively independently correlated to the IOP and that the correlations were statistically significant. Some studies have found that a change in the IOP was directly and significantly associated with a change in the BP [14,15,24-28]. A positive association between the systolic BP and a raised IOP has constantly been shown in both cross sectional and longitudinal studies [24,29-32]. Some studies have shown that the diastolic BP was positively associated with a raised IOP [4,33,34].

The IOP may have been increased in patients with an increased BP due to an increased retinal blood volume after a rise in the central retinal vein pressure because of an increased pressure in the adjacent central retinal artery [34]; an increased blood volume in the ciliary body and a decreased facility of the aqueous outflow, owing to an increase in the resistance in the episcleral and the anterior ciliary veins [34]; an increased ultrafiltration of the aqueous fluid in the ciliary body, owing to the increased perfusion pressure in the ciliary arteries; [4,19,33-36] obstruction to the aqueous drainage at the anterior chamber angle due to the increasing episcleral venous pressure [3,4,34]. The IOP rises and falls by 1 mmHg with every heart beat; during systole, the central

retinal artery compress the accompanying vein to increase the vascular resistance in this vessel [34]. Follow-up studies which were done for five years have shown that the cumulative probability of untreated patients developing glaucoma was calculated to be greater than twice the rate of that in the treated patients [16].

The findings from this study indicate that the IOP increased with age in both men and women and that it was statistically significant. The systolic BP and the diastolic BP were positively and significantly correlated with the IOP.

CONCLUSION

It can be concluded that persons with hypertension and advancing age need to be monitored for high IOP. By symmetry, in persons with an elevated IOP, periodic BP monitoring may be indicated. Hence, a population based screening for an elevated IOP and its control could reduce the number of people who are at the greatest risk of glaucoma, which is the second commonest cause for blindness and visual impairment in India and also worldwide.

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