Original Research

STUDY OF THE RELATIONSHIP BETWEEN SYSTEMIC HYPERTENSION AND RETINAL VASCULAR ALTERATIONS IN ADULTS ATTENDING A TERTIARY CARE HOSPITAL

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ABSTRACT

Background: Systemic hypertension is a major risk factor for cardiovascular, cerebrovascular, and renal diseases. Persistent elevated blood pressure causes retinal microvascular changes collectively known as hypertensive retinopathy. Retinal examination provides a non-invasive method for assessing vascular damage and target organ involvement in hypertensive patients. The present study aimed to evaluate the association between systemic hypertension and retinal vascular changes in adults attending a tertiary care hospital.

Methodology: This hospital-based cross-sectional study was conducted in the Department of General Medicine at Sree Mookambika Institute of Medical Sciences from January 2025 to January 2026. A total of 200 hypertensive patients were included. Blood pressure was measured using standard methods and patients were categorized as controlled or uncontrolled hypertension. Detailed ophthalmologic examination and fundus photography were performed after pupillary dilatation. Retinal changes were graded according to the Keith–Wagener–Barker classification. Statistical analysis was performed to determine associations between hypertension and retinal vascular changes.

Results: Among 200 patients, 67% showed evidence of hypertensive retinopathy. Grade 1 retinopathy was the most common finding (36%), followed by Grade 2 (21%), Grade 3 (8%), and Grade 4 (2%). Severe retinopathy was observed exclusively in uncontrolled hypertensive patients ($p<0.001$). Longer duration of hypertension was significantly associated with increased severity of retinal vascular changes.

Conclusion: Hypertensive retinopathy is strongly associated with uncontrolled and long-standing hypertension. Retinal examination is a valuable non-invasive tool for early detection of vascular damage and assessment of systemic complications in hypertensive patients.

Keywords: Systemic Hypertension, Hypertensive Retinopathy, Retinal Vascular Changes, Fundus Examination, Blood Pressure, Target Organ Damage.

INTRODUCTION

Systemic hypertension is one of the most common chronic non-communicable diseases worldwide and represents a major public health challenge due to its association with cardiovascular, cerebrovascular, and renal complications [1]. Persistent elevation of blood pressure causes structural and functional alterations in blood vessels, leading to target organ damage involving the heart, kidneys, brain, and eyes. Hypertension contributes significantly to global morbidity and mortality and remains a leading risk factor for ischemic heart disease, stroke, heart failure, and chronic kidney disease [2].

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Among the various target organs affected by hypertension, the retina provides a unique opportunity to directly visualize the microcirculation non-invasively. Retinal blood vessels are the only vessels in the body that can be examined directly using ophthalmoscopy, making the retina an important site for assessing systemic vascular changes [3]. Retinal vascular abnormalities may reflect generalized vascular damage and provide valuable information regarding the severity and duration of systemic hypertension. Consequently, retinal examination plays an important role in the evaluation of hypertensive patients and may aid in the early detection of vascular complications.

Hypertensive retinopathy (HR) refers to the spectrum of retinal vascular changes caused by

elevated systemic blood pressure. The retinal manifestations of hypertension include generalized and focal arteriolar narrowing, arteriovenous nicking, copper and silver wiring of retinal arterioles, retinal hemorrhages, cotton wool spots, hard exudates, and optic disc edema in severe cases [4]. These changes occur due to vasospasm, endothelial dysfunction, increased vascular permeability, arteriosclerosis, and ischemic injury resulting from sustained hypertension [5]. Acute elevations in blood pressure may produce reversible vasoconstriction, whereas chronic hypertension leads to permanent structural vascular changes and retinal ischemia.

Several studies have shown that hypertensive retinal vascular changes are closely associated with systemic target organ damage. Retinal microvascular abnormalities have been linked to left ventricular hypertrophy, coronary artery disease, cerebrovascular accidents, and renal dysfunction [6]. Evidence also suggests that retinal vascular changes may serve as predictors of stroke, cardiovascular events, and mortality independent of traditional cardiovascular risk factors [7]. Therefore, assessment of hypertensive retinopathy may have prognostic value in risk stratification and long-term management of hypertensive patients.

The Keith–Wagener–Barker classification remains one of the most widely used systems for grading hypertensive retinopathy based on the severity of retinal vascular changes [8]. However, mild and early retinal changes are frequently overlooked in asymptomatic patients despite their potential association with systemic vascular injury. Recent advances in retinal imaging techniques have improved the understanding of retinal microvascular alterations and their relationship with systemic hypertension.

In developing countries such as India, the burden of hypertension is rapidly increasing due to urbanization, sedentary lifestyle, dietary changes, obesity, and aging population [9]. Early identification of retinal vascular changes in hypertensive individuals may help prevent serious cardiovascular and cerebrovascular complications through timely intervention and strict blood pressure control. Despite the growing prevalence of hypertension, there is limited data regarding the pattern and severity of retinal vascular changes among hypertensive adults attending tertiary care hospitals.

Hence, the present study was undertaken to evaluate the association between systemic hypertension and retinal vascular changes in adults attending a tertiary care hospital and to assess the relationship between the severity of hypertension and hypertensive retinopathy.

Aim

To evaluate the association between systemic hypertension and retinal vascular changes in adults attending a tertiary care hospital.

Objectives

1. To identify retinal vascular changes in adult patients diagnosed with systemic hypertension.
2. To classify hypertensive retinopathy based on the severity of retinal vascular changes.
3. To assess the relationship between duration and severity of hypertension and retinal vascular abnormalities

MATERIALS AND METHODS

This hospital-based cross-sectional observational study was conducted in the Department of General Medicine at Sree Mookambika Institute of Medical Sciences during the period from January 2025 to February 2026. A total of 200 hypertensive patients were enrolled in the study using convenience sampling. Adult patients with a confirmed diagnosis of systemic hypertension based on JNC-7 or ESC 2013 guidelines and willing to provide informed consent were included in the study. Patients with pre-existing retinal diseases such as diabetic retinopathy and retinal vein occlusion, media opacities including advanced cataracts preventing proper fundus visualization, and those with a history of ocular surgery within the preceding six months were excluded from the study.

Detailed demographic and clinical data including age, gender, duration of hypertension, and current antihypertensive medications were recorded using a structured proforma. Blood pressure was measured using a calibrated sphygmomanometer under standard conditions. Three readings were obtained at appropriate intervals, and the average value was considered for analysis. Based on blood pressure recordings, patients were categorized into controlled hypertension (BP <140/90 mmHg) and uncontrolled hypertension (BP ≥140/90 mmHg).

All study participants underwent detailed ophthalmologic evaluation. Visual acuity assessment was performed using a Snellen chart. Following pupillary dilatation with tropicamide 1% eye drops, fundus photography was carried out using a non-mydriatic retinal camera such as Canon CR-2. Retinal vascular changes were independently graded by two ophthalmologists according to the Keith–Wagener–Barker classification system. Grade 1 hypertensive retinopathy included mild generalized arteriolar narrowing; Grade 2 included focal arteriolar constriction with arteriovenous nicking; Grade 3 included retinal hemorrhages, exudates, and cotton-wool spots; and Grade 4 included papilledema suggestive of malignant hypertension.

The collected data were entered into Microsoft Excel and analyzed using appropriate statistical software. Quantitative variables were expressed as mean ±

standard deviation, while qualitative variables were presented as frequencies and percentages. Associations between retinal vascular changes and blood pressure status, duration of hypertension, and demographic variables were analyzed using Chi-square test and Student's t-test wherever appropriate. Correlation analysis was performed to determine the relationship between severity of hypertension and grades of hypertensive retinopathy. A p-value of less than 0.05 was considered statistically significant.

RESULT

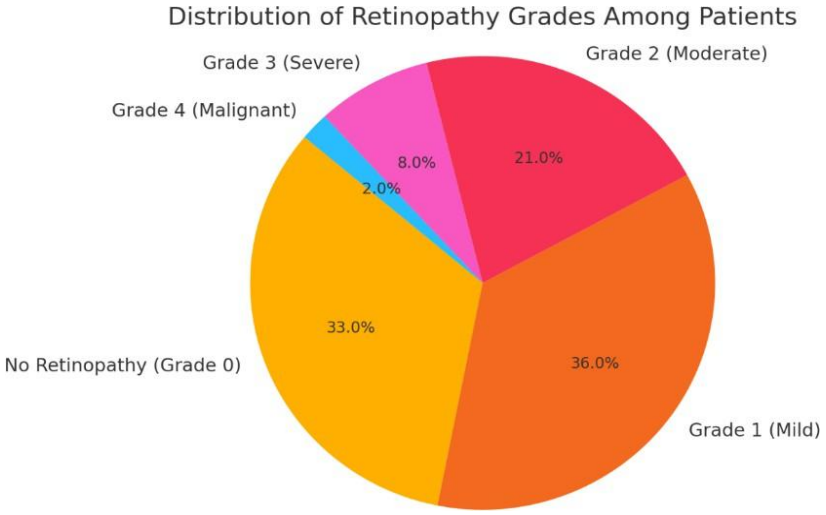
The study included 200 hypertensive patients (mean age: 58.4 ± 10.2 years), with 112 (56%) males and 88 (44%) females. Among them, 124 (62%) had uncontrolled hypertension (BP ≥140/90 mmHg), while 76 (38%) had controlled hypertension (BP <140/90 mmHg).

1. Prevalence and Severity of Hypertensive Retinopathy

- Overall, 134 patients (67%) exhibited some degree of hypertensive retinopathy (HR).
- The distribution based on Keith-Wagener-Barker classification was as follows:

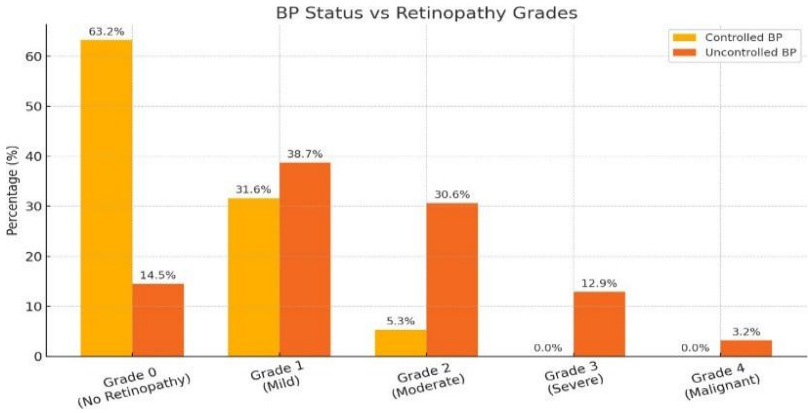
Grade of Retinopathy	Number of Patients (n=200)	Percentage (%)
No Retinopathy (Grade 0)	66	33.0%
Grade 1 (Mild)	72	36.0%
Grade 2 (Moderate)	42	21.0%
Grade 3 (Severe)	16	8.0%
Grade 4 (Malignant)	4	2.0%

Patients with uncontrolled hypertension had significantly higher-grade retinopathy ($p < 0.001$).



1. Association between Blood Pressure Control and Retinopathy

BP Status	No Retinopathy (n=66)	Grade 1 (n=72)	Grade 2 (n=42)	Grade 3 (n=16)	Grade 4 (n=4)
Controlled (n=76)	48 (63.2%)	24 (31.6%)	4 (5.3%)	0 (0%)	0 (0%)
Uncontrolled (n=124)	18 (14.5%)	48 (38.7%)	38 (30.6%)	16 (12.9%)	4 (3.2%)

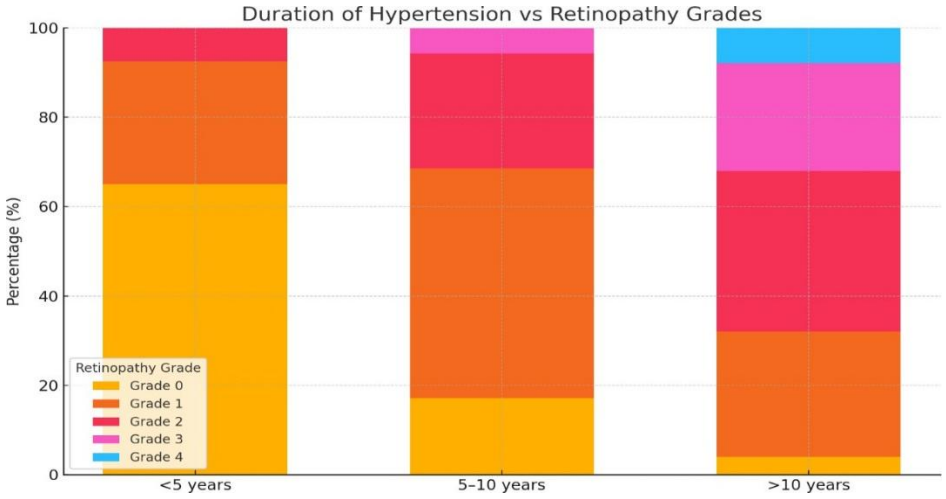


63.2% of controlled hypertensives had no retinopathy, whereas only 14.5% of uncontrolled hypertensives had no retinal changes. Severe retinopathy (Grades 3 & 4) was exclusively seen in uncontrolled hypertensives (16.1% vs. 0%, $p < 0.001$).

2. Correlation between Hypertension Duration and Retinopathy Severity

Durationof HTN (Years)	No Retinopathy (n=66)	Grade1 (n=72)	Grade2 (n=42)	Grade3 (n=16)	Grade4 (n=4)
<5 years (n=80)	52 (65.0%)	22 (27.5%)	6 (7.5%)	0 (0%)	0 (0%)
5–10 years (n=70)	12 (17.1%)	36 (51.4%)	18 (25.7%)	4 (5.7%)	0 (0%)
>10 years (n=50)	2 (4.0%)	14 (28.0%)	18 (36.0%)	12 (24.0%)	4 (8.0%)

Longer hypertension duration strongly correlated with worse retinopathy ($p < 0.001$). 96% of patients with >10 years of hypertension had retinopathy, compared to 35% in those with <5 years.



3. Logistic Regression: Risk Factors for Severe Retinopathy (Grades 3 & 4)

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Uncontrolled HTN	8.42	3.21–22.10	<0.001
HTN Duration >10 years	5.87	2.45–14.06	<0.001
Age >60 years	1.94	0.92–4.10	0.08
Male Gender	1.32	0.67–2.60	0.42

Uncontrolled BP increased severe retinopathy risk by 8.4 times. Hypertension duration >10 years increased risk by 5.9 times. Age and gender were not significant independent predictors.

DISCUSSION

The present study evaluated the association between systemic hypertension and retinal vascular changes among adult hypertensive patients attending a tertiary care hospital. The findings demonstrated a high prevalence of hypertensive retinopathy, particularly among patients with uncontrolled and long-standing hypertension. The study highlights the importance of retinal examination as a useful and non-invasive tool for assessing microvascular damage in hypertensive individuals.

In the present study, 67% of hypertensive patients exhibited some degree of hypertensive retinopathy. Grade 1 hypertensive retinopathy was the most commonly observed retinal change, followed by Grade 2 retinopathy, while severe retinal involvement such as Grade 3 and Grade 4 changes were less common. Similar findings have been reported in previous studies where mild retinal vascular abnormalities were found to be more prevalent in hypertensive populations [9]. Early retinal changes such as generalized arteriolar narrowing and arteriovenous nicking reflect chronic vascular remodeling due to sustained elevated blood pressure [10].

The study also demonstrated a significant association between blood pressure control and the severity of hypertensive retinopathy. Patients with uncontrolled hypertension showed a markedly higher prevalence of retinal vascular abnormalities compared to those with controlled blood pressure. Severe hypertensive retinopathy (Grades 3 and 4) was observed exclusively among patients with uncontrolled hypertension, and this association was statistically significant ($p < 0.001$). Persistent elevation of systemic blood pressure results in endothelial dysfunction, increased vascular permeability, and ischemic retinal damage, leading to progressive retinal vascular alterations [11]. These findings support previous reports that inadequate blood pressure control is strongly associated with worsening retinal microvascular injury and target organ damage [12].

Another important observation in the current study was the relationship between duration of hypertension and retinopathy severity. Patients with hypertension duration less than 5 years predominantly showed either no retinopathy or mild retinal changes, whereas individuals with hypertension duration greater than 10 years demonstrated higher frequencies of moderate and severe retinopathy. Chronic exposure to elevated blood pressure causes progressive arteriosclerotic changes in retinal vessels, leading to narrowing, sclerosis, hemorrhages, exudates, and optic disc edema in advanced stages [13]. Similar correlations between duration of hypertension and retinal vascular abnormalities have been documented in earlier studies [14].

The retina serves as an accessible site for direct visualization of systemic microcirculation and may provide important information regarding generalized vascular health. Retinal vascular changes have been associated not only with hypertension severity but also with increased risks of stroke, coronary artery disease, left ventricular hypertrophy, and chronic kidney disease [15]. Therefore, routine retinal screening in hypertensive patients may help identify individuals at increased cardiovascular and cerebrovascular risk.

The present study findings reinforce the clinical relevance of the Keith–Wagener–Barker classification in grading hypertensive retinopathy and assessing disease severity. Even mild retinal vascular changes may indicate ongoing systemic vascular injury and should not be overlooked during clinical evaluation. Early detection of retinal changes can facilitate timely intervention, optimization of blood pressure control, and prevention of further target organ damage.

However, the study has certain limitations. It was conducted in a single tertiary care center using convenience sampling, which may limit the generalizability of the findings. In addition, long-term follow-up was not performed to evaluate progression or regression of retinal changes following blood pressure control. Further multicentric prospective studies with larger sample sizes are required to better establish the prognostic significance of hypertensive retinal vascular changes.

CONCLUSION

The present study demonstrated a significant association between systemic hypertension and retinal vascular changes. Hypertensive retinopathy was more prevalent and severe among patients with uncontrolled and long-standing hypertension. Increasing duration and poor control of blood pressure were strongly correlated with progressive retinal microvascular damage. Retinal examination serves as a valuable, non-invasive tool for early detection of target organ involvement and may help identify hypertensive patients at increased risk of cardiovascular and cerebrovascular complications. Routine ophthalmologic screening and effective blood pressure control are essential for preventing progression of hypertensive retinopathy and associated systemic complications.

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