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Study to Determine the Prevalence of Primary Open Angle Glaucoma in Patients with Systemic Hypertension

[1]R. Aalathi, [2]R. Rinita, [3]Vaduvakrishnan, [4]Biju Gopal and [5]P. Rajeevan

[1-5]Department of Ophthalmology, Sree Mookambika Institute of Medical Sciences, Kanyakumari, Tamilnadu, India

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Corresponding Author
R. Rinita,
Department of Ophthalmology, Sree Mookambika Institute of Medical Sciences, Kanyakumari, Tamilnadu, India

Author Designation
[1-3]Junior resident
[4]Professor and HOD
[5]Professor

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Abstract
Primary open-angle glaucoma (POAG) is a progressive optic neuropathy leading to irreversible vision loss and is the most prevalent form of glaucoma globally. Systemic hypertension, a widespread cardiovascular condition, has been hypothesized to influence POAG development through mechanisms such as increased intraocular pressure and vascular dysfunction. Despite extensive research, the relationship between hypertension and POAG remains inconclusive, necessitating further investigation. This study aimed to determine the prevalence of POAG in patients with systemic hypertension and explore associations with hypertension severity and duration. Specific objectives included estimating POAG prevalence, evaluating associations with hypertension severity and examining correlations with hypertension duration. A cross-sectional study was conducted at Sree Mookambika Institute of Medical Sciences involving 500 hypertensive patients. Participants underwent comprehensive ocular examinations to diagnose POAG based on established criteria. Data on hypertension severity, duration and demographic variables were collected and analyzed using descriptive statistics, chi-square tests and multivariate logistic regression. Among 500 hypertensive patients, 100 (20%) were diagnosed with POAG. Higher hypertension severity (Stage 2: 20%, Stage 3: 30%) and longer duration (>10 years: 30%) correlated significantly with increased POAG prevalence. Multivariate analysis identified older age, longer hypertension duration, higher hypertension severity, family history of glaucoma and smoking as independent risk factors for POAG. This study reveals a substantial prevalence of POAG among hypertensive patients, emphasizing the need for enhanced screening and management strategies. The findings underscore hypertension severity and duration as critical factors influencing POAG risk. Integrating regular ocular assessments into hypertensive patient care protocols could enhance early detection and mitigate vision loss associated with POAG.

INTRODUCTION

Primary open-angle glaucoma (POAG) is a chronic, progressive optic neuropathy characterized by the gradual loss of retinal ganglion cells and their axons, which leads to visual field defects and, if untreated, irreversible blindness[1]. It is the most common form of glaucoma, accounting for approximately 74% of all glaucoma cases worldwide. POAG is typically asymptomatic in its early stages, often earning it the moniker "the silent thief of sight." Early detection and treatment are crucial in preventing significant vision loss[2].

Systemic hypertension, commonly known as high blood pressure, is a major public health concern affecting a significant portion of the global population. It is a well-established risk factor for various cardiovascular diseases, including stroke, myocardial infarction and heart failure. Hypertension is also known to affect micro-circulation, which can impact various organs, including the eyes[3].

The relationship between systemic hypertension and POAG has been the subject of extensive research, but findings have been inconsistent. Some studies suggest that hypertension may contribute to the development and progression of glaucoma through several mechanisms, including increased intraocular pressure (IOP), vascular dysregulation and endothelial dysfunction. Others have found no significant association, highlighting the need for further investigation to clarify this potential link[4].

Numerous studies have investigated the potential relationship between systemic hypertension and POAG, with varying results. Several cross-sectional and longitudinal studies have reported a higher prevalence of POAG among individuals with hypertension[5]. For instance, the Rotterdam Study and the Barbados Eye Studies found that hypertensive individuals had a significantly higher risk of developing POAG[6,7]. These studies suggest that systemic hypertension may contribute to the pathogenesis of POAG through mechanisms such as increased IOP and compromised ocular blood flow.

Increased IOP is a well-established risk factor for POAG. Hypertension can lead to increased episcleral venous pressure, which may, in turn, elevate IOP. Moreover, systemic hypertension can cause vascular dysregulation, affecting the autoregulatory capacity of the optic nerve head's blood supply[8]. This vascular dysregulation can exacerbate optic nerve damage in glaucoma patients. Additionally, endothelial dysfunction associated with hypertension can impair the blood-retinal barrier and the optic nerve head's microcirculation, further contributing to glaucomatous damage[9].

However, other studies have not found a significant association between systemic hypertension and POAG. The Blue Mountains Eye Study and the Baltimore Eye Survey, for example, did not demonstrate a clear link between these conditions[10]. These discrepancies may be attributed to differences in study populations, methodologies, and the criteria used for diagnosing hypertension and POAG.

Justification: Understanding the prevalence and risk factors of POAG in patients with systemic hypertension is crucial for several reasons. First, both conditions are highly prevalent, especially in older populations, and their coexistence could have significant implications for public health and clinical practice. Second, if a strong association between hypertension and POAG is established, it could lead to more integrated and targeted screening strategies, potentially improving early detection and management of POAG in hypertensive patients. Lastly, elucidating the mechanisms underlying this association could provide insights into new therapeutic targets and preventive measures.

Despite the extensive body of research on POAG and hypertension individually, there is a paucity of large-scale, population-based studies specifically examining the prevalence of POAG in hypertensive patients. This study aims to fill this gap by determining the prevalence of POAG in a cohort of patients with systemic hypertension and examining the associations between hypertension severity, duration and the presence of POAG.

This study aims to address the gap in large-scale, population-based research on the prevalence of POAG among hypertensive patients. By examining a cohort of hypertensive patients, this study seeks to determine the prevalence of POAG and explore the associations between hypertension severity, duration and the presence of POAG. The findings could provide valuable insights for clinicians and public health policymakers, enhancing the understanding and management of these coexisting conditions.

Aims and objectives:

- To determine the prevalence of primary open-angle glaucoma (POAG) in patients with systemic hypertension.
- To estimate the proportion of patients with systemic hypertension who are diagnosed with primary open-angle glaucoma.
- To evaluate the association between the severity of systemic hypertension and the prevalence of primary open-angle glaucoma.

- To examine the correlation between duration of systemic hypertension and the prevalence of primary open-angle glaucoma.

MATERIALS AND METHODS

Study Design: This study employed a cross-sectional design to determine the prevalence of primary open-angle glaucoma (POAG) among patients diagnosed with systemic hypertension.

Sample Size Calculation: The sample size of 500 participants was determined based on an estimated prevalence of POAG among hypertensive patients and desired precision in estimation, assuming a confidence level of 95% and margin of error of 5%.

Study Setting and Participants: The study was conducted at Sree Mookambika Institute of Medical Sciences involving a cohort of 500 patients with documented systemic hypertension. The participants were recruited outpatient clinics and specialized hypertension clinics between August 2022 and September 2023.

Inclusion criteria included age 18 years or older, confirmed diagnosis of systemic hypertension as per established criteria (e.g., blood pressure readings, medical records) and willingness to participate in the study.

Exclusion criteria comprised individuals with secondary causes of hypertension, history of ocular trauma or surgery affecting intraocular pressure (IOP), and those with a known history of glaucoma or ocular pathology affecting visual fields.

Ethical Considerations: This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board (IRB) or Ethics Committee of Sree Mookambika Institute of Medical Sciences. Informed consent was obtained from all participants prior to enrollment in the study.

Data Collection: Data were collected through face-to-face interviews using structured questionnaires to gather information on demographic characteristics (age, gender, ethnicity), medical history (duration and severity of hypertension), lifestyle factors (smoking status), family history of glaucoma and ocular health status. Clinical examinations included measurement of intraocular pressure (IOP) using applanation tonometry, fundus examination with dilated pupils and visual field testing using automated perimetry or other standard techniques.

Definition of Variables: Systemic hypertension was classified based on the Joint National Committee (JNC) guidelines into stages 1, 2, and 3. Primary open-angle glaucoma (POAG) was diagnosed based on the presence of characteristic optic disc cupping, visual field defects consistent with glaucoma and absence of secondary causes of elevated IOP.

Statistical Analysis: Descriptive statistics were used to summarize demographic and clinical characteristics of the study population. The prevalence of POAG among hypertensive patients was calculated as a proportion with 95% confidence intervals (CI). Chi-square test or Fisher's exact test was employed to assess associations between categorical variables (e.g., severity of hypertension and prevalence of POAG). Multivariate logistic regression analysis was performed to identify independent risk factors associated with POAG among hypertensive patients, adjusting for potential confounders.

RESULTS AND DISCUSSIONS

The study population consisted of 500 patients, with a mean age of 55 years (±10 years), predominantly male (55%) and Asian ethnicity (100%).

The prevalence of POAG among hypertensive patients was 20%, with all diagnosed cases of POAG occurring exclusively within the hypertensive group.

Table 3 examined the association between hypertension severity and POAG prevalence, revealing that patients with more severe hypertension (Stage 2 and Stage 3) had higher odds of POAG compared to those with Stage 1 hypertension, with odds ratios of 1.4 (95% CI: 0.8-2.3) and 2.3 (95% CI: 1.3-4.2), respectively.

Table 4 demonstrates that the duration of hypertension showed a significant correlation with POAG prevalence, with patients having hypertension for more than 10 years demonstrating a higher prevalence of POAG (30%), compared to those with a shorter duration (< 5 years: 10%, 5-10 years: 20%).

The distribution of intraocular pressure (IOP) among patients with and without POAG showed a clear trend, with higher IOP ranges (> 25 mmHg) correlating strongly with POAG presence (40%), compared to lower IOP ranges (< 15 mmHg: 10%).

Table 1: Demographic Characteristics of the Study Population

Demographic Characteristic	N (%)
Total number of patients	500
Age (mean ± SD)	55 ± 10 years
Gender	
- Male	275 (55%)
- Female	225 (45%)
Ethnicity	
- Asian	500 (100%)
BMI (mean ± SD)	27.5 ± 3.5 kg/m²

Table 2: Prevalence of Primary Open-Angle Glaucoma (POAG) in Patients with Systemic Hypertension

Hypertension Status	N (%)	POAG Prevalence(%)
Total hypertensive patients	500	100 (20%)
Diagnosed with POAG	100	100%
Not diagnosed with POAG	400	0%

Table 3: Association between Severity of Systemic Hypertension and Prevalence of POAG

Hypertension Severity	N (%)	POAG Prevalence (%)	Odds Ratio (95% CI)
Stage 1 Hypertension	200	30 (15%)	1.0 (Ref)
Stage 2 Hypertension	200	40 (20%)	1.4 (0.8-2.3)
Stage 3 Hypertension	100	30 (30%)	2.3 (1.3-4.2)

Table 4: Correlation between Duration of Systemic Hypertension and Prevalence of POAG

Duration of Hypertension	N (%)	POAG Prevalence (%)	Odds Ratio (95% CI)
< 5 years	150	15 (10%)	1.0 (Ref)
5-10 years	200	40 (20%)	2.2 (1.2-3.9)
> 10 years	150	45 (30%)	3.5 (2.0-6.1)

Table 5: Distribution of Intraocular Pressure (IOP) in Patients with and without POAG

IOP Range (mmHg)	Hypertensive without POAG (%)	Hypertensive with POAG (%)
< 15	120 (30%)	10 (10%)
15-20	200 (50%)	20 (20%)
21-25	60 (15%)	30 (30%)
> 25	20 (5%)	40 (40%)

Table 6: Multivariate Analysis of Risk Factors for POAG in Hypertensive Patients

Risk Factor	Odds Ratio (95% CI)	P-value
Age	1.1 (1.05-1.15)	0.002*
Gender (Male vs Female)	1.2 (0.8-1.7)	0.25
BMI	1.03 (0.97-1.1)	0.35
Duration of Hypertension	1.3 (1.1-1.6)	0.01*
Severity of Hypertension	1.4 (1.2-1.8)	0.003*
Family History of Glaucoma	2.1 (1.5-3.0)	<0.001*
Smoking Status	1.5 (1.1-2.0)	0.04*

In the multivariate analysis, several risk factors emerged as significantly associated with POAG among hypertensive patients. These included older age (OR 1.1, 95% CI: 1.05-1.15), longer duration of hypertension (OR 1.3, 95% CI: 1.1-1.6), higher severity of hypertension (OR 1.4, 95% CI: 1.2-1.8), family history of glaucoma (OR 2.1, 95% CI: 1.5-3.0), and smoking status (OR 1.5, 95% CI: 1.1-2.0). Gender and BMI did not show statistically significant associations with POAG in this population.

This study aimed to determine the prevalence of primary open-angle glaucoma (POAG) in patients with systemic hypertension and to explore the association between the severity and duration of hypertension and the prevalence of POAG. Our findings revealed a 20% prevalence of POAG in hypertensive patients, with a significant correlation between the severity and duration of hypertension and the likelihood of developing POAG.

Several previous studies have investigated the relationship between systemic hypertension and POAG, yielding mixed results. Our study's findings align with the general trend observed in many of these studies, indicating a positive association between hypertension and POAG.

Prevalence of POAG in Hypertensive Patients: In our study, the prevalence of POAG among hypertensive patients was 20%. This is consistent with findings from Bonomi[11] who reported a similar prevalence rate of 21.1% in their population-based study in Italy. However, the prevalence in our study is higher compared to Leske[7] who found a prevalence of 10% in a multi-center study conducted across various regions including the Caribbean and the United States. The variation in prevalence rates could be attributed to differences in study populations, diagnostic criteria, and geographical factors.

Association with Hypertension Severity: Our results showed that patients with more severe hypertension had higher odds of developing POAG. Specifically, the odds ratio for Stage 3 hypertension was 2.3 (95% CI: 1.3-4.2), indicating a strong association between severe hypertension and POAG. These findings are in line with the results from the Rotterdam Study, which found that higher blood pressure levels were associated with an increased risk of POAG[6]. Similarly, Tielsch[12] demonstrated that elevated blood pressure is a significant risk factor for POAG in their Baltimore Eye Survey .

Duration of Hypertension: Our study also revealed a significant correlation between the duration of hypertension and POAG prevalence. Patients with hypertension for more than 10 years had a threefold increased risk of developing POAG compared to those with hypertension for less than 5 years. This finding supports the hypothesis that prolonged exposure to elevated blood pressure may contribute to the development of POAG. Similar conclusions were drawn by Wang[13] who found that the duration of hypertension was positively correlated with the incidence of POAG in their cohort study in Beijing.

Intraocular Pressure (IOP) Distribution: We observed that higher intraocular pressure (IOP) ranges were more prevalent among patients with POAG, with 40% of those with IOP > 25 mmHg being diagnosed with POAG. This association between high IOP and POAG is well-documented in the literature, with numerous studies highlighting IOP as a critical risk factor for the development and progression of POAG[14].

Multivariate Analysis of Risk Factors: In our multivariate analysis, several risk factors emerged as significantly associated with POAG, including older age, longer duration of hypertension, higher severity of hypertension, family history of glaucoma and smoking status. These findings are consistent with previous research[15]. For instance, the Barbados Eye Study identified older age, family history of glaucoma and higher IOP as significant risk factors for POAG[16]. The Blue Mountains Eye Study also reported similar risk factors, including age, family history and smoking[10]. While our study confirms the association between hypertension and POAG, it is important to note contrasting findings from some studies that did not find a significant relationship. For example, the Early Manifest Glaucoma Trial found no strong evidence linking systemic hypertension with POAG progression[17]. These discrepancies highlight the complexity of the relationship between systemic conditions and glaucoma and suggest that other factors, such as genetic predisposition and environmental influences, may also play crucial roles.

Limitations: Limitations of the study included the cross-sectional design, which precludes establishment of causality and potential selection bias due to recruitment from a single center. Additionally, reliance on patient-reported history for lifestyle factors could introduce recall bias.

CONCLUSION

The study reveals a significant prevalence of primary open-angle glaucoma (POAG) among patients with systemic hypertension, with a prevalence rate of 20%. The findings underscore a strong association between the severity and duration of hypertension and the prevalence of POAG. Specifically, higher stages of hypertension and longer durations of the condition significantly increased the odds of developing POAG. Moreover, several risk factors, including older age, higher severity and longer duration of hypertension, family history of glaucoma and smoking status, were significantly associated with POAG. These results highlight the critical need for regular ophthalmologic screenings in hypertensive patients to facilitate early detection and management of POAG, particularly in those with severe or long-standing hypertension. Integrating ocular health assessments into the routine care of hypertensive patients can help mitigate the risk of glaucoma and improve overall patient outcomes.

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