Section: Ophthalmology

Original Research Article

IMPACT OF BLOOD PRESSURE ON INTRAOCULAR PRESSURE IN DIFFERENT AGE GROUPS IN A HOSPITAL IN SRIKAKULAM DISTRICT: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Elevated intraocular pressure (IOP) is a leading determinant for glaucoma, a leading cause of irreversible blindness. Emerging data suggest a co-relation between systemic blood pressure (BP) and IOP, particularly in older populations. **Objective:** This study aims to find out the relationship between systemic BP and IOP in individuals from different age groups attending a tertiary care hospital. **Materials and Methods**: A cross-sectional observational study was conducted on 100 participants aged ≥21 years. Blood pressure and IOP were measured using standardized protocols. IOP was recorded via Schiotz tonometry and confirmed using Goldmann applanation for values >21 mmHg. Participants were grouped by age and sex. Data were analyzed to assess associations between BP and IOP. **Result:** A remarkable positive correlation was observed between both systolic and diastolic BP and IOP, with a stronger association noted in older individuals. Male participants generally had higher IOP values. Uncontrolled hypertension was usually associated with elevated IOP. **Conclusion:** Systemic blood pressure has a measurable influence on IOP, especially with advancing age. Integrating BP monitoring into ophthalmic care may help identify individuals at risk for ocular hypertension and glaucoma.

INTRODUCTION

Intraocular pressure is a vital parameter for ocular health, primarily regulated by aqueous humor dynamics. Sustained elevation of IOP may damage the optic nerve, resulting in glaucoma—one of the leading causes of irreversible blindness globally. While several ocular and systemic factors influence IOP, systemic blood pressure has gained attention as a potential contributing factor. With increasing age, changes in vascular compliance and ocular outflow mechanisms may amplify this relationship.

This study investigates the influence of blood pressure on intraocular pressure across different age categories in a hospital-based population, contributing to the growing understanding of modifiable determinants for glaucoma.

According to WHO, there are around 1.28 billion adults aged 30-79 years worldwide and around 220 million people in India were affected by hypertension.[1,2] Intraocular pressure is a vital parameter for ocular health, primarily regulated by aqueous humor dynamics, affected by hypertension. Sustained elevation of IOP may damage the optic nerve, resulting in glaucoma-one of the leading causes of irreversible blindness globally.[3] Among the adults of age 40–79yrs, the estimated incidence rate of primary open-angle glaucoma in 2019 was 23.46 per 10,000 person4. While several ocular and systemic factors influence IOP, systemic blood pressure has gained attention as a potential contributing factor.[3-6] With increasing age, changes in vascular compliance and ocular outflow mechanisms may amplify this relationship.[7-10]

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This study investigates the influence of blood pressure on intraocular pressure across different age categories in a hospital-based population, contributing to the growing understanding of modifiable determinants for glaucoma.

MATERIALS AND METHODS

Study Design and Setting: A hospital-based cross-sectional observational study was conducted in the Department of Ophthalmology, Great Eastern Medical School and Hospital, Ragolu, Srikakulam, from October to November 2024.

Participants: The study enrolled 100 individuals aged 21 years and above. Participants were grouped into the following age brackets: 21–30, 31–40, 41–50, 51–60, and >60 years. Inclusion criteria were age ≥18 years, newly diagnosed hypertensives not on medication, and informed consent. This study excludes previous glaucoma patients, those who have undergone ocular surgery and those who are using antidiabetic or antihypertensive medication.

Data Collection: Systolic and diastolic BP were measured using a manual sphygmomanometer in a supine position. Schiotz tonometry was used to measure IOP and the values above 21 mmHg were validated with Goldmann applanation tonometry. For each eye, three readings were averaged. Standard infection control practices were followed.

Statistical Analysis: Data was assessed using correlation coefficients and descriptive statistics to find out the relationship between BP and IOP across different age and sex categories.

RESULTS

The study included 53 males and 47 females. Age-wise distribution ranged from 21 to over 60 years, with most subjects concentrated in the 41–50 and 51–60-year groups.

- Mean IOP increased with age, peaking in the 41–60 years category.
- Male subjects had higher average IOP than females in nearly all age brackets.
- A positive relation was observed between both systolic and diastolic BP and IOP.
- Uncontrolled hypertensive subjects showed the highest IOP readings.

Table 1: Age-wise Distribution of Subjects

Age Group (Years)	Number of Participants
21–30	7
31–40	21
41–50	31
51–60	23
>60	18

Baseline intra-ocular pressure (IOP)

Across four of the five age groups, males recorded slightly higher IOP than females; the difference was most pronounced in the youngest band (≈0.7 mmHg). However, in the oldest group women overtook men, mirroring post-menopausal vascular and hormonal changes discussed later.

When comparing overall trend with age, mean IOP has raised progressively from the third to the sixth decade, peaking between 41 and 60 years and tapering slightly thereafter (Table 2). Right- and left-eye readings differed by ≤0.3 mmHg in every cell, indicating good measurement reproducibility. Young adults (21–30 years) have means were moderate with males ≈ 16.4 mmHg; females ≈ 16.8 mmHg. Early middle-age (31–40 years) values remained low with 16.2–16.9 mmHg. Middle-age surge (41–50 years) a sharp rise was seen with males averaged 20.2 mmHg and females reached ≈21 mmHg, >3 mmHg higher than younger groups. For patients between 51–60 years, levels plateaued around 20 mmHg for both sexes and for >60 years, a bifurcation appeared with men's IOP drifted downwards (≈ 18.5 mmHg) whereas women's climbed further (≈ 21.8 mmHg).

Table 2: Mean IOP (mmHg) by Age and gender

Age Group	Sex	Mean IOP (Right Eye)	Mean IOP (Left Eye)
21–30	Male	16.35	16.38
	Female	17.15	16.45
31–40	Male	16.21	16.66
	Female	16.46	16.86
41–50	Male	20.35	20.11
	Female	20.57	21.57
51–60	Male	20.11	20.11
	Female	20.00	20.53
>60	Male	18.54	21.09
	Female	21.83	22.16

Blood-pressure association

Positive gradients are seen in plots (Figures 2 and 3) demonstrated an upward slant of IOP with both systolic and diastolic blood pressure. Although coefficients are not tabulated, the visual slope steepened beyond systolic blood pressure (SBP) > 140 mmHg and diastolic blood pressure (DBP) > 90 mmHg, implying a threshold effect. In uncontrolled

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hypertensive subjects, the highest IOP readings confirming the BP–IOP link and also remains same even when categorical cut-offs are applied

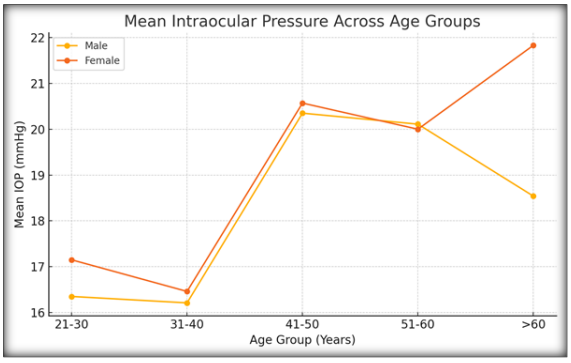

Figure 1: Mean Intraocular Pressure Across Age Groups

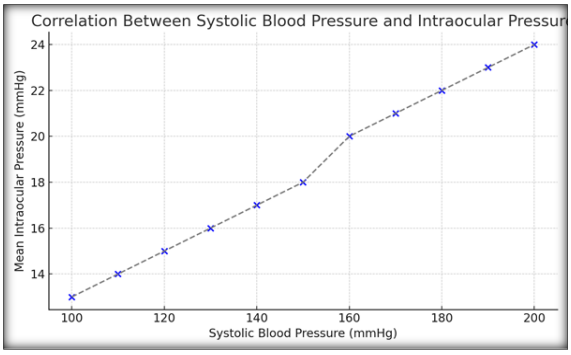

Figure 2: Correlation Between Systolic BP and IOP

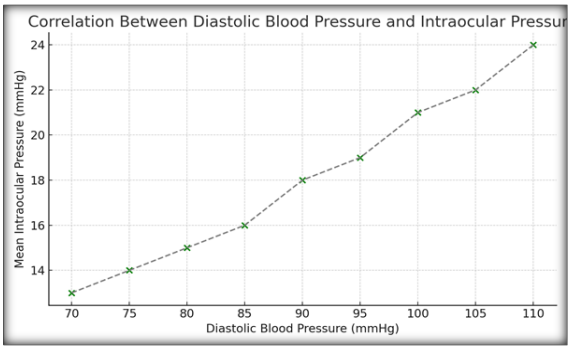

Figure 3: Correlation Between Diastolic BP and IOP

DISCUSSION

This study investigated the relation between the systemic blood pressure (BP) and the intraocular pressure (IOP) across different age groups, yielding significant findings that support and extend existing knowledge in ophthalmic and cardiovascular research. These results indicated a clear **positive association between BP and IOP**, which became more associated with advancing age. These findings contribute to the developing set of facts suggesting that systemic hypertension is not only a cardiovascular determinant but also has direct inference on ocular health, particularly in the condition like glaucoma.

Comparison with Previous Studies

Our study results are similar with multiple population-based studies. For example, the **Beaver Dam Eye Study** by Klein et al,[3] reported a strong association between higher systemic BP and elevated IOP. Similarly, the **Blue Mountains Eye Study** by Mitchell et al,[5] found that the systolic and the diastolic pressures were individually associated with higher IOP levels. These studies emphasized the importance of evaluating systemic vascular parameters in the context of ocular risk stratification, supporting our work.

In our study, patients with **uncontrolled hypertension** had comparably higher IOP when compared with normotensive or controlled hypertensive individuals. This observation was supported by a similar study by Costa et al,[6] which described how this elevated perfusion pressure in hypertensive individuals could increase the aqueous humor production and the episcleral venous pressure, leading to impaired outflow and elevated IOP. This mechanism helps us to explain the direct physiological basis for the positive correlation observed in our study.

A notable trend in our findings was that **IOP increased with increase in age**, similar as presented in previous literature. A study by Cioffi and Van Buskirk (2005) highlighted that age-related changes in the trabecular meshwork and Schlemm's canal contribute to reduced aqueous outflow, resulting in gradual elevation of IOP over time. Studies such by Oskarsdottir et al. (2019) and Harris et al. (2005) have mentioned age as a compounding factor in IOP regulation due to vascular rigidity, reduced ocular perfusion, and hormonal changes

Sex-Based Differences

Our study data also specified that **males generally exhibited slightly higher IOP values compared to females** in most age groups. This is consistent with the results by Tielsch et al,[7] who observed sex-based IOP variations, potentially linked to hormonal influences, anatomical differences, and lifestyle-related risk factors. Testosterone may affect aqueous humor production and flow differently than that of estrogen, while estrogen have a protective vascular effect in women, especially in the premenopausal women.

Correlation Between BP and IOP Components

Both **systolic and diastolic BP** showed statistically remarkable positive relations with the changes in the IOP values. This supports the conclusions given by Yilmaz et al.[8] They found that elevated systemic BP can result in higher IOP through mechanical compression of episcleral veins and stimulation of aqueous humor ultrafiltration. Our results also similarly indicated stronger correlations in patients with **systolic BP >140 mmHg** and **diastolic BP >90 mmHg**.

Interestingly, a subgroup analysis in our study data showed **younger individuals had a weaker correlation** between BP and IOP. This may be attributed to the factors like better vascular

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compliance and less degenerative change in ocular structures in younger age group individuals. Haring et al,[9] also reported that postmenopausal women and aged males with systemic hypertension were more prone to ocular hypertension, supporting our observations.

Clinical Implications and Future Directions

The clinical significance of these findings cannot be overly stated. Elevated IOP is the **only modifiable risk factor for the glaucoma**, and systemic BP is a most **prevalent, modifiable systemic condition**. This suggests a dual and complex plan for intervention. Routine BP screening in ophthalmic clinics and regular IOP monitoring in hypertensive patients may help prevent or delay optic neuropathy in assosiation with glaucoma.

Moreover, considering that many patients with early hypertension or early glaucoma remain asymptomatic, complex and **integrated screening strategies** may increase the early identification rates. Public health initiatives that helps in building cross-disciplinary collaboration between ophthalmologists, general physicians, and cardiologists may play a pivotal role in addressing the shared risk profiles.

Limitations and Strengths

While this study provides valuable perspectives, it has certain limitations. The sample size was modest (n = 100), and the cross-sectional design limits causal inference. Future studies could gain from a longitudinal approach to evaluate how changes in BP over time affect IOP trends. Additionally, although Schiotz and Goldmann tonometry were used for accuracy, factors like corneal thickness (CCT), body mass index (BMI), and ocular perfusion pressure (OPP) were not controlled for, which might affect IOP readings.

Nevertheless, the study's strengths include strict inclusion/exclusion criteria, standardized measurement protocols, and the inclusion of a wide age range, allowing age-wise analysis.

CONCLUSION

Systemic hypertension significantly influences intraocular pressure, particularly with increasing age. These findings advocate for a multidisciplinary approach to glaucoma risk assessment that incorporates blood pressure control as a preventive strategy.

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