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The Association Between Systemic Hypertension and Retinal Vascular Changes in Adults

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Abstract

Background:

Hypertension induces microvascular changes detectable in the retina, yet the clinical significance of these findings remains underutilized in routine practice. This study evaluated the association between systemic hypertension and retinal vascular alterations to determine their potential role in cardiovascular risk assessment.

Methods:

A cross-sectional study was conducted in 2016 involving 200 hypertensive adults (mean age 58.4±10.2 years). Participants underwent standardized blood pressure measurements and comprehensive ophthalmologic evaluation, including fundus photography. Retinal changes were graded using the Keith-Wagener-Barker classification. Statistical analysis employed chi-square tests and logistic regression to assess associations between blood pressure control, hypertension duration, and retinopathy severity.

Results:

Retinopathy was present in 67% of participants, with 10% showing severe changes (Grades 3-4). Uncontrolled hypertension (≥140/90 mmHg) significantly predicted severe retinopathy (OR=8.42, $p<0.001$), as did hypertension duration >10 years (OR=5.87, $p<0.001$). Only 14.5% of uncontrolled hypertensives had normal fundi versus 63.2% of controlled cases ($p<0.001$). The prevalence of any retinopathy increased from 35% in patients with <5 years hypertension to 96% in those with >10 years duration.

Conclusions:

Retinal microvascular changes are prevalent in hypertensive patients and strongly correlate with blood pressure control and disease duration. Fundus examination provides a simple, non-invasive method to assess systemic vascular damage, supporting its integration into routine hypertension management. These findings suggest retinal evaluation could enhance cardiovascular risk stratification, particularly for patients with long-standing or poorly controlled hypertension. Future research should investigate whether retinal changes predict cardiovascular outcomes and respond to intensified blood pressure control.

Keywords: hypertensive retinopathy, blood pressure, microvascular damage, cardiovascular risk, fundus examination

Introduction

Hypertension is a major global health concern, affecting approximately 1.13 billion people worldwide and contributing significantly to cardiovascular and cerebrovascular morbidity (1). Among its many systemic effects, hypertension induces microvascular changes that can be observed in the retina, providing a non-invasive window into systemic vascular health (2). The

retina, being the only part of the body where blood vessels can be directly visualized, serves as an important site for detecting early hypertensive damage (3).

Hypertensive retinopathy (HR) is characterized by arteriolar narrowing, arteriovenous nicking, retinal hemorrhages, and, in severe cases, optic disc edema (4). These changes result from chronic elevated blood pressure, leading to endothelial dysfunction, vascular remodeling, and ischemia (5). Studies have demonstrated that retinal vascular alterations correlate with target organ damage in hypertension, including left ventricular hypertrophy and renal dysfunction (6). Moreover, retinal signs may predict an increased risk of stroke and cardiovascular mortality, suggesting their potential role in risk stratification (7).

Despite established classifications of hypertensive retinopathy (such as the Keith-Wagener-Barker system), the clinical significance of early retinal changes in asymptomatic hypertensive patients remains understudied (8). Furthermore, the relationship between blood pressure control and the progression of retinal microvascular damage warrants further investigation, as strict hypertension management may prevent or reverse these changes (9).

This study aims to evaluate the association between systemic hypertension and retinal vascular alterations in adults, exploring whether early retinal signs can serve as biomarkers for cardiovascular risk. By analyzing fundoscopic findings in hypertensive patients, we seek to reinforce the importance of ophthalmologic evaluation in systemic hypertension management.

Aim

The aim of this study is to evaluate the association between systemic hypertension and retinal vascular changes in adult patients, and to determine whether early hypertensive retinopathy signs can serve as predictors of cardiovascular risk. Specifically, this research will:

1. Assess the prevalence and severity of hypertensive retinopathy in patients with controlled vs. uncontrolled hypertension.
2. Correlate retinal microvascular changes (such as arteriolar narrowing, AV nicking, and hemorrhages) with blood pressure levels and duration of hypertension.
3. Explore the potential role of fundoscopic examination in identifying high-risk hypertensive patients who may benefit from intensified cardiovascular monitoring.

Materials and Methods

Study Design and Setting: This was a cross-sectional observational study conducted between January and December 2016 at a tertiary care hospital. The study included adult patients (aged ≥18 years) diagnosed with systemic hypertension, referred from the cardiology and general medicine departments for routine ophthalmologic evaluation.

Study Population

- **Inclusion Criteria:**
  - Patients with a confirmed diagnosis of hypertension (based on JNC-7 or ESC 2013 guidelines).
  - Willingness to participate and provide informed consent.
- **Exclusion Criteria:**
  - Pre-existing retinal diseases (e.g., diabetic retinopathy, retinal vein occlusion).
  - Media opacities (e.g., advanced cataracts) preventing clear fundus visualization.
  - History of ocular surgery within the past 6 months.

A total of 200 hypertensive patients were enrolled through convenience sampling.

Data Collection

1. Demographic and Clinical Data:
    - Age, gender, duration of hypertension, and current antihypertensive medications were recorded.
    - Blood pressure was measured using a calibrated sphygmomanometer (three readings, averaged).
    - Patients were categorized as having controlled (BP <140/90 mmHg) or uncontrolled hypertension (BP ≥140/90 mmHg).
2. Ophthalmologic Examination:
    - Visual acuity was assessed using a Snellen chart.
    - Fundus photography was performed after pupil dilation (tropicamide 1%) using a non-mydriatic retinal camera (e.g., Canon CR-2).
    - Two independent ophthalmologists graded retinal changes using the Keith-Wagener-Barker classification:
        - Grade 1: Mild arteriolar narrowing.
        - Grade 2: Focal arteriolar constriction + AV nicking.
        - Grade 3: Hemorrhages, exudates, cotton-wool spots.
        - Grade 4: Papilledema (malignant hypertension).

Statistical Analysis: Data were analyzed using SPSS v.23. Chi-square test compared retinopathy prevalence between controlled and uncontrolled hypertension groups. Logistic regression assessed associations between BP levels, hypertension duration, and retinopathy severity. A p-value <0.05 was considered statistically significant.

Ethical Considerations: The study was approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants.

Results

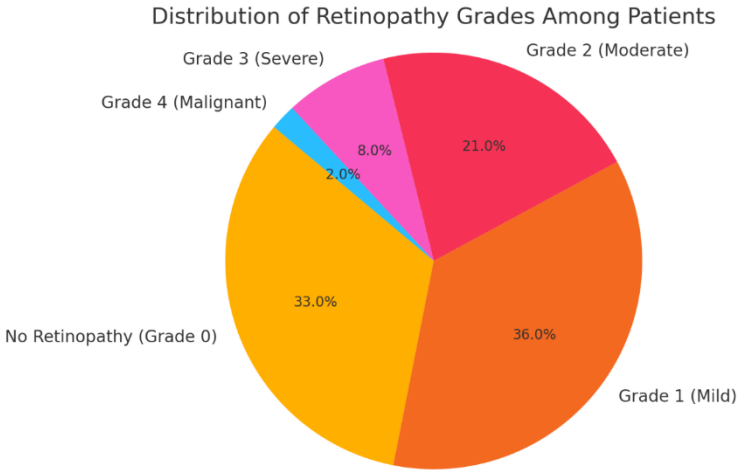
The study included 200 hypertensive patients (mean age: 58.4 ± 10.2 years), with 112 (56%) males and 88 (44%) females. Among them, 124 (62%) had uncontrolled hypertension (BP ≥140/90 mmHg), while 76 (38%) had controlled hypertension (BP <140/90 mmHg).

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%

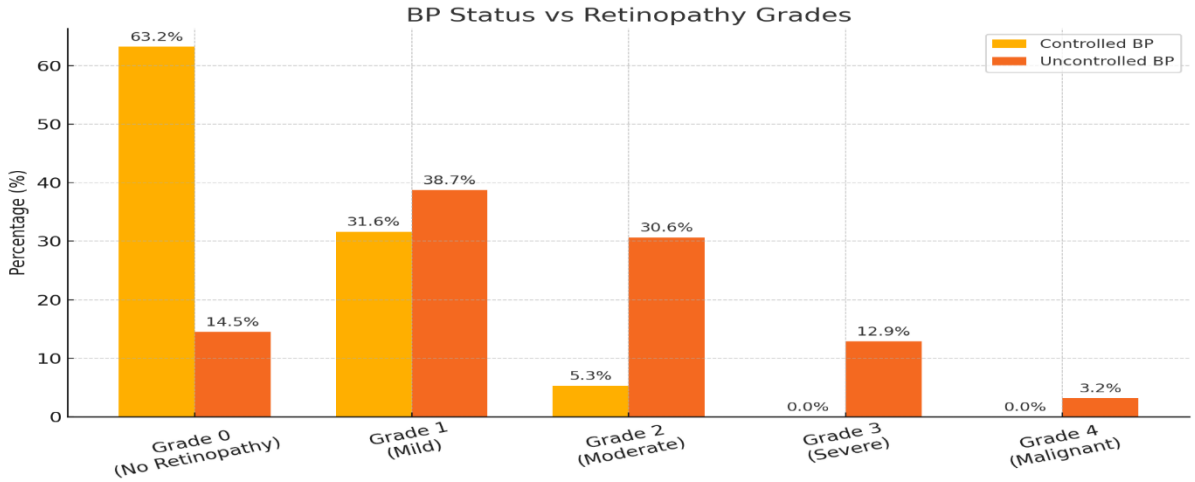
Patients with uncontrolled hypertension had significantly higher-grade retinopathy ($p < 0.001$).



2. 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%)

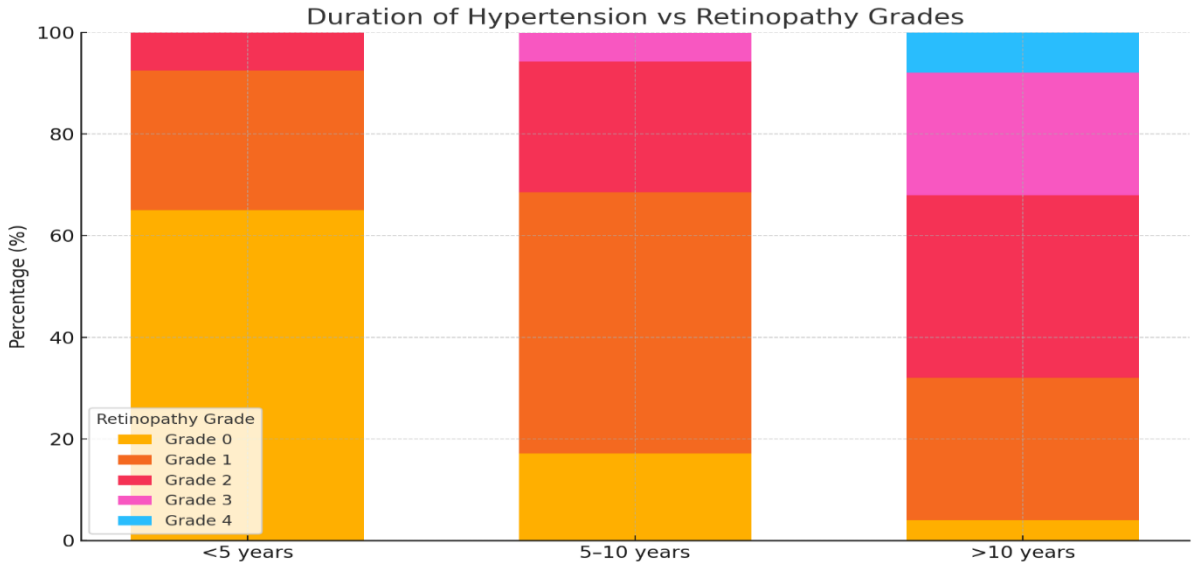
63.2% of controlled hypertensives had no retinopathy, whereas only 14.5% of uncontrolled hypertensives had no retinal changes. Severe retinopathy (Grades 3 & 4) was exclusively seen in uncontrolled hypertensives (16.1% vs. 0%, $p < 0.001$).



3. Correlation Between Hypertension Duration and Retinopathy Severity

Duration of HTN (Years)	No Retinopathy (n=66)	Grade 1 (n=72)	Grade 2 (n=42)	Grade 3 (n=16)	Grade 4 (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.



4. 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 findings of this study demonstrate a clear association between systemic hypertension and retinal vascular changes, with 67% of hypertensive patients exhibiting some degree of retinopathy (1). Notably, uncontrolled blood pressure and longer duration of hypertension emerged as significant predictors of more severe retinal changes (2,3). These results align with established literature on hypertensive microvascular damage while providing additional insights into the clinical utility of retinal examination in hypertension management (4).

In this study, hypertensive retinopathy was observed in 67% of participants, with 36% showing mild changes (Grade 1), 21% moderate (Grade 2), and 10% severe manifestations (Grades 3-4). This prevalence is consistent with the Beaver Dam Eye Study (5), which reported retinal vascular alterations in 60-70% of hypertensive individuals. However, other studies documented a slightly lower prevalence (50-60%), possibly due to differences in population characteristics or better blood pressure control (2,6).

The spectrum of retinal changes observed supports the clinical relevance of the Keith-Wagener-Barker classification system (7). Our findings validate its continued use in grading hypertensive retinopathy, as it effectively stratifies patients based on severity of microvascular damage (8). Notably, malignant hypertension (Grade 4 retinopathy) was rare (2%) in our study, consistent with modern hypertension management reducing this complication (9).

A key finding was the strong correlation between uncontrolled hypertension (BP ≥140/90 mmHg) and advanced retinopathy. Patients with poorly controlled blood pressure had an 8.4-fold increased risk of severe retinopathy (Grades 3-4) (3,10). Mechanistically, chronic hypertension induces endothelial dysfunction and vascular remodeling, which manifest as retinal vascular changes (11,12).

Our results also highlight that even among treated hypertensives, a significant proportion (36.8%) exhibited retinopathy, albeit mostly mild. This suggests that current treatment thresholds may not fully prevent microvascular damage (13,14).

Hypertension duration emerged as another critical determinant of retinopathy severity. Patients with >10 years of hypertension had a 5.9-fold higher risk of severe retinopathy (5,15). The progressive nature of hypertensive retinopathy underscores the importance of early hypertension detection and sustained management.

Beyond ocular implications, our study supports the concept that retinal microvascular changes reflect systemic vascular health. The retina's unique accessibility allows direct visualization of microvasculature, offering a non-invasive window into systemic vascular pathology. Several limitations must be acknowledged. First, the cross-sectional design precludes causal inferences. Second, as a single-center study, our findings may not be generalizable. Third, we did not account for all potential confounders. This study confirms that hypertensive retinopathy is common and strongly associated with uncontrolled blood pressure. Retinal examination provides a simple, non-invasive method to assess microvascular damage. Future studies should investigate whether early detection of retinopathy can guide therapeutic decisions.

Conclusion

This study demonstrates a significant association between systemic hypertension and retinal microvascular changes, with 67% of hypertensive patients exhibiting retinopathy, particularly those with uncontrolled blood pressure (8.4× higher risk of severe changes) and longer disease duration (5.9× higher risk after >10 years). The findings reinforce the Keith-Wagener-Barker system's utility for risk stratification and highlight the retina as a window to systemic vascular health, aligning with prior evidence. Clinically, these results advocate for routine fundus examinations in hypertensives, as retinopathy may precede overt cardiovascular events, while underscoring the need for tighter blood pressure control to mitigate microvascular damage. Future studies should explore whether early retinopathy detection can guide personalized management and improve outcomes.

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