Comparison of intraocular pressure among individuals with systemic hypertension and those with normal blood pressure

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Abstract

Background

Systemic blood pressure, by far is one of the most important factors that can have an effect on intraocular pressure. There is a limited set of studies regarding the effects of increased blood pressure on intraocular pressure. As for our knowledge, this study was first of its kind in Nepal. We have tried to compare the intraocular pressure (IOP) among patients with systemic hypertension and those with normal blood pressure.

Methods

A hospital based prospective case control study was conducted from March 2017 to March 2018 in the outpatient department of the department of ophthalmology in Dhulikhel hospital. A total of 100 patients with hypertension were included in case group (hypertensive group) and 100 cases with no systemic or ocular disease were included in control group (normotensive group). Mean intraocular pressures were calculated and compared along with the different range of blood pressure levels.

Results

Mean age of patients was 49.03 years in hypertensive group and 47.53 years in Normotensive group. Mean IOP of right eye in those with hypertension was 16.10 mmHg and in left eye was 15.8 mmHg. Similarly mean IOP of right eye in normotensive group was 15.8 mmHg and left eye was 16.2 mmHg. The difference between mean of IOP of hypertensive and normotensive individuals were not statistically significant. The prevalence of ocular hypertension in this study population was found to be 7.5% in that age group. The prevalence of primary open angle glaucoma (POAG) in this study population was found to be 1.5%.

Conclusion

There was no statistically significant difference in IOP between hypertensive and normotensive individuals. There was statistically significant difference in IOP in hypertensive with controlled BP and hypertensive with uncontrolled BP indicating that high BP may be associated with high IOP.

Background

Intraocular pressure (IOP) is maintained by the equilibrium in production and drainage of the aqueous humor and normally ranges from 10–21 mm Hg (mean 16 ± 2.5) [1] Intraocular pressure is affected by various factors such as age, blood pressure and blood sugar level.[2] [3] Increased ciliary epithelial sodium transport has been reported in systemic hypertension. This leads to excessive aqueous humor

formation and high IOP. Variations in systolic blood pressure also results in small changes in aqueous humour formation as a result of increased in capillary pressure in the ciliary body. This indeed could result in increased intraocular pressure. [4] Blood pressure also affects episcleral venous pressure, which is important in regulating the flow of aqueous across the trabecular meshwork into Schlemm's canal. [5] Intraocular pressure is regarded as the most important modifiable risk factor which is associated with the development of glaucomatous optic neuropathy. [6] [7] In many studies the relationship between intraocular pressure and blood Pressure has been studied and concluded that intraocular pressure and high blood pressure have positive correlation. [8] Also it was found that population based screening for an elevated intraocular pressure and its control could reduce the number of people who are at the greatest risk of glaucoma. [8]

Systolic blood pressure has been shown to have a strong correlation with intraocular pressure. [9][10] Studies conducted by Drance et al, Goldberg et al have shown an association between systolic blood pressure and normal- tension glaucoma has been established in some studies.[11][12] Whereas studies conducted by Leighton et al, Rouhiainen et al have shown an association between systemic blood pressure and high-tension glaucoma. [13][14] Leske et al have found an association between systemic and ocular hypertension and between high diastolic blood pressure and open angle glaucoma. [15] Also, in Beaver Dam Eye Study it was found that change in intraocular pressure is directly and significantly associated with changes in systemic blood pressures. [3] Thus, all the patients with high blood pressure must be investigated for raised intraocular pressure so as to identify glaucoma as early as possible and decrease the morbidity caused by the disease.

Methods

A hospital based prospective case control study was conducted from March 2017 to March 2018 in the outpatient department of the department of ophthalmology, Dhulikhel hospital-Kathmandu university hospital. Ethical consideration was taken from the Institutional review committee (IRC-KUSMS). A total of 100 patients with hypertension were included in case group and 100 cases with no systemic or ocular disease were included in control group. Control group were taken after matching the age and gender with case group. 100 patients were taken in in each group as there was no data available on the prevalence of IOP in hypertensive individuals. Primary Objective was to compare the variation of IOP in patients with systemic hypertension and individuals with normal blood pressure. Secondary objective was to look for the prevalence of ocular hypertension in these patients. Every 3rd patient of age more than 40 years with diagnosed hypertension, including both the old cases and recently diagnosed cases of hypertension attending the ophthalmology OPD irrespective of the duration of hypertension were included in the study. Every 3rd patient was taken to avoid selection bias. After matching the age and gender, the individuals without hypertension were included in control group. Exclusion criteria: included patients with Age < 40 years, diabetes mellitus (type 1 or type 2), high myopia or history of glaucoma, ocular pathology which can cause increase in intraocular pressure or glaucomatous changes in optic disc like uveitis, vein occlusions, media opacities like significant cataract, corneal opacity which would hamper posterior segment examination. For every case, a detailed history was obtained regarding the age, sex, ocular

symptoms, duration of hypertension, treatment of hypertension, was recorded and presence of other diseases was be noted. Those patients who were never found to have high blood pressure and whose blood pressure is < 140/90 mmHg were kept in the normotensive group. Among patients with diagnosed hypertension, those with BP < 140/90 mm Hg were kept under hypertensive with controlled BP group whereas those with BP > 140/90 mmHg were kept under hypertensive with uncontrolled BP group. Ocular examination included recording of visual acuity with Snellen's chart, retinoscopy, anterior and posterior segment examination with slit lamp biomicroscopy and measurement of intraocular pressure by Goldman's applanation tonometer. For every control, a detailed history was obtained regarding the age, sex, ocular symptoms and presence of other diseases was be noted. Ocular examination included recording of visual acuity with Snellen's chart, retinoscopy, anterior and posterior segment examination with slit lamp biomicroscopy and measurement of intraocular pressure by Goldman's applanation tonometer similarly as for the case.Optic disc evaluation was done on both the eyes of every case and control. The optic disc evaluation included colour, shape, size, margin, cup disc ratio, neuroretinal rim, retinal nerve fiber layer loss, peipapillary atrophy and specific signs like bayonetting sign, baring sign or laminar dot sign. For measurement of intraocular pressure the patient was first well explained about the procedure and topical anesthetics xylocaine 4% was instilled in both the eyes of the patient. Then the eyes were stained with fluorescein strip (Fluorotouch 1 mg, Madhu instruments Pvt. Ltd.) and Goldmann's applantion tonometry (Haag Streit BQ 900) was carried out in blue filter. Ocular hypertension was diagnosed as those with IOP > 21 mm Hg in atleast 1 eye without field defects. POAG was diagnosed as patients with suspicious disc and visual field defects. For every case with suspicious disc visual field testing was done on Humphrey's automated visual field (Carl Zeiss Meditec AG). For all cases, grading of hypertension was done according to Keith-Wagener-Barker classification. [16] This data so collected was then entered in Microsoft Excel 2013 and analyzed by Statistical Package for the Social Sciences (SPSS) version 25. Mean of IOP of each group was calculated and comparison was carried out using paired t test.

Results

In this study a total of 200 patients were included among which 100 were hypertensive patients as diagnosed by medicine department of Dhulikhel hospital and the other 100 were normotensive patients. Mean age of patients were 49.03 in hypertensive group and 47.53 years in Normotensive group. 59 males and 41 females were included in hypertensive group whereas 62 males and 38 females were included in normotensive group. (Table 1)

Table 1
Comparison of demographic parameters in both hypertensive and normotensive group

Parameters	Hypertensive group	Normotensives group
Mean Age	49.03 years	47.53 years
Males	59	62
Females	41	38

Mean systolic and diastolic blood pressure in hypertensive group was 136.96 mm Hg and 85.66 mmHg respectively. Mean systolic and diastolic blood pressure in normotensive group was 124.38 mmHg and 79.34 mmHg respectively. Mean IOP in hypertensive group was 15.95 mm Hg and in normotensive group was 16 mm Hg. (Table 2)

Table 2
Comparison of blood pressure and IOP between hypertensive and normotensive groups

Parameters	Hypertensive group	Normotensive group
Mean Systolic BP	136.96 mm Hg	124.38 mm Hg
Mean Diastolic BP	85.66 mm Hg	79.34 mm Hg
Mean IOP	15.95 mm Hg	16 mm Hg

Mean IOP of right eye in those with hypertension was 16.10 mmHg and in left eye was 15.8 mmHg.Similarly mean IOP of right eye in normotensive group was 15.8 mmHg and left eye was 16.2 mmHg. Comparing the two groups with paired t test the difference was not statistically significant ($p > 0.05$) (Table 3)

Table 3
Comparison of mean IOP between Hypertensive and normotensive group

	Hypertensive group	Normotensive group	P value
Mean IOP RE	16.10	15.8	0.632
Mean IOP LE	15.8	16.2	0.229

Among the hypertensive group, patients were further classified into those with uncontrolled blood pressure and those with controlled blood pressure. Mean IOP in each eye were compared between two groups. Surprisingly, there was a statistically significant difference between IOP of individuals with high blood pressure and those whose blood pressure were controlled in both right eye and left eye. (Table 4)

Table 4
Comparison of mean IOP between right eye and left eye of hypertensive individuals with controlled and uncontrolled blood pressure

Hypertensive group			
	Controlled BP	Uncontrolled BP	P value
Mean IOP Right eye	15.55	16.73	0.045
Mean IOP Left eye	15.29	16.39	0.045

In both hypertensive group and normotensive group there was a steady rise in IOP with systolic and diastolic blood pressure (Table 5, 6)

Table 5
Mean IOP for specified levels of blood pressure in hypertensive individuals

Range of systolic BP	**Number of individuals**	**Mean IOP**
< 120 mm Hg	3	14.33 mmHg
120–130 mm Hg	18	15.5 mm Hg
130–140 mm Hg	33	15.48 mm Hg
140–150 mm Hg	40	16.8 mm Hg
> 150 mm Hg	6	15 mm Hg
Range of diastolic BP	**Number of individuals**	**Mean IOP**
< 80 mm Hg	21	14.90 mm Hg
80–90 mm Hg	78	15.9 mm Hg
90–100 mm Hg	25	16.2 mm Hg
> 100 mm Hg	6	15.66 mm Hg

Table 6
Mean IOP for specified levels of blood pressure in normotensive group

Range of systolic BP	Number of individuals	Mean IOP
< 120 mm Hg	19	14.8 mm Hg
120–130 mm Hg	51	16.03 mm Hg
130–140 mm Hg	30	16.33 mm Hg
Range of diastolic BP	**Number of individuals**	**Mean IOP**
< 80 mm Hg	42	16.02 mm Hg
80–90 mm Hg	58	15.8 mm Hg

Of all the patients included in the study a total of 15 patients had ocular hypertension (IOP > 21 mm Hg) in at least 1 eye. Deducting the patients with POAG, the prevalence of ocular hypertension in this study population was found to be 7.5% in that age group. Also presence of ocular hypertension was seen in total 6 patients (10 of 200 eyes) in hypertensive group (Table 7) and 9 patients (14 of 200 eyes) in normotensive group. (Table 8)

Table 7
Variation of IOP with different blood pressure levels in Hypertensive group

Range of systolic BP	IOP 8–15 mm Hg	IOP 15–21 mm Hg	IOP ≥ 21 mmHg
110–120 mm Hg	2	1	0
120–130 mm Hg	8	10	0
130–140 mm Hg	11	20	2
≥ 140 mm Hg	12	28	6
Range of diastolic BP	**IOP 8–15 mm Hg**	**IOP 15–21 mm Hg**	**IOP ≥ 21 mm Hg**
< 90 mm Hg	23	41	5
90–100 mm Hg	8	14	3
≥ 100 mm Hg	2	4	0

Table 8
Variation of IOP with different blood pressure levels in Normotensive group

Range of systolic BP	IOP 8–15 mm Hg	IOP 15–21 mm Hg	IOP ≥ 21 mmHg
110–120 mm Hg	6	13	0
120–130 mm Hg	17	29	5
130–140 mm Hg	8	19	3
≥ 140 mm Hg	0	0	0
Range of diastolic BP	**IOP 8–15 mm Hg**	**IOP 15–21 mm Hg**	**IOP ≥ 21 mm Hg**
< 90 mm Hg	31	61	8
90–100 mm Hg	0	0	0
≥ 100 mm Hg	0	0	0

Total 9 patients in hypertensive group had suspicious disc findings whereas 5 patients in normotensive group had such findings. Further evaluation with visual fields were done in these patients which demonstrated field defect in 2 patients in hypertensive group and 1 in normotensive group. 2 patients in hypertensive group and 1 patient in normotensive group were diagnosed to have Primary open angle glaucoma. This interprets to a prevalence of POAG of 1.5% in this study population.(Table 9)

Table 9
Frequency table showing different parameters

Parameters:	Hypertensive group	Normotensive group
Total number of individuals with ocular hypertension (IOP > 21 mmHg)	6	9
Total number of individuals with Suspicious Disc in atleast 1 eye	9	5
Total number of individuals with documented Visual field defect in atleast 1 eye	2	1
Total number of individuals diagnosed to have POAG	2	1

we could appreciate that grade 3 hypertensive retinopathy were present in cases with uncontrolled hypertension suggesting that high blood pressure was more closely related to higher grades of retinopathy.(Table 10 and Table 11)

Table 10
Duration of hypertension with different grades of retinopathy

Duration of Hypertension in years	No retinopathy	Grade 1 hypertensive retinopathy	Grade 2 hypertensive retinopathy	Grade 3 hypertensive retinopathy	Total
Newly diagnosed	5	3	0	0	8
1–5 years	45	9	2	1	57
5–10 years	21	8	1	3	33
10 years or more	1	0	1	0	2
Total	72	20	4	4	100

Table 11
Comparison of controlled and uncontrolled blood pressure with grade of hypertension

Hypertensive individuals with:		No retinopathy	Grade 1 hypertensive retinopathy	Grade 2 hypertensive retinopathy	Grade 3 hypertensive retinopathy	Total
A) B)	Controlled blood pressure	42	10	2	0	54
	Uncontrolled Blood pressure	31	10	1	4	46
Total		73	20	3	4	100

Discussion

In this hospital based case control study, there were a larger number of males in the total study population which suggests that there is a male predominance in hypertension compared to females. Study conducted by Mondal et al also showed a male predominance. [17]

In this study there was no statistically significant (p value < 0.05) difference between the mean IOP in hypertensive and normotensive individuals in both right eye and left eye as shown by the paired t-test. Sithole et al showed in his study a weak correlation between systemic blood pressure and intraocular pressure in a young South African adult population. [18]

A statistically significant difference of mean intraocular pressures between hypertensives with uncontrolled blood pressure and hypertensives with controlled blood pressure was observed in our study.

This relation of blood pressure and IOP was also seen in the Egna-neumarkt study. [19] Similar results were also seen in the study by Thampi et al where the mean IOP in the hypertensive group was significantly higher than those without hypertension. IOP was also seen to have a positive correlation with mean arterial pressure (MAP). [20] Similarly in the Beaver Dam Eye Study increased IOP was associated with increased blood pressure. Kishan et al. conducted a study where blood pressure was positively independently correlated to the IOP. [8] A positive association between the systolic BP and a raised IOP has constantly been shown in both cross sectional and longitudinal studies. [21] [22][23] Some studies have shown that the diastolic BP was positively associated with a raised IOP. [3] [17][24] The Los Angeles Latino Eye Study also reported an increase in IOP with increase in blood pressure. [25]

Prevalence of ocular hypertension in this study population was found to be 7.5% in this study which is comparable to the prevalence of ocular hypertension in Framingham Eye Study and the Baltimore Eye Survey which found the prevalence of ocular hypertension to be 4–7% of people aged ≥ 40 years. [26] The prevalence of POAG in our study was 1.5% .The prevalence of POAG in our study is similar to prevalence in Bhaktapur glaucoma study where the age and sex standardized prevalence of POAG was 1.24%.[26]

In our study it was seen that all patients with POAG were above 55 years of age which has also been seen in the Bhaktapur glaucoma study where there was an increase in the prevalence of glaucoma with increase in age. [26] In our study we found 2 POAG patients in hypertensive group and 1 in normotensive group. Blue Mountains Eye Study showed a significant association between hypertension and OAG. Association was strongest in those with poorly controlled hypertension (OAG prevalence 5.4%) as compared to those with normal BP (OAG prevalence 1.9%). [23] Also in the Egna-neumarkt study, the association was found between primary OAG and systemic hypertension. [19] The Rotterdam study, however, has shown contrary results. The presence of systemic hypertension was not significantly associated with OAG. [27] Similarly, in the Barbados Eye study, it was concluded that systemic hypertension was unrelated to the prevalence of OAG. 28 Studies by Vijaya et al. in a rural and urban south Indian population also did not find association of POAG with systemic hypertension. [29] [30] The Baltimore Eye Survey identified high IOP and systemic hypertension as potential risk factors in the development of glaucomatous optic nerve damage. [31] [32]

Hypertensive retinopathy was seen in 27 of 100 hypertensive patients. This prevalence of retinopathy is comparable to prevalence seen in other studies done by Shanta et al. [33] Similar was the results in study conducted by Besharati et al.[34] This study has shown a male preponderance in the hypertensive group which is comparable to the results of the study done by Mondal et al. in which also the male preponderance was seen. [17] In our study highest number of individuals had grade 1 hypertensive retinopathy which is also comparable to the results of the study done by Mondal et al with highest number of individuals with grade 1 retinopathy and lowest number with grade 4 retinopathy. [17] The presence of hypertensive retinopathy was seen more in patients with uncontrolled blood pressure indicating direct relation of grade of hypertension with the level of blood pressure. This is supported by the study conducted by Klein et al in Beaver dam study which had shown a relation of control of

hypertension with the grades of retinopathy and prevalence of higher grade of retinopathy with poor blood pressure control. [3]

In this study, IOP was taken in only one sitting and the diurnal variation was not taken into account. This may give false results in some patients who may show a normal IOP level at certain time of the day but may show a larger diurnal variation.

Conclusion

There was no statistically significant difference in IOP between hypertensive and normotensive individuals whereas there was statistically significant difference in IOP in hypertensives with controlled BP and hypertensives with uncontrolled BP. The prevalence of ocular hypertension was 7.5% and the prevalence of POAG in this population was 1.5%.The prevalence of higher grades of hypertensive retinopathy was noted in hypertensives with uncontrolled BP. So our study enforces the fact that all patients with hypertension must undergo periodic eye examination for early diagnosis of POAG and hypertensive retinopathy.

Abbreviations

Intraocular pressure (IOP), Mean arterial pressure (MAP), Primary open angle glaucoma (POAG), Open angle glaucoma (OAG)

Declarations

- Ethics approval and consent to participate : Approved by Institutional Review committee, Dhulikhel hospital- Kathmandu university hospital (IRC-KUSMS) (Approval number: 86/17), written informed consent from all participants
- Consent for publication: provided to the journal
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- Authors' contributions: SP conducted and drafted the study, PS and JkS guided the research throughout. All authors have fully read and approved the manuscript.
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