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The acute effect of systemic blood pressure reduction on intraocular pressure in hypertensive patients

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Abstract:

OBJECTIVES: Previous studies have shown an association between systemic hypertension and intraocular pressure (IOP). We analyzed the relationship between the decreases of the blood pressure (BP) and IOP in hypertensive patients.

METHODS: The study includes a total of 214 patients: 158 hypertensive and 56 normotensive patients as study and control groups, respectively. The IOP of each eye in both the groups was measured once with a noncontact tonometer at presentation and an hour after BP reduction to normal in the study group. We analyzed the reduction in IOP with decreasing BP.

RESULTS: In the study group, the mean IOP was 15.29 ± 4.05 mmHg in the right and 15.11 ± 3.78 mmHg in the left eyes. The mean IOP measured an hour after the patients became normotensive was 13.78 ± 4.06 mmHg in the right and 13.51 ± 3.82 in the left eyes. There was a statistically significant decrease in the IOPs ($P < 0.001$). The mean IOP in the control group was 13.54 ± 3.51 mmHg in the right and 13.20 ± 3.33 mmHg in the left eyes. The mean IOP at presentation in the study and control groups was found to be significantly different ($P < 0.001$).

CONCLUSIONS: Patients in the study group showed a significantly higher IOP compared to patients in the normotensive group. Furthermore, patients in the study group showed a significant reduction in IOP after BP reduction. This may indicate that uncontrolled hypertension poses a risk for prolonged higher IOP. Prolonged higher IOP can be considered a risk factor for the glaucoma.

Keywords:

Emergency medicine, glaucoma, hypertension, intraocular pressure

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Introduction

Hypertension is currently the most commonly seen cardiovascular disease.[1] Despite the availability of safe and effective medications, most hypertensive patients are known to have uncontrolled blood pressures (BPs). The prevalence of high BP in the emergency department (ED) was found to be 43.7%.[2]

Glaucoma is defined as a multifactorial optic neuropathy. Previous studies have shown an association between elevated intraocular pressure (IOP) and the development and progression of glaucoma.[3] In addition, studies have also shown an association between systemic BP and IOP. For example, in 2005, Klein *et al*. found a significant relationship between systemic BP and IOP.[4] Chua *et al*. found that increased age, BMI, diabetes mellitus, and increased systemic BP increased the IOP.[5]

To the best of our knowledge, the association between acutely treated hypertensive emergency or urgency in the ED and IOP has not been analyzed. In this study, the

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Box-ED

What is already known on the study topic?

- There is an association between elevated intraocular pressure (IOP) and the development of glaucoma
- There is a relationship between systemic hypertension and IOP.

What is the conflict on the issue? Has it important for readers?

- Higher IOP is associated with hypertension. The IOP reduces with the treatment of hypertension. Hence, the uncontrolled hypertension may pose a risk for prolonged higher IOP. Prolonged higher IOP can be considered as a risk factor for the glaucoma.

How is this study structured?

- This was a single-center, prospective observational study, which was divided into a study group and a control group that includes data from approximately 214 patients.

What does this study tell us?

- Patients in the study group showed a significantly higher IOP compared to patients in the normotensive group
- The patients in the study group showed a significant reduction in IOP after blood pressure reduction.

effect of decreasing systemic BP in the ED on IOP was investigated.

Methods

Study design and setting

This single-center, prospective, observational case–control study was carried out at the ED in a tertiary university hospital in Turkey between January 30, 2019, and January 30, 2020. Ethical approval was obtained from the Hacettepe University's Ethics Committee numbered 2019/03-29 (KA-19001).

Study population

The study group consisted of patients over 18 years old with systolic BPs (SBP) over 180 mmHg or diastolic BPs (DBP) over 120 mmHg and with no previous diagnosis of glaucoma. The control group consisted of volunteers over 18 years old with SBP <130 mmHg and DBP <80 mmHg with no comorbidities such as hypertension and symptoms indicating increased IOP such as headache and eye ache. Volunteers, who included in the control group, were selected consecutively from patients who admitted to the ED with complaints other than hypertension, headache, or eye ache. The first six patients who met the specified criteria were included in the control group every day for 10 consecutive days. A total of 158 patients were included in the study group and 56 patients were included in the control group [Figure 1]. Informed consent was obtained from all patients.

Study protocol and measurements

A single BP measurement was taken from all patients at the triage of the ED, and measurements were recorded. In the control group, BP was measured only once, which was during the initial presentation. On the other hand, in the study group, BP was measured at presentation, and an hour after, the BP decreased to normal level with antihypertensive treatment. All patients in the study group were treated with ACE inhibitors and calcium channel blockers.

IOP was measured with the noncontact tonometer (Noncontact Tonometer FT-1000 CE 0120, Tomey Corporation, Germany, SN 784210) that was available at the ED. IOP measurements at the ED were taken by one emergency resident doctor who had a 2-h training program on how to operate the noncontact tonometer. In addition, measurements on 10 volunteers under the supervision of an ophthalmologist before the study were carried out. All measurements taken during the study were recorded. Patients whose IOP could not be measured with a tonometer, including patients who were in a poor condition, unconscious, and with a Glasgow Coma Score <15, were excluded from the study. The patients who were not treated with predetermined treatment were excluded from the study.

In the study group, the IOP of the right and left eye was measured once with the noncontact tonometer, while the patients were hypertensive. After patients were treated with antihypertensive medications, IOP measurements were taken again when the SBP and DBP were under 130 mmHg and 80 mmHg, respectively. According to the European Glaucoma Society guidelines, high IOP was defined as 21 mmHg or more.[6]

The IOP of both the eyes of the control and study groups at presentation was compared. In the study

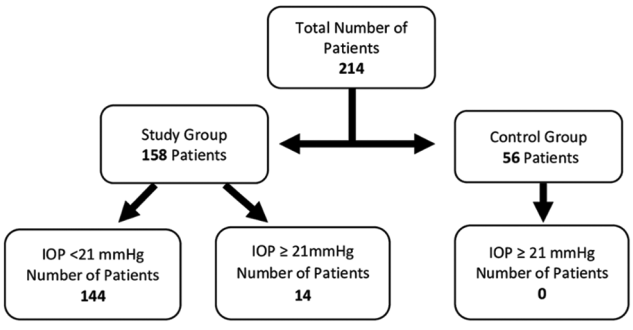

Figure 1: Study flow chart. IOP: Intraocular pressure

group, the effect of decreasing the systemic BP in the case of hypertensive emergency or urgency on the IOP was analyzed. As a result of the evaluation in the ED, patients with IOP above 21 mmHg were referred to the ophthalmologist for the evaluation of glaucoma. The ophthalmological evaluations were analyzed.

Statistical analysis

Statistical analysis was performed using IBM SPSS for Windows, Version 23.0 (IBM® Corporation, New York, United States). Kolmogorov–Smirnov test was used to examine whether quantitative variables distributed normally. The normal distributed quantitative variables were described using mean ± standard deviation. The qualitative variables were described using the frequency and percentage. The Chi-square test was used to compare the qualitative variables. The independent samples *t*-test was used to compare two independent groups, which had normally distributed quantitative. The paired samples *t*-test was used to compare the means of two dependent groups, which had normally distributed quantitative. $P < 0.05$ was considered statistically significant.

Results

A total of 158 patients had their BP measured 180/120 mmHg or more and were categorized in the study group. Fifty-six patients were found to be normotensive in which their BP was measured 130/80 mmHg or less, and these patients were included in the control group. The mean age of the patients was 60.4 ± 11.6 years in the study group and 47.0 ± 7.0 years in the control group ($P < 0.001$). In the study group, 46.2% ($n = 73$) of the patients were male, and in the control group, 46.4% ($n = 26$) of the patients were male. No statistically significant difference was found in the gender distribution between the two groups ($P = 0.977$) [Table 1].

Table 1: The demographic characteristics, and initial means of IOP and systemic blood pressure values of study and control groups

	Study group (*n*=158)	Control group (*n*=56)	*P*
Age (year)	60.4±11.6	47.0±7.0	<0.001
Gender (%)			
Male	46.2	46.4	0.977
Female	53.8	53.6	
Mean SBP±SD (mmHg)	194.84±14.20	120.98±9.42	<0.001
Mean DBP±SD (mmHg)	101.18±15.91	77.82±7.68	<0.001
Mean IOP of the right eye±SD (mmHg)	15.29±4.05	13.54±3.51	<0.001
Mean IOP of the left eye±SD (mmHg)	15.11±3.78	13.20±3.33	<0.001

SD: Standard deviation, IOP: Intraocular pressure, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

In the study group, 130 patients (82.27%) had comorbidities. The most common comorbidity was hypertension (65.80%). The patients in the control group were all healthy individuals, and therefore, no comorbidities were found.

In the study group, the most common reason for presentation to the ED was high BP measured at home (39.87%). Headache was the second-most common presenting symptom (24.68%).

The mean SBP and DBP in the study group were 194.84 ± 14.20 mmHg and 101.18 ± 15.91 mmHg, respectively. The mean SBP and DBP in the control group were 120.98 ± 9.42 mmHg and 77.82 ± 7.68 mmHg, respectively. In the study group, the mean IOP measured at presentation while patients were hypertensive was 15.29 ± 4.05 mmHg in the right eye and 15.11 ± 3.78 mmHg in the left eye. In the control group, the mean IOP measured was 13.54 ± 3.51 mmHg in the right eye and 13.20 ± 3.33 mmHg in the left eye. A statistically significant difference was found between the two groups when IOP measured at admission was compared ($P < 0.001$) [Table 1].

After patients were treated with antihypertensive medications at the ED, the mean IOP measured while the patients were normotensive was 13.78 ± 4.06 mmHg in the right eye and 13.51 ± 3.82 mmHg in the left eye. A statistically significant difference was found between the IOP measurements before and after antihypertensive treatment. An average 1.50 mmHg decrease in the right eye ($P < 0.001$) and 1.59 mmHg decrease in the left eye ($P < 0.001$) were found [Table 2].

In the study group, 96.20% ($n = 151$) of the patients had hypertensive urgency, and 3.79% ($n = 6$) had hypertensive emergency. In the hypertensive urgency group, the mean IOP of the right and left eyes was 15.30 ± 4.09, 15.0 ± 3.68, respectively. In the hypertensive emergency group, the mean IOP of right and left eyes were 15.17 ± 3.18 and 17.83 ± 5.52, respectively. There was no statistically significant difference between the average IOP of right and left eyes among the two groups ($P = 0.749$ and $P = 0.186$).

In our study, none of the patients in the control group had IOP over 21 mmHg. However, in the study group, 14 patients (8.86%) had IOP of 21 mmHg or higher in at least one eye. The mean SBP and DBP of these patients were 201.43 ± 13.28 mmHg and 105.64 ± 16.55 mmHg, respectively. The mean IOP of both the eyes before and after antihypertensive treatment is shown in Table 3. Although 8.86% of the patients were diagnosed with intraocular hypertension, none of the patients were diagnosed with glaucoma as a result of the evaluations made in the ophthalmology outpatient clinic.

Table 2: The mean of intraocular pressure of the right and left eye in the study group before and after treatment with antihypertensive drugs

	Before hypertensive treatment	After hypertensive treatment	Mean decrease after treatment (95% CI)	*P*
Right eye IOP (mmHg) (mean±SD)	15.29±4.05	13.54±3.51	1.50 (1.13-1.87)	<0.001
Left eye IOP (mmHg) (mean±SD)	15.11±3.78	13.20±3.33	1.59 (1.28-1.90)	<0.001

IOP: Intraocular pressure, CI: Confidence interval, SD: Standard deviation

Table 3: The mean of intraocular pressure of the right and left eye in the patients who had intraocular pressure over 21 mmHg

	Before hypertensive treatment	After hypertensive treatment	Mean decrease after treatment (95% CI)	*P*
Right eye IOP (mmHg) (mean±SD)	23.07±2.61	21.57±2.76	1.50 (−0.32–3.03)	0.054
Left eye IOP (mmHg) (mean±SD)	22.64±2.95	20.57±2.82	2.07 (0.38–3.75)	0.020

IOP: Intraocular pressure, CI: Confidence interval, SD: Standard deviation

Discussion

One hundred and fifty-eight patients who presented to the ED with severe hypertension were included in the study group. Gender distributions were similar in the control and the study groups. In a study by Deb *et al*., in 2014, 66% of patients in the hypertensive group were male and 34% were female patients, whereas in the normotensive group, 47% of patients were male and 53% were female patients.[7] The results in our study were similar to those previously reported.

There was a statistically significant difference between the mean age of the patients in the study and control groups. The mean age of the patients in the study by Deb *et al*. was 55.5 in the hypertensive group and 55.1 in the normotensive group.[7] The difference in these findings could be because most of the hypertensive patients in the study group had common age-related diseases such as hypertension and coronary artery disease. However, in the control group, normotensive patients without any known diseases were included. Therefore, in our study, the patients in the control group were younger than the patients in the study group.

In the study group, 82.27% of 158 patients had known comorbidities; the most common comorbidity was hypertension (65.80%). The patients in the control group were all healthy individuals, and therefore, no comorbidities were found. In a 6-year population-based cohort study conducted by Chua *et al*. in 2019, changes in IOP were positively associated with body mass index, diabetes mellitus, hypertension, and baseline SBP and DBP.[5]

In the study group, the most common reason for presentation to the ED was high BP measured at home and headache. In a study by Zampaglione *et al*., in 1996, the most common presenting complaint in hypertensive emergency and urgency patients was headache (22%).[8] Conversely, in the Studying the Treatment of Acute Hypertension registry, shortness of breath (29%), chest pain (26%), headache (23%), altered mental status (20%), and focal neurologic deficit (11%) were more frequently reported.[9] In our study, the frequency of headaches as a common complaint in hypertensive emergency and urgency was similar to that found in other studies.[8,9] However, complaints such as chest pain and shortness of breath were much less compared to other studies. In addition, patients with complaints such as epistaxis, altered mental status, and focal neurological deficit were not included in our study. The reason for this was that patients with these complaints were unstable or did not meet the appropriate conditions to have their IOP measured with the tonometer.

In the evaluation of the study group, hypertensive urgencies were only 3.4% of the whole group. Similar to our study, previous studies have also estimated that hypertensive emergencies occur in up to 2%–3% of hypertensive patients.[8,10]

The mean IOPs of the patients in the study group before being treated with antihypertensive medications were 15.29 ± 4.05 mmHg in the right eye and 15.11 ± 3.78 mmHg in the left eye. The mean IOP measured when BPs returned to normal was 13.78 ± 4.06 mmHg in the right eye and 13.51 ± 3.82 mmHg in the left eye. A decrease in IOP was found to be 1.50 mmHg in the right eye and 1.59 mmHg in the left eye. The decrease in IOP was found to be statistically different ($P < 0.001$). In addition, the mean IOP measured at presentation in the control group was 13.54 ± 3.51 mmHg in the right eye and 13.20 ± 3.33 mmHg in the left eye. The mean IOPs in the study group after treatment with antihypertensive medications were similar to the mean IOP in the control group, in which patients with normal BPs presented to the ED.

To the best of our knowledge, this is the first study conducted in literature in which the association between IOP and systemic BP was studied in an emergency

setting. In the cross-sectional observational study by Deb *et al*., the relationship between BP, IOP, mean ocular pressure, and primary open-angle glaucoma in patients with hypertension was studied, and these patients were compared to a control group of normotensives without diagnosed hypertension. This study was carried out at the department of ophthalmology in a tertiary health-care center in India. The mean age for each group was 55 years old. A single BP measurement was taken. The mean systolic and diastolic pressures in the hypertensive group were 142.6 mmHg and 86.7 mmHg, respectively. The mean systolic and diastolic pressures in the normotensive group were 126.6 mmHg and 77.5 mmHg, respectively. The mean IOP in the hypertensive group was 15.2 mmHg in the right eye and 15.6 mmHg in the left eye, whereas the IOP in the normotensive group was 13.5 mmHg in both the right and left eyes. The means of the two groups were found to differ significantly ($P < 0.001$).[7] Although patients in this study did not have severe hypertensive values as the patients in our study did, the mean IOP in this study was similar to that found in our study.

In a systematic review and meta-analysis by Di Zhao *et al*., in 2014, the association between BP levels and hypertension with primary open-angle glaucoma and IOP endpoints was studied. Sixty observational studies were included. This study concluded that hypertension and increased SBP and DBP were consistently associated with increased IOP.[11]

Several mechanisms that could explain an increase in IOP with higher BP have been proposed. Increasing BPs may result in increased production of aqueous humor through elevated capillary pressure in the ciliary body.[12] Increased BP may also reduce aqueous humor outflow through elevated episcleral venous pressure.[13]

In our study, none of the patients in the control group had IOP over 21 mmHg. However, 14 patients (8.86%) in the study group had IOP of 21 mmHg or higher in at least one eye. The mean SBP and DBP of these patients were 201.43 ± 13.28 mmHg and 105.64 ± 16.55 mmHg, respectively. One of these patients had hypertensive emergency due to exacerbation of renal function.

In the Blue Mountains Eye Study conducted by Mitchell *et al*., in 2004, an association between hypertension and intraocular hypertension (defined as IOP >21 mmHg with no optic disc and visual field pathology) was observed. 3654 patients aged 49–97 years old were examined at the department of ophthalmology. Hypertension was defined as a history of hypertension currently receiving treatment or SBP ≥160 mmHg and/or DBP ≥95 mmHg at the examination. Hypertensive patients were then divided into three subgroups: treated and controlled, treated and uncontrolled, and untreated hypertensive. The prevalence of ocular hypertension was 8.1% in patients with treated and poorly controlled hypertension and 8.2% in untreated hypertension compared with 4.2% in normotensive patients. This was around twice the prevalence compared with normotensive patients.[14] In our study, intraocular hypertension was found in 8.86% of patients with severe hypertension. Therefore, the findings in our study are similar to those found in literature.

Limitation

An important limitation in this study is that one measurement of BP and IOP was taken, which could have led to measurement errors. The lack of detailed evaluation of corneal thickness is another limitation of our study. This could have resulted in inaccurate IOP measurements.

Strengths of this study include that IOP measurements were always taken by the same physician. It was predicted that the inaccurate measurement rate will be less with one practitioner who is experienced in using tonometer than that of inexperienced practitioners. However, assessing inter-rater reliability between measurements made by different practitioners could have made the study more reliable.

Furthermore, only cooperated patients were included in the study. This could have contributed to lower measurement errors. In addition, the IOP of severely hypertensive patients was compared with healthy normotensive individuals. This allowed the comparison of IOP between patients after being treated with antihypertensive medications and normotensive patients with no known history of hypertension.

Conclusions

Patients in the study group showed a significantly higher IOP compared to patients in the normotensive group. The patients in the study group showed a significant reduction in IOP after BP reduction. This may indicate that uncontrolled hypertension poses a risk for prolonged higher IOP. Prolonged higher IOP can be considered a risk factor for the glaucoma. Further studies with larger numbers of subjects, including ophthalmologic evaluation of patients with uncontrolled hypertension, will help predict possible glaucoma in this group.

Author contributions' statement (CRedIT statement)

- CT: Methodology, software, investigation, resources, writing – original draft
- AB: Methodology, validation, formal analysis, writing – original draft
- ÖD: Investigation, validation, resources, supervision
- NMA: Project administration, writing – review and editing, conceptualization, supervision.

Ethical approval
Ethical approval was obtained from the Hacettepe University Ethical Committee numbered 2019/03-29 (KA-19001).

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Conflicts of interest
None declared.

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